



Republic of the Philippines
DEPARTMENT OF AGRICULTURE
PHILIPPINE FISHERIES DEVELOPMENT AUTHORITY
PCA Annex Building, Elliptical Road, Diliman, Quezon City

SECTION VI. TECHNICAL SPECIFICATIONS



CONSTRUCTION, REHABILITATION AND IMPROVEMENT OF ILOILO FISH PORT COMPLEX (IFPC)

Iloilo City

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SCHEMA
Eng'rs & Associates

Joint venture with



WSP Philippines, Inc.

CONSTRUCTION, REHABILITATION AND IMPROVEMENT OF ILOILO FISHPORT COMPLEX

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DIVISION 1

GENERAL REQUIREMENTS

DIVISION 1 - GENERAL REQUIREMENTS

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1.1 INTRODUCTION

The Specifications defines the requirements for the quality of materials and workmanship management for the satisfactory completion of the Works under the Contract.

These Specifications shall be read in conjunction with the other Contract Documents. In case of ambiguities or discrepancies, the Specifications shall have precedence over the Drawings and Bill of Quantities, but be overridden by the Conditions of Contract.

The Contractor shall carefully read and understand the exact meaning of the Specifications and/or Drawings.

In case of ambiguities or discrepancies or omission, in the opinion of the Contractor, he shall inform it to the Engineer for actions to be taken. This information shall be submitted in writing at the time of submission of Detailed Construction Schedule in accordance with appropriate-Clause of Conditions of Contract. The Engineer shall evaluate the related documents and decide the Works to be carried out based on the Contract. If the Contractor find out any discrepancies and carry out the Works without any consultation with the Engineer, all the risks based on these discrepancies shall be borne by the Contractor.

1.1.1 DESCRIPTION OF PROJECT

- a) Work under this Contract shall be subject to the terms and conditions stipulated in appropriate Section of the Conditions of Contract.
- b) This Section generally defines the Project as a whole and the items of work to be done under this Contract.

1.1.2 BRIEF PROJECT LOCATION

Iloilo Fish Port Complex (IFPC) is situated in a 21 hectare reclaimed area at Barangay Tanza, Iloilo City. It is served by extensive concrete road network that links it to the major business centers in the region and adjacent municipalities.

1.1.3 ITEMS OF WORK AND QUANTITIES

The Contractor, unless otherwise specified, shall furnish all labor, tools, equipment, materials, supplies, superintendence and other incidentals and shall perform all operations and maintenance work necessary to complete the work under the contract.

Refer to appropriate Section on the Bill of Quantities.

1.2 SITE CONDITIONS

1.2.1 GENERAL

Work under this contract shall be subject to the terms and conditions stipulated in the Conditions of Contract.

This Section sets forth supplementary and additional information on existing physical condition of the project.

1.2.2 INDIVIDUAL PORT CONDITIONS

a) Climate

Iloilo City's climate is monsoonal and has two (2) pronounced seasons namely, the dry and wet seasons. The following are the tables of the 2009 Meteorological Profile, Climatological Data and the Tropical Cyclones.

b) Natural and Physical Condition

(1) Prevailing Wind / Wave Direction

The Fish Port of Iloilo is facing at the southern side of the Philippine Archipelago. The prevailing wind direction is west southwest (WSW) based on PAGASA. It is necessary for the orientation of the berthing structure for easy maneuvering, economical operation and to avoid mishaps.

(2) Seismic Load

The National Structural Code of the Philippine (NSCP) 2010 (6th edition) is used in the conceptual design for seismic load input. According to the reference seismic map of the Philippines in NSCP, the project site is located in Zone 4, which shall be assigned a seismic zone factor, Z , of 0.40, as shown in Figure 1.1.

Figure 1.1 - Seismic Zoning Map



Table 1.1 Seismic Coefficient Derived from NSCP 2010

Parameter	Symbol	Value
Seismic Source Type	A	M > 7.0
Seismic Zone Factor, Zone 4	Z	0.40
		Soil Type: S _D
*Near Source Factor	N _a '	1.0
*Near-Source Factor	N _v '	1.0
Seismic Coefficient	C _a	0.44
Seismic Coefficient	C _v	0.64

The Peak Ground Acceleration (PGA) representative shall as a minimum has 10% probability of being exceeded in 50 years (475 years return period). NSCP defines 6 (six) types of Soil Profiles, namely SA, SB, SC, SD, SE, and SF.

(3) Tidal Data

The tidal range along the location of the Iloilo Fish Port Complex is shown in Table 1.2.

Table 1.2 - Tidal and Current Table

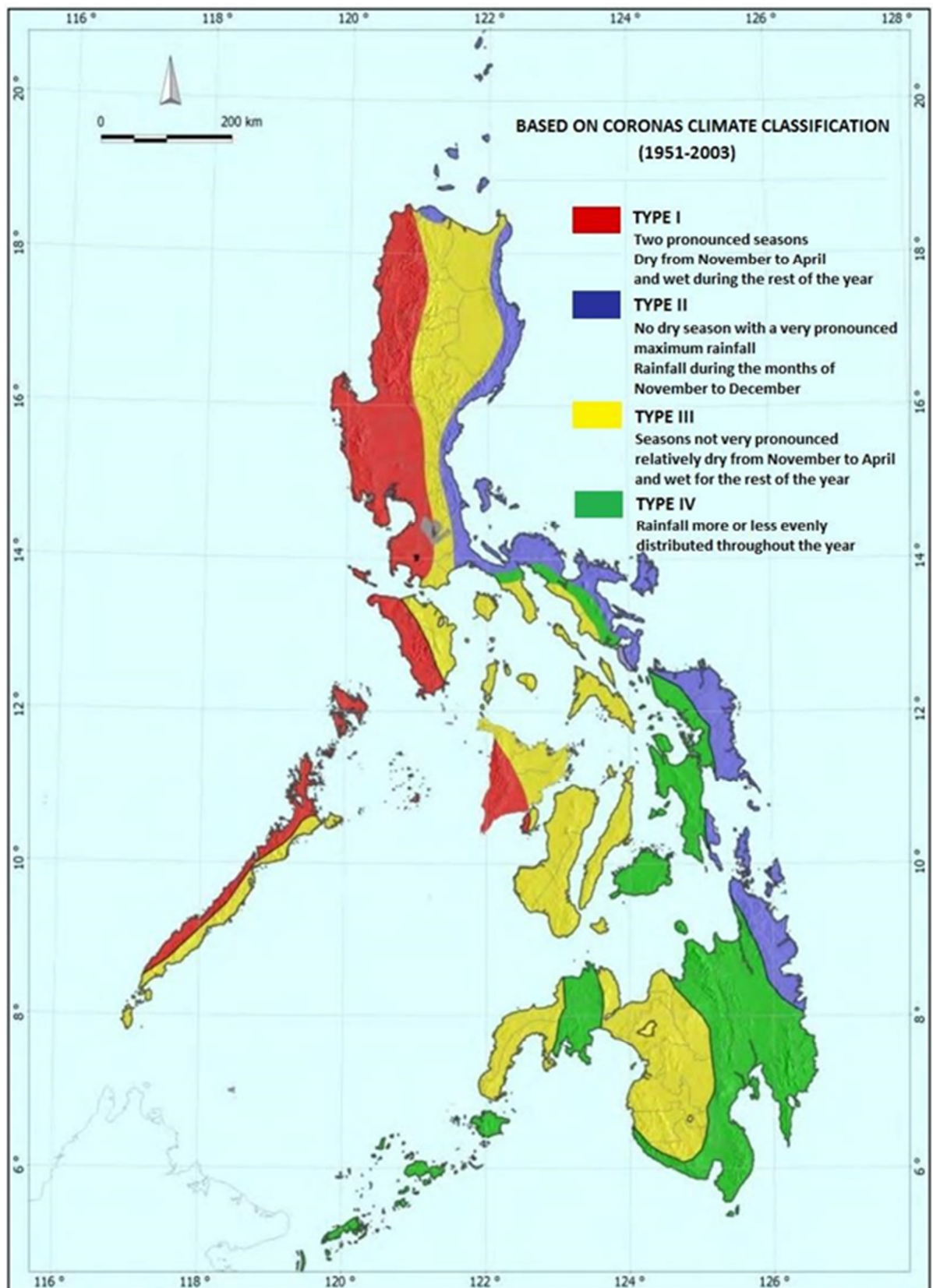
Reference Station	Iloilo
Mean High Higher Water Level, MHHW	+1.59 m
Mean Tide Level, MTL	+ 0.78 m
Mean Low Lower Water Level, MLLW	+ 0.00 m

Source: Tide and Current Table in the Philippines 2015

(4) Climatology and Tropical Cyclones

The Fish Port of Iloilo belong to Type 3 position of the Modified Coronas' Climate Classification of the Climate Map of the Philippines, which has no pronounced maximum period with dry season lasting only from one to three months either during the period from December to February or resembles Type 1 since it has short dry season. (See Figure 1.2 Climate Map of the Philippines).

Figure 1.2 - Climate Map of the Philippines



1.3 MATERIALS AND WORKMANSHIP

1.3.1 GENERAL

Work under this Contract shall be subject to the terms and conditions stipulated in the Conditions of Contract.

This Section sets forth supplementary and additional provisions relating to materials, products, equipment and workmanship required under this Contract.

1.3.2 MATERIALS

- a) All materials used in the construction of the Permanent Works required under this Contract shall be of first class quality of their respective kinds as specified herein and or described in the Drawings and Bill of Quantities, obtained from approved sources and suppliers of materials conforming to Specifications and shall comply strictly with the current issue of the appropriate standards published by the American Society for Testing and Materials (ASTM), the Japanese Industrial Standards (JIS) or other equivalent national or international standards. Reference to Philippine, American Standards in the Specifications or Bill of Quantities does not imply any bias in favor of equipment, fittings, finishing, etc. The Contractor may relate his offer to other National Standards or Codes of Practice but shall explain the system used and provide the Engineer with all the necessary information and comparisons in English showing that his proposed standards are equivalent to the specified standards. Three (3) copies of such alternative standards in English are to be supplied by the Contractor to the Engineer when required. Any material not fully specified herein shall be the best of their kind and be specifically in accordance to the specified material requirements as indicated in the appropriate Section of the Specifications.
- b) Grade of Materials: When reference to a standard is made without indication of a specific grade, the materials shall comply with the suitable grade thereof to be selected in consideration of their purpose and approved by the Engineer.
- c) Trade Names of the materials indicated in the Contract Documents are intended only to show the standard of the materials on which the design of the particular work is based and also to avoid ambiguous descriptions of the materials in the Drawings and Specifications.
- d) The indication of the trade names, therefore, shall in no way be considered a limit to the acceptability of other products of equal or better functions, performances, reliability and durability.
- e) Approval of Manufacturer and/or Materials (including alternative materials, equipment): refer to Section 1.7 "Submittals" for specific requirements.
- f) Order of Materials: After obtaining the Engineer's approval of the materials which conform with the requirements specified in the Specifications and as indicated on the Drawings, the Contractor shall place the order for materials in accordance with appropriate Section of Conditions of Contract. The Contractor shall forward copies in duplicate to the Engineer of all orders placed by him for the supply of materials to be used in the Permanent Works.

- g) Packaging: All materials shall be delivered to the Site in such packages as are normally used for transporting the same to a tropical country and shall be identifiable in a manner acceptable to the Engineer.
- h) Raw sand and gravel materials to be used shall be stockpiled properly on flat areas away from drainage routes. Cement, steel bars, concrete, culverts, etc. shall have own proper storage area and kept away from working

1.3.3 NOTICE OF MANUFACTURES

The Contractor shall give the Engineer a written notice of the articles or materials to be prepared or manufactured off-site, stating the place and time of the preparation or manufacture, in sufficient time for the Engineer to make inspections at all stages of the work and not only when any such article or material is completed.

Any article or material which is prepared or manufactured without giving such prior written notice to the Engineer may be rejected if the Engineer considers that inspection was necessary during the progress of the preparation or manufacture.

1.3.4 WORKMANSHIP

The workmanship employed in all works shall be of first class grade in the light of accepted internationally recognized standards of practice and the whole shall be in accordance with the requirement indicated in the Specifications and the Drawings. During its progress, and upon completion, the Works shall conform to the lines, elevations, and grades as shown on the Drawings. The Contractor shall complete the proposed Works in every detail as specified. However, should there be any detail or details omitted from the Drawings or Specifications which are essential to the intended completeness of any work, then it shall be the responsibility of the Contractor to furnish and install such details, subject to approval by the Engineer. Any work or workmanship not conforming to the best practices shall be subject to rejection. The whole of Permanent Works shall be subjected to the Engineer for its approval as to its compliance with the requirement indicated in the Specifications and Drawings.

1.3.5 MEASUREMENT AND PAYMENT

The requirements under materials and workmanship are incidental to other items of work and will not be measured for payment unless otherwise specified in the Bill of Quantities.

1.4 TEMPORARY FACILITIES

1.4.1 SCOPE OF WORK

This section shall include the mobilization and demobilization of Contractor's plant, equipment, materials and employee to the site; provision and maintenance of Engineer's field office/Living Quarters and facilities to include service vehicles; compliance with the contract requirements, and provision for the health/safety and environmental protection during the entire project duration.

This section shall include the furnishing of labor, materials, transportation, tools, supplies, plant, equipment and appurtenances to complete satisfactorily the construction of the proposed project.

1.4.2 FIELD OFFICE AND LIVING QUARTERS FOR THE ENGINEER/ PFDA STAFF

During the performance of the contract, the Contractor shall maintain the field office and living quarters for the Engineer/ PFDA Staff within the site of the work at designated location approved by the Philippine Fisheries Development Authority (PFDA) at which the Engineer/PFDA Staff shall be holding office at all times, while the work is in progress and within the number of months during the Project Implementation.

The Contractor shall provide 24-hour supply of potable water, electricity and other services for the field office and living quarters throughout the period of the Contract.

Construction shanties, sheds and temporary facilities provided as required for the Contractor's convenience shall be maintained in good condition and neat appearance including finishes as required by the Engineer.

1.4.3 TEMPORARY LIGHT AND POWER

The Contractor shall provide and maintain temporary electrical service including installation of temporary power and lighting within the construction site and facilities thereat. Likewise, provide lights for night protection as necessary.

The electrical services shall be adequate in capacity to supply power to construction tools and equipment without over-loading the temporary facilities and shall be made available to supply power, lighting and construction operations of all trades. All temporary equipment and wiring for power and lighting shall be in accordance with the applicable provisions of the local governing codes. At the completion of the construction work all temporary wiring, lighting, equipment and devices shall be removed.

The Contractor shall provide and maintain rented generator of adequate capacity to reasonably serve the Project.

The Engineer will assist the Contractor to secure the necessary power source and permit prior to the temporary location of electric services to Site. However, the cost of installation, permits and other related works for this purpose shall be borne by the Contractor.

1.4.4 TEMPORARY WATER SERVICE

The Contractor shall maintain temporary water supply service, complete with necessary connections and appurtenances. Installed water supply lines shall be used as a source of water for construction purposes subject to the approval of the Engineer. The Contractor shall pay the cost of operation and maintenance of the water system. All temporary water service including equipment and piping shall be removed upon completion of the work and all worn out and damaged parts of the permanent system shall be replaced and restored in first class condition equal to new.

1.4.5 SECURITY

The Contractor shall provide sufficient security in the construction site to prevent illegal entry or work damaged during nights; holidays and other period when work is not executed; and during working hours. The Contractor shall take ample precautions against fire by keeping away flammable materials, and ensure that such materials are properly handled and stored. Fires shall not be allowed within the area of construction, except when permitted by the Engineer.

The Contractor shall be responsible for the maintenance and protection of all facilities (to include the facilities of the Engineer/ PFDA staff) to be provided during the Contract. He shall provide one (1) utilityman to maintain all the facilities keeping them in good condition. He shall provide minimum of three (3) security guards in 3 shifts, 1 guard per shift to safeguard and secure, day and night, the field office, living quarters, vehicles, equipment, furnishings and the personal property of the occupants, all as directed and/or approved by the Engineer.

1.4.6 DISPOSAL AREA

Unless otherwise specified, the proposed location of disposal area shall be at the site designated by the Engineer. It is the responsibility of the Contractor to disposed off site all construction debris and be considered in the preparation of his proposal.

1.4.7 CONTRACTOR'S KEY PERSONNEL AND MAINTENANCE STAFF

By way of maintenance, the Contractor shall provide the necessary personnel specified under **Schedule A.1** for the field office who shall maintain all of the facilities in good operating condition and adequately safeguard and secure the building, equipment and property day and night, regularly and properly cleaned, and to take care household helps, all as directed and approved by the Engineer. The Contractor, if requested by the Engineer, shall immediately replace assigned personnel for reasons arising from misconduct and/or unsatisfactory performance.

The following are the list of Contractor's Key Personnel and Maintenance Staff to be assigned to the Project:

SCHEDULE A.1 – OPERATE AND MAINTENANCE OF FIELD OFFICE FOR THE ENGINEER/ PFDA STAFF

REF. NO.	DESCRIPTION	QTY	UNIT
I.	Operation/Maintenance Staff (Monthly)		
a.	Clerk/Encoder	1	no.
b.	Utility	1	no.
c.	Security Guard	3	no.
II	Key Personnel (on-full time basis) / Monthly		
d.	Project Manager (Licensed Civil Engineer)	1	no.
e.	Asst. Project Manager (Licensed Civil Engineer)	1	no.
f.	Mechanical Engineer (Professional)	1	no.
g.	Electrical Engineer (Professional)	1	no.

h.	Electronics and Communication Engineer (Licensed)	1	no.
i.	Plumbing/Sanitary Engineer (Licensed)	1	no.
j.	Materials Engineer II (DPWH Accredited Materials Engineer II)	1	no.
k.	Safety Engineer/Officer (Certified by the Bureau of Working Conditions of DOLE or with Certificate of Training in Occupational Safety and Health)	1	no.
l.	Foreman	1	no.
Note: Payment for the above key personnel (d) to (j) are incidental to items of the permanent works, hence, will not be measured and paid separately. However, Safety Engineer/Officer is included under Pay-item No. B.2 (Construction Health and Safety) of the Bill of Quantities.			
III.	Miscellaneous (Monthly)		
a.	Water Bill	36	mos.
b.	Electric Bill (including replacement of defective lighting fixtures)	36	mos.
c.	Provision for Electrical Installation	1	lump sum
d.	Provision for Water Installation	1	lump sum

SCHEDULE A.2 – OPERATE AND MAINTENANCE OF LIVING QUARTERS FOR THE ENGINEER/ PFDA STAFF

REF. NO.	DESCRIPTION	QTY	UNIT
I.	Miscellaneous (Monthly)		
a.	Water Bill	36	mos.
b.	Electric Bill (including replacement of defective lighting fixtures)	36	mos.

The Contractor shall at all times during the duration of the contract provide for the use of the Engineer/ PFDA staff all equipment, instruments and apparatus, all information and records and qualified chainmen and laborers required by the Engineer/ PFDA staff for inspecting and measuring the works. Such equipment, instruments and apparatus shall include those listed in this provision.

1.4.8 ITEMS TO BE CONSIDERED FOR THE FACILITIES FOR THE ENGINEER/ PFDA STAFF

The Contractor shall provide and maintain the field office and living quarters for the Engineer/ PFDA Staff but not be limited to the items specified below.

1.4.8.1 Furniture, Fixtures, Office Equipment and Appliances for the Field Office and Living Quarters

The field office and living quarters to be provided by the Contractor for the Engineer/ PFDA Staff at site shall before occupancy be provided with furniture, fixtures, office equipment, air-conditioning units and toilet facilities as specified in **Schedule B**.

The Contractor shall pay all bills for water, electricity, and other services.

The furniture and fixtures, office equipment, appliances except rented genset shall become the property of the Owner upon their payment.

SCHEDULE B - FURNITURE, FIXTURES, OFFICE EQUIPMENT AND APPLIANCES FOR THE FIELD OFFICE AND LIVING QUARTERS FOR THE ENGINEER / PFDA STAFF

(ALL ITEMS SHALL BE APPROVED BY THE ENGINEER)

a. FIELD OFFICE		
QUANTITY	UNIT	DESCRIPTION
1	each	Ordinary Office desk, KD Tanguile, dark brown, non-gloss varnish, 70x160 cm with 3 drawers on each side of center drawer, with locks and keys and ¼" thick glass top
4	each	Ordinary Office desk, KD Tanguile, dark brown, non-gloss varnish, 70x120 cm with 3 drawers at each side of center drawer, with locks and keys
1	each	Conference Table for 15 persons, KD Tanguile, dark brown, non- gloss varnish
1	each	Drafting table, KD Tanguile, dark brown, non-gloss, varnish, 60 cm x 100 cm
1	each	Executive Swivel chair on rollers, padded seat, back and arms rests, dark brown synthetic leather upholstery
7	each	Swivel chair on rollers, padded Seat, back and arms rests, dark brown synthetic leather upholstery
8	each	Monoblock Chairs
1	each	White Board 75x150 cm.
1	each	Wall Clock
1	each	Refrigerator, 5 cubic feet
1	each	Computer table , 400 x 1200 cm

1	each	Swivel Chair for computer
1	each	Drafting stool for Draftsman, KD Tanguile, dark brown, non-gloss varnish
2	each	Desktop computer, Intel® Core™ i7 Processor or higher, with minimum 1 TB hard disk drive, 8 GB RAM memory, DVD- ROM Drive, with LED monitor, Voltage Regulator, UPS and Windows/Office Professional License
2	each	Laptop computer, Intel Core i7 Processor, 8 MB Cache) or higher, minimum 1TB hard disk drive, 8 GB RAM memory, Voltage Regulator, UPS and Windows/Office Professional License (latest version)
2	each	Portable printer DeskJet or equivalent compatible with the personal computer, for both A4 and A3 paper
1	set	Rented Electric Generator at least 20 kVA, Diesel Engine
4	each	Electronic Calculators, battery operated w/ adaptors, type CASIO, FX model or approved equal
1	set	Complete set of Technical pen #.10 - #1.20
1	each	Fire Extinguisher (not less than 10 lbs.)
1	each	First Aid Kit
4	each	Air-con, 1 hp
b. LIVING QUARTERS		
QUANTITY	UNIT	DESCRIPTION
1	each	Dining table, KD Tangile, dark brown varnish, (for 8 persons)
6	each	Ordinary chairs, KD Tangile, padded seats with dark brown synthetic leather upholstery
5	each	Single bunk bed, 105 cm wide and 187 cm long, each provide with 10 cm thick foam rubber mattress
2	each	Nite table, KD Tangile, dark brown non-gloss varnish, 45 cm x 60 cm

1	each	Gas Range complete
2	each	Emergency Light use in case of brownout
1	each	Electric Stand Fan

1.4.8.2 Supplies and Consumables Stores for the Engineer /PFDA Staff

The Contractor shall provide for the field office sufficient and necessary supply for all normal stationary, printing paper, consumable items as specified under **Schedule C**, all as required by and to the satisfaction of the Engineer/ PFDA Staff.

If the Contractor cannot provide the articles on time, the Engineer shall secure the items and the Contractor shall immediately reimburse the Engineer for the cost thereof.

SCHEDULE C - PROVISION OF OFFICE SUPPLIES AND CONSUMABLE STORES FOR THE ENGINEER/ PFDA STAFF

DESCRIPTION	QTY.	UNIT
OFFICE SUPPLIES (to be supplied during the first month only)		
Incoming/Outgoing Tray	3	each
Stapler (small)	2	each
Stapler Wire Remover	2	each
Puncher (small), 2 hole	2	each
Metric Scale	2	each
T-square, 42"	1	each
Template (Circular)	1	each
Lettering Set (Leroy)	1	set
Triangle, 30 x 60	2	each
Triangle, 45 x 45	2	each
Protractor	2	each
Waste Can	3	each
Drinking Cups with Saucer	1	dozen
Cork Board, 920mm x 1220mm	1	each
Airpot Electric, 3.8 liters Capacity	1	each
Drawing Rack	1	each
Flash Light, Heavy Duty	2	each
OFFICE SUPPLIES (Monthly)		
Computer ink	3	each

DESCRIPTION	QTY.	UNIT
CDRW	2	box
Staple wire	3	box
Bond Paper	8	ream
Yellow pad	10	pad
Scotch Tape, ¾" x 60m	10	roll
Masking Tape, ¾"	10	roll
Magic Tape, ¾"	10	Roll
Batteries, Size "AA" and "B"	84	each
Pens (Ballpen)	2	doz
Printed Rooms	2	ream
Brown Envelope (Long)	20	each
Brown Envelope (Short)	20	each
Folder, Long	20	each
Folder, Short	20	each
Expanding Envelope	10	each
Pentel Pen	3	each
Plastic Fastener	1	box
Pencil/ Staedler	6	each
Eraser	10	each
Paper Clip	1	box
Sample Bags	100	each
Laboratory Worksheets	2	ream
Log Book	2	each
Field Book	2	each
CONSUMABLE STORES for Field Office (Monthly)		
Toilet Soap	14	each
Toilet Paper	14	each
Insect spray (Baygon), 350g	1	each
Toilet Deodorant	7	each
Map	1	each
Broom	0.5	each
Dust Pan	0.5	each
Replenishment of First Aid Kit	1	lot

DESCRIPTION	QTY.	UNIT
Incandescent Bulb, 60-100W	2	each
Fluorescent Tube 20-40W	2	each
Distilled Water (5gal)	40	each

1.4.8.3 Vehicles for the Engineer/ PFDA Staff

The Contractor shall provide within thirty (30) calendar days after notice to proceed, the vehicles listed in **Schedule D** for the exclusive use of the Engineer/PDFA Staff.

The vehicles shall comply in all respects with all relevant Philippine national or local laws, statutes and regulations. All vehicles shall carry or be fitted with the accessories as may be prescribed by laws and have comprehensive insurance. The vehicles on delivery shall be in good running condition, of the latest model and shall be driven by a competent qualified and experienced drivers who shall be under the direct order of the Engineer/ PFDA Staff.

The Contractor shall maintain the vehicles in first class condition and shall be supplied with appropriate fuel and lubricants at all times. Provide a minimum of 30 liters of fuel per day as well as 4 spare tires for each vehicle.

He shall provide equivalent substitute vehicles when taken out of service for maintenance, repair or any other reason. The vehicles shall be turned over to PFDA upon completion of the project.

SCHEDULE D - SERVICE VEHICLES FOR THE ENGINEER/ PFDA STAFF

DESCRIPTION	QUANTITY	UNIT
Brand new (latest model) one (1) unit – 14 seater passenger van, at least 2755 cc diesel engine 4 cylinder 16 valves, 6 speed automatic power transmission, 70L fuel capacity with stereo, air conditioner unit	1	unit
Brand New 4x4 vehicle pick-up type double cab, not less than 2500cc Diesel, complete with standard tools and accessories, in good running condition and of the latest model	1	unit

1.4.8.4 Assistance to the Engineer/ PFDA Staff

The Contractor shall, at all times during the duration of the Contract, provide for the use of the Engineer/ PFDA Staff all new survey equipment, instruments and apparatus, provision of survey personnel and aerial imaging drone as listed in **Schedule E.1, E.2 and E.3.**

SCHEDULE E.1 – SURVEYING INSTRUMENT

REF NO.	DESCRIPTION	QUANTITY	UNIT
1	Reflectorless Total Station with Mini USB/USB/SD Card Slot, Model ZTS-320R or approved equal	1	pc.
2	Automatic level complete with aluminum tripod 3x magnification, +/-0.80 mm standard deviation, erect image telescope, 0.50 m shortest focusing distance, with built-in compensator of less than 0.3" setting built-in compensator of less than 0.3" setting accuracy, fully waterproof and dust resistant with a horizontal circle that can be in grads or degrees and aluminum tripod	2	pc.
3	Leveling Rod (5 m ht.) Aluminum	4	pc.
4	50 m Fiberglass Tape	2	pc.
5	5 m Carpenter's Tape	2	pc.
6	Range Poles	4	pc.
7	Survey Umbrella	2	pc.

SCHEDULE E.2 - PROVISION OF SURVEY PERSONNEL

REF NO.	DESCRIPTION	QTY.
	OPERATION / MAINTENANCE STAFF	
1	Instrument man	1
2	Level man	2
3	Survey Aide	4
4	CADD Operator	1

SCHEDULE E.3 – AERIAL IMAGING DRONE

DESCRIPTION	QUANTITY	UNIT
Aerial Imaging Drone	2	sets

Provide two (2) sets of aerial imaging drones featuring a three-axis gimbal stabilized camera housing a side-by-side 4K sensor for capturing visible light and an imaging sensor for capturing thermal data.

- a) Multi-Spectral Dynamic Imaging - combines data from visual and thermal cameras in real time to enhance visual details, helping pilots quickly identify and interpret critical data that may not be immediately visible to the naked eye.
- b) Spot Meter - Displays the average temperature of an object, helping to monitor and measure critical or hazardous objects while maintaining a safe distance.
- c) Area measurement - Displays the average, lowest, and highest temperature, as well as corresponding locations each area, allowing inspectors to quickly access objects and determine if an asset may be overheating.
- d) Isotherm - Allows to designate specific temperature ranges to be displayed using a custom color palette so objects within the range relay higher contrast and better visibility. This feature includes custom profile to aid in identifying people and to help fire fighters identify hot spots in fires, as well as custom profile setting for added flexibility.

Each drone comes with Data Security, GPS, Timestamping, Airsense, OCUSYNC 2.0.

AIRCRAFT

Takeoff Weight (Without Accessories)	899g
Max Takeoff Weight	1100g
Max. Ascent Speed	5 m/s (S-mode[1]) 4 m/s (P-mode) with accessories
Max. Descent Speed	3 m/s (S-mode[1]) 3 m/s (P-mode)
Max Speed (near sea level, no wind)	72 kph (S-mode, without wind) 50 kph (P-mode without wind)
Max Service Ceiling Above Sea Level	6000m
Max Flight Time (no wind)	31 min (at a consistent speed of 25 kph)
Max Hovering Time (no wind)	29 min (with beacon turned on) 27 min (with beacon turned off) 22 min (with spotlight turned on) 26 min (with spotlight turned off) 25 min (with speaker turned on) 26 min (with speaker turned off)
Max Wind Speed Resistance	29–38 kph
Operating Temperature Range	-10 °C to 40 °C

GNSS	GPS+GLONASS
Hovering Accuracy Range	Vertical: ± 0.1 m (with Vision Positioning) ± 0.5 m (with GPS Positioning) Horizontal: ± 0.3 m (with Vision Positioning)
Transmission Power (EIRP)	2.400 - 2.4835 GHz FCC : ≤ 26 dBm CE : ≤ 20 dBm SRRC : ≤ 20 dBm MIC : ≤ 20 dBm 5.725-5.850GHz FCC : ≤ 26 dBm CE : ≤ 14 dBm SRRC : ≤ 26 dBm
Internal Storage	24 GB

Camera

Sensor	1/2.3" CMOS ; Effective pixels:12 Megapixels
Lens	FOV : 82.6°(24 mm) ; 47.8°(48mm) Format equivalent : 24-48 mm Aperture : f/2.8(24 mm)-f/3.8(48 mm) Auto focus at : 0.5 - ∞
ISO Range	Video : 100-3200 Photo : 100-1600(Auto)100-200(Manual)
Shutter Speed	8-1/8000s
Video Resolution	4K: 3840×2160 24/25/30p 2.7K: 2720×1530 24/25/30/48/50/60p FHD: 1920×1080 24/25/30/48/50/60/120p
Max Video Bitrate	100mbps
Supported File System	FAT32(≤ 32 GB) ; exFAT(> 32 GB)
Photo Format	JPEG, DNG (RAW)
Video Format	MP4 / MOV (MPEG-4 AVC/H.264)

Inclusive of the following:

- Charge batteries while driving
- Charge multiple Batteries in sequence
- 2 x Self Heating Flight batteries
- 2 x Pair of Low Noise Propellers

- 1 x charging hub & car charger
- 1 x power bank adapter
- 1 x travel should bag
- Battery

All above-listed equipment and instruments provided by the Contractor for the use of the Engineer during the Project duration and shall be measured and paid as indicated in the Bill of Quantities.

1.4.8.5 Photographs

The Contractor shall provide record progress photographs (at least 120 photographs per month) taken as, when and where directed by the Engineer at intervals of not more than one month. The photographs shall be sufficient in number and location to record the exact progress of the works. The Contractor shall provide one proof print of each photograph taken, and the electronic file and three (3) copies, in 3R size and printed on glossy paper, of any of the photographs selected as progress photographs by the Engineer. The photographs retained by the Engineer will become the property of PFDA and the Contractor shall supply approved albums to accommodate them. Two copies are to be signed by the Contractor, one of which will be signed by the Engineer and returned to the Contractor.

The Contractor shall include under pay-item A.1.4(1) (Progress Photographs) the purchase of Digital Camera high resolution capability (24.1 megapixel minimum) with 4 GB memory.

1.4.8.6 Provision of Communication Facilities for the Engineer/ PFDA Staff

The Contractor shall provide communication facilities for the exclusive use of the Engineer/ PFDA Staff as listed in **Schedule F** within the required number of months during the Project implementation. Should the specified number of months be insufficient to cover the period until Project completion, said period of maintenance of said communication facilities shall be extended upon approval of the Engineer.

In order to have continuous operation and efficient maintenance of the equipment, the Contractor shall provide monthly operating expenses including cost for servicing and minor repairs.

SCHEDULE F –COMMUNICATION EQUIPMENT FOR THE ENGINEER/PFDA STAFF

(ALL ITEMS SHALL BE APPROVED BY THE ENGINEER)

QUANTITY	UNIT	DESCRIPTION
1	each	Radio base (including microphone, power cord and bracket)
3	each	Handheld Radio (including battery, charger, antenna and belt)
36	mo.	Telephone Landline with internet (Subscription and Installation Fee inclusive)
36	mo.	Prepaid card for 10 cellular phones worth Php500 each

1.4.9 MEASUREMENT AND PAYMENT FOR THE FIELD OFFICE AND LIVING QUARTERS

- a) For all work executed or goods, materials, or services supplied by the Contractor under lump sum items, the quantities as determined above shall be paid for at the appropriate contract lump sum unit price as indicated in the Bid Schedule. The Contractor shall submit breakdown of Lump Sum Bid Items using the Form Detailed Cost Estimates.
- b) The quantities to be paid for as mentioned below shall be paid for at appropriate Contract Unit Price for each of the Particular Pay-Item shown in the Bid Schedule.
- c) The quantities determined as provided above of the provision furnishing of furniture, survey equipment/aerial imaging drone, consumable stores, operation and maintenance staff, communication equipment, photographs shall not be subjected to OCM mark-up.

The Provision of Service Vehicles to be paid for shall not be subjected to OCM and profit mark-up.

- d) Payment for the provision of Assistance to the Engineer (Operation and Maintenance Staff) as provided herein shall be deemed to be included in pay-item A.1.1(1) and A.1.1(2) - "Operate and Maintain of Field Office" and "Operate & Maintain Living Quarters", respectively.
- e) The quantities for the provision of vehicles for the Engineer/ PFDA Staff shall be the number of each type of vehicle supplied. The unit of measurement is "Lump Sum". The quantities for the operation and maintenance of vehicles for the Engineer shall be the time the Engineer is supplied with each vehicle prior to their finally becoming the property of PFDA. The unit of measurement is "month".
- f) The requirement that ownership of facilities shall revert to PFDA shall not apply if such facilities are provided on rental basis under terms approved by PFDA.

Pay Item	Description	Unit of Measurement
A	FACILITIES FOR THE ENGINEER	
A.1.1	Field Office for the Engineer/ PFDA Staff	
A.1.1(1)	Operate and Maintain of Field Office Note: to include Schedule A.1	Lump Sum
A.1.1(2)	Operate and Maintain of Living Quarters Note: to include Schedule A.2	Lump Sum
A.1.1(3)	Provision of Furniture, Fixtures, Office Equipment and Appliances for the Field Office and Living Quarters (Schedule B)	Lump Sum
A.1.1(4)	Provision of Office Supplies and	Month

	Consumable (Schedule C)	
A.1.2	SERVICE VEHICLES FOR THE ENGINEER/PFDA STAFF	
A.1.2(1)	Provide two (2) units Brand New Service Vehicles (Schedule D)	Lump Sum
A.1.2(2)	Operation and Maintenance of Two (2) Service Vehicles	Month
A.1.3	ASSISTANCE TO THE ENGINEER/ PFDA STAFF	
A.1.3(1)	Assistance to the Engineer – Provision of Survey Equipment and Survey Personnel Note: to include Schedule E.1, E.2 and EF.3)	Month
A.1.4	PROGRESS PHOTOGRAPH	
A.1.4.(1)	Progress Photographs Note: to include Digital Camera	Month
A.1.5	COMMUNICATION FACILITIES FOR THE ENGINEER/ PFDA STAFF	
A.1.5(1)	Provision of Radio Communication Equipment (Schedule F)	Lump Sum

1.4.10 TESTS AND INSPECTIONS

1.4.10.1 General

Work under this Contract shall be subject to the terms and conditions stipulated in the Conditions of Contract.

This Section set forth general provisions regarding tests and inspections required under this Contract.

1.4.10.2 Test

- a) The Contractor shall carry out all tests required under the various sections of the Specifications in the presence and under the supervision of the Engineer.
- b) All materials delivered to the site shall be subject to examinations and tests, should such test be desired by the Engineer, the Contractor will be given sufficient time to test said materials.

All tests required shall be performed at any accredited regional Laboratory of the Bureau of Research and Standard (BRS) of the DPWH or Department of Science and Technology (DOST). PFDA must accept results of materials test(s) coming only from DOST/BRS Accredited Laboratories.

The service(s) of accredited private testing laboratories shall be engaged only upon a certification from BRS or the concerned DPWH Regional or District Testing Laboratory stating that it does not have the capability to undertake the desired tests. All testing shall be witnessed both by the authorized representatives of the Contractor and the Engineer.

- a) The provisions of testing shall be closely-knit with the Construction Schedule so that all specified/required tests can be completed within the normal working hours on a one-shift basis, except for those that would require longer time to be carried out.
- b) All tests shall generally be carried out in accordance with the requirements and procedures of accepted/established standards or as instructed by the Engineer.

As for the testing methods, other accepted/approved equivalent standards may be applied; in such case the Contractor shall submit the copies of such standards for the Engineer approval beforehand.

- c) The Engineer shall have the right to reject all materials which do not comply with the requirements of the Contract notwithstanding any previous approval thereof.
- d) On account of the rejection of materials due to their non-compliance with the requirements of the Contract or due to the waiting time reasonably required for carrying out the examinations and tests, the Contractor shall not be entitled to any extra payment or extension of time for completion of the Works.
- e) The Contractor shall furnish test samples as requested and shall provide reasonable assistance and cooperation as deemed necessary to permit the tests to be performed on materials or work in place including reasonable stoppage of work during testing.

1.4.10.3 Contractor's Laboratory Equipment, Apparatus and Appliances

<u>Quantity</u>	<u>Description</u>
TESTING OF SOILS	
Gradation	
1	3" x 8" dia. Brass Sieve
1	2" x 8" dia. Brass Sieve
1	1-1/2" x 8" dia. Brass Sieve
1	1" x 8" dia. Brass Sieve
1	3/4" x 8" dia. Brass Sieve
1	1/2" x 8" dia. Brass Sieve
1	3/8"x 8" dia. Brass Sieve
1	#4 x 8" dia. Brass Sieve
1	#10 x 8" dia. Brass Sieve
1	#20 x 8" dia. Brass Sieve
2	#40 x 8" dia. Brass Sieve

1	#100 x 8" dia. Brass Sieve
1	#200 x 8" dia. Brass Sieve
1	#200 x 8" dia. Brass Sieve 4" deep for washing
1	Brass Pan, 8" dia. x 2" deep
1	Brass Cover with ring
2	Galvanized Steel Pan, 24" x 24" x 3"
2	Volumetric Flask, 500 ml with top
1	Hand Operated Sieve Shaker (for 8" dia. sieve)
1	Wire Basket (2.36 mm mesh)
1	Triple Beam Balance, 2610 grams
1	Heavy Duty Solution Balance 0.1 gram sensitivity

ATTERBERG LIMITS

1	Liquid Limit Set
1	Plastic Limit Set
1	Wash Bottle, 25 ml
1	Cent-0-Gram Balance, 310 grams

MOISTURE-DENSITY RELATIONS (AASHTO T-99 and T-180)

1	Compaction Mold, 4" dia.
1	Compaction Rammer, 5.5 lbs.
1	Compaction Mold, 6" dia.
1	Compaction Rammer, 10 lbs.
1	Steel Straightedge, 12"
1	Mixing Trowel, 2.5" x 4.5" Blade
1	Spatula, 4 inches
1	Trimming Knife
1	Heavy Duty Solution Balance
1	20 kgs cap., 1 gram sensitivity
1	Mixing Pan. 24" x 24" x 3"
24	Moisture Can, 3 ounces

FIELD DENSITY

2	Sand Cone and Jug (Plastic)
2	Replacement Jug (Plastic)
2	Density Plate
500	Plastic Bags, 8" x 14" Size 0.0035 substance
2	Sampling Spoon
2	One-gallon Field Cans
3	One-inch Steel Chisel
2	Sand Scoop
2	Ball Hammer
1	Field Scale, 15 kg, 4.5 gram sensitivity

CONCRETE TESTING EQUIPMENT

1	Concrete compressive/flexural strength testing machine
1	#8 x 8" dia. Brass Sieve
1	#16 x 8" dia. Brass Sieve

1	#30 x 8" dia. Brass Sieve
1	#50 x 8" dia. Brass Sieve
1	#100 x 8" dia. Brass Sieve
1	Sampler Splitter, 2-1/2" Chutes
1	Slump Cone and Base with Graduated Tamping Rod
12	Cylinder Mold, 6" dia. x 12"
1	Precision Air Meter, 1/4 cu.ft.
1	Mixing Pan, 24" x 24" x3"
1	Cement Trowel
1	Thermometer, 0-250 degrees C, 8" long, Armoured
1	Yield Bucket, 1/10 cu.ft.
2	Yield Bucket, 1/2 cu.ft.

1	Sand Absorption Cone and Tamper (AASHTO T-84)
1	Pycnometer Top and Jar (AASHTO T-84)
1	Density Basket (AASHTO T-85)

MISCELLANEOUS EQUIPMENT

1	Laboratory Oven, Double Wall
	Gravity Connection, 220/60 Hz A.C. cap. 1. cu.m.
1	Hot Plate, 12" x 12", 220 volts
1	Speedy Moisture Tester
1	Organic Impurities Test Set
1	Sand Equivalent Test Set
1	Gas Range, 2 Burners

OTHERS

2 bottles	Sodium Hydroxide Solution
1 carton	Capping Compound
4 bottles	Sodium Sulfate
1 carton	Calcium Carbide Reagent
3 bottles	Sand Equivalent Stock Solution
1	Color Standard Chart
5 gallons	Distilled Water

1.4.10.4 Measurement and Payment

Unless otherwise expressly stated, all tests and the works in connection therewith shall be considered as incidentals to the Permanent Works which require such tests and all costs thereof shall be deemed to be included in and covered by the scheduled rates of the Pay Items.

1.5 OTHER REQUIREMENTS

1.5.1 OFFICE, SHOPS, STORES AND WORKMENS ACCOMMODATION FOR CONTRACTOR

The Contractor shall provide and maintain such offices stores, workshops, latrines, housing and messing accommodations as are necessary. These shall be located in the Contractor's compound, distinct and separate from the Engineer's compound.

The Contractor shall not be permitted to erect temporary buildings or structures on the site without the specific permission in writing of the Engineer including approval of the dimensions of such buildings or structures.

The selection of the site shall be the responsibility of the Contractor and shall be approved by the Engineer. It is entirely up to the Contractor to make whatever arrangements he deems necessary with landowners regarding use of land for the purpose of erecting camps, workshops, garages, stockpiling of materials, location of plants, housing of labor and staff, welfare facilities, etc. and all costs incurred in connection with rental or lease of such land shall be at the Contractor's expense.

The Contractor shall be solely responsible for the erection, maintenance and subsequent disposal of whatever facilities he deems necessary to execute the work.

The Contractor shall not erect temporary buildings or structures within the road right-of-way without the prior written approval of the Engineer.

1.5.2 CONSTRUCTION HEALTH AND SAFETY

a) Health and Safety Plan

Within one month of his arrival on the project site, the Contractor shall submit a Health and Safety Plan/Program with operational details of his proposals to the Engineer for prior approval.

b) Accident Prevention Officer; Accidents

Due precautions shall be taken by the Contractor, at his own cost, to ensure the safety and protection against accidents of all staff and labor engaged on the Works, local residents in the vicinity of the Works, and the public traveling through the Works.

The Contractor shall have on his staff on Site a designated Safety Officer qualified to promote and maintain safe working practices. This Safety Officer shall have authority to issue instructions and shall take protective measures to prevent accidents, including but not limited to, the establishment of safe working practices and the training of staff and labor in their implementation.

The Contractor shall be responsible for all costs including medical treatment, transport, accommodation etc. incurred by any member of the public or his labor force whether on direct contract or sub-contract as a result of injuries or illness arising from the execution of the Works.

c) Protective Clothing and Safety Equipment

The Contractor shall, at his own expense, provide protective clothing and safety equipment to all staff and labor engaged on the Works to the satisfaction of the Engineer. Such clothing and equipment shall include, at a minimum, high visibility vests for workers directing traffic, protective footwear for workmen undertaking concrete mixing work, protective footwear and gloves for workmen performing paving works, dust masks, rubber boots, rain coats and otherwise as appropriate to the job on hand and to the Engineer's satisfaction.

Refer to **Schedule G** below, after Sub-item d), “Medical and First Aid Facilities” for the breakdown of protective clothing and safety equipment as well as Staff to be supplied by the Contractor for the entire duration of the Project.

d) Medical and First–Aid Facilities

The Contractor shall provide and maintain throughout the duration of the Contract, a medical examining room and sickbay together with all necessary supplies and equipment to be sited in the Contractor’s main camp. The rooms shall be used exclusively for medical purposes and shall be of good quality construction with electric lighting and otherwise suitable for their purpose. The sickbay shall have at least one bed, and shall be provided with adjacent washing and sanitation facilities.

The Contractor shall employ permanently on site at least one fully trained medical aide, nurse or paramedic who shall be engaged solely for medical duties.

The Contractor shall, at his own expense, provide first aid equipment at all camps and work sites to the satisfaction of the Engineer, and shall ensure that at all camps and works sites where 20 or more persons are engaged on the Works there shall at all times be a person qualified in first-aid with access to appropriate first-aid equipment.

The location of the medical room and other medical and first-aid arrangements shall be made known to all employees by posting suitable notices at prominent locations around the site and by verbal instruction upon recruitment.

The Contractor’s arrangements for complying with this Sub-section shall be subject to the prior approval of the Engineer and also to the approval of any qualified Medical Officer designated by the Employer to inspect or supervise medical arrangements on the Site.

SCHEDULE G –CONSTRUCTION SAFETY AND HEALTH

Description	Quantity	Unit
Labor		
Safety Officer	36	month
Safety Aide	36	month
Medical Aide	36	month
Materials (Quantities shown below shall be supplied for the entire contract duration of 36 months)		
Protective Footwear	60	each
Hard Hats	60	each
Reflectorized Vest	30	each
Safety Glasses	30	each

e) Supply of Drinking Water, Sanitation

The Contractor shall provide on the Site at his expense, an adequate supply of drinking water for all staff and labor engaged on the Works, together with sanitary facilities (portable toilets or latrines), to the satisfaction of the Engineer. The Contractor shall thoroughly disinfect and fill all latrine pits, sumps and trenches when no longer required.

Payment of the provision of construction safety and health shall be full compensation for fully satisfying the requirement of this Item to the approval of the Engineer.

f) Measurement and Payment

The quantities for the provision of construction safety and health are provided under Schedule G. Payment of this item will be under:

Pay Item	Description	Unit of Measurement
B.1	Construction Safety and Health	Month

Payment of this item shall be full compensation for full satisfying the requirements of this item to the approval of the Engineer.

1.5.3 ENVIRONMENTAL AND SOCIAL SAFEGUARDS

The following Environmental Protection and Social Safeguard Clauses are to be read in conjunction with the remainder of the Contract Documents.

1.5.3.1 General Provisions

The Contractor shall take all necessary measures and precautions to ensure that the execution of the Works and all associated operations are carried out in conformity with statutory and regulatory environmental and social requirements of the Government of the Philippines. The Contractor shall be required to develop an Environmental Management Plan (EMP) that follows the framework of this bidding document, and shall comply with the Contract Specifications.

The Contractor will be required to develop or update their EMP to comply with site-specific requirements and other mitigating measures (if any) identified in the Environmental Compliance Certificate (ECC) issued by the Department of Environment and Natural Resources (DENR) – Environmental Management Bureau (EMB).

In the event of serious or repeated violations of the conditions stipulated in the ECC, EMP and the Contract Specifications, the Employer reserves the right to withhold payments and/or stop construction.

A 2' x 4' Billboard containing "Notice to Public, This Project (title of the Project) of (Name of Proponent) has been issued an Environmental Compliance Certificate ____ (ECC Number) by the Environment Management Bureau of the Department of Environment and Natural Resources, Region VI, on ____ (date)"

- This message should be installed at all entry and exit points at all perimeters of the project facing the road to inform the general public, 30 days from the receipt of ECC.
- A copy of ECC shall be posted at the Barangay Bulletin Board within 30 days from its receipt.

- An accomplishment report with picture verification of compliance to the posting of notices and the billboards shall be submitted to EMB Office within 90 days from receipt of ECC.

Allow entry of DENR, CENRO, PENRO, EMB r6 Focal Persons into the project site at all times to conduct tangible monitoring and to validate project's compliance to ECC and EMP.

1.5.3.2 Environmental Management Plan (EMP)

The Contractor is required to prepare and submit a Project Environmental Management Plan (EMP) with operational details for review and approval by the Engineer not later than 30 days after the receipt of the Notice to Proceed.

The ESMP shall be organized in four sections as follows:

a) Management Acknowledgements

1) Certification and Commitment

The EMP submitted by the Contractor shall provide a signed statement from the Contractor's managing directors attesting to a commitment that all environmental protection, safety and industrial health aspects of the Contract shall be given the highest priority in the discharge of contractual obligations and certifying a commitment to the provisions specified by the EMP as approved by the Engineer.

2) Statutory Understanding and Compliance

The EMP shall provide a statement attesting the firm's understanding of, and means of ensuring due compliance with, the statutory regulations relating to construction work in the GOP, specifically in regard to compliance with:

All safety and industrial health legislation including, without limitation, the Rules and Regulations of the GOP and the authorities having jurisdiction;

All current environmental laws and regulations - be they national or local – related but not necessarily limited to:

- (a) Noise
- (b) Air pollution
- (c) Water contamination
- (d) Solid waste disposal
- (e) Liquid waste disposal
- (f) Sanitary conditions (water supply, sewerage, etc.)
- (g) Use of explosives and

(h) Protection of public traffic

The Contractor shall restore areas locating temporary plants to their original condition on completion of Project works. This shall include the clean-up of spillage and debris before leaving any temporary construction site.

3) Availability of Documents

The Plan shall state where copies of safety and industrial health regulations and documents will be available on the construction site and verify that all regulations and documents have been or will be available and displayed or kept.

4) Management of Subcontractors

The Plan shall provide a commitment that the Contractor for the work shall:

- Provide subcontractors with copies of the EMP and the ECC and incorporate provisions of the EMP and ECC into all subcontract documentation to ensure the compliance with the Plan at all tiers of the subcontracting.
- Require all subcontractors to appoint a safety representative who shall be available on the Site throughout the operational period of the respective subcontract; and
- Ensure, as far as is practically possible, that employees of subcontractors of all tiers are conversant with appropriate parts of the EMP, ECC and the statutory regulations.

5) Organization and Staffing

(a) Organization Chart.

The Plan shall include an organization chart identifying (by job title and by the name of the individual) the personnel to be engaged solely for environmental protection and safety. The chart and the supporting text shall identify the designated Environmental Officer and identify other participants and their Areas of responsibility.

(b) Identification of Responsibilities.

The Plan shall provide a description of the responsibilities of the Environmental Staff appearing on the Organization Chart.

(c) Nomination of proposed Environmental Officer

The Plan shall indicate the name of this proposed personnel.

(d) Certification related to the Environmental Officer (EO)

The Plan shall certify that:

The EO will be appointed and assigned duties throughout the period of the Contract entirely connected with the environmental and safety activities on the Site.

The proposed EO shall be suitably qualified and experienced to supervise and monitor compliance with the EMP and will, in particular but without limitation, carry out auditing of the operation of the EMP to be submitted, from time to time, to the Engineer for his consent.

The EO shall not be removed from the Site without the express, prior written permission of the Engineer. Within fourteen (14) days of any such removal or notice of intent of removal, replacement staff shall be nominated for the Engineers approval.

The EO shall be provided with supporting staff in accordance with the staffing levels set out in the Plan.

The EO will be empowered to instruct all employees of the Contractor or Subcontractors at any level to cease operations and take urgent and appropriate action to make safe the Site and prevent unsafe working practices or other infringements of the Plan or the statutory regulations.

The EO shall maintain a daily Site Diary in order to comprehensively record all relevant matters concerning Site environmental management and safety, inspections and audits, related incidents and the like. The Site Diary shall be available at all times for inspection by the Engineer.

(e) Contact Information.

Contact information for the Environmental Officer and his staff shall be provided in the Plan.

6) Communications and Reporting

(a) Communications & Routine Reporting Procedures

The Plan shall explain the proposed interaction and communication procedures between construction personnel and environmental protection, safety and traffic control staff, including:

- Communication facilities; and
- Routine reporting systems

(b) Environmental and Safety Reports

The following environmental and safety reports shall be submitted:

Weekly Environmental and Safety Reports. Documented safety and environmental audits shall be undertaken on weekly basis.

Incorporation of Summaries in the Project Monthly Report. Summaries of the Weekly Environmental and Safety Reports will be included in the Project's Monthly Progress Report.

(c) Notification of Accidents

The Plan shall verify that provisions have been made to ensure that:

The Engineer will be notified immediately of any accidents which occur whether on-site or off-site in which the Contractor, his personnel or construction plant, or those of any subcontractors are directly or indirectly involved and which result in any injuries to any persons.

Such initial notification may be verbal and shall be followed by a written comprehensive report within 24 hours of the accident.

(d) Communications with Subcontractors

The Plan shall specify:

The means by which environmental management, safety and traffic control and industrial health matters and requirements will be communicated to Subcontractors at all levels and their due compliance with the EMP and all relevant statutory regulations is ensured. Subcontractors shall be supplied with copies of the EMP. Additional activities may include attendance at training programs, circulation of newsletters and other means as specified by the Plan.

The method by which the procedures and practices proposed by subcontractors will be reviewed for compliance with the EMP and statutory regulations. This could include, for example, the inclusion of environmental and safety criteria as a part of daily and/or weekly Site inspections.

1.5.3.3 Environmental Control Provisions

The required project specific EMP shall consider amongst others, the following Environmental Provisions:

a) Environmental Protection during Construction

Notwithstanding approval of the intended method of working, the Contractor shall at all times be responsible for constructing the earthworks in accordance with the Specifications and Drawings.

The project area can experience inclement weather – fog, heavy rainfall, monsoons and earthquakes. It will be deemed that the Contractors is familiar with these conditions and has formulated his Works Program considering possible loss of time due to these causes, and it shall be the obligation of the Contractor to revise his program and enhance his construction efforts as necessary to ensure timely completion of the work schedule for each working season.

b) Pollution Control (Dust, Air and Noise)

The Contractor shall cover or wet down dry materials and rubbish to prevent blowing dust and debris, and provide dust control for temporary roads and yards.

Equipment should be properly maintained in order to limit emissions. Dust from Construction areas may be limited by watering down bare areas especially during dry season. Delivery trucks should be equipped with tarpaulin covers and stockpile of construction materials should be covered with bund walls.

Air emission generated by the Project shall pass the emission standard. In case it will exceed the standards, Clear Air Act and its Implementing Rules and Regulations (IRR) shall apply.

Equipment should be fitted with mufflers to minimize noise levels. All construction personnel using noisy equipment should use ear plugs in order to prevent damage to the ears.

The Contractor shall control noise level from his construction operations to satisfy the Noise Standards of the “Rules and Regulations of the National Pollution Control Commission” (1978) for general areas as shown:

Noise standards in general areas are shown in the table:

MAXIMUM VALUES OF AIR POLLUTANTS

Category of Area¹	Daytime²	Morning³ and Evening⁴	Night Time⁵
AA	50dB	45dB	40dB
A	55	50	45
B	65	60	55
C	70	65	60
D	75	70	65

Legend:

- AA - A section or contiguous area which requires quietness, such as an area within 100 meters from school sites, hospitals, and special homes for the aged.
- B - A section or contiguous area which is primarily used for residential purposes.
- C - A section primarily reserved as a light industrial area.
- D - A section which is primarily reserved as a heavy industrial area

- Daytime² - 9:00 a.m. to 6:00 p.m.
- Morning³ - 5:00 a.m. to 9:00 p.m.
- Evening⁴ - 6:00 a.m. to 10:00 p.m.
- Night Time - 10:00 p.m. to 5:00 a.m.

Noise control measures shall include:

- Selecting construction equipment used or the modes of operation adopted that produce less noise. For instance, rotating or impacting machines can be based on anti-vibration mountings. Noisy construction equipment or internal combustion engines must be fitted with silencers.
- Measures such as installation of road/noise barriers must be undertaken to minimize excessive generation of noise and vibrations brought about by earthwork activities and heavy equipment during construction especially along portions of the route close to noise-sensitive areas, such as hospitals, schools and churches.
- Proper scheduling so that noisy construction activities will be done at daytime.
- Providing earmuffs to construction workers exposed to noise.
- Monitoring noise levels during construction.
- Management of traffic during construction to produce a smooth flow instead of a noisier stop-and-start flow.
- The source can be enclosed to insulate or absorb the sound.

c) Disposal of Waste

The Contractor shall not bury rubbish and solid waste materials on the Site unless approved by the Engineer.

The Contractor shall not dispose of dredging spoils, waste or volatile materials, such as mineral spirits, oil or paint thinner into the sea, waterways, storm water drainage or sanitary sewers.

Properly labeled waste bins must be provided in strategic locations around IFPC. Separate bins for biodegradable, non-biodegradable and hazardous wastes should be provided. In addition, regular information campaign should be conducted to inform IFPC workers, users and locators about proper waste management practices and provisions of R.A. 9003 or the Ecological Solid Waste Management Act that need to be complied with. Notices and signages should be posted in strategic areas to remind IFPC workers, users and locators on waste management practices that are being implemented.

IFPC Management should also ensure that residual wastes are properly hauled out of the complex and disposed in the LGU landfill. Burning of waste generated from land clearing such as leaves and branches shall be strictly prohibited.

Portable toilets should be placed near active construction sites for use of construction workers. Regular monitoring will help determine if construction activities impact on coastal water quality.

d) Fire Prevention

Fires and burning of rubbish on the site are not permitted except when authorized by the Port Fire Marshall and the Engineer.

Where fires or burning is permitted, the Contractor shall prevent the structures, materials or vegetation which is to be preserved from staining and/or smoke damage. When so happen, the Contractor shall restore, clean and return stained or damaged work to fresh conditions.

e) Drainage

The Contractor shall provide temporary drainage and pumping facilities as necessary to keep the Site free from water.

The Contractor shall pay attention not to cut waterway or drainage from existing reclaimed areas. The Contractor shall provide when required temporary storm water drainage to prevent existing port area from being flooded.

f) River Diversion

The Contractor shall provide and maintain along temporary river diversion whenever a present river is closed or affected by his works. Such diversion works shall be well protected and enough size to prevent the upstream area from being flooded.

g) Possible Disruption of Fish Port Operations and Traffic to and from IFPC

Construction Activities have the potential of disrupting fish port operations. Stockpile of construction materials may cause nuisance to fish traders. Although construction activities and market hall operations are not expected to occur at the same time considering that construction activities will be during daytime while fish trading occur at night time, stockpile of construction materials may cause nuisance to fish traders. As such, provision of locating stockpile of construction materials away from high traffic areas and screening active construction areas to avoid accidents to fish port users.

Delivery of construction materials should be scheduled during off peak hours. This is not expected to nuisance as fish port operations normally occur at night until the early morning.

h) Shore Protection

The Contractor shall construct riprap and embankments along the periphery/shoreline of the port site to serve as a buffer zone, and to prevent erosion/siltation.

i) Protection of Corals, Mangroves, Estuaries and Forest

The Contractor shall conserve and protect from injuries the corals, mangroves, estuaries and forest found within the vicinity throughout project implementation.

j) The Contractor shall allocate an Environmental Monitoring Fund (EMF) during the construction period in coordination with City ENRO.

k) The Contractor shall comply with all the conditions stipulated in the Environmental Compliance Certificate (ECC).

l) Relationships with Local Communities and Authorities

In siting and operating his facilities and in executing the Works, the Contractor shall, at all times, and to the extent possible, minimize the impact of his activities on existing communities. Where communities are likely to be affected by major activities such as the establishment of a camp or extensive road closure or bypassing, he shall liaise closely with the concerned communities and their representatives and, if so directed, shall attend additional meetings arranged by the Engineer to resolve issues and claims and minimize impacts on local communities.

Any problems arising from his operations and which cannot be resolved by the Contractor shall be referred to the Engineer. The Contractor shall be responsible for any compensation due to reinstatements necessary with respect to any damage caused by him to areas outside the Site and no separate payment will be made in this regard.

m) Privately or Community-Owned Services and Structures

The Contractor shall take all necessary precautions to ensure that no public or Works. These precautions shall include but not be limited to liaison with public and private service providers, local government units, and private owners; a condition survey of all affected services; provision of a satisfactory alternative service while the works are carried out; and reinstatement of a satisfactory permanent facility after completion of the Works in each area.

No service or utilities shall be disturbed or cut before arrangements have been made for a satisfactory alternative service, or the Contractor has obtained agreement in writing from the service provider or owner to a temporary cessation of service.

Not less than 14 days before commencing site clearance on any particular section of the Project in accordance with his agreed Program of Work, the Contractor shall supply to the Engineer for his prior approval, a copy of his condition survey of all utilities and services to be affected, copies of any agreements with service providers and owners, his plans for providing temporary service, and his plans for reinstating permanent service following construction of the Works.

Provision of temporary and permanent services shall be to at least the pre-existing level of service and to the satisfaction of the Engineer.

1.5.3.4 Measurement and Payment

- a) Payment for the Cost of Environmental Control Provision during construction prescribed in Sub-item 1.6.5 and any associated construction measures shall not be paid separately, and should be considered as subsidiary to the other pay items in the contract.
- b) Payment for the cost of the following items will be included and paid under pay-Item on Environmental and Social Safeguard.

Description	Quantity	Unit
Labor		
Environmental Officer	13	mo.
Community Monitoring Team (to include honoraria, transportation meals/ snacks)	13	mo.
Materials		
Consumables for Reporting and Motoring:	13	mo.
Routine Periodic Monitoring (air, wind & noise)	13	mo.
Information, Education and Communication	13	mo.

c) Payment will be made under:

Pay Item No.	Description	Unit of Measurement
B.2	Environmental and Social Safeguards	month

1.5.4 SIGNBOARD

1.5.4.1 Project Signboard

The Contractor shall install at the construction site two (2) Project Signboard measuring 1200 mm x 2400 mm (4ft x 8ft) bearing the name of the project, location, project cost, starting date and completion date, name of implementing agency, the name of the Contractor and other information that shall be required by PFDA.

The signboard shall be made of tarpaulin posted on 5mm (3/16 inch) marine plywood framing. It shall be erected with necessary wooden support and bracing. The signboard shall be erected by the Contractor within two (2) weeks after the project commence.

Project signboard shall be installed, one at the beginning and one at the end of the project. Name(s) or picture(s) of any personages should not appear in the billboard.

1.5.4.2 COA Billboard

The Contractor shall also install one (1) signboard per COA Circular No 2013-004 containing the following information:

Name of Agency Business Address							
Project: _____	Cost: _____						
Location: _____	Fund Source/s: _____						
Implementing Agency/ies: _____							
Development Partner/s: _____							
Contractor/Supplier: _____							
Brief Description of Project: _____							
Project Details:							
Project Date			Project Status			Remarks	
Duration	Started	Target Date of Completion	Percentage of Completion	As of (Date)	Cost Incurred to Date		Date Completed

For particulars or complaints about this project, please contact the Regional Office or Cluster which has audit jurisdiction on this project:

COA Regional Office No./Cluster: _____

Address : _____

Contact No. : _____ or Text COA Citizen's Desk at 0915-5391957

1.5.4.3 Upon completion of the work, all signboards shall be removed from the site.

1.5.5 MOBILIZATION/DEMOBILIZATION

1.5.5.1 General

Work under this Contract shall be in accordance with the terms and conditions stipulated in the Conditions of Contract and Section 1 "General Requirements" of these Specifications and shall apply to this Section whether herein referred to or not.

1.5.5.2 Scope of WORK

This Section includes mobilization, demobilization, assembly and disassembly of equipment/plants including incidentals necessary to complete the work.

1.5.5.3 Mobilization

- a) The Contractor shall mobilize and put into operation all equipment and plants required to undertake the Contract.
- b) Mobilization shall include the transferring to the job-sites of all equipment, plants, supplies and materials, personnel, and all items necessary for the execution and completion of the work, and shall also include the setting up of all equipment, instruments and all other plants until rendered operable, subject to the confirmation of the Engineer.
- c) Sufficient supply of spares for the equipment and plants shall be carried on-board the towing/carrying vessels. Equipment/plants encountering breakdowns must be repaired on site by the most expeditious method possible at no cost to PFDA. In the event that the equipment/plants call for major repair works that

cannot be undertaken at the site, the Contractor shall replace such equipment/plants with equal or better performance capacity at no additional mobilization costs to PFDA and the Contractor shall not be entitled to any time extension.

1.5.5.4 Demobilization

Demobilization upon request of the Contractor and approved by the Engineer, shall include the following:

- a) The dismantling, preparation and loading for removal and shipment of all Contractor's plant, equipment and personnel at each site after completion of the works.
- b) Transportation of all the above plant, equipment and materials from each site to the Contractor's home station or somewhere else outside the sites.
- c) Removal of all supplementary markers furnished and installed by the Contractor, provided that the Engineer has not taken the option to retain the markers.
- d) The clean-up of the Site and the removal of materials, debris, waste, etc., and making good damages or temporary alterations.

1.5.5.5 Measurement and Payment

Payment for this item includes the expenses incurred by the Contractor for moving-in of minimum major equipment and/or plant required for the project and moving out of the same after issuance of certificate of completion of the work including cleaning-up. Fifty percent (50%) of the total amount shall be payable after mobilization activity while the remaining fifty percent (50%) payable after issuance of certification of completion of the project. A list of equipment showing the detailed cost for its mobilization and demobilization works shall be included in the bid amount for this item.

1.5.6 ACCESS

The Contractor shall provide and maintain adequate access to the Project Site and all areas related to the works at no expense to the government. If existing roads are to be used for access to the Site, the Contractor shall maintain such roads for the duration of their use.

1.5.7 NAVIGATION MARKERS, ETC.

The Contractor shall provide all temporary and navigational aids, markers, lights and notices required for the works or required by law, regulations, and all authorities having jurisdiction over the area covered by the work on land or at sea. The Contractor shall replace at his own expense/cost any navigational or other facilities damaged by Contractor or his Sub-contractors.

1.5.8 PROTECTION OF THE PUBLIC

The Contractor shall provide safety devices (i.e. barricades, warning signs and other appropriate tools) as necessary for public protection.

1.6 SUBMITTALS

1.6.1 GENERAL

- a) Work under this Contract shall be subject to the terms and conditions stipulated in the Conditions of Contract.
- b) This Section sets forth general provisions regarding submittals required of the Contractor.
- c) Related submittals other than sureties and insurances:
 - 1) Contractor-furnished drawings, data and samples
 - 2) Temporary access and haul roads
 - 3) Monthly Progress Report with Photographs
 - 4) Construction schedule
 - 5) Tests and Inspection Sub - section 1.4.11
 - 6) As-built drawings
 - 7) Final construction report
- d) Until submittal is reviewed by the Engineer and approved and released for distribution, work involving the relevant product data shall not proceed.
- e) The Engineer's review will be signified by comments as required, identifying items for resubmission and by the Engineer's stamp when work is released for distribution.

1.6.2 CONTRACTOR-SUPPLIED DOCUMENTS

- a) The Contractor shall supply the following documents as required by the Specifications or as requested by the Engineer.
 - 1) Surveying and sounding drawings, and reports on sub-soil investigations when required.
 - 2) Structural calculations for temporary construction and erection stages of the permanent structures, inclusive of the determination of the strength and stability of the already completed structural members, as well as the stability of excavations, embankments, retaining walls and dikes, insofar as concerns additional loads that occur in the course of the execution of the construction work.

- 3) Drawing and calculations in connection with any alternative proposal for design and execution of the special construction method or sequence for construction or erection of the permanent structures or parts thereof.
- 4) Reports and records of all tests on materials carried out by the Contractor or by his Suppliers.
- 5) Construction Schedules, monthly progress reports, final construction reports, shop drawings, as-built drawings, product data, samples and construction photographs.

1.6.3 CONSTRUCTION SCHEDULES, SURVEY DATA AND SHOP DRAWINGS

- a) Construction schedules, survey data, field drawings and shop drawings shall be originally prepared by Contractor, Subcontractor, Supplier or Distributor to illustrate the appropriate portion of work. The work item shall be described in relation to responsibility, fabrication, layout, setting or erection details as specified in appropriate Sections.
- b) Submittal drawings to be reproducible transparency with one opaque print.
- c) Maximum sheet size is 610 mm x 810 mm (24" x 32").

1.6.4 PRODUCT DATA

- a) Certain sections of the Specifications state that manufacturer's standard schematic drawings, catalogue sheets, diagrams, schedules, performance charts, illustrations and other standard descriptive data will be accepted in lieu of shop drawings.

- b) From the above and when necessary:

Delete information which is not applicable to the project;

Supplement standard information to provide additional information applicable to the project;

Show dimensions and clearances required;

Show performance characteristics and capacities; and

Show wiring diagrams and controls.

1.6.5 SAMPLES

- a) Submit samples in sizes and quantities specified.
- b) Where color is a criterion, submit full range of colors.
- c) Construct field samples and mock-ups at locations acceptable to the Engineer.

- d) Construct each sample or mock-up complete, including work of all trades required to finish work.
- e) Reviewed and approved samples or mock-ups will become standards of workmanship and material against which, installed work will be checked on the project.

1.6.6 CONTRACTOR'S RESPONSIBILITIES

- a) Review shop drawings, product data and samples prior to submission.
- b) Verify:
 - Field measurements
 - Field construction criteria
 - Catalogue numbers and similar data
- c) Coordinate each submittal with the Project requirements and Contract Documents.
- d) Contractor's responsibility for errors and omissions on submittals is not relieved by the Engineer's review and approval of submittals.
- e) Contractor's responsibility for deviations on submittals from requirements of Contract Documents is not relieved by the Engineer's review of submittals, unless the Engineer give written acceptance of specified deviations.
- f) Notify the Engineer, in writing at time of submission, of deviation on submittals from requirements of Contract Documents.

After the Engineer 's review, distribute copies.

1.6.7 SUBMISSION REQUIREMENTS

- a) Schedule submissions at least five (5) working days before dates reviewed submittals will be needed.
- b) Submit one reproducible transparency and one opaque print of schedules, survey data and shop drawings, and the number of copies of product data which Contractor requires for distribution plus three (3) copies which will be retained by the Engineer.
- c) Accompany submittals with transmittal letters, in duplicate copies, containing:
 - (1) Date
 - (2) Project title and number
 - (3) Contractor's name and address
 - (4) Number of each shop drawing, product data and sample submitted
 - (5) Other pertinent data

- d) Submittals shall include:
 - (1) Date and revision dates
 - (2) Project title and number
 - (3) Name of - Contractor
 - Sub-Contractor
 - Supplier
 - Manufacturer
 - Separate retailer when pertinent
 - (4) Identification of product or material
 - (5) Relation to adjacent structure or materials
 - (6) Field dimensions, clearly identified as such
 - (7) Specifications Section Number
 - (8) Applicable standards, such as ASTM numbers
 - (9) Contractor's stamp, initialed or signed, certifying review of submittal, verification of field measurements and compliance with Contract Documents.
- e) Test reports shall be submitted in seven (7) copies at Contractor's expense within five (5) working days of the completion of respective tests or within such times as may be specifically directed by the Engineer.
- f) Additional copies of any information if and when found to be necessary shall be furnished by Contractor at his own expense upon request by the Engineer.

1.6.8 DISTRIBUTION OF SUBMITTALS AFTER REVIEW

- a) Distribute copies of shop drawings and product data which carry the Engineer's stamp, to:
 - (1) Job-site file
 - (2) Record documents file
 - (3) Sub-contractors
 - (4) Suppliers
 - (5) Fabricators

As appropriate in each case.

1.6.9 MONTHLY PROGRESS REPORT

- a) The Contractor shall maintain a daily log describing the important events pertaining to the Works, the working hours, the number of laborers employed, effective operation time of equipment, overtime hours, delays due to meteorological and maritime conditions, lack of labor, materials or equipment, progress made including those for dredging and reclamation works, and instructions, notifications and recommendations made by the Engineer.
- b) The Contractor shall furnish the Engineer with eight (8) copies of the monthly progress reports within seven (7) days after the end of every month, indicating progress made, construction activities, inventories of material used and stored on job site, number of laborers, equipment available and hours utilized, number of working days, the summary of the daily log of the month and all important events in relation to the Works.

1.6.10 GENERAL OPERATION AND MAINTENANCE MANUAL

The Contractor shall produce and supply to the Engineer three bound hard copies and two disk copies (Microsoft Word and Microsoft Excel) of an operation and maintenance manual on the target completion date for the contract.

No separate payment for the Operation and Maintenance Manual as this is deemed to be included as incidental to other items of work.

1.6.11 AS-BUILT DRAWINGS AND FINAL CONSTRUCTION REPORT

Within thirty (30) calendar days after the issuance of the Certificate of Completion, the Contractor shall prepare and submit As-built drawings of the works consisting of one (1) set of original size reproducible (in tracing paper), two (2) sets of blue print copies and electronic file in USB.

Within thirty (30) calendar days after the issuance of the Certificate of Completion, the Contractor shall also submit (5) sets of the Final Construction Report.

1.6.12 MEASUREMENT AND PAYMENT

Items of this section are incidental to the Works and will not be measured for payment.

1.7 STANDARDS AND ABBREVIATIONS

1.7.1 GENERAL

- a) Work under this Contract shall be subject to the terms and conditions stipulated in the Condition of Contract.
- b) This Section sets forth standards and abbreviations referred to in the various Sections of the Technical Specifications.

1.7.2 STANDARDS

- a) In the Specifications, reference are made to the standards issued by the following organizations and referred to by the abbreviations shown:

<u>Organization</u>	<u>Abbreviation</u>
1) Philippine National Standard (Product Standard Agency)	PNS
2) Japanese Industrial Standards	JIS
3) Standard Specifications, by DPWH (1995 edition Volume I & III) (2012 edition Volume II)	SS (DPWH)
4) Design Guidelines Criteria and Standards, Volume II (DPWH)	DGC
5) Technical Standards for Ports and Harbor Facilities (DPWH)	TS
6) Design Manual for Port and Harbor Facilities in Japan, the Ministry of Transport, Japan 1989	DN
7) Technical Standards and Commentaries for Port and Harbor Facilities in Japan (2002)	TSCPHFJ
8) Philippine Institute of Civil Engineers	PICE
9) Association of Structural Engineers of the Philippines	ASEP
10) American Association of State Highway and Transportation Officials	AASHTO
11) American Concrete Institute	ACI
12) American Institute of Steel Construction	AISC
13) American National Standards Institute	ANSI
14) American Petroleum Institute	API
15) American Society for Testing and Materials	ASTM
16) American Welding Society	AWS
17) American Water Works Association	AWWA
18) Steel Structures Painting Council	SSPC

- (a) Standards listed above, may be considered to be equally applicable/acceptable, provided that performance and functions of materials or workmanship or methods of tests, etc. are equal to or better than those specified in the above-listed standards and provided that the quantity of the Works will not be increased/adjusted just to comply with the proposed standard.
- (b) The Contractor shall submit proof that, when a standard other than that specified is proposed, it is in fact equal to or better than the specified standard. Such reference shall in every case be considered to be made in accordance with the latest edition of the said reference.
- (c) The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

1.7.3 ABBREVIATIONS

In the Technical Specifications, the following abbreviations are used:

ITEMS		ABBREVIATIONS
a)	Millimeter (s)	mm (s)
b)	centimeter (s)	cm (s)
c)	meter (s)	m (s)
d)	kilogram (s)	kg (s)
e)	metric tonne (s)	t (s)
f)	maximum	max.
g)	minimum	min.
h)	typical	Typ.
i)	Drawing (s)	Dwgs.
j)	Elevation	Elev.
k)	diameter	dia.
l)	Division	Div.
m)	Approximately	approx.
n)	Kilometer (s)	km (s)
o)	Quantity	Q'ty
p)	Linear meter (s)	l.m.
q)	Length	L
r)	Pascal	Pa
s)	Megapascal	MPa
t)	Kilopascal	Kpa
u)	Newton	N
v)	Liter	L
w)	Knot	Kn

DIVISION 2

SITE WORKS

DIVISION 2 SITE WORKS

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2.1 DEMOLITION AND REMOVAL WORKS

2.1.1 DESCRIPTION

The work includes the furnishing of all labor, materials and equipment required to carry out the demolition and removal of obstructions, demolition of existing market hall, portion of existing pavements, utilities i.e. existing drainage & water pipes, etc., as required for the execution of the Contract.

The Contractor shall submit the proposed methodology or procedure of demolition work with detailed drawings and calculations if necessary, to the Engineer for approval, before the execution of the Works.

The Contractor shall keep all pavements and landing areas to and from the site of the disposal area clean and free of mud, dirt and debris during and after the execution of disposal. Disposal of debris and materials shall be as directed by the Engineer

For off-shore obstructions to dredging, survey shall be executed by the Contractor with the Engineer before any demolition and removal of wrecks commence and shall be as directed by the Engineer.

2.1.2 GENERAL PROVISIONS

2.1.2.1 The Contractor shall be deemed to have satisfied himself of the site conditions, and to have included in his unit prices provision for all risks that may arise during or in connection with the work.

2.1.2.2 The demolition work shall be carried out by approved methods and equipment such as concrete breakers, gas-cutters, hydraulic jacks, compressed air disintegrators, etc., however, no blasting shall be used unless approved in writing by the Engineer and after obtaining the written permission of the concerned Authorities.

2.1.2.3 The Contractor shall provide suitable equipment, skilled labor and appropriate temporary works such as scaffoldings to ensure safety in his demolition works as well as in the adjacent area.

2.1.2.4 The Contractor shall demolish all the structural members above the level on which the subsequent and permanent works under this Contract will begin. To this end, the temporary construction works such as excavation shall be conducted by the Contractor.

2.1.2.5 Materials coming from the demolition works, except general earth, shall remain the property of the Procuring Entity, the designated part of which shall be stored by the Contractor at places specified by the Engineer's authorized Representative.

2.1.3 INTERFERENCE WITH PORT OPERATIONS

2.1.3.1 During the execution of the work, the Contractor shall not interfere with the shipping, navigation and other traffic in the port.

2.1.3.2 The Contractor shall make arrangements with the operations people on the schedule of demolition and related works to keep port operation activities undisturbed at all times.

2.1.3.3 Prior to commencement of the demolition works, the Contractor shall inform/announce to port users the schedule of disconnection of utilities.

2.1.4 STORAGE AND DUMPING

2.1.4.1 Prior to the commencement of the demolition work, the Engineer shall submit to the Contractor a list in which all the materials to be salvaged and overhauled, as property of PFDA and the location of their storage shall be described. Materials embedded in concrete units shall not be salvaged.

2.1.4.2 The Contractor shall separate materials to be salvaged from debris. Salvaged materials shall be loaded, transported and unloaded by the Contractor at the specified locations.

2.1.4.3 Debris, if it does not contain any pollutant in the opinion of the Contractor may be dumped at the offshore area.

2.1.4.4 The Contractor may dump debris on land areas but out of the site, which areas shall be procured and prepared at his own expense. In this case, safety measures shall be undertaken in the transporting, unloading, covering and others as requested by the Engineer.

2.1.5 EXECUTION

2.1.5.1 Prior to the commencement of demolition works, the alignments of the new construction works to existing building shall be checked.

2.1.5.2 The width and alignment of portion of existing structure to be demolished shall be marked by paint.

2.1.5.3 With these lines as guides, concrete shall be broken and reinforcing bars cut, such that panels or portions of the structure can be lifted out for disposal elsewhere outside of the operational work area.

2.1.5.4 Demolish existing market hall, portions of existing pavement, utilities i.e. drainage & water pipes, and the like as determined in the field and as shown on the drawings or as directed by the Engineer.

2.1.5.5 Materials coming from the demolish works shall be properly disposed by the Contractor.

2.1.6 SAFETY

At the end of each day's work, the site shall be left in safe condition, so that no part is in danger of toppling, or falling or creating hazards to personnel or equipment.

2.2 SURVEYS, SOUNDINGS AND INSTALLATION OF MARKERS, ETC.

2.2.1 GENERAL

Work under this Contract shall be in accordance with Section 1, "General Requirements" of these Specifications and shall apply to this Section whether herein referred to or not.

2.2.2 SCOPE OF WORK

This Section covers topographic and hydrographic surveys including setting out of works.

2.2.3 PRELIMINARY REMARK

All data relating to surveys, soundings, included in the Bid Documents and all data contained in the Drawings are honestly given in order to provide the Contractor with the best possible information needed for the proper performance of the works.

Relating to these data, the Contractor will have to make his own investigations to verify and to complete the given data.

2.2.4 TOPOGRAPHIC AND HYDROGRAPHIC SURVEYS

References: All surveys shall be carried out with reference to benchmarks or monuments and Chart Datum proposed by the Contractor and approved by the Engineer.

Surveying: All survey work specified in this Section shall be carried out by licensed surveyors. The Contractor shall submit in advance for the Engineer's approval, true copies of the license and qualifications of the surveyors to be employed for the works.

The Contractor shall carry out the topographic and hydrographic surveys of the job-site, as required for the proper performance and quantity measurement of the works, by means of traversing, sounding and leveling, and shall prepare topographic maps and/or hydrographic charts at the appropriate scales.

2.2.5 SETTING OUT OF WORKS

The Contractor shall set out the Works and shall be solely responsible for the accuracy of such setting out. The Contractor shall provide, fix and maintain all stakes, marks or the like which are necessary for the accurate setting out of the

Works, and shall take all necessary precautions to prevent their removal or disturbance, all as approved by the Engineer. The Contractor shall provide a suitable range in the water to indicate the face lines of the quays, revetment, breakwater and related facilities.

Setting Out of Works shall include the verifications of position of all markers and the supply and installation of any and all other markers which the Contractor may require for the proper execution and completion of the Works, and shall also include the repositioning of the PFDA's markers if such repositioning is deemed necessary by the Contractor and approved by the Engineer.

2.2.6 FIELD NOTES, ETC.

Field notes, calculation sheets and all other documents shall be prepared in the English language and in a manner acceptable to the Engineer. The Contractor shall submit such notes and other documents upon completion of the respective works or if so required, the Engineer may have the option to inspect even during the progress of works.

DIVISION 3

PORT FACILITIES

DIVISION 3 - PORT FACILITIES

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3.1 LAYOUT AND INSTALLATION OF MARKERS

3.1.1 GENERAL

- a) Work under this contract shall be in accordance with Division 1, "General Requirements" of these Specifications and shall be applicable to this Section, herein referred to or not.
- b) Applicable requirement under Section 2.2 "Surveys/Soundings, Installation of Markers, etc." shall apply to this section.

3.1.2 SCOPE OF WORK

This Section covers layout and setting of reference points.

3.1.3 SETTING OF REFERENCE POINTS

- a) The Contractor shall establish new permanent benchmarks and monuments based on existing ones designated by the Engineer that can serve as reference points to delineate the technical description of the port zone and plan layout.
- b) The Contractor shall submit field notes and computations regarding the above item 3.1.3.a) for reference of the Engineer.
- c) Setting of reference points shall include the supply and installation of markers which the Contractor may require for the proper execution and completion of the project. The Contractor shall be solely responsible for the accuracy of setting surveyed points.

3.2 CONCRETE WORKS

3.2.1 GENERAL

Work under this Contract shall be in accordance with Division 1 "General Requirements" of these Specifications and shall be applicable to this Section, whether herein referred to or not.

3.2.1.1 Scope of Work

All works falling under this Section shall include reinforced concrete for all kinds and parts of any reinforced concrete structure.

3.2.1.2 General Provisions

Full cooperation shall be given to the other trades to install embedded items. Suitable templates or instructions will be provided for setting, items shall have been inspected, and tests for concrete or other materials or for mechanical operations shall have been completed and approved.

The following publications of the issues listed below, but referred to thereafter by basic designation only, form as an integral part of this Specification to the extent indicated by the reference thereto:

a) American Concrete Institute (ACI) Standards:

ACI 117	Standard Specifications for Tolerances for Concrete Construction and Materials
ACI 121R	Quality Management System for Concrete Construction
ACI 201.2R	Guide to Durable Concrete
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214R	Recommended Practice for Evaluation of Strength Test Results of Concrete
ACI 301	Specifications for Structural Concrete
ACI 304.2R	Placing Concrete by Pumping Methods
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305R	Hot Weather Concreting
ACI 306.1	Standard Specification for Cold Weather Concreting
ACI 308R	Guide to Curing Concrete
ACI 309R	Guide for Consolidation of Concrete
ACI 311.4R	Guide for Concrete Inspection

ACI 318M	Metric Building Code Requirements for Structural Concrete and Commentary
ACI 347	Guide to Formwork for Concrete
ACI SP-15	Field Reference Manual: Standard Specifications for Structural Concrete with Selected ACI and ASTM References
ACI SP-2	ACI Manual of Concrete Inspection

b) American Society for Testing and Materials (ASTM) Publications:

ASTM A 185	Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 496	Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement
ASTM A 497	Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A 706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 82	Standard Specification for Steel Wire, Plain, for Concrete Reinforcement
ASTM A 934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A 966	Standard Test Method for Magnetic Particle Examination of Steel Forgings Using Alternating Current
ASTM C 1017	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C 1064	Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
ASTM C 1077	Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 1107	Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
ASTM C 1157	Standard Specification for Hydraulic Cement

ASTM C 1202	Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
ASTM C 1218	Standard Specification for Water-Soluble Chloride in Mortar and Concrete
ASTM C 1240	Standard Specification for Silica Fume Used in Cementitious Mixtures
ASTM C 1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C 131	Test Method for Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 127	Test Method for Specific Gravity and Absorption of Coarse Aggregate
ASTM C 138	Standard Test Method for Density ("Unit Weight"), Yield, and Air Content (Gravimetric) of Concrete
ASTM C 143	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C 150	Standard Specification for Portland Cement
ASTM C 171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C 172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C 192	Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 227	Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
ASTM C 231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 295	Petrographic Examination of Aggregates for Concrete
ASTM C 309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 42	Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 441	Effectiveness of Pozzolans or Ground Blast-Furnace Slag in Preventing Excessive Expansion of Concrete Due to the Alkali-Silica Reaction
ASTM C 469	Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 496	Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
ASTM C 595	Standard Specification for Blended Hydraulic Cements
ASTM C 597	Pulse Velocity Through Concrete
ASTM C 618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C 642	Density, Absorption, and Voids in Hardened Concrete
ASTM C 805	Rebound Number of Hardened Concrete
ASTM C 881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 920	Standard Specification for Elastomeric Joint Sealants
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 989	Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
ASTM C 1751	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction. (Non-extruding and Resilient Bituminous Types).

ASTM D 1179	Fluoride Ion in Water
ASTM D 1190	Standard Specification for Concrete Joint Sealer, Hot-Applied Elastic Type
ASTM D 1339	Sulfite Ion in Water
ASTM D 1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)
ASTM D 1752	Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Nitrite-Nitrate in Water
ASTM D 3867	Nitrite-Nitrate in Water
ASTM D 512	Chloride Ion in Water
ASTM D 516	Sulfate Ion in Water
ASTM E 329	Standard Specification for Agencies Engaged in the Testing and/ or Inspection of Materials Used in Construction

c) American Welding Society (AWS)

D 12 Welding Reinforcing Steel, Metal Inserts and Connections in Reinforced Concrete Construction.

d) All other standards hereinafter indicated.

The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

3.2.1.3 Submittals

- a) Refer to The Technical Specifications Division 1, "General Requirements".
- b) Test Reports and Certificates shall be furnished in conformity with Division 1 and approval received before delivery of certified or tested materials to the Project Sites.
 - 1) Submit Test Reports for the following:
 - (a) Concrete mixture proportions

Submit copies of test reports by independent test labs conforming to ASTM C 1077 showing that the mixture has been successfully tested to produce concrete with the properties specified and that mixture will be suitable for the job conditions. Test reports shall be submitted along with the concrete mixture proportions. Obtain approval before concrete placement. Fully describe the processes and methodology whereby mixture proportions were developed and tested and how proportions will be adjusted during progress of the work to achieve, as closely as possible, the designated levels of relevant properties.

(b) Aggregates

Submit test results for aggregate quality in accordance with ASTM C 33. Where there is potential for alkali-silica reaction, provide results of tests conducted in accordance with ASTM C 227 or ASTM C 1260. Submit results of all tests during progress of the work in tabular and graphical form as noted above, describing the cumulative combined aggregate grading and the percent of the combined aggregate retained on each sieve.

(c) Admixtures (if required to be used by field conditions subject to approval by the Design Engineer)

Submit test results in accordance with ASTM C 494 and ASTM C 1017 for concrete admixtures, ASTM C 260 for air-entraining agent, and manufacturer's literature and test reports for corrosion inhibitor and anti-washout admixture. Submitted data shall be based upon tests performed within 6 months of submittal.

(d) Cement

Submit test results in accordance with ASTM C 150 Portland cement and/or ASTM C 595 and ASTM C 1157 for blended cement. Submit current mil data.

(e) Water

Submit test results in accordance with ASTM D 512 and ASTM D 516.

(f) Reinforcement and Protective Coating

Provide coating manufacturer's and coating applicator's test data sheets certifying that applied coating meets the requirements of ASTM A 934.

2) Submit Certificates for the following:

(a) Curing concrete elements

3) Submit proposed materials and methods for curing concrete elements.

(a) Form removal schedule

4) Submit proposed materials and methods for curing concrete elements.

(a) Concrete placement and compaction

- (i) Submit technical literature for equipment and methods proposed for use in placing concrete. Include pumping or conveying equipment including type, size and material for pipe, valve characteristics, and the maximum length and height concrete will be pumped. No adjustments shall be made to the mixture design to facilitate pumping.
- (ii) Submit technical literature for equipment and methods proposed for vibrating and compacting concrete. Submittal shall include technical literature describing the equipment including vibrator diameter, length, frequency, amplitude, centrifugal force, and manufacturer's description of the radius of influence under load. Where flat work is to be cast, provide similar information relative to the proposed compacting screed or other method to ensure dense placement.

(b) Mixture designs

Provide a detailed report of materials and methods used, test results, and the field test strength (fcr) for marine concrete required to meet durability requirements.

- c) The Contractor shall submit shop drawings and erection drawings for formwork and scaffolding at least 14 days prior to commencing the work.

Each shop drawing and erection drawing shall bear the signature of a Contractor's qualified Engineer. Details of all proposed formwork to be prefabricated and formwork to produce special finishes shall be submitted to the Engineer for approval before any materials are ordered. If the Engineer so requires, samples of proposed formworks shall be constructed and concrete placed at the Contractor's expense so that the proposed methods and finished effect can be demonstrated.

The Contractor shall submit shop drawings showing reinforcing bar placing and bar lists for the Engineer's approval. Such shop drawings shall show also supplemental bars for forming, strengthening frames of bars of sufficient rigidity to withstand forces during placing concrete. If necessary, shaped steel may be added to improve rigidity of the frame of bar.

Such shop drawings shall clearly indicate bar sizes, spacing, location and quantities of reinforcement, mesh, chairs, spacers and other details to be as per ACI Manual of Standard Practice for Detailing Reinforced Concrete Structures.

Details shall be prepared for placement of reinforcement where special conditions occur, including most congested areas and connection between precast concrete and concrete in-situ.

All shop drawings shall be reviewed by the Engineer within seven (7) days after receiving them.

At least two (2) days prior to pouring concrete, the Contractor shall submit to the Engineer a pouring permit for his inspection and approval.

d) Field Samples

1) Slab Finish Sample

Install minimum of 3m x 3m slab. Finish as required by Specification.

2) Underwater Concrete Sample

Place concrete in four 5 gallon buckets below water. Permanently mark as "7 days," "14 days," "28 days," and "Extra." Include date and station. Provide specimen sets at every 46 lineal meter of seawall with a minimum of one set per day of underwater concrete placement. Retrieve specimens at specified intervals. Extract 100 mm diameter by 250 mm core and test in accordance with ASTM C 39.

3.2.2 MATERIAL REQUIREMENTS

3.2.2.1 Cement

Unless otherwise specified in the Drawings, only one (1) brand of cement shall be used for any individual structure. In determining the approved mix, only Portland cement shall be used as the cementitious material.

- a) Portland Cement: Use ASTM C 150, Type II for general use in construction, more especially when moderate Sulfate resistance is desired.
- b) High-Early Strength Portland Cement may be used for precast concrete. Cement Type III shall conform to ASTM C 150 with a tricalcium aluminate limited to 8 percent.

3.2.2.2 Admixture (If Necessary)

Unless otherwise required by field conditions, admixture may be used subject to the expressed approval of the Engineer. The cost of which shall already be included in the unit cost bid of the Contractor for the concrete.

- a) Air Entraining Admixture shall conform to ASTM C 260.
- b) Admixture other than air entraining agent shall conform to ASTM C 494.
- c) Admixture containing chloride ions, or other ions producing deleterious effect shall not be used.

3.2.2.3 Aggregates

a) Crushed Coarse Aggregate

Conforming to ASTM C 33 and having nominal sizes passing 38.0 mm to 19.0 mm, 19.0 mm to 9.5 mm to No. 4 sieve. The material shall be well graded

between the limits indicated and individually stockpiled. It shall be the Contractor's responsibility to blend the materials to meet the gradation requirements for various types of concrete as specified herein.

Nominal sizes for combined gradation shall be as follows:

ASTM Sieves	Nominal Size of Coarse Aggregates % by Weight Passing			
	40 mm	25 mm	19 mm	10 mm
50.0 mm (2")	100	-	-	-
38.0 mm (1 1/2")	95-100	100	-	-
31.8 mm (1 1/4")	-	90-100	100	-
25.0 mm (1")	-	-	90-100	-
19.0 mm (3/4")	35-70	25-90	-	100
16.0 mm (5/8")	-	-	20-55	85-100
9.5 mm (3/8")	10-30	0-10	0-10	0-20
No. 4	0-5			

b) Fine Aggregate

ASTM C 33 except for gradation which has been revised to meet local conditions unless otherwise required by the Engineer, grading of fine aggregate shall be as follows:

ASTM Sieves	% by Weight Passing
9.5 mm (3/8")	100
No. 4	90 - 100
No. 8	80 - 100
No. 16	50 - 90
No. 30	25 - 60
No. 50	10 - 30
No. 100	2 - 10

- 1) Grading of fine aggregates shall be reasonably uniform and fineness modulus thereof shall not vary more than 0.2 from that of the representative sample in which mix proportions of concrete are based.
- 2) Due care shall be taken to prevent segregation.

3.2.2.4 Water

The water used in concrete, mortar and grout shall be free from objectionable quantities of silt, organic matter, alkali, salts and other impurities. Sea water shall not be used at any time.

3.2.2.5 Anchorage Items

Dowels for anchoring mechanical items to concrete shall be in conformity to manufacturer's standard and of types required to engage with the anchors to be provided and installed therein under other sections of these Specifications, and shall be subject to the approval of the Engineer.

3.2.2.6 Curing Materials

- a) Impervious Sheet Materials: ASTM C 171 type, optional, except that polyethylene film, if used, shall be white opaque.
- b) Burlap of commercial quality, non-staining type, consisting of 2 layers minimum.
- c) Membrane Forming Curing Compound: ASTM C 309; submit evidence that product conforms to specifications.

3.2.2.7 Jointing Materials

- a) Sealant: Sealant shall be multi-component, polyurethane base compound, gray in color, self-leveling for horizontal joints, 2 part polythremdyne, terpolymer compound, gray in color; non-sag for vertical joints.

Sealant shall be compatible with materials in contact and to perform satisfactorily under salt water and traffic conditions, and be capable of making joint watertight and allow movement 25% of the width of joint in any direction.

Sealant shall be guaranteed against leakage, cracking, crumbling, melting, shrinkage, running, loss of adhesion for a period of five years from the date of acceptance of work.

- b) Joint backing shall be expanded extruded polyethylene, low density, oval in shape to fit the joints as indicated on the drawings and to be compatible with sealant.
- c) Where required, primer shall be compatible with joint materials and installed in accordance with manufacturer's instructions.
- d) Joint filler shall conform to ASTM D1751 (AASHTO M213) non-extruding, resilient bituminous type. Filler shall be furnished for each joint in single piece for depth and width required for joint, unless otherwise authorized by the Engineer. When more than one piece is authorized for a joint, abutting ends shall be fastened and hold securely to shape by stapling or other positive fastening.

3.2.2.8 Epoxy Bonding Compound

ASTM C 881. Provide Type I for bonding hardened concrete to hardened concrete; Type II for bonding freshly mixed concrete to hardened concrete; and Type III as a binder in epoxy mortar or concrete, or for use in bonding skid-resistant materials to hardened concrete. Provide Class B if placement temperature is between 4 and 16 °C; or Class C if placement temperature is above 16 °C.

3.2.2.9 Neoprene Bearing Pad

Neoprene bearing pad shall be of 60 Durometer Hardness and of size as shown on drawings. It shall conform to AASHTO M 251.

3.2.2.10 Reinforcement

Steel reinforcement, other than Steel for Prestressing, used in Reinforced Concrete, shall conform to ASTM as follows:

- ASTM Designation A615-Deformed Billet Steel Bars for Concrete Reinforcement. Minimum yield strength of 275.8MPa (40,000 psi) for 12mmØ and smaller and 413.7MPa (60,000 psi) for diameter of 16 mmØ and larger.
-
- Welded steel wire ASTM Designation A185, Fabric for Reinforcement of Concrete.

All bar reinforcement shall have deformed surfaces except that 6 mm bars may be plain.

3.2.2.11 Tie Wire

Tie wire shall be plain, cold drawn annealed steel wire 1.6 mm diameter.

3.2.3 SAMPLES AND TESTING

- a) Refer to Section 1.5.11.
- b) Cement: Sampled either at the mill or at the site of work and tested by an independent commercial or government testing laboratory duly accredited by the Bureau of Research and Standards (BRS) of the DPWH, Department of Science and Technology (DOST) or the Department of Trade and Industry (DTI) at no additional cost to PFDA. Certified copies of laboratory test reports shall be furnished for each lot of cement and shall include all test data, results, and certificates that the sampling and testing procedures are in conformance with the Specifications. No cement shall be used until notice has been given by the Engineer that the test results are satisfactory. Cement that has been stored, other than in bins at the mills, for more than 3 months after delivery to the Site shall be re-tested before use. Cement delivered at the Site and later found after test to be unsuitable shall not be incorporated into the permanent works.
- c) Aggregates: Tested as prescribed in ASTM C 33

At least 28 days prior to commencing the work, the Contractor shall inform the Engineer of the proposed source of aggregates and provide access for sampling.

Gradation tests will be made on each sample without delay. All other aggregates tests required by these Specifications shall be made on the initial source samples, and shall be repeated whenever there is a change of source. The tests shall include an analysis of each grade of material and an analysis of the combined material representing the aggregate part of the mix.

- d) Reinforcement: Certified copies of mill certificates shall accompany deliveries of steel bar reinforcement. If requested by the Engineer additional testing of the materials shall be made at the Contractor's expense.

- e) **Concrete Tests:** For test purposes, provide three (3) sets of test specimens taken under the instruction of the Engineer from each 50 cu.m. or fraction thereof of each class of concrete placed. At least one (1) set of test specimen shall be provided for each class of concrete placed in each 8-hour shift. Each shall consist of two test specimens, and shall be made from a separate batch. Samples shall be secured in conformance with ASTM C 172. Tests specimens shall be made, cured, and packed for shipment in accordance with ASTM C 31. Cylinders will be tested by and at the expense of the Contractor in accordance with ASTM C 39. Test specimens will be evaluated separately by the Engineer, for meeting strength level requirements for each with concrete quality of ACI 318. The standard age of test shall be 28 days, but 7 day tests may be used, with the permission of the Engineer, provided that the relation between the 7-day and 28-day strengths of the concrete is established by tests for the materials and proportions used. When samples fail to conform to the requirements for strengths, the Engineer shall have the right to order a change in the proportions of the concrete mix for the remaining portions of the work at no additional cost to the Engineer.
- f) **Test of Hardened Concrete in or Removed from the Structure:** When the results of the strength tests of the concrete specimens indicates the concrete as placed does not meet the Specification requirements or where there are other evidences that the quality of concrete is below the specification requirement in the opinion of the Engineer, tests on cores of in-place concrete shall be made in conformance with ASTM C 42.

Core specimens shall be obtained by the Contractor and shall be tested. Any deficiency shall be corrected or if the Contractor elects, he may submit a proposal for approval before the load test is made. If the proposal is approved, the load test shall be made by the Contractor and the test results evaluated by the Engineer in conformance with Chapter 20 of ACI 318. The cost of the load tests shall be borne by the Contractor. If any concrete shows evidence of failure during the load test, or fails the load test as evaluated, the deficiency be corrected in a manner approved by the Engineer at no additional cost to the Engineer.

- g) **Admixtures/Additives:** The admixtures/additives if approved shall be tested for conformance to the referenced specification under which it is furnished. The testing shall be conducted with cement and aggregate proposed for the Project. The admixtures/additives shall be tested and those that have been in storage at the Project Site for longer than six (6) months shall not be used until proven by retest to be satisfactory.

Five (5) liters of samples of any admixtures/additives proposed by the Contractor shall be submitted for testing at least 56 days in advance of use, , which shall require approval of the Engineer. Testing of admixtures/additives proposed by the Contractor including test mixing and cylinder test shall be at the Contractor's expense.

- h) **Jointing Materials and Curing Compound Samples:** At least 28 days prior to commencing the work, the Contractor shall submit to the Engineer for his approval samples of the following materials proposed for use together with manufacturer's certificate.

- 1) 10 kg of joint sealant
- 2) 1 m length of joint filler
- 3) 5 liters of curing compound
- 4) 1 m length of joint backing

The Engineer shall deliver to the Contractor his assessment on the materials within seven (7) days after receiving them.

3.2.4 DELIVERY, STORAGE AND HANDLING OF MATERIALS

- a) Cement: Do not deliver concrete until vapor barrier, forms, reinforcement, embedded items, and chamfer strips are in place and ready for concrete placement. ACI 301 and ASTM A 934 for job site storage of materials. Protect materials from contaminants such as grease, oil, and dirt. Ensure materials can be accurately identified after bundles are broken and tags removed.

Immediately upon receipt at the Site, the cement shall be stored separately in a dry weathertight, properly ventilated structures with adequate provisions for prevention of absorption of moisture. Storage accommodations for concrete materials shall be subject to approval and shall afford easy access for inspection and identification of each shipment in accordance with test reports.

Cement shall be delivered to the Site in bulk or in sound and properly sealed bags and while being loaded or unloaded and during transit to the concrete mixers whether conveyed in vehicles or in mechanical means, cement shall be protected from weather by effective coverings. Efficient screens shall be supplied and erected during heavy winds.

If the cement is delivered in bulk, the Contractor shall provide, at his own cost, approved silos of adequate size and numbers to store sufficient cement to ensure continuity of work and the cement shall be placed in these silos immediately after it has been delivered to the Site. Approved precautions shall be taken into consideration during unloading to ensure that the resulting dust does not constitute a nuisance.

If the cement is delivered in bags, the Contractor shall provide, at his own cost, perfectly waterproofed and well ventilated sheds having a floor of wood or concrete raised at least 0.5m above the ground. The sheds shall be large enough to store sufficient cement to ensure continuity of the work and each consignment shall be stacked separately therein to permit easy access for inspection, testing and approval. Upon delivery, the cement shall at once be placed in these sheds and shall be used in the order in which it has been delivered.

Cement bags should not be stacked more than 13 bags high. All cement shall be used within two months of the date of manufacture. If delivery conditions render this impossible, the Engineer may permit cement to be used up to three (3) month after manufacturing, subject to such conditions including addition of extra cement as he shall stipulate.

- b) Aggregate: All fine and coarse aggregate for concrete shall be stored on close fitting, steel or concrete stages design with drainage slopes or in bins of

substantial construction in such a manner as to prevent segregation of sizes and to avoid the inclusion of dirt and other foreign materials in the concrete. All such bins shall be emptied and cleaned at intervals of every six (6) months or as required by the Engineer. Each size of aggregate shall be stored separately unless otherwise approved by the Engineer.

Stockpiles of coarse aggregate shall be built in horizontal layers not exceeding 1.2 m in depth to minimize segregation.

3.2.5 FORMWORK

- a) Forms: Designed, constructed, and maintained so as to insure that after removal of forms the finished concrete members will have true surfaces free of offset, waviness or bulges and will conform accurately to the indicated shapes, dimensions, lines, elevations and positions. Form surfaces that will be in contact with concrete shall be thoroughly cleaned before each use.
- b) Design: Studs and wales shall be spaced to prevent deflection of form material. Forms and joints shall be sufficiently tight to prevent leakage of grout and cement paste during placing of concrete. Junction of formwork panels shall occur at vertical control joints, and construction joints. Forms placed on successive units for continuous surfaces shall be fitted in accurate alignment to assure smooth completed surfaces free from irregularities and signs of discontinuity. Temporary opening shall be arranged to wall and where otherwise required to facilitate cleaning and inspection. Forms shall be readily removable without impact, shock, or damage to the concrete.
- c) Form Ties: Factory fabricated, adjustable to permit tightening of the forms, removable or snap-off metal of design that will not allow form deflection and will not spall concrete upon removal. Bolts and rods that are to be completely withdrawn shall be coated with a non-staining bond breaker. Ties shall be of the type which provide watertight concrete.
- d) Chamfering: External corners that will be exposed shall be chamfered, beveled, or rounded by mouldings placed in the forms.
- e) Coatings: Forms for exposed surfaces shall be coated with form oil or form-release agent before reinforcement is placed. The coating shall be a commercial formulation of satisfactory and proven performance that will not bond with, stain, or adversely affect concrete surfaces, and shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. The coating shall be used as recommended in the manufacturer's printed or written instructions. Forms for unexposed surfaces may be wet with water in lieu of coating immediately before placing of concrete. Surplus coating on form surfaces and coating on reinforcement steel and construction joints shall be removed before placing concrete.
- f) Removal of Forms shall be done in a manner as to prevent injury to the concrete and to insure complete safety of the structure after the following conditions have been met. Where the structure as a whole is supported on shores, forms for beam and girder sides, and similar vertical structural members may be removed before expiration of curing period. Care shall be taken to avoid spalling the

concrete surface or damaging concrete edges. Wood forms shall be completely removed.

Minimum stripping and striking time shall be as follows unless otherwise approved by the Engineer.

Vertical sides of beams, walls, and columns, lift not 12 hours exceeding 1.2 m

Vertical sides of beams and walls, lift exceeding 1.2 m 36 hours

Softlifts of main slabs and beams (props left under) 5 days

Removal of props from beams and mains slabs and other work 10 days

- g) Control Test: If the Contractor proposes to remove forms earlier than the period stated above, he shall be required to submit the results of control tests showing evidence that concrete has attained sufficient strength to permit removal of supporting forms. Cylinders required for control tests shall be provided in addition to those otherwise required by this Specification. Test specimens shall be removed from molds at the end of 24 hours and stored in the structure as near the points as practicable, the same protection from the elements during curing as is given to those portions of the structure which they represent, and shall not be removed from the structure for transmittal to the laboratory prior to expiration of three fourths of the proposed period before removal of forms. Cylinders will be tested by and at the expense of the Contractor. Supporting forms or shoring shall not be removed until control test specimens have attained strength of at least 160 kg/sq cm. The newly unsupported portions of the structure shall not be subjected to heavy construction or material loading.

3.2.6 REINFORCEMENT

- a) Reinforcement: Fabricated to shapes and dimensions shown and shall be placed where indicated. Reinforcement shall be free of loose or flaky rust and mill scale, or coating, and any other substance that would reduce or destroy the bond. Reinforcing steel reduced in section shall not be used. After any substantial delay in the work, previously placed reinforcing steel for future bonding shall be inspected and cleaned. Reinforcing steel shall not be bent or straightened in a manner injurious to the steel or concrete. Bars with kinks or bends not shown in the drawings shall not be placed. The use of heat to bend or straighten reinforcing steel shall not be permitted. Bars shall be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than one bar diameter, the resulting arrangement of bars including additional bars necessary to meet structural requirements shall be approved before concrete is placed. In slabs, beams and girders, reinforcing steel shall not be spliced at points of maximum stress unless otherwise indicated. Unless otherwise shown in the drawings, laps or splices shall be 40 times the reinforcing bar diameter.
- b) The nominal dimensions and unit weights of bars shall be in accordance with the following table:

Nominal Diameter (mm)	Nominal Perimeter (mm)	Nominal Sectional Area (mm²)	Unit Weight (kg/m)
6	18.8	28.27	0.222
10	31.4	78.54	0.616
12	37.7	113.10	0.888
16	50.3	201.10	1.579
20	62.8	314.20	2.466
25	78.5	490.90	3.854
28	88.0	615.70	4.833
32	100.5	804.20	6.313
36	113.1	1017.60	7.991
40	125.7	1256.60	9.864
50	157.1	1963.50	15.413

- c) Welding of reinforcing bars shall only be permitted where shown; all welding shown shall be performed in accordance with AWS D 12.1.
- d) Exposed reinforcement bars, dowels and plates intended for bonding with future extensions shall be protected from corrosion.
- e) Supports shall be provided in conformance with ACI 315 and ACI 318, unless otherwise indicated or specified.
- f) Concrete Protection for Reinforcement
 - 1) The minimum concrete cover of reinforcement shall be as shown below unless otherwise indicated in the drawings.
 - 2) Tolerance for Concrete Cover of Reinforcing Steel other than Tendons.

Minimum Cover	Maximum Variation
7.5 cm or more (marine structures and concrete cast against and permanently exposed to earth)	9 mm
less than 7.5 cm (other structures)	6 mm

3.2.7 CLASSES OF CONCRETE AND USAGE

- a) Strength Requirement:
 - 1) Concrete of the various classes unless specified in other Sections or indicated on the Drawings or directed by the Engineer shall be proportioned and mixed to achieve the following strengths:

Class	Specified Compressive Strength - 28 days	
	fc' = MPa	fc' = psi
A	34.5	5,000
B1	27.6	4,000
B2	24.1	3,500
C	20.7	3,000
D	17.2	2,500
E	41.4	6,000

- 2) In addition to the above, the maximum permissible water-cement ratio by weight shall not be greater than 0.55 unless otherwise permitted by the Engineer.

b) Usage: Concrete of the various classes to be used shall be as follows:

- 1) Class A concrete : Marine Structures (Breakwater caisson, concrete block at both sides of breakwater)
- 2) Class B1 concrete : Building Works (columns, beams, suspended slabs, shear walls, stairs, foundation, slab on grade), rainwater Tanks, retaining wall
- 3) Class B2 concrete : Concrete pavement for roads, stair landings, and concrete curb
- 4) Class C concrete : Non-structural R.C. walls, Utility RC Works
- 5) Class D concrete : levelling concrete, concrete bedding.
- 6) Class E concrete : Interlocking Concrete Block Pavement

3.2.8 PROPORTIONING OF CONCRETE MIXES

- a) Trial design batches and testing to meet requirements of the classes of concrete specified shall be the responsibility of the Contractor. The design mix shall be of consistencies specified hereinafter in Paragraph 3.2.8.6. Tests for slump, unit weight, and air content shall be performed in the field under the presence of the Engineer.
- b) Concrete Proportioning: Samples of approved aggregates shall be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregates shall be representative of those proposed for the Project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Trial mixes having proportions, consistencies and air content suitable for the work shall be made based on ACI Standard 211.1 using at least three different water-cement ratios which will produce a range of strength encompassing those required for the work. Trial

mixes shall be designed for maximum permitted slump and air content. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 39. From these test results, a curve shall be plotted showing the relationship between water-cement ratio and strength.

- c) **Average Strength:** For each portion of the structure, proportions shall be selected so that the maximum permitted water-cement ratio is not exceeded and so as to produce an average strength to exceed the specified strength f_c' by the amount indicated below. Where production facility has a standard deviation record determined in accordance with ACI 214, based on 30 consecutive strength tests of similar mixture proportions as proposed it shall be used in selecting average strength.

The average strength used as the basis for selecting proportions shall exceed the specified strength f_c' by at least:

- 1) 2.94 MPa if standard deviation is less than 1.96 MPa
 - 2) 3.92 MPa if standard deviation is 1.96 to 2.94 MPa
 - 3) 4.90 MPa if standard deviation is 2.94 to 3.92 MPa
 - 4) 5.88 MPa if standard deviation is 3.92 to 4.90 MPa
 - 5) If a standard deviation record is not available, proportions shall be selected to produce an average strength of at least 6.86 MPa greater than the specified strength.
- d) **Corrective additions to remedy deficiencies in aggregate gradation** shall be used only on written approval of the Engineer.
- e) **Slump:** Tests shall be made in conformance with ASTM C 143, and unless otherwise specified by the Engineer, slump shall be within the following limits:

Structural Element	Slump for Vibrated Concrete	
	Minimum	Maximum
Pavement Concrete	25 mm	50 mm
Precast Concrete	50 mm	70 mm
Lean Concrete	100 mm	200 mm
All other Concrete	50 mm	90 mm

Sampling: Provide suitable facilities and labor for obtaining representative samples of concrete for the Contractor's quality control and the Engineer's quality assurance testing. All necessary platforms, tools and equipment for obtaining samples shall be furnished by the Contractor.

3.2.9 MIXING CONCRETE

3.2.9.1 General

- a) Concrete shall be thoroughly mixed in a mixer of an approved size and type that will insure a uniform distribution of the materials throughout the mass.
- b) All concrete shall be mixed in mechanically operated mixers. Mixing plant and equipment for transporting and placing concrete shall be arranged with an ample auxiliary installation to provide a minimum supply of concrete in case of breakdown of machinery or in case the normal supply of concrete is disrupted. The auxiliary supply of concrete shall be sufficient to complete the casting of a section up to a construction joint that will meet the approval of the Engineer.
- c) Equipment having components made of aluminum or magnesium alloys, which would be in contact with plastic concrete during mixing, transporting or pumping of Portland cement concrete, shall not be used.
- d) Concrete mixers shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the amount of water used.
- e) Materials shall be measured by weighing. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. The accuracy of all weighing devices except that for water shall be such that successive quantities can be measured to within one percent of the desired amounts. The water measuring device shall be accurate to plus or minus 0.5 percent. All measuring devices shall be subject to the approval of the Engineer. Scales and measuring devices shall be tested at the expense of the Contractor as frequently as the Engineer may deem necessary to insure their accuracy.
- f) Weighing equipment shall be insulated against vibration or movement of other operating equipment in the plant. When the entire plant is running, the scale reading at cut-off shall not vary from the weight designated by the Engineer by more than one percent for cement, 1-½ percent for any size of aggregate, or one percent for the total aggregate in any batch.
- g) Manual mixing of concrete shall not be permitted unless approved by the Engineer.

3.2.9.2 Mixing Concrete At Site

- a) Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixers shall be restored or replaced when any part or section is worn 20 mm or more below the original height of the manufacturer's design. Mixers and agitators which have an accumulation of hard concrete or mortar shall not be used.

- b) When bulk cement is used and the volume of the batch is 0.5 m³ or more, the scale and weigh hopper for Portland cement shall be separate and distinct from the aggregate hopper or hoppers.

The discharge mechanism of the bulk cement weigh hopper shall be interlocked against opening before the full amount of cement is in the hopper. The discharging mechanism shall be interlocked against opening when the amount of cement in the hopper is underweight by more than one percent or overweight by more than 3 percent of the amount specified.

- c) When the aggregates contain more water than the quantity necessary to produce a saturated surface dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.
- d) The batch shall be so charged into the mixer that some water enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.
- e) Cement shall be batched and charged into the mixer by such means that it will not result in loss of cement due to the effect of wind, or in accumulation of cement on surfaces of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.
- f) The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are place therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.
- f) All concrete shall be mixed for a period of not less that 3 minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.
- g) Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed.
- h) The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat the inside of the drum without reducing the required mortar content of the mix. When mixing is to cease for a period of one hour or more, the mixer shall be thoroughly cleaned.

3.2.9.3 Mixing Concrete In Trucks

- a) Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant. Except as subsequently provided, the truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in which case a tank is not required. Truck mixers may be required to be provided with a means by which the mixing time can be readily verified by the Engineer.

- b) The maximum size of batch in truck mixers shall not exceed the minimum rated capacity of the mixer as stated by the manufacture and stamped in metal on the mixer. Truck mixing shall, unless otherwise directed, be continued for not less than 100 revolutions after all ingredients, including water, are in the drum. The mixing speed shall not be less than 4 rpm, nor more than 6 rpm.
- c) Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above 32 °C, this limit shall be reduced to 15 minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.
- d) When a truck mixer is used for transportation, the mixing time in stationary mixer may be reduced to 30 seconds and the mixing completed in a truck mixer. The mixing time in truck mixer shall be as specified for truck mixing.

3.2.10 JOINTS

- a) No reinforcement, corner protection angles or other fixed metal items shall be run continuously through joints containing expansion-joint filler, through crack-control joints in slabs on grade and vertical surfaces.
- b) Preformed Expansion Joint Filler
 - 1) Joints with Joint Sealant: At expansion joints in concrete slabs to be exposed, and at other joints indicated to receive joint sealant, preformed expansion-joint filler strips shall be installed at the proper level below the elevation with a slightly tapered, dressed-and-oiled wood strip temporarily secured to the top thereof to form a groove. When surface dry, the groove shall be cleaned of foreign matter, loose particles, and concrete protrusions, then filled flush approximately with joint sealant so as to be slightly concave after drying.
 - 2) Finish of concrete at joints: Edges of exposed concrete slabs along expansion joints shall be neatly finished with a slightly rounded edging tool.
 - 3) Construction Joints:

Unless otherwise specified herein, all construction joints shall be subject to approval of the Engineer. Concrete shall be placed continuously so that the unit will be monolithic in construction. Fresh concrete may be placed against adjoining units, provided the set concrete is sufficiently hard not to be injured thereby. Joints not indicated shall be made and located in a manner not to impair strength and appearance of the structure. Placement of concrete shall be at such rate that the surface of concrete not carried to joint levels will not have attained initial set before additional concrete is placed thereon. Lifts shall terminate at such levels as are indicated or as to conform with structural requirements as directed. If

horizontal construction joints are required, a strip of 25 mm square-edged lumber, beveled to facilitate removal shall be tacked to the inside of the forms at the construction joint. Concrete shall be placed to a point 25 mm above the underside of the strip. The strip shall be removed one hour after the concrete has been placed. Any irregularities in the joint line shall be leveled off with a wood float, and all laitance removed. Prior to placing additional concrete, horizontal construction joints shall be prepared as specified in sub-section 3.2.14, "Bonding."

Construction Joint which is not indicated in the Drawings shall be located as to least affect the strength of the structure. Such locations will be pointed out by the Engineer.

3.2.11 PREPARATION FOR PLACING

Hardened concrete, debris and foreign materials shall be removed from the interior of forms and from inner surfaces of mixing and conveying equipment. Reinforcement shall be secured in position, and shall be inspected, and approved before placing concrete. Runways shall be provided for wheeled concrete-handling equipment. Such equipment shall not be wheeled over reinforcement nor shall runways be supported on reinforcement.

Notice of any concreting operations shall be served to the Engineer at least three (3) days ahead of each schedule.

3.2.12 PLACING CONCRETE

- a) Handling Concrete: Concrete shall be handled from mixers and transported to place for final deposit in a continuous manner, as rapidly as practicable, and without segregation or loss of ingredients until the approved unit of work is completed. Placing will not be permitted when the sun, heat, wind or limitations of facilities furnished by the Contractor prevent proper finishing and curing of the concrete. Concrete shall be placed in the forms, as close as possible in final position, in uniform approximately horizontal layers not over 40 cm deep. Forms splashed with concrete and reinforcement splashed with concrete or form coating shall be cleaned in advance of placing subsequent lifts. Concrete shall not be allowed to drop freely more than 1.5 m in unexposed work nor more than 1.0 m in exposed work; where greater drops are required, tremie or other approved means shall be employed. The discharge of the tremie shall be controlled so that the concrete may be effectively compacted into horizontal layers not more than 40 cm thick, and the spacing of the tremies shall be such that segregation does not occur. Concrete to be overlaid shall be screeded to the proper level to avoid excessive shimming or grouting. Conduits and pipes shall not be embedded in concrete unless specifically indicated.
- b) Time Interval between Mixing and Placing: Concrete mixed in stationary mixers and transported by non-agitating equipment shall be placed in the forms within 30 minutes from the time ingredients are charged into the mixing drum. Concrete transported in truck mixers or truck agitators shall be delivered to the site of work, discharged in the forms within 45 minutes from the time ingredients are discharged into the mixing drum. Concrete shall be placed in the forms within 15 minutes after discharged from the mixer at the jobsite.

- c) **Hot Weather Requirements:** The temperature of concrete during the period of mixing while in transport and/or during placing shall not be permitted to rise above 36 °C. Any batch of concrete which had reached a temperature greater than 36 °C at any time in the aforesaid period shall not be placed but shall be rejected, and shall not thereafter be used in any part of the permanent works.
 - 1) **Control Procedures:** Provide water cooler facilities and procedures to control or reduced the temperature of cement, aggregates and mixing handling equipment to such temperature that, at all times during mixing, transporting, handling and placing, the temperature of the concrete shall not be greater than 36 °C.
 - 2) **Cold Joints and Shrinkage:** Where cold joints tend to form or where surfaces set and dry too rapidly or plastic shrinkage cracks tend to appear, concrete shall be kept moist by fog sprays, or other approved means, applied shortly after placement, and before finishing.
 - 3) **Supplementary Precautions:** When the aforementioned precautions are not sufficient to satisfy the requirements herein above, they shall be supplemented by restricting work during evening or night. Procedure shall conform to American Concrete Institute Standard ACI 305.
- d) **Conveying Concrete by Chute, Conveyor or Pump:** Concrete may be conveyed by chute, conveyor, or pump if approved in writing. In requesting approval, the Contractor shall submit his entire plan of operation from the time of discharge of concrete from the mixer to final placement in the forms, and the steps to be taken to prevent the formation of cold joints in case the transporting of concrete by chute, conveyor or pump is disrupted. Conveyors and pumps shall be capable of expeditiously placing concrete at the rate most advantageous to good workmanship. Approval will not be given for chutes or conveyors requiring changes in the concrete materials or design mix for efficient operation.
 - 1) **Chutes and Conveyors:** Chutes shall be of steel or steel lined wood, rounded in cross section rigid in construction, and protected from overflow. Conveyors shall be designed and operated and chute sections shall be set, to assure a uniform flow of concrete from mixer to final place of deposit without segregation of ingredients, loss of mortar, or change in slump. The discharged portion of each chute or conveyor shall be provided with a device to prevent segregation. The chute and conveyor shall be thoroughly cleaned before and after each run. Waste material and flushing water shall be discharged outside the forms.
 - 2) **Pumps** shall be operated and maintained so that a continuous stream of concrete is delivered into the forms without air pockets, segregation or changes in slump. When pumping is completed, concrete remaining in the pipeline shall be ejected and wasted without contamination of concrete already placed. After each operation, equipment shall be thoroughly cleaned and the flushing water shall be splashed outside the forms.

e) Wall and Abutments

No load shall be placed upon finished walls, foundations or abutments until authorized by the Engineer. Minimum time before loading shall be 7 days.

f) Concrete Placing on Wharf Deck

When placing concrete on wharf decks, the Contractor shall:

- Ensure that rate of placing is sufficient to complete proposed placing, finishing and curing operations within the scheduled time; that experienced finishing machine operators and concrete finishers are provided to finish the deck; that curing equipment and finishing tools and equipment are at the site of work and in satisfactory condition for use.
- Immediately prior to placing, the Contractor shall place scaffolding and wedges and make necessary adjustments. Care shall be taken to ensure that settlement and deflection due to added weight of concrete will be minimal. The Contractor shall provide suitable means to readily permit measurement of settlement deflection as it occurs.
- Should any event occur which, in opinion of the Engineer, would prevent the concrete conforming to specified requirements, the Contractor shall discontinue placing of concrete until corrective measures are provided satisfactory to the Engineer. If satisfactory measures are not provided prior to initial set of concrete in affected areas, the Contractor shall discontinue placing concrete and install a bulkhead at a location determined by the Engineer. Concrete in place beyond bulkheads shall be removed. The Contractor shall limit the size of casting to that which can be finished before beginning of initial set.

3.2.13 COMPACTION

- a) Immediately after placing, each layer of concrete shall be completed by internal concrete vibrators supplemented by hand-spading, rodding, and tamping. Tapping or other external vibration of forms will not be permitted unless specifically approved by the Engineer. Vibrators shall not be used to transport concrete inside the forms. Internal vibrators submerged in concrete shall maintain a speed of not less than 7,000 impulses per minute. The vibrating equipment shall at all times be adequate in number of units and power to properly consolidate all concrete.
- b) Spare units shall be on hand as necessary to insure such adequacy. The duration of vibrating equipment shall be limited to the time necessary to produce satisfactory consolidation without causing objectionable segregation. The vibrator shall not be inserted into the lower courses that have begun to set. Vibrator shall be applied vertically at uniformly spaced points not further apart than the visible effectiveness of the machine.

3.2.14 EPOXY BONDING COMPOUND

Before depositing new concrete on or against concrete that has set, the surfaces of the set concrete shall be thoroughly cleaned so as to expose the coarse aggregate

and be free of laitance, coatings, foreign matter and loose particles. Forms shall be re-tightened. The cleaned surfaces shall be moistened, but shall be without free water when concrete is placed.

ASTM C 881. Provide Type I for bonding hardened concrete to hardened concrete; Type II for bonding freshly mixed concrete to hardened concrete; and Type III as a binder in epoxy mortar or concrete, or for use in bonding skid-resistant materials to hardened concrete. Provide Class B if placement temperature is between 4 to 16 °C; or Class C if placement temperature is above 16 °C.

Apply a thin coat of compound to dry and clean surfaces. Scrub compound into the surface with a stiff-bristle brush. Place concrete while compound is tacky. Do not permit compound to harden prior to concrete placement. Follow manufacturer's instructions regarding safety and health precautions when working with epoxy resins.

3.2.15 SETTING OF BASE PLATES

- a) Preparation: After being plumbed and properly positioned, base plates shall be provided with full bearing with damp-pack bedding mortar, except where expansive grout is indicated. The space between the top of concrete or masonry bearing surfaces and the bottom of the plate shall be approximately 1/24 of the width of the plate, but not less than 13 mm for plates less than 30 cm wide. Concrete surfaces shall be rough, clean, free of oil, grease and laitance, and shall be damp. Metal surfaces shall be cleaned and free of oil, grease and rust.
- b) Mortar: Damp-pack bedding mortar shall consist of one part Portland cement and 2.5 parts of fine aggregates, suitable to the work required, proportioned by weight and not more than 17 liters of water per bag of cement. The space between the top of the plate shall be packed with the bedding mortar by tamping or ramming with a bar or rod until the voids are completely filled.
- c) Expansive Grout: Grout shall derive its expansive properties from the liberation of gas into the mixture during and after mixing. This includes typically, the chemical reaction of metallic aluminum with alkali hydroxides in solution which causes the evolution of hydrogen gas. Expansion of such materials may be expected to continue after the gas liberating mechanism has been exhausted or until the mixture has solidified to such an extent that the tendency for the evolving gas to expand is effectively registered by the stiffness of the grout.

When tested as provided for herein, an expansive grout shall meet the following performance requirements:

Expansion, 28 days, %	0.4 (max)
	0.03 (min)

It will be the Contractor's responsibility to supply the necessary manufacturer's certificates.

3.2.16 FINISHES OF CONCRETE

Within 12 hours after the forms are removed, surface defects shall be remedied as specified herein. The Temperature of the concrete, ambient air and mortar during

remedial work including curing shall be above 10 °C. Fine and loose material shall be removed. Honeycomb, aggregate pockets, voids over 13 mm in diameter, and holes left by the rods or bolts shall be cut out to solid concrete, reamed, thoroughly wetted, brush-coated with neat cement grout, and filled with mortar. Mortar shall be a stiff mix of one part Portland cement to not more than 2 parts fine aggregate passing the No. 16 mesh sieve, with a minimum amount of water. The color of the mortar shall match the adjoining concrete color. Mortar shall be thoroughly compacted in place. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through the outside face. Holes which do not pass entirely through wall shall be packed full. Patchwork shall be finished flush and in the same plane as adjacent surfaces. Exposed patchwork shall be finished to match adjoining surfaces in texture and color. Patchwork shall be damp-cured for 72 hours. Dusting of finish surfaces with dry material or adding water to concrete surfaces will not be permitted.

3.2.17 CONCRETE FINISHING DETAILS

Concrete Paving: After concrete is placed and consolidated, slabs shall be screeded or struck off. No further finish is required.

Smooth Finish: Required only where specified; screed concrete and float to required level with no coarse aggregate visible. After surface moisture has disappeared and laitance has been removed, the surface shall be finished by float and steel trowel. Smooth finish shall consist of thoroughly wetting and then brush coating the surfaces with cement to not more than 2 parts fine aggregate passing the no. 30 mesh sieve and mixed with water to the consistency of thick paint.

Broom Finish: Required for paving, stair landings; the concrete shall be screeded and floated to required finish level with no coarse aggregate visible. After the surface moisture has disappeared and laitance has been removed, surface shall be float-finished to an even, smooth finish. The floated surfaces shall be broomed with a fiber bristle brush in a direction transverse to the direction of the main traffic.

Tolerance: Smooth and broom finished surfaces shall be true to plane with no deviation in excess of 3 mm in any direction when tested with a 3 m straightedge.

3.2.18 CURING

- a) Concrete shall be protected against moisture loss, rapid temperature changes, mechanical injury from rain or flowing water, for a minimum period of time given below:

Types A, B1 and B2	7 days
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Types C and D	5 days
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- b) Concrete shall be maintained in a moist condition throughout the specified curing period and until remedial work is started under sub-section 3.2.16, "Finishes of Concrete". Curing activities shall be started as soon as free water has disappeared from the surface of the concrete after placing and finishing. Formed under-surfaces shall be moist cured with forms in place for the full curing period or, if forms are removed prior to the end of the curing period, by

other approved means. Curing shall be accomplished by any of the following methods or combination thereof, as approved.

- c) **Moist Curing:** Unformed surfaces shall be covered with burlap or mats, wetted before placing and overlapped at least 15 cm. Burlap or mats shall be kept continually wet and in intimate contact with the surface. Where formed surfaces are cured, the forms shall be kept continually wet. If the forms are removed before the end of the curing period, curing shall be continued as on unformed surfaces, using suitable materials.
- d) **Impervious-sheet Curing:** All surfaces shall be thoroughly wetted with a fine spray of water and be completely covered with waterproof paper, polyethylene sheeting or with polyethylene coated burlap having the burlap thoroughly water saturated before placing. Covering shall be laid with light-colored side up. Covering shall be lapped not less than 30 cm and securely weighted down or shall be lapped not less than 10 cm and taped to form a continuous cover with completely close joints. Sheets shall be weighted to prevent displacement or billowing from winds. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.
- e) **Membrane-forming Compound Curing:** Before applying curing compound, tops of joints that are to receive sealant shall be tightly closed with temporary material to prevent entry of the compound and to prevent moisture loss during the curing period. The compound shall be applied on damp surfaces as soon as the moisture film has disappeared. The curing compound shall be applied by power spraying using a spray nozzle equipped with a wind guard. The compound shall be applied in a two-coat, continuous operation at a coverage of not more than 10 sqm per liter for each coat.

When application is made by hand sprayers the second coat shall be applied in a direction approximately at right angles to the direction of the first coat. The compound shall form a uniform, continuous, adherent film that shall not check, crack, or peel and shall be free from pinholes or other imperfections. Surfaces subjected to rainfall within 3 hours after compound has been applied, or surfaces damaged by subsequent construction operations within the curing period, shall be immediately re-sprayed at the rate specified above. Membrane forming curing compound shall not be used on surfaces that are maintained at curing temperatures with free steam. Where membrane-forming curing compounds are permitted, permanently exposed surfaces shall be cured by use of non-pigmented membrane-forming curing compound containing a fugitive dye. Where non-pigmented type curing compounds are used, the concrete surface shall be shaded from the direct rays of the sun for the duration of the curing period. Surfaces coated with curing compound shall be kept free of foot and vehicular traffic, and from other causes of abrasion and contamination during the curing period.

3.2.19 UNDER WATER CONCRETE

- a) Concrete placement under water, when unavoidable, shall be made in accordance with the following requirements and provided always with the Engineer's approval.

- 1) Water cement ratio shall be within 50 percent.
- 2) Weight of cement per one cubic meter shall be not less than 370 kg.
- 3) Use of water reducing admixtures and/or admixtures that reduce concrete contamination by sea water shall be recommended.
- 4) Slump shall be within the following limits:

Construction Method	Slump
Using tremie or concrete pump	Between 13 to 18 cm
Using bottom opening type box or buck	Between 10 to 13 cm

- 5) Coverage of reinforcement shall be 10 cm or more.
- 6) Concrete shall be placed under water in accordance with Sub-section 3.2.12 "Placing Concrete" unless otherwise mentioned below.
 - (a) Concrete shall be placed under calm weather conditions and current shall be within 3 m/min.
 - (b) Concrete shall be placed using tremies or concrete pumps or any other approved equipment.
 - (c) Tremies shall be watertight and of size which can deliver concrete freely without any segregation or change in slump. Tremies shall be filled with concrete fully during placing.
 - (d) Pipes of concrete pumps shall be watertight.
 - (c) Tremies shall move carefully up to the designated height under continuous concrete placement operations so that concrete can spread uniformly.
 - (d) Concrete shall not be agitated after placing in the forms in order to prevent laitance formation at the top of the works.
 - (e) Successive concrete placement can be carried out only after all laitance has been removed from existing surfaces.

3.3 BREAKWATER

3.3.1 GENERAL

Work under this Contract shall be in accordance with Division 1, "General Requirements" and shall apply to this section, whether herein referred to or not.

3.3.1.1 SCOPE OF WORK

This Specification covers the construction of the breakwater for the Project. The works to be carried out shall be, but not limited to the following:

- a) Dredging of the existing seabed and disposal of dredged materials.
- b) Supply and laying of core rocks
- c) Supply and laying of secondary rock - one (1) or two (2) layers
- d) Supply and laying of armour rock - one (1) or two (2) layers
- e) Supply and laying of quarry run filler to fill the voids of top core rocks.
- f) Casting of concrete with reinforcement and for concrete blocks for caisson
- g) Supply and laying of sand fill materials
- h) Supply and laying of bamboo mat

Refer to the Drawings for details

3.3.1.2 SETTING OUT WORKS

- a) Topographic/Hydrographic Survey:

Prior to commencement of the work, the Contractor shall conduct a topographic/hydrographic survey in conjunction with the Engineer's instructions. This survey shall form the basis for future quantity measurements.

- b) The Contractor shall set out works and be solely responsible for accuracy of such setting out.

Prior to placement of any material, the Contractor shall establish construction markers to clearly define the horizontal and vertical limits of works.

3.3.2 MATERIAL REQUIREMENTS

- a) Concrete and Reinforcement Works

Concrete work and reinforcement work for caisson shall be in accordance with Section 3.2, "Concrete Works", where concrete compressive strength (f_c') = 34.5MPa. (5000 psi).

- b) Rockworks

- 1) All rocks to be used shall be angular, hard, durable and not likely to disintegrate in seawater. Rock layers to be installed should more or less be 'global in shape', "angular in surface" and should avoid "river run rocks". Rocks that are sub-angular may be subject to the approval of the Engineer. Rounded or well rounded pieces will not be accepted.

- 2) All rocks shall have a minimum unit weight of 2,650 kg per cubic meter (specific gravity 2.65) of solid materials when measured dry.
- 3) Rocks with specific gravity higher than the above specified is preferable and will readily be accepted. But no adjustment (increase) in the contract price will be made on this account.
- 4) Rocks of the primary cover layer should be sound, durable and hard. It should be free from laminations, weak cleavages, and undesirable weathering, and should be of such character that it will not disintegrate from the action of the air, seawater, or in handling and placing. All stone should be angular quarry stone.
- 5) The greatest dimensions individual rock unit should be no greater than three times the least dimensions.
- 6) All rocks should conform to the following test designations: Apparent specific gravity, ASTM C-127 and abrasion, ASTM C-535.
- 7) Weight of the individual pieces of rock.
 - (a) Armour Rock

Refer to the Drawings for the required sizes of the armour rocks for the 1st and 2nd layers.
 - (b) Core Rock

Refer to the Drawings for the required sizes of the core rock.

Core rock bedding shall be reasonably well graded in weight between the minimum and maximum sizes.
 - (c) Quarry run filler

Quarry run filler shall consists of pieces of varied sizes of small rocks from quarry (minimum of 10% of the weight of core rocks) to fill the voids of top rocks prior to the placing of subbase course.
- c) Sand Fill
 - 1) Sand shall be natural sand conforming to ASTM C33.
- d) Bamboo Mat
 - 1) Materials for bamboo mat which shall be used underneath the structures or rock moved surface shall be free from short or reversed bends and shall be straight as possible.
- e) Concrete Block: Refer to Section 3.10, Precast Concrete, of these Specifications

3.3.3 EXECUTION

- a) Breakwater maybe constructed by any method acceptable to the Engineer. Prior to the start of the work, the Contractor shall submit to the Engineer for approval his method and sequence of construction. The Engineer's approval of the method and sequence of construction shall not release the Contractor from the responsibility to achieve the satisfactory implementation of the work.
- b) Dredging and Disposal
 - 1) The Contractor shall bear in mind the fact that the following materials maybe encountered in the area to be dredged:
 - (a) Old wire ropes and wire rope nets
 - (b) Anchor and sinkers
 - (c) Small sunken crafts
 - (d) Metal keel from boats
 - (e) Rubble stone (at the place of breakwater)
- c) No claim for extra payment for the removal of such items and the like be entertained.
 - 1) The dredge materials shall be disposed in deep waters as far away as possible from the harbor area or at designated location by the Engineer, to ensure that no spoils dumped could return to the dredging site or access channel. The dredging and dumping shall be conducted by the Contractor in whatever manner which he may choose subject to compliance with laws and regulations of the Republic of the Philippines.
 - 2) The Contractor shall provide and install, at his own cost, an adequate type of manner of palisade, if necessary.
 - 3) The excavation shall be performed with the tolerance of +0cm (upward) and -30cm (download) to the levels approved by the Engineer for all sections of excavation.
- d) Construction method of concrete works for breakwater shall be in accordance with Division 3.0 "Concrete Works".
- e) Sand filling works shall be performed according to the detailed working plan of the Contractor, subject to the approval of the Engineer.

The filling shall be performed within the tolerance of ± 30 cm (downward) to the level approved by the Engineer for all sections of the filling.
- f) Rock Materials shall be dumped as uniformly as possible with the use of chutes or other suitable means as approved by the Engineer.

The placing operation shall be carried out with frequent checking on the work being done.

Surfaces of core rocks which shall receive subsequent placement of armour rocks shall be levelled into even and uniform surfaces and voids shall be filled with pebbles and sand within a tolerance of -5cm from levels and slopes approved by the Engineer.

Prior to installation of armour rocks, prepared surfaces of riprap shall be inspected and approved by the Engineer.

Armour rocks shall be placed as uniformly and rigidly as possible with the use of suitable equipment to within a tolerance of +20cm of levels of slopes approved by the Engineer.

g) Bamboo Mat

Prior to installation of armor rocks, prepared surfaces shall be inspected and approved by the Engineer. Bamboo mat shall be placed as neatly as possible and properly tied with each other as approved by the Engineer.

3.3.4 QUARRY SITE AND ROCK QUANTITY

- a) It is the Contractor's responsibility to make necessary surveys / investigations on quarry sites applicable to the Works, taking into consideration the nature of the rockworks required under the Contract such as required quality, total quantity and daily required quantity, transportation method and route etc.,
- b) The Contractor shall submit data on characteristics of proposed quarry sites together with the location of sites, test results of their products and samples for the approval of the Engineer.
- c) When the Contractor intends to operate a quarry for the Works, the Contractor shall take all the responsibilities in connection with its operation including, but not limited to, obtaining all necessary permits and approvals, payment of safety measures or like (if any), provisions and maintenance of safety measures and temporary access roads, all of private and public roads and temporary jetties to be used to transport quarried materials and the compliance with all regulations etc. required by the authorities having jurisdiction over any part of the operation.

Should any explosive be used in the quarry operations, the Contractor shall be responsible to meet laws and regulations, wherever applicable, established by the Local Government and Central Government Department concerned.

- d) Despite the Engineer's previous approval of the natural rock and borrow pits, the Engineer reserves the right to suspend any operation in connection with the rock, if, in its opinion, such rock is not suitable for the work. In such case, the Contractor shall comply with the Engineer's instructions.

3.3.5 SAFETY MEASURES

To prevent the collusion of floating equipment, which are undertaking excavation and/or filling work, or with other vessels in the harbor, working lights on anchor lights and shapes shall be installed. Provided and maintained by the Contractor at night time and during daytime to meet the requirements of safety precaution, subject to the approval of the Engineer.

3.4 DREDGING

3.4.1 GENERAL

Work under this Contract shall be in accordance with Division 1, "General Requirements" shall apply to this Section whether herein specified or not.

3.4.1.1 Scope of Work

Dredging of the sea bed where required (where shown on the drawings). Transporting and disposing of dredged materials away from the Project Site at location designated by the Engineer.

The work includes the furnishing of all labor, materials, plants and equipment required to complete/finish the dredging works in accordance with the Dredging Specifications.

3.4.1.2 General Requirements

- a) A marine survey of the dredged area inside the port shall be carried out by the Contractor and monitored by the Engineer after dredging stages are completed. In the event the survey reveals that any finished area was under-dredged, the Contractor shall complete that portion of the dredging.
 - 1) Upon assumed completion of all the dredging operations inside the project area, the Contractor shall sweep the dredged areas within the limits stated in the specification to ensure that no shoals higher than the specified depth exist. The Contractor shall remove all shoals so discovered.
 - 2) The Contractor shall be responsible during the Work for all horizontal layouts and vertical profiling of the dredging work inside the port.

3.4.1.3 Characteristics of Materials

Information regarding the characteristics of soils which may be encountered in the performance of this Contract is shown in the Tender Drawings for review.

3.4.1.4 Interference with Navigation

- a) The Contractor shall familiarize himself with vessel movement and fishery activities in the area affected by dredging operations. The work shall be in a manner that will not impede navigation including movement of vessels at adjacent wharf or interfere with fishing operations.

- b) The Contractor shall coordinate dredging works with Harbor Authorities, port users and other Contractors.

3.4.1.5 Nature of Materials to be Dredged

- a) Refer to borehole logs as indicated in the drawings for characteristics of material to be dredged at each location. The data is made available for information only and the Engineer does not warrant its accuracy at any location other than the referenced borehole.
- b) After examination, determine properties of materials to be dredged, the most suitable method and equipment to be employed including disposal of dredged spoil.

3.4.1.6 Assistance to the Engineer

On request of the Engineer, furnish use of such boats, equipment, labor and materials forming ordinary and usual part of dredging plant as may be reasonably necessary to inspect and supervise work.

3.4.2 EXECUTION

- a) Dredging shall consist of all underwater excavation/removal of all materials.
- b) The equipment to be used in dredging and filling operations is subject to approval by the Engineer.
- c) Dredging shall be carried out only in the locations and in the order as approved by the Engineer, and only within limits shown on the drawings or as shown on drawings prepared by the Contractor and approved by the Engineer.
- d) Approved dredged materials is to be deposited in areas allocated for port developments whereas dredged material, unsuitable for fill, shall be deposited in areas approved by the Engineer.
- e) The dredging and the disposal of the dredged material including placing and operation of equipment and conveying pipes, and transportation of dredged material to disposal sites shall be done without interference with port operations.
- f) Stones which may be encountered in the materials to be dredged, and having a smallest dimension of at least 300 mm may be buried in the seabed. No part of buried stones must extend above a level 500 mm below the dredging levels indicated. Stones smaller than those mentioned above may be left on the seabed of partly embedded provided that the stones are below the dredging levels indicated.

3.4.3 PREPARATION

- a) The Contractor shall mark floating equipment with lights in accordance with International Regulations for Prevention of Collision at Sea and maintain a radio watch on board.

- b) The Contractor shall place and maintain buoys, markers and lights required to define work and disposal areas.
- c) The Contractor shall layout work from baseline established by the Engineer. He shall be responsible for accuracy of work relative to established baseline and shall provide and maintain equipment as normally required for accurate dredging control.
- d) The Contractor shall establish and maintain tide gauges in order that proper depth of dredging can be determined. Locate gauges so as to be clearly visible.
- e) The Contractor shall establish and maintain on-land targets for location and definition of designated dredge area limits. Targets to be suitable for control of dredging operations and locating soundings. Remove targets on completion of work.

3.4.4 DREDGING OF SLOPES FOR DIKES

- a) Details on temporary slopes, dredged for the execution of Dikes, to be provided by the Contractor and shall be included in their construction method.
- b) The work shall be measured and approved by the Engineer before any sand or stone material is placed unless directed otherwise by the Engineer.
- c) Spoils including dredging materials shall be stockpiled on flat surfaces away from drainage routes.

3.4.5 DREDGING OF BASINS AND APPROACH CHANNEL

- a) The lines shown on drawings indicate the boundaries of the dredging. Carry out dredging to a depth equal to or below the specified level, with a maximum permissible over-dredging of 400 mm below the specified level.
- b) Cut side slopes between original seabed and dredged levels as shown on the drawings unless otherwise authorized in writing by the Engineer.
- c) The Engineer shall verify that the dredging has been carried out as required. In general, the dredged depths shall be checked by Echo-Sounder recording. The survey pattern and method, and the Echo-Sounder type shall be approved by the Engineer. In areas where additional precision is required, the verification shall be carried out by suspending a 6 to 10m long straight edge from a vessel, so that the underside of the straight edge is horizontal and level with the indicated dredging level. A sounding rod shall be connected to each end of the straight edge and shall extend vertically above the water surfaces in order to determine the vertical movements of the straight edge.
- d) The vessel shall be moved slowly across the area in a manner which will ensure that the total area is covered by the straight edge. Areas where the straight edge cannot pass freely shall be marked and dredged and the check shall be repeated.

- e) In case of excessive overdredging, the Contractor shall backfill the overdredged areas and/or take all necessary measures as directed by the Engineer without cost to the Engineer.

3.4.6 DREDGING IN FRONT OF WATERFRONT STRUCTURE

- a) In addition to the requirements of Sub-section 3.4.5, the following shall apply for dredging carried out in front of waterfront structure.
- b) The maximum permissible overdredging is 200 mm.
- c) Dredging may proceed unrestricted in accordance with Section 3.4.5 and provided that in the opinion of the Engineer, a stable, temporary slope to the edge of the strip is maintained.
- d) The Contractor shall be fully responsible for the safety of the permanent structures in the temporary phases of construction. Temporary and permanent bench marks and reference points shall be established as directed by the Engineer for recording immediate and future movements of waterfront structures.
- e) In case of excessive overdredging, the Contractor shall on his account backfill the overdredged areas and/or take all necessary measures as directed by the Engineer.

3.4.7 SPOILS FROM DREDGING

- a) All dredged material, which in the opinion of the Engineer is unsuitable for fill, shall be dumped at the spoil area indicated on the drawings or into the open sea as directed by the designated/assigned project Engineer.
- b) All dredged material, which in the opinion of the Engineer, is suitable for fill but is in excess of the quantities required for the present project shall be deposited as directed by the Engineer.

3.4.8 ARTICLES OF VALUE

Disposal of all articles of value discovered on the site of the works shall be in accordance with appropriate provision of Conditions of Contract.

3.4.9 WRECKS

Should any wreck or obstruction be found, other than that caused by the Contractor, the Contractor is to comply with such instructions as the Engineer may issue regarding its removal.

3.5 MULTI-PURPOSE WHARF ACCESSORIES

3.5.1 GENERAL

Work under this contract shall be in accordance with Division 1, "General Requirements" and shall apply to this section, whether herein referred to or not.

3.5.1.1 Scope of Work

This Section includes the furnishing of all labor, materials, equipment and all incidentals for the removal and replacement of existing bollard and rubber fender at existing multi-purpose wharf.

3.5.1.2 Survey and Setting Out

Contractor shall set out Works and shall be solely responsible for accuracy of such setting out. Prior to placement of any materials, the Contractor shall establish visible construction markers to clearly define horizontal / vertical of works.

3.5.2 MATERIALS REQUIREMENTS

a) Submittal

1) Certified Laboratory Test Report

Before delivery of materials, certified copies in triplicate of the reports of all tests required herein under materials shall be submitted for approval by the Engineer.

2) Materials Samples

Representative samples of all materials to be used when required by the Engineer shall be submitted before the delivery of the materials. Representative samples shall be accompanied by certified laboratory test reports.

b) Materials

1) Accessories

(a) Mooring Bollards, - refer to material requirements in Section 3.7.

(b) Rubber Fenders - refer to material requirements in Section 3.7.

3.5.3 EXECUTION

a) Concrete Works

All concrete works shall follow specifications prescribed in Section 3.2, "Concrete Works."

b) Shop Drawings

The Contractor will submit shop drawings and erection drawings for formwork, falsework and the reinforcing bar lists for the Engineer's review and approval in accordance with the applicable requirements in Section 3.2, "Concrete Works."

- c) Mooring Bollards and Rubber Dock Fenders
 - 1) All materials shall be installed at the location shown on the drawings in accordance with the approved manufacturer's instructions and shop drawings.
 - 2) The Contractor shall submit the detailed construction method based on the manufacturer's recommendations for the Engineer's approval.
 - 3) The installation and testing procedure for the mooring bollards and rubber dock fenders shall follow specifications prescribed in Section 3.7, "Mooring and Fender System."

3.6 REPAIR AND REHABILITATION OF EXISTING PORT FACILITIES

3.6.1 DESCRIPTION

- a) The work consists of furnishing all labor, materials, equipment and incidentals necessary to undertake rehabilitation of existing port facilities, in accordance with the Specification, the Drawings and to the approval of the Engineer.
- b) The Contractor shall be deemed to have satisfied himself of the site conditions and to have included in his unit prices all risks that may arise during or in connection with the work.
- c) This Section shall be read together with the Section on concrete works, fender systems of these Specifications.
- d) The location and position for repair and rehabilitation works shall be in accordance with the Drawings and as directed by the Engineer.
- e) The Contractor shall submit his proposal of work methods for the approval of the Engineer prior to the commencement of the works.

3.6.2 MATERIAL REQUIREMENTS

- a) All the materials to be used for the works described in this Section shall have the same strength as, or more than, that of the original materials which are to be repaired, unless otherwise specifically stated. The materials shall be approved by the Engineer before use.
- b) Fill repair materials shall be non-shrinkage type of either concrete, cement mortar or epoxy mortar. The selection of materials as well as the mix design shall be approved by the Engineer.
- c) Adhesive bond shall be of epoxy type especially manufactured for the purpose of the concrete repair. Its application shall be in accordance with the manufacturer's specifications.

d) Epoxy Application to patching of concrete

Epoxy shall be furnished as two (2) components which shall be mixed together at the site of the work. The material shall be low viscosity liquid polysulfide extended epoxy formulated primarily for use in making high-strength epoxy concrete and epoxy mortar and in pressure grouting of cracks in concrete. The epoxy shall satisfy the following composition:

Component A:

- | | | |
|---------------------|---|---------------------|
| 1) Epoxy Resin | - | 425.00 kg/100 gals. |
| 2) Titanium Dioxide | - | 12.75 kg/100 gals. |

Component B:

- | | | |
|------------------------|---|---------------------|
| 1) Polysulfide Polymer | - | 183.00 kg./50 gals. |
| 2) Triphenol | - | 42.50 kg./50 gals. |
| 3) Talc | - | 4.25 kg./50 gals. |
| 4) Carbon Black | - | 0.85 kg./50 gals. |

The physical properties of the epoxy shall satisfy the following:

Gel Time of Combined Compounds- 15 to 30 minutes

1) Viscosity

- | | | |
|-------------|---|----------------|
| Component A | - | 5 to 10 Poises |
| Component B | - | 7 to 15 Poises |

2) Density

- | | | |
|-------------|---|-----------------------|
| Component A | - | 4.25 to 4.40 kg./gal. |
| Component B | - | 4.50 to 4.65 kg./gal. |

Epoxy shall not be used prior to sampling and testing unless permitted by the Engineer. All test shall be conducted in accordance with the latest ASTM test methods. Any material which shows evidence of crystallization or a permanent increase in viscosity or settling of pigments which cannot be readily redispersed with a paddle shall not be used.

The mixing ratio shall be two (2) parts by volume of Component A to one (1) part by volume of Component B. No mixing operations shall start. The ingredients in Component A and B shall be thoroughly dispersed such that each component forms a fluid mixture. At the time of mixing, Component A and B shall be at temperature between 60 degrees F and 85 degrees F, unless otherwise specified. Any heating of the adhesive components, where required, shall be done by application of indirect heat. Immediately prior to mixing, each component shall be thoroughly mixed with separate paddles, and shall be mixed together on the specified ratio. No solvent shall be added to an epoxy. After mixing, all epoxies shall be placed in the work immediately before thickening of the epoxy has begun.

3.6.3 EXECUTION

a) Preparatory Work

The Contractor shall verify the dimensions and locations of damaged portions of existing structures and confirm the type of repair works prior to the commencement of works.

Within twenty eight (28) days from the commencement of the work, the Contractor shall submit to the Engineer for approval his detailed methodology and sequence of construction including the mix proportion and materials he proposes to use for the works.

The Contractor shall carry out all the necessary preparatory works needed such as setting out, marking, temporary staging etc., prior to the commencement of such works.

The Contractor shall also clean all the surfaces to be repaired by means of brushing, sand blasting or any other appropriate means for rust, dust, weathered materials or any other deteriorated part of structures.

b) Records of Repair Works

The Contractor shall take photographs including underwater photographs for all the places to be repaired prior to the commencement of such works.

These photographs shall be in the monthly reports with identification numbers for each location, namely bay number for slab, etc.

Photographs after repairing works shall be also taken at the same locations and from the same directions. The Contractor shall submit two (2) copies of color photos to the Engineer upon the completion of such works.

c) Rehabilitation of Concrete Slabs (For Breakwater)

1) Repair and rehabilitation works of concrete slabs shall be carried out according to the specified type of repair works as shown on the Drawings.

2) The location and position of each type of repair and rehabilitation works of damaged slabs at existing breakwater, shall be in accordance with the drawings and as directed by the Engineer.

d) Epoxy Application for Concrete Patching

1) Patching Depth less than 25 mm

Deteriorated concrete and loose materials on the area to be repaired shall be removed to a sufficient depth to expose sound concrete. Surfaces of repair area shall be blast cleaned to remove laitance and other deleterious materials. The concrete that is to receive the epoxy mortar shall be primed with a neat coat of epoxy binder without aggregate material just prior to the application of mortar. The finish layer of mortar shall be finished to provide satisfactory appearance. When epoxy is used as a binder to make epoxy

mortar, the two (2) components of epoxy shall be thoroughly mixed together before the aggregate is added, and unless otherwise specified, the mix proportion shall consist of one (1) part of binder to approximately four (4) parts of aggregate by volume.

2) Patching Depth 25 mm to 75 mm

The Contractor shall outline the area with a 19mm (3/4 inch) deep saw cut prior to the removal of the deteriorated concrete. Care should be exercised so as not to cut the existing reinforcement bars. If during the removal of the deteriorated concrete, it is found that the limits of the repair area need to be extended, additional area shall be delineated with 19mm deep saw cut as directed by the Engineer. The existing concrete that is to come in contact with epoxy mortar or new concrete shall be blast cleaned and shall be free of loose concrete chips and surface laitance. Epoxy bonding compound shall be applied to the cleaned concrete and reinforcing steel just prior to placing the patching material. Patching material to be used shall be as specified on the Plans or as directed by the Engineer and shall be either epoxy mortar composed of thoroughly mixed epoxy components with mix proportion of one (1) part epoxy binder to approximately four (4) parts aggregates by volume or concrete Class A In accordance with the requirements specified in "Concrete*.

3) Applying Mortar on Overhead Areas

For overhead areas where forming and casting are not feasible, hand applied mortar can be used. After removing the deteriorated concrete, preparing the surface, and applying epoxy binder, the repair material shall be troweled on in layers. The materials should be of thick enough consistency not to run or displace. It is very important to cure the material properly after placement to reduce differential shrinkage.

4) Epoxy Resin Injection

In grouting of cracks in concrete, the epoxy resins shall be applied by means of high pressure injection equipment. Cracks upon which epoxy is to be placed shall be cut or chipped into V-notch and blown clean and dry with compressed air to remove all excess moisture and debris. Cracks shall be surface sealed except entry and exit ports using materials specified by the manufacturer. High strength low viscosity structural epoxy shall be injected through entry ports using inject port nozzle attached to a pressure machine with a variable dispense pressure of 0-14 MPa (0-2,000 psi). When the epoxy comes out on the adjacent port and the material injected has reached the full depth of the concrete fissures, the injection port is plugged and the injection is resumed at the next entry port. These steps are to be followed until all ports are similarly pressure injected. Remove surface solid and wipe off excess adhesive material after completion of injection.

Existing steel reinforcement or the concrete that is to remain in place shall not be damaged during the removal operation and shall be placed at the position and manner indicated on the Plans or required by the Engineer. The Contractor shall repair at his own expense any damage to the structure beyond the removal area caused by the removal operation to the

satisfaction of the Engineer. Steel reinforcement exposed during the removal operation shall be blast clean and shall be free from dirt, oil paint, grease, loose or thick rust and other deleterious substances which could impair bond of the steel with the concrete. Any dowels or grout which fall to bond or are damaged before the new concrete is placed shall be removed and replaced.

The Contractor shall furnish and place concrete in accordance with the applicable requirements specified herein to the required limits and to the grades and elevations shown on the Plans. Before depositing new concrete on or against existing concrete, the surface of the existing concrete shall be roughened as required by the Engineer, in a manner that will not leave loose particles of aggregate or damage at the surface. It shall be thoroughly cleaned of dust, laitance and foreign matter. The surface of the existing concrete which will come in contact with the new concrete shall be flushed with water and allowed to dry a surface dry condition immediately prior to placing concrete.

Saw cut on the deck slab shall be cut by means of approved concrete saws to the depth, width and line shown in the Plans. Suitable guidelines or devices shall be used to assure cutting on the true line. Saw cut shall be done before any equipment or vehicles are allowed in the deck slab. The area sawed shall be thoroughly cleaned and the groove shall immediately be filled with joint filler (sealant).

Forms where required, shall be built and set -in- place as tightly as possible that can rigidly held in line and grade and removed without injury to concrete.

e) Installation or Demolition of Bollards

- 1) The specified existing bollards installed at the existing wharf shall be removed from their existing positions in accordance with the Drawings or as directed by the Engineer.
- 2) The removed bollards shall be stored in the Contractor's storage for re-use or dumped in the disposal area, as directed by the Engineer.
- 3) The Contractor shall repair the concrete base after the removal of bollards.
- 4) Strengthening of existing concrete slab and/or beam for installation of bollards, shall be undertaken if instructed by the Engineer.

f) Installation of Rubber Fenders

- 1) Concrete base for installation of rubber fenders shall be provided to the existing marginal wharf in accordance with the Drawings.
- 2) The face line of the rubber fenders after installation shall be straight for safe ship operation.
- 3) Rubber fender shall be set as shown on the Drawings with anchor bolts as specified in Section 3.7 "Mooring and Fender System".

3.7 MOORING AND FENDER SYSTEMS

3.7.1 GENERAL

3.7.1.1 Scope of Work

- a) The work includes furnishing of all labor, materials and equipment to complete the installation of mooring bollards and fenders in the existing wharf.
- b) The Contractor shall furnish and install the necessary fittings for a complete job as shown on the drawings and/or as specified.

Supplementary parts necessary to complete and install each item of works shall be included whether or not shown or specified. The Contractor shall furnish to relevant trades all anchors, fastenings, inserts, fittings, fixtures or the like to be installed on or required for securing the works.

The Contractor shall submit shop drawings of all fitting works prior to placing orders and commencement of any fabrication.

3.7.1.2 Mooring System

- a) Designated load capacity of mooring bollards shall be as shown on the drawings, and shall refer to the safe working load. The bollards shall be capable of withstanding a proof test load of 1.5 times the safe working load.
- b) The following publications listed below shall form a part of these Specifications to the extent indicated by the reference thereto.

Publication

G 5101 SC 46, Carbon Steel
G 3101 SS 41, Rolled Steel for General Structures
JIS B0205 Standard M Screw
JIS B1181 Hexagon Nut

3.7.1.3 Rubber Fender Systems

- a) Material for fender systems such as rubber fenders, anchor bolts and templates shall be supplied by the Contractor.
- b) The Contractor shall install the fender system properly according to the drawings and the instructions prepared by the Engineer.
- c) Performance Requirements

The fenders shall be procured in accordance with the performance characteristics, under 45%-50% fender deflection, specified hereunder:

Type of Fender	Min. Energy Absorption (Ton-M)	Max. Reaction Force (Ton)
300mm in height and 1.5m in length	2.8	32

d) Manufacturing Rubber Main Body

Rubber fenders shall be manufactured at the factories of approved makers.

Basic manufacturing methods shall be as follows:

- Shape of rubber main body: refer to the Drawings
- Fabrication of rubber main body shall be completed at the factory
- No connection of main body shall be permitted out of the factory
- Steel plate shall be embedded in the deck sides of rubber main body.
- The Contractor shall submit manufacturer's methods of manufacturing for approval by the Engineer.

3.7.1.4 Submittals

- a) Shop drawings and/or catalogues of mooring bollards and rubber fenders indicating size, weight and mounting requirements shall be submitted for approval of the Engineer.
- b) No materials or fitting shall be ordered without prior approval of the Engineer.

3.7.2 MATERIAL REQUIREMENTS

3.7.2.1 Mooring System

- a) Mooring bollards shall be of the dimensions, weights, capacities and design in accordance with shop drawings approved by the Engineer and shall be fabricated by approved manufacturers with cast steel conforming to the following requirements or approved equivalent.

The size of the bolts, nuts and washers shall be in accordance with the specifications provided in the plans/drawings. The anchor plate shall be connected to the holding down bolt with 12.5 mm weld, as shown on the drawings. All bolts, nuts, washers, etc. that are exposed shall be hot-dip galvanized. Provide lead cover for exposed threads of galvanized anchor bolts.

Samples of the bolts, nuts, washers and anchor plates shall be submitted to the Engineer for approval before being used in the Works.

- 1) The upper parts of bollards and based plates which are embedded in concrete shall be painted. The surface of bollards shall be cleaned thoroughly by wire brush or other means prior to painting to remove rust or any other contamination which may interfere with bond of paint to metal.

The exposed surface shall be coated with rust proof paint and finishing paint, which shall be coal-tar epoxy of 120 micron thickness in accordance with JIS K5623 or the approved standard.

2) Concrete foundation

Concrete Foundation for mooring bollards shall conform to the requirements of Section 3.2, "Concrete Works."

3) Base Steel

Chemical composition and mechanical properties of base metal to be used for fabrication of mooring bollard and its accessories shall comply with ASTM C36 and other required standard stated therein.

4) Visual Inspection

All mooring bollards delivered to site shall be inspected by the Engineer for any signs of flaws or defects inimical to usage.

5) Mill Test Certificates

Two (2) copies of mill test reports shall be submitted certifying that materials meet the specified standards.

6) Tests and Inspection

Inspection of all materials and methods of fabrication shall be carried out by the Contractor. However, the Engineer reserves the right to inspect all facilities at any time during the manufacture to ensure that the materials and workmanship are in accordance with the specifications and the best workmanship.

3.7.2.2 Rubber Fender System

- a) Concrete with reinforcing bars on which the fenders are fixed shall conform to the requirements of Section 3.2, "Concrete Works."

b) Physical Properties

Material for rubber fenders will be one of the international accepted materials.

The rubber material used for rubber fenders shall be of high quality natural rubber and synthetic rubber or mixed rubber blended with carbon black used in the rubber industry and shall have sufficient resilience, anti-aging, weathering, abrasion, wear and oil resistant properties. The rubber dock fender shall be free from bubbles, cracks and other harmful defects.

The physical properties of the rubber compound used for the fenders shall comply with the following requirements:

PHYSICAL PROPERTIES AND TEST METHOD

Test Item			Properties	Test Method	
Physical Test	Before Aging	Tensile Strength	160kg/sqm minimum	Test piece: Dumbell No. 3	ASTM D412
		Elongation	350% minimum		ASTM D1456
		Hardness	76Hs maximum	Spring Type hardness Test (Type A)	ASTM D2240
	After Aging	Tensile Strength	Not less than 80% of original value	Aging by air heating: 70±1°C	ASTM D412
		Elongation			ASTM D456
		Hardness	Not more than original value +8		ASTM D2240
	Compression Test		30% maximum	Heat treatment: 70±1°C x 22 hours	ASTM D395

Note: Equivalent standard are acceptable.

c) Anchor

Anchor Bolts and connecting hardware shall be fabricated from type SUS 304 stainless steel to the required shapes and sizes as shown on the approved shop drawings, and conforming to JIS G 4303 or equivalent.

d) Testing

The Contractor shall be required to submit test certificates showing compliance to the above requirements. The test certificates should be certified by an independent inspection organization recommended by the Contractor and approved by the Engineer.

One fender selected at random shall be tested for performance. The fender shall be compressed repeatedly three times to the minimum deflection at speed from 2 to 8 cm. per minute. The load and deflection values shall be recorded with a precision of 0.5 mm. The results shall be plotted in the form of load-deflection-energy absorption curves. The average data obtained in the second and third test loadings shall be considered as performance values. The tests and reporting shall be carried by an approved laboratory and shall be supervised and certified by the independent inspection organization.

The performance shall satisfy the requirements indicated in Sub-section 3.7.1.3.c.

If any of the tested fenders fail to satisfy the performance requirements, retesting shall be conducted on one piece for every 10 fenders. If the second sample still fails the test, all the remaining fenders shall be tested.

e) Sampling of Specimen

The specimens of rubber shall be taken at the mixing stage directly from each batch of rubber compound for manufacturing of fenders. The specimens shall be tested for compliance with requirements as specified in paragraph b of this Sub-section.

f) Inspection for Dimension

The fenders shall be inspected by the independent inspection organization.

One fender out of five fenders shall be inspected for compliance with dimensions.

Five percent (5%) of anchor bolts and fittings shall be selected at random and inspected. Materials for bolts and fittings to be covered by certified steel manufacturer's mill sheet shall be verified by the independent inspection organization.

g) Acceptance Tolerance

The acceptance tolerances shall be as stipulated in the following:

1) Fender Dimension

	Length	Width	Height	Thickness
Tolerance	+4% -2%	+4% -2%	+4% -2%	+8% -2%

2) Anchoring Bolt Holes in Fender

	Diameter of the Hole	Pitch of the Hole
Tolerance	+2 mm	+4 mm

3) Performance requirements shall conform to paragraph c of Sub-section 3.7.1.3

As basis for acceptance of all finished fenders supplied, a tolerance of +10% on the performance requirements indicated will be acceptable.

The cost of tests and inspection required herein are all for the Contractor's account.

h) Marking

All fender units shall be clearly numbered and marked. Each fender shall have the following marking:

- 1) Fender type and manufacturer's name or trademark
- 2) Production serial number
- 3) Date of manufacturing
- 4) Main dimensions (length, height)
- 5) Bill number in accordance with the project code specified in the Bill of Quantities.
- 6) Warranty

The Contractor shall guarantee the fenders against any defects that are attributable to faulty design and manufacture and shall also guarantee the performance of the fenders under normal working conditions. The guarantee shall be for a minimum period of 12 months from the date of the issuance of Certificate of Completion of the Works.

During the period of guarantee, repairs and replacement of defective fender units and/or material shall be carried by the Contractor at his own cost.

3.7.3 EXECUTION

3.7.3.1 Mooring System

All bollards shall be installed at the locations shown on the drawings and in accordance with the approved manufacturer's recommendations and shop drawings, and as directed by the Engineer.

3.7.3.2 Rubber Fender System

All fenders shall be installed at the locations shown on the drawings and in accordance with the approved manufacturer's recommendations and shop drawings.

3.8 STEEL AND METAL WORKS

3.8.1 GENERAL

3.8.1.1 Scope of Work

The work includes the furnishing of all labor, material and equipment required for performing all operations in the fabrication and installation of structural steel and miscellaneous metal work as specified and shown on the drawings.

Materials shall conform to the requirements hereinafter specified. Connections for which details are not indicated shall be designed in accordance with the American Institute of Steel Construction, Manual of Steel Construction, latest edition, and shall be welded or bolted, except as shown otherwise.

Bolted connections for structural steel work shall be made with high strength steel bolts. Holes shall be provided where necessary for securing other work to steel framing. Steel less than 4.75 mm thick shall be in accordance with the American Iron and Steel Institute's light gauge Steel Design Specification.

Materials and parts necessary to complete each item, even though such work is not definitely shown or specified, shall be included. Miscellaneous bolts and anchors, supports, braces and connections necessary for completion of the work shall be provided.

3.8.1.2 Standards Included In the Specifications

The following publications listed below form a part of these Specifications to the extent indicated by the reference thereto.

a) American Institute of Steel Construction (AISC) Publication:

Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

b) American Society for Testing and Materials (ASTM) Publications:

A-123 Zinc (Hot-Galvanized) Coating Products Fabricated from Rolled Pressed and Forged Steel Shapes, Plates, Bars and Strips

A-153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A-386 Zinc Coating (Hot-Dip) on Assembled Steel Products

c) American Welding Society (AWS) Publications:

D1.1 Structural Welding Code

d) Japanese Industrial Standard (JIS) Publication:

JIS B 1186 Sets of High Strength Hexagon Bolts, Hexagon Nuts, and Plain Washers for Friction Grip Joints

JIS G 3101 Rolled Steel for General Structures

JIS G 3444 Carbon Steel Tubes for General Structural Purposes

JIS G 3445 Carbon Steel Tubes for General Structural Purposes

JIS G 3452 Carbon Steel Pipes for Ordinary Piping

JIS G 3454 Carbon Steel Pipes for Pressure Services

JIS G 4303	Stainless Steel Bars
JIS G 4313	Cold Rolled Stainless Steel Strip for Spring
JIS G 4051	Carbon Steel for Machine Structural Use

3.8.1.3 Storage

Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids or other supports. Materials shall be kept free from dirt, grease and other foreign matter and shall be protected from corrosion.

3.8.1.4 Submittals

a) Shop Drawings

The Contractor shall submit shop drawings for the whole of the steelwork to the Engineer for approval. All such drawings shall show the dimensions of all parts, method of construction, spacing of rivets, bolts, welding, sectional areas and all other details. Riveted or welded construction may be employed subject to approval and neatness of design. Where welds are used, either at works or on site, they shall wherever possible, be continued and returned around any meeting face to ensure that the joints are completely sealed against corrosion.

The details of connections on shop drawings shall be such as to minimize formation of pockets to hold condensation, water or dirt and a minimum gap between abutting angles and the like shall be provided wherever possible to eliminate any traps and facilitate maintenance painting.

No material shall be ordered nor fabrication commenced until such drawings are approved by the Engineer in writing.

The Contractor shall be responsible for all errors of detailing fabrication and for correct fitting of the structural members.

b) Erection Procedures

The Contractor shall submit work program and statement to illustrate the structural steel erection and temporary staying and bracing and to give clarification on data submitted by him should the Engineer requested the same. He shall also submit the data on welding equipment he proposes to use in the field, such data shall include the type, voltage and amperage of the said equipment and be subject to approval of the Engineer.

c) Proof of Compliance with the Specifications for Materials

The Contractor shall submit the following test results as a proof that the materials he will use complies with the requirement of the specifications.

1) Reports of ladle analysis for steel

(a) Mill tests reports for main members

- (b) Fabrication's affidavit for secondary and detail members.
- 2) Reports of tensile properties and bed tests for:
 - (a) Steel shapes
 - (b) Steel bars
 - (c) Steel plates
- 3) Certification of conformance for:
 - (a) Structural steel tubing
 - (b) Steel bar grating
 - (c) Filler metals for welding
- 4) Reports of mechanical properties of headed stud type shear connectors.
- 5) Reports of mechanical tests for high strength threaded fasteners.
- d) Manufacturer's Literature

The Contractor shall submit manufacturer's literature describing the type of welding studs and arc shields used.
- e) Inspection Report

The Contractor shall likewise submit the result of inspection tests specified in this Sub-section 3.8.3.2.

3.8.2 MATERIAL REQUIREMENTS

- a) All materials shall be of new stock, free from surface imperfections and shall conform to the applicable ASTM, JIS, AISC or other equivalent standards.
- b) Structural steel plates, shapes, grating and bars shall conform to JIS G 3101 SS 41.
- c) Structural carbon steel shall conform to ASTM designations A 36 or equivalent. Shapes of structural members shall be as given in AISC, Manual of Steel Construction or equivalent.
- d) High strength structural bolts, nuts and washers shall conform to ASTM A325.
- e) Electrodes for arc welding shall conform to American Welding Society Specification A5.1.
- f) Chains and fittings for fender systems shall conform to JIS F 3303 "Electrical Welded Anchor Chain Cables". All chains and accessories shall be hot-dip galvanized.

3.8.3 EXECUTION

3.8.3.1 Qualification

a) Steel Fabricator

Steel Fabricators shall have a minimum of 5 years experience in fabrication of structural steel for projects of similar size. The Contractor shall submit a written description of fabrication ability including facilities, personnel and lists of similar completed projects, including quality control capability and specifically the type and extent of quality control procedure which the fabricator intends to employ on this project.

b) Steel Erector

Steel Erectors shall have a minimum of 5 years experience in the erection of structural steel structures of similar size to the proposed structure. The Contractor shall submit a written description of structural steel erection ability including equipment, personnel and a list of completed projects.

c) Qualified Welders and Welding Procedures

Welders, tackers, welding procedures and operations shall be in accordance with AWS D1.1. The Contractor shall submit for the Engineer's approval the welding procedure, welder's qualifications and the test results of each type of welding to be performed.

Procedures shall be developed for welding all metals included in the work. The Contractor shall not start welding until procedures, welders, welding operator and tackers have been qualified as specified herein. The Contractor shall perform qualification testing by an approved testing laboratory, or by the Contractor if approved by the Engineer. Cost of such testing shall be borne by the Contractor.

The Contractor shall qualify each welder, welding operator and tacker assigned to work on this project by tests using equipment, positions, procedures, base metal and electrodes that will be encountered in their assignment. The Contractor shall furnish to the Engineer for approval certification that each welder, welding operator and tacker is qualified in accordance with the requirements of AWS D1.1 or approved equal.

3.8.3.2 Welding

a) General

All welders, welding operators and tackers to be employed on the Works shall have been qualified by tests prescribed by the Structural Welding Code of American Welding Society (AWS D1).

Before the work is started the welding procedure of each type of joint shall be approved by the Engineer and the Contractor shall make such trial welds and tests as required for the proposed method.

b) Equipment

Machine welding shall be used wherever possible. All shop welds shall be carried out by qualified operators under proper supervision. The work shall be properly prepared for welding and the correct sequence adhered to.

All site welding shall be carried out by the electric arc process, with coated electrodes.

The welding plant shall be of modern design and with ample capacity to provide the required current to each welding point without appreciable fluctuations.

c) Welding Material

The Contractor shall employ only welding electrodes, welding wire and fluxes capable of producing satisfactory welds when used by qualified welders or welding operators using qualified welding procedures. Filler metals for welding may be any or combination of the following:

- 1) Shielding metal-arc welding: AWS A5.1 or A 5.5
- 2) AWS A 5.18 and Article 417 of AWS Building code
- 3) Flux core arc welding: AWS A5.2 and article 418 of AWS Building Code.

d) Welded Construction

Welded connection shall be permitted only where indicated on the approved shop drawings. Welded construction shall conform to the following:

- 1) Surfaces to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign materials except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas cutting shall, wherever practicable, be done by a mechanically guided torch.
- 2) Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4.75 mm. If the separation is 1.6 mm or greater, the size of the filler welds shall be increased by the amount of the separation. The separation between facing surfaces of lap joints and the butt joints on a backing structure shall not exceed 1.6 mm. The fit of joints at contact surfaces which are not completely sealed by welds shall be close enough to exclude water after painting.
- 3) Abutting parts to be butt welded shall be carefully aligned. Misalignments greater than 3.2 mm shall be corrected and in making the correction, the part shall not be drawn into a sharper slope than 2 degrees. Prior to welding, all parts shall be held securely in position by tack welds, clamps or other means.

- 4) The work shall be positioned for flat welding whenever practicable.
- 5) The technique of welding employed, the appearance and quality of welds made, and the methods used in correcting defective work shall conform to Section 4 - Workmanship, of the Standard Code for Arc and Gas Welding in Building Construction of the American Welding Society.

3.8.3.3 Fabrication

The Contractor shall fabricate structural steel in the shop to the greatest extent possible for transporting in accordance with AISC Building Code with the modifications and additional requirements specified in this section.

Bolted or welded connections shall be provided whether constructed in the shop or in the field as shown on the drawings or as approved by the Engineer. High strength threaded fasteners for all bolted connections shall be used unless otherwise shown on the drawings or approved by the Engineer.

Connections shall be as shown on the drawings or as approved by the Engineer. Holes shall be cut, drilled, or punched at right angles to the surface of the metal and shall not be made or enlarged by burning. Draw allowance shall be made for draw in all tension bracing.

All sharp edges and corners be ground to a minimum radius of 1 mm and all sharp irregularities, burrs, slag and spatters on welds shall be removed.

Bearing plates shall be provided under beams resting on concrete walls.

3.8.3.4 Test and Inspection

Welds shall be inspected visually. A min. 10% of all butt welds and a min. 5% of all fillet welds to be designated by the Engineer shall be examined by radiographic, liquid penetrant, magnetic particle or ultrasonic method, alone or in combination to determine conformance to the acceptance specified herein. All testing shall be performed by an approved testing agency performed in the presence of the Engineer. All tests shall be certified and submitted to the Engineer.

3.8.3.5 Delivery to Site

Anchor bolts and other anchorage devices which are to be embedded in cast-in-place concrete construction shall be delivered to site before the start of the said work.

The Contractor shall number in accordance with shop drawings the materials tested and approved by the Engineer before delivery to the site, and prepare a list showing number, size, quality and quantities of materials.

Material shall be transported in accordance with material list and transportation schedule approved by the Engineer.

Materials shall be protected to prevent damage during transportation. The Contractor shall package and label small parts such as bolts and rivets.

3.8.3.6 Field Erection

Steel erection shall conform to the requirements of these Specifications and to the applicable requirements of AISC, "Specification for the Design, Fabrication, and Erection of Structural Steel for Building" and the AISC "Code of Standard Practice for the Steel Building and Bridges".

The Contractor shall set and wedge or shim loose bearing plates and erect individual pieces not deviating from vertical level and alignment more than 1 in 500.

For the field assembly the Contractor shall:

- a) Assemble structural steel frames accurately to the lines and elevations indicated and within the specified erection tolerance.
- b) Align and adjust accurately various members forming parts of a complete frame of structure before fastening.
- c) Fasten splices of compression members after the abutting surfaces have brought completely into contact.
- d) Clean bearing surfaces in permanent contact of all rust and scale and surface coated with the required corrosion protection before members are assembled.
- e) Provide splices only where indicated.
- f) Provide bolted and welded field connections as specified in this Section.
- g) Remove run-off tabs and grid surfaces where requested by the Engineer.
- h) Clean weld spatter from contact surface.

Field correction of fabrication by gas cutting shall not be permitted on any major member of the structural framing without prior approval of the Engineer.

Structural steel members of high strength steel shall be marked to permit visual verification of the grade of steel used.

3.8.3.7 Bolting

Bolts shall be driven accurately into the holes without damaging the thread. Bolt heads shall be protected from damage during driving. Bolt heads and nuts shall rest squarely against the metal. Where bolts are to be used on beveled surfaces having slopes greater than 1 in 20 with a plane normal to the bolt axis, beveled washers shall be provided to give full bearing to the head or nut. Where self-locking nuts are not furnished, bolt threads shall be upset to prevent the nuts from backing off.

Unfinished bolts transmitting shear shall be threaded to such a length that not more than one thread will be within the grip of the metal. The bolts shall be of the length that will extend entirely through but not more than 6.4 mm beyond the nuts. Bolts heads and nuts shall be drawn tight against the work with a suitable wrench not less

than 80 mm long. Bolt heads shall be tapped with a hammer while the nut is being tightened. After having been finally tightened, nuts shall be locked.

Alternatively, bolts shall be tightened with a torque wrench to the appropriate torque for the bolt diameter.

3.8.3.8 Galvanizing

Galvanizing, where called for, shall conform to the requirements of ASTM A 123. The required weight of the zinc coating for each type of material category with corresponding range of thickness is shown below in compliance with ASTM A 123.

Minimum Average Coating Thickness Grade by Material Category

Materials Category	All Specimens Tested (Steel Thickness Range (Measured), in. (mm))				
	<1/16 (<1.6)	1/16 to < 1/8 (1.6 to <3.2)	1/8 to <3/16 (3.2 to 4.8)	>3/16 to <1/4 (>4.8 to <6.4)	≥1/4 (≥6.4)
Structural Shapes & Plate	45	65	75	85	100
Strip & Bar	45	65	75	85	100
Pipe & Tubing	45	45	75	75	75
Wire	35	50	60	65	80

Coating Thickness Grade

Coating Grade	mils	Oz/ft ²	μm	g/m ²
35	1.4	0.8	35	245
45	1.8	1	45	320
50	2	1.2	50	355
55	2.2	1.3	55	390
60	2.4	1.4	60	425
65	2.4	1.5	65	460
75	3	1.7	75	530
80	3.1	1.9	80	565
85	3.3	2	85	600
100	3.9	2.3	100	705

Conversion Factors

Mils = μm x 0.03937

Oz/ft² = μm x 0.02316

g/m² = μm x 7.067

3.8.3.9 Painting

Shop paint for all structural steel shall be carried out in accordance with Sub-section 4.7.5, "Painting".

3.8.3.10 Inspection

- a) Recommendation and procedures governing inspection are in general described in API RP 2A Section 7 - Inspection, and description in this Section.
- b) Inspection by the Engineer does not relieve the Contractor of his responsibility to provide the necessary inspection of his own work, and that of his sub-contractors, to ensure compliance with Contract Drawings and Specifications.
- c) All sub-contractors, used for steel fabrication work by the Contractor shall be subject to the approval of the Engineer prior to their start of any work for this project.
- d) The fabrication and erection facilities, materials and quality workmanship of the Contractor and his sub-contractors shall be available for inspection by the Engineer at all times during the progress of work. The Engineer shall have the right to reject work not satisfying the requirements of their governing references as mentioned herein before.

3.9 NAVIGATIONAL AID

3.9.1 SCOPE OF WORK

This Section covers the procurement and installation of light beacons for navigational aid including sinkers and reinforced concrete foundation. Unless otherwise instructed by PFDA, the Contractor shall procure and install beacons at the location as indicated on the drawings.

3.9.2 MATERIAL REQUIREMENTS

3.9.2.1 General Description

For reference and guidance, hereunder are the general descriptions of the light beacons to be procured and installed by the Contractor.

3.9.2.2 Description of Navigational Aids

Materials shall conform with the specified material or approved equivalent.

a) Light Beacon

1) Beacon Data

- | | | | |
|-----|----------------|---|-------------|
| (a) | Main material | : | Mild Steel |
| (b) | Height overall | : | Approx. 4 m |

- (c) Focal plane height : Approx. 3.5 m
 - (d) Outside diameter of body : Approx. $\phi 216.3$ mm
 - (e) Total weight : Approx. 150 kg
- 2) Body
- (a) Material : 5.8 mm thick steel pipe
 - (b) Bolts and nuts : Stainless steel
 - (c) Buoy color : White
- 3) Superstructure
- (a) Material : Steel pipe
 - (b) Bolts and nuts : Stainless steel
- 4) Lighting Equipment
- (a) Lantern : (1 layer LED model)
 - (b) Lens : Polycarbonate Fresnel lens
 - (c) Light color : White
 - (d) LED load : 12V 4.8W White color light
 - (e) Flasher : Solid state system
Pre-programmed w/ 256 flashing characters (248 pre-programmed, 8 as specified by customer). And 256 flashing characters are field adjustable. At least 248 flashing characters should be pre-programmed.
 - (f) Sun Switch : Photo electric cell system
 - (g) Luminous intensity (fixed) : 40 cd for White
 - (h) Effective luminous intensity : 28 cd for White
 - (i) Effective Range (T=0.74) : 3.7 N Miles for White
 - (j) Light Character : Fl.4 sec. (0.5+3.5 = 4 sec)
for white
Fl.6 sec. (0.5+5.5 = 6 sec)
for white
- 5) Power Source
- (a) Solar cell module : (12V, 11W) x 1 pc
 - (b) Charging controller : Over voltage charger
 - (c) Storage battery : Sealed lead acid battery
 - (d) (12V, 40Ah) x 1 pc
 - (e) Battery life (without charge): Approx. 30days operation
- 6) Paint Schedule

Process	Kind of Paint	Number of Coat	Thickness
Interior of battery box body			Total more than 220 microns
Under coat	Epoxy zinc rich primer	1	more than 25 microns

	Epoxy resin	2	more than 125 microns
Final coat	Polyurethane resin	1	more than 35 microns
	Polyurethane resin	2	more than 35 microns
Exterior of body			Total more than 220 microns
Under coat	Epoxy zinc rich primer	1	more than 25 microns
	Epoxy resin	2	more than 125 microns
Final coat	Polyurethane resin	1	more than 35 microns
	Polyurethane resin	2	more than 35 microns

3.9.3 EXECUTION

- a) Prior to procurement of light beacons, the Contractor shall submit the manufacturer's catalogue, with detailed information of the product, for approval of the Engineer. The Contractor shall carry out detailed hydrographic survey in the vicinity of the place where light beacons are intended to be installed for Engineer's approval. The Contractor shall also secure permit/clearance to install the light beacons from the Philippine Coast Guard.
- b) After installation, the actual location of light beacons as installed shall again be surveyed and the results thereof shall be submitted to the Engineer for approval.

3.10 PRECAST CONCRETE

3.10.1 GENERAL

Work under this Contract shall be in accordance with Division 1 "General Requirements" of these Specifications and shall be applicable to this Section, whether herein referred to or not.

Precast concrete to be used shall comply generally with the sections relating to concrete and reinforcement concrete and the following clauses, including those for prestressed concrete where applicable.

Concrete members so specified shall be fabricated as precast units with concrete for the specified class placed into a grout-tight mould. If so required, the mould shall be laid on the vibrating table and vibration applied while the concrete is placed.

Permanently exposed surfaces shall have a finish given by moulds of closely-jointed steel material. The surface shall be improved by carefully removing all fins and other projections. After inspection by the Engineer, any concrete surfaces which have been accepted but contain blemishes filled with a cement and fine aggregate paste matching the color of the concrete.

Surfaces which will subsequently receive grout or concrete to complete a structural connection or other composite structural component of which the precast unit forms a part, shall be prepared for surfaces treatment as early as possible after casting. This preparation shall be carried out preferably when the concrete has set but not hardened, by jetting with a fine spray of water or rushing with a stiff brush, just

sufficient to remove the outer mortar skin and to expose the larger aggregate without its being disturbed. Where this treatment is impractical, sand blasting or a needle gun should be used to remove the surface skin and laitance. Hacking shall be avoided.

The Contractor will be permitted to obtain precast concrete units from outside suppliers provided that they comply with the Specification and that the Contractor obtains the Engineer's approval for each supplier.

The Contractor shall give to the Engineer full details of proposed methods of handling and stacking precast concrete units. The Engineer will examine these details and will either approve the methods or cite other modifications design to ensure that no excessive stresses are set up in the units. The finally approved methods shall be adhered to at all times and the Contractor shall be deemed to have included in his rates for all measures required to handle and stack beams and units safely and without undue stressing.

3.10.2 CASTING BED AND MARKING

All precast units shall be cast on a suitably prepared level, unyielding paved area or on suitable platforms. A suitable serial number indicating the date of casting shall be impressed or painted on each unit or portions cast.

3.10.3 CONSTRUCTION JOINT

Every unit shall be cast in one continuous operation. Construction joints shall be avoided.

3.10.4 TOLERANCES FOR INDIVIDUAL UNITS

Precast concrete units shall be true to the size and dimensions shown on the Drawings within the following limits:

Lengths

up to 3 meters	± 6
More than 3 meters but less than 6 meters	± 9
6 meters or more	± 12

Cross Section (each direction)

up to 0.5 meters	± 6
More than 0.5 meters but less than 0.75 meters	± 9
0.75 meters or more	± 12

Straightness or bow (deviation from intended line)

up to 3 meters	± 6
More than 3 meters but less than 6 meters	± 9
6 meters or more	± 12

3.10.5 SQUARENESS

When measuring the squareness of a corner, the longer of the two adjacent sides shall be taken as the base line. The shorter side shall not vary in its distance from a perpendicular so that the difference in mm. between the greatest and shortest dimensions exceeds :

Lengths of short side

up to 1.2 meters	± 6
More than 1.2 meters but less than 3 meters	± 9
3 meters or more	± 12

3.10.6 TWIST

Any corner shall not be more than the tolerance stated in mm. from the plane containing the other three corners:

up to 0.7 meter wide and up to 6 meters in length	± 6
over to 0.7 meter wide and for any length	± 9

3.11 PAINTING OF PORT FACILITIES

3.11.1 GENERAL

VOLUME I, preceding these Technical Specifications and Section these Technical Specifications and Section I, - General Requirements contain provisions and requirements essential to these specifications; and apply to this Section, Whether or not referred to herein.

3.11.1.1 Scope of Work

This Section covers the surface preparation, coating materials and application of coatings system required for the Works.

3.11.1.2 General Provisions

All exposed metal surfaces, except metal surfaces embedded in concrete or galvanized shall be painted unless otherwise specified. All tools and equipment shall be suitable for the work and shall be maintained in good order.

Applicable Publications: The following publications listed below, but referred to thereafter by basic designation only, forms a part of this specification to the extent indicated by the reference thereto:

Steel Structures Painting Council (SSPC) U.S. Specification.

JIS K 5628 Red-lead Zinc Chromate Anti-Corrosive Paint.

3.11.1.3 Storage and Delivery

- a) The Contractor shall deliver all materials to the job site in the original labeled sealed cans and containers, with labels intact and seal unbroken.
 - 1) Seals shall remain unbroken until after inspection and acceptance of materials by the Engineer.
 - 2) The Contractor shall deliver materials in ample quantities in advance of the need to avoid any delays or interruptions in the Work.
- b) Storage: Paint and thinner shall be stored in accordance with the manufacturer's printed instructions.
 - 1) Observe all regulations required for storage of paint and post all necessary safety signs required by governing codes.
 - 2) Repair any damage caused by failing to exercise proper precautions in paint storage.
 - 3) All containers of paint shall remain unopened until required for use; containers which have been opened shall be used first, otherwise the oldest paint shall be used first.
 - 4) No paint material shall be used which has exceeded the manufacturer's recommended shelf life.

3.11.1.4 Quality Assurance

- a) Surface preparation and painting work shall be carried out in accordance with the requirements specified herein.
- b) The paint manufacturer's instructions shall be observed at all times, with particular reference to storage, mixing, thinning, application and the time interval between paint coats.

- c) The Contractor shall ensure that his shop and site personnel, have at all times, available for the Engineer copies of all above mentioned standard Specifications and the applicable manufacturer's instructions and data sheets.

3.11.2 MATERIALS

3.11.2.1 General

Paints for the protective coating system shall be the product of a manufacturer, approved by the Engineer.

3.11.2.2 General Paint Schedule

- a) Protective shop coating for metal works shall be as follows:
 - 1) Primer: One (1) coat of red-based zinc chromate anti-corrosive paint 3 mils (76 microns) conforming to JIS K 5628 or approved equal.
 - 2) Coating: Two (2) coats of anti-corrosive paint 6 mils conforming to JIS K 5621 or approved equal.
- b) Protective shop coating for exposed general metal structures.
 - 1) Primer: One (1) coat of red-lead zinc chromate anti-corrosive paint 3 mils (76 microns) conforming to JIS K 5628 or approved equal.
 - 2) Coating: Two (2) coats of anti-corrosive paint for general use 6 mils conforming to JIS K 5621 or approved equal.
 - 3) Color: As shown on the Drawings or as requested by the Engineer.
- c) Cement Mortar Wall and Wood as shown on the Drawings or as directed by the Engineer shall be painted with one coat of linseed oil and two coats of oil paint of approved quality.
- d) Equipment
 - 1) Paint Mixers: Mechanical mixers shall be employed for all paint mixing operations, except that the Engineer may allow hand mixing of small quantities at his discretion.
 - 2) Compressed air supply for blast cleaning and paint spraying shall be adequate in pressure and volume.

3.11.3 EXECUTION

- a) Steel surface shall be cleaned in accordance with the approved method as described below:
 - 1) All ground welds, burrs and sharp surface projection shall be ground smooth and all weld splatter shall be removed prior to blast cleaning.

- 2) The grit size shall be 20-40 mesh Ottawa Fint Silica or equivalent. Grit or shot blasting which obtain the desired profile and degree of cleaning are also acceptable.
 - 3) Blast cleaning operations shall not be conducted on surfaces that will be wet after blasting and before coating, or when the surfaces are less than 10°C above degree points, or when the relative humidity of the air is greater than 95 percent.
 - 4) Any oil grease, soil, dust or other foreign matter deposited on the cleaned surfaces shall be removed prior to painting. In the event that rusting occurs after completion of the surface preparation, the surfaces shall be cleaned again in accordance with the specified method.
 - 5) Particular care shall be taken to prevent contamination of cleaned surfaces with the salt, acids, alkali or other corrosive chemicals before the application of the paint. Such contamination shall be removed from the cleaned surface by flash blasting and the paint applied immediately.
 - 6) Care shall be taken to prevent contamination of cleaned and painted surfaces by cleaning operations in an adjacent area.
 - 7) Surfaces not included to be painted shall be suitably protected from the effects of cleaning and painting operation.
- b) All loose mill scaled and all loose or non-adherent rust and all loose paint, shall be removed by one or more of the following methods; but large areas of tight, well adhered paint, even though they may be removable, shall be removed only if specified. The methods for such removal are:
- 1) Power wire brushing using rotary radial or cup brushes of suitable size, entering all accessible openings, angles, joints, and corners. The steel wire of such brushes shall have sufficient rigidity to clean the surface. Brushes shall be kept free of excess foreign matter, and shall be discarded shall be cleaned but not burnished to a detrimental degree.
 - 2) Power impact tool cleaning using power driven needle guns, chipping or scaling hammers, scalers, or other similar impact cleaning tools. Cutting edges of such tools shall be kept in effective condition.
 - 3) Power grinding using abrasive wheels or power sanding using abrasive materials. Sanding or abrasive materials shall be discarded when they become in effective.
- c) Mill scale, rust and paint are classified as “loose mill scale”, “loose and non-adherent rust,” and “loose” or “removable paint” if they can be removed from a steel surface by power wire brushing using a commercial air or electric wire brushing machine operated at a speed under load of 3450 RPM and equipped with a 150 mm diameter cup brush, of double row knotted construction made of No. 20 gauge music wire (Osborn Manufacturing Company), Cleveland, Ohio, Brush No. 4503 or equal. The brush shall be held against the steel surface with a force of 35.2 kgs And the rate of cleaning shall be 0.186 square meters of surface per minute. This test must be conducted on an area

not previously brushed, scrapped, or sanded, but from which all detrimental stratified rust (rust-scale), oil and grease, if present, have been removed. This test establishes a standard for surface preparation and shall not be considered as establishing the production rate of cleaning.

- d) Regardless of the method use for cleaning under this specification, the surface shall be cleaned at least as well as the surface resulting from the test as specified in this specification or to match the alternatively specified visual standard.
- e) In preparing surfaces for repainting, all loose paint shall be removed. Thick edges of remaining old paint shall be feathered so that the repainted surface can have a smooth appearance. The remaining old paint shall have sufficient adhesion so that it cannot be lifted as a layer by inserting the blade of a dull putty knife under it.
- f) All accessible weld flux and spatter shall be removed by blast cleaning or by power tools. Any remaining detrimental weld flux deposits shall be removed by blast cleaning, thorough power tool cleaning, or by washing with water or with phosphate solution as described in the approved standard specifications.
- g) The accessible portions of all partially enclosed steel members shall be cleaned. On new work, areas which will be inaccessible after assembly shall be cleaned before assembly.
- h) Rivet heads, cracks, crevices, gap joints, filler welds, and re-entrant angles shall be cleaned by the use of power wire brushes, needles, guns, sharp chisels used in chipping, scaling hammers, rotary grinders, or sanders, or by a combination of such tools.
- i) All tools shall be operated in such a manner that no burns or sharp ridges are left on the surface and no sharp ridges are left on the surface and no sharp cuts are made into the steel.
- j) Areas inaccessible for cleaning by power tools but accessible for hand cleaning shall be cleaned by the approved methods.
- k) After the aforesaid operations are completed, dust and other loose matter shall be removed from the surface. If detrimental amounts of grease or oil are still present, these areas shall be spot cleaned with solvent.
- l) The pretreatment (if any), or the prime coat of paint shall be applied as soon as possible after cleaning and before further deterioration of the surface occurs.

3.11.3.1 Alternative Surface Preparation of Steel

- a) The procedures required for the pickling process of steel surfaces prior to the application of Inorganic zinc coating shall consist of the following sequences of operations:
 - 1) Pretreatment: Remove soil, drawing compounds, salts or other foreign matter (other than grease or oil) by brushing with stiff fiber or wire brushes or by scraping.

- (a) Deposits of oil grease shall be completely removed by solvent wiping the surface with rags or brushes soaked in solvent. The final cleaning shall be done using clean solvent and clean rags or brushes to provide an oil-free surface.
 - (b) An alternate method may be used where heavy deposits are removed by the above method, followed by vapor degreasing using stabilized chlorinated hydrocarbon solvents.
- 2) Acid Baths: The steel shall then be dipped into a solution of 5 - 6 percent sulphuric acid that is maintained at a temperature of 71 - 82°C until all rust and scale is removed. The required time for removal of rust and scale can vary from 5 - 32 minutes, depending on thickness of the steel.
 - 3) Water Rinse: The steel is then rinsed in a fresh water tank maintained at a temperature of 38 - 60°C for a minimum time of two minutes to completely neutralize the steel surface.
 - 4) Caution: Prolonged immersion in the acid bath will caused smut deposit on the surface. Steel surfaces shall be examined prior to coating and, if surface is contaminated with smut, the surface shall be cleaned with rags.
 - 5) Requirements: The maximum allowable concentration of dissolved iron content shall not exceed 5 percent in the sulphuric acid bath. Water rinse tanks shall contain only fresh water. The rinse tank shall be continuously supplied with fresh water and the total sulphate shall not exceed 0.1 percent by weight.

3.11.3.2 Surface Preparation of Wood

- a) Wood surfaces shall be sanded to a fresh surface. Surface mould where present, shall be removed by washing, rubbing down and burning off as necessary. Oily timbers shall be swabbed with white spirit. Resinous exudation and large knots shall be removed and replaced with filler or knotting.
- b) Parts of timber to be enclosed in walls shall always be primed unless already impregnated. Priming shall be brushed on and a minimum of two coats applied to end grain. When the priming paint is hard, all cracks, holds, open joints, etc. Shall be made good hard stopping and rubbed down with fine abrasive paper. Priming of joinery shall be applied only on site after the Engineer has approved such joinery and before it is fixed. For internal surfaces primer coats shall be carefully flattened.

3.11.3.3 Mixing and Thinning

- a) Mixing and thinning of paint shall be done in accordance with the manufacturer's printed instructions. The pot life of each paint as stated by the manufacturer shall not be exceeded.

3.11.3.4 Weather Condition

- a) The paint shall not be applied when the relative humidity is above 85 percent. The paint shall not be applied in rain, wind, fog, dust or mist.

3.11.3.5 Application

- a) Paint shall be applied in accordance with the manufacturer's printed instructions.
- b) The paint work crew shall be properly trained in the use of the paint materials specified herein. Paint shall not be applied by personnel who are not familiar with the paint and its application.
- c) Each coat of paint shall be applied as a continuous film of uniform thickness free of pores. Any thin spots or missed areas shall be repainted and permitted to dry before the following coat of paint is applied.
- d) During the application of the paint care shall be taken to prevent all runs or sags. Should either occur, they shall be brushed out. Paint shall be worked into all crevices and corners.
- e) If during the application of the paint, there appears faulty paint, i.e., in color, consistency, dry lime or quality of finish, then the work shall be stopped by the Contractor and the manufacturer consulted. The Contractor shall also notify the Engineer in writing. The responsibility for such action lies solely with the Contractor.
- f) Areas where field welds are to be made shall not be painted within the 150 mm of the edges to be field welded.
- g) After the application of each coat, the dry film thickness shall be checked by means of a micrometer or magnetic thickness gauge.
- h) Paint that curls or lifts after application shall be removed and the area shall be cleaned and repaired in accordance with these Specifications.

3.11.3.6 Touch-Up Painting

- a) Touch-up painting shall be done with the same paint as used for the original coat. The resulting minimum dry film thickness shall be the same as for the original coat.
- b) Touch-up painting shall include cleaning and painting of field connections, welds and all damaged or defective paint and rusted areas.
- c) During touch-up painting, only loose, cracked brittle or non-adherent paint shall be removed during cleaning. All exposed edges shall be feathered. Touch-up painting shall be performed in a manner which will minimize damage to sound paint. Rust spots shall be thoroughly cleaned and edges of the existing paint shall be scraped back to sound material.

3.11.3.7 Drying

- a) No primer or paint shall be forced dried under conditions which will cause cracking, wrinkling, blistering, formation of pores which would detrimentally affect the condition of the paint.
- b) No drier shall be added to the paint unless specified in the manufacturer's printed instructions.
- c) Painted surfaces shall be protected from dust, dirt, and the elements of the weather until dry to the fullest extent practicable.
- d) After drying, any areas of paint damaged from any cause shall be removed, the surface again prepared and then repainted with the same paint and to the same thickness as the undamaged areas.

3.11.4 HANDLING

- a) Paint which is damaged in handling shall be scraped off the touched-up with the same paint and in the same thickness as was previously applied to the damaged are at Contractor's expense.
- b) Precautions shall be taken to minimize damage to paint films resulting from stacking for drying.

3.11.5 INSPECTION

- a) All work and materials supplied under this specification shall be subject to inspection by the Engineer.
- b) The Contractor shall correct such work or replace such material as is found defective under this Specification at his own expense.

DIVISION 4

BUILDING WORKS

DIVISION 4 BUILDING WORKS

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4.1 SURVEY AND LAYOUT WORK

4.1.1 GENERAL

- a) Work under this Contract shall be subject to Division 1,"General Requirements," which contain provisions and requirements essential to these specifications and apply to this section, whether or not referred to herein.
- b) This Section sets forth provisions relating to general surveying and other layout Works required under this Contract.

4.1.1.1 General Requirements for Survey and Layout Work

- a) Data and information developed as work herein shall be reviewed with the Engineer when requested.
- b) Survey and layout works may be reviewed, verified or checked at any time by and at discretion of the Engineer.
- c) Field work or calculations found incorrect, and any work installed improperly due to incorrect field and layout work or calculations, shall be corrected by the Contractor as directed by the Engineer.

- d) Checking or verifications of work herein by the Engineer shall not relieve the Contractor from responsibility for providing work in compliance with requirements of contract documents.
- e) No work under this Contract shall be permitted to proceed until respective survey and layout work have been provided and verified correct.

4.1.1.2 General Requirements

- a) Survey work under this Section shall be under direct control and continuous supervision of a registered Civil/Geodetic Engineer or Licensed Surveyor; qualified and experienced in type of work herein required; retained and paid by Contractor as part of work under this Contract.
- b) Survey calculations and drawings shall be developed as necessary for work required.

4.1.2 SURVEY FIELD WORK

- a) Survey field work shall be performed using established surveying, measuring and leveling methods; and using orderly and methodical procedures.
- b) Surveying instruments and measuring equipment shall be precision made, with standard calibration, accurately adjusted, and of types sufficiently refined for work as required.
- c) Field markings, lines, colored markers or other indicators shall be materials not readily faded by sun or washed away by water.
- d) Stakes, markers, survey pins, and other devices shall be provided as necessary to enable setting or erecting various structures, items or portions of work without resorting to any further special calculations or particularly difficult measurement or use of other than regular straight edge, rule, snap-line and plumb bob methods.
- e) Datum for the work shall be as indicated on drawings or as established in the field under separate Civil Engineering Works Contract.

4.1.3 CONSTRUCTION SURVEY REQUIREMENTS

Following herein are items which the Contractor shall provide prior to commencement of and during construction operations at premises for work under this Contract.

- a) Establishment in the field of a building column/grid reference system; and boundary or primary perimeter lines of buildings and various other structures included under this Contract.
- b) Utility entrance points at perimeters of buildings or other structures or areas as applicable.
- c) Establishment and control of floor and other structures; and finish grades or areas, as applicable.

4.1.4 OTHER LAYOUT WORK

- a) Other layout work required of Contractor shall be based upon lines and levels developed and provided under Survey Work.
- b) Primary layout work extended in from survey layouts shall be performed by a civil, geodetic engineer or a licensed surveyor.
- c) Layout work herein shall be provided to the extent as necessary to assure all work is placed and positioned as required by Contract drawings, approved shop drawings or other related instructions issued by the Engineer.
- d) Interior Layout Work
- e) Layout, locations and dimensions shall be rechecked and verified with the drawings prior to making roughing-ins or setting of other work.

4.2 EXCAVATION AND BACKFILLING FOR BUILDINGS

4.2.1 GENERAL

Division 1, "General Requirements", contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.2.1.1 Scope of Work

- a) This Section sets forth general requirements applicable to excavation and backfilling works required for the foundation of buildings.
- b) Each Section in which this Section is referenced shall include same as part of that Section; unless otherwise specified.

4.2.1.2 General Provisions

- a) Excavated materials required and approved for backfill shall be stockpiled in areas approved by the Engineer.
- b) Remove all unsuitable or excess materials from the site.
- c) Each phase of excavation and backfilling work shall be approved by the Engineer as completed prior to removing earthwork equipment from the site or prior to proceeding with subsequent operations which cover or disturb completed phases of works.

4.2.2 EXCAVATION

General: The excavation shall conform to the dimensions and elevations indicated for each building and structure, except as specified hereinafter, and shall extend a sufficient distance from walls and footings to allow for placing and removal of forms, installation of services and for inspection, except where the concrete for walls and footings is authorized to be deposited directly against excavated surfaces.

Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Unsatisfactory materials encountered below the grades shown shall be removed as directed and replaced with satisfactory materials; satisfactory materials below the depths indicated without specific direction of the Engineer shall be replaced at no additional cost to PFDA to the indicated excavations grade with satisfactory materials, except that concrete footings shall be increased in thickness to the bottom of the overdepth excavations. Satisfactory/backfill shall be placed and compacted as specified in paragraph: "Backfilling." Determination of elevations and measurements of approved overdepth excavation of unsatisfactory material below grades indicated shall be done as directed by the Engineer.

- a) Drainage: Excavation shall be performed such that the areas of the site including its immediate surroundings and other areas affected by the operation, will be continually and effectively drained. Waters shall not be permitted to accumulate in the excavation. The excavation shall be drained by pumping or other satisfactory methods to prevent softening of the foundation bottom, undercutting of footings, or other actions detrimental to proper construction procedure and stability of the structures.
- b) Classification of Excavation: Excavation will be unclassified regardless of the nature of material encountered and excavated.
- c) Blasting will not be permitted.
- d) Excavated Material: Satisfactory excavated material required for fill or backfill shall be placed in the proper sections of the permanent work as required. Satisfactory excavated material in excess of that required for the work under this section shall be made available for use in other portions of the permanent site work required for the permanent work; and unsatisfactory material shall be Contractor's responsibility. No satisfactory material shall be wasted or used for the convenience of the Contractor unless so authorized. Stockpiles and waste materials shall be placed, graded, and shaped for proper drainage giving due consideration to drainage from adjacent properties.
- e) Final grade of surfaces to support concrete: Care shall be taken not to disturb the bottom of the excavation. Excavation to final grade shall not be made until the concrete is just ready to be placed.

4.2.3 BACKFILLING

- a) Satisfactory materials shall be used in bringing fills to the lines and grades indicated and for replacing unsatisfactory material. Satisfactory material shall be free from roots and other organic matter, trash, debris, and stones larger than 75mm in any dimension.
- b) Backfilling shall not begin until construction below finish grade has been approved, underground utilities systems have been inspected, tested and approved; forms removed and the excavation cleaned of trash and debris. Backfill shall be brought to indicate finish grades and shall not be placed in wet, muddy or spongy areas. Backfill shall be of satisfactory materials placed and compacted as specified.

Heavy equipment for spreading and compacting backfill shall not be operated closer to foundation or retaining walls than a distance equal to the height of backfill above the top of footing; the area remaining shall be compacted to required thickness with power driven hand tampers suitable for the material being compacted. Backfill shall be placed carefully around pipes to avoid damage to coatings or wrappings. Backfill shall not be placed against foundation walls prior to seven (7) days after completion of the walls. As far as practicable, backfill shall be brought up evenly on each side of the wall and sloped to drain away from the wall.

- c) Placing: Satisfactory material (fill and backfill materials) shall be placed in horizontal layers not exceeding 150mm in loose depth and then compacted. No material shall be placed on surfaces that are wet, muddy or spongy.
- d) Compaction shall be accomplished by sheep-foot rollers, or other approved equipment well suited to the soil being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.
- e) Tests shall be performed on backfill as required by the Engineer. Fill and backfill materials shall be composed of granular materials (less than 7% fines) compacted to minimum 95 percent maximum dry density (MDD) based on ASTM D698 with quality of compaction strictly monitored by Field Density Tests (ASTM D1558).
- f) Structural Fill placed under slab on grade shall be compacted to 95% of dry unit weight as determined by ASTM D1557.

4.2.4 PROTECTION

Settlement or washing that occurs in graded or backfilled areas prior to acceptance of the work shall be repaired and graded re-established to the required elevations and sloped at no additional cost to PFDA.

4.2.5 GRAVEL BEDDING

Gravel Bedding shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm stable base.

4.3 TERMITE PROOFING, BUKBOK PROOFING

4.3.1 GENERAL

Division 1, "General Requirements", contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.3.1.1 Scope of Work

The Contractor shall hire the services of an approved or accredited pesticide company to furnish all labor, materials, equipment, tools, plant, and services to complete the termite and "bukbok" proofing work hereinafter described.

4.3.1.2 Examination of Site

Inspect the site of work and examine the premises to fully understand existing conditions with respect to the work involved. Prior to soil stripping, excavation or filling all termite mounds within the area should be demolished, removed and treated.

4.3.2 MATERIAL REQUIREMENTS

4.3.2.1 Chemicals and Equipment

For termite proofing, use LENTREK TC Termiticide Concentrate or approve equal.

For “bukbok” proofing of kiln dried wood, use Pentachlorophenon while for untreated wood, use chemical name accredited name/or acceptable to the PFDA and should have valid license from Fertilizer and Pesticide Authority (FPA).

The pest control Contractor shall submit the specified chemicals in their original manufacturer sealed containers to the Project Inspector of inspection, sampling and safekeeping. Containers with broken seal shall not be accepted.

Dilution ratings (for LENTREK TC):

1 part LENTREK TC to 50 parts water

Pentachlorophenon – 1 : 100 concentration

Dilutions shall be done only at the jobsite in the presence of the Project Inspector. The strength of the mixture or solutions shall be made uniform by thorough stirring. All solutions prepared for termite proofing shall be used within 24 hours.

4.3.3 EXECUTION

4.3.3.1 Contractor License and Certification Requirement

The pesticide company should have a valid license from Fertilizer and Pesticide Authority of the Department of Agriculture.

All pesticide shall be applied by or under the direct supervision of a certified pesticide applicator.

4.3.3.2 Environmental and Safety Conditions

Formulation, treatment, storage and disposal of pesticide shall be in accordance with label directions. Water for formulation shall be drawn only from site(s) designated by the Project Inspector, and the filling hose shall be fitted with a backflow preventor meeting local plumbing codes/standards. The filling operation shall be under the direct and continuous observation of the Project Inspector to prevent overflow.

4.3.3.3 Application

a) Termite Control

Application of solution shall be done by means of power sprayers fitted with flow meters for accurate monitoring of actual quantity used. At the time of soil treatment application, the soil shall be preferably in a friable condition with low moisture content to allow uniform distribution of the treatment solution throughout the soil. Do not apply pesticide during or immediately following heavy rains, or when conditions will cause runoff and create an environmental hazard. Cover treated area with waterproof sheeting if concrete is not poured on the same day as the soil treatment. Take precautions to prevent disturbance of the pesticide barrier. Before the placement of structural components, re-treatment where soil or fill is disturbed after treatment. Apply pesticide prior to placement of gravel base, vapor barrier or waterproof membrane.

- 1) Slab on Grade Construction: Establish a horizontal pesticide barrier over areas intended for covering by floors, porches, attached entryways, garages, carports and terraces. Apply treatment solution with a low pressure coarse spray at the rate of four (4) liters solution per square meter. Apply at the rate of seven (7) liters solution per square meter if the fill is washed gravel or other coarse material. Establish a continuous chemical barrier in the voids of hollow block foundation or voids of masonry. Apply treatment at the rate of seven (7) liters per 3 linear meter. Make pesticide band at least 15 cm wide the pesticide evenly distributed throughout. Treat buildings constructed with basement slabs in the same manner.
- 2) Crawl Space Construction: Establish a vertical pesticide barrier inside of foundation walls, both sides of interior partition walls, around piers, plumbing, and rodding and utility conduits. Apply treatment solution by rodding or rodding and trenching the fill at the rate of 15 liters solution per 3 linear meter, and 30 cm deep from grade to bottom of foundation. Treat both sides of foundation and around all piers and pipes. Make treated barrier of fill at least 15 cm wide with the pesticide evenly distributed throughout.
- 3) Dry Pipes and Conduits: Establish pesticide barrier on various dry pipes and conduits such as electrical service entrance, raceways, pipe chase, vents. Use powder type termiticide by injecting it inside the pipe.
- 4) Termite Mounds: Demolish and treat all termite mounds within the property found after the construction.

b) “Bukbok” Proofing

Kiln-dried wood, plywood, tanguile, apitong, cabinets, dividers, and paneling shall be brushed generously with Penthachlorophenon before painting or varnishing.

c) Sun-Dried Wood Treatment

Sun-dried lumber to be used for ceiling joint runners, nailer, etc. shall be brushed with Pentachlorophenon before installation of plywood or ceiling panels.

4.3.3.4 Engineers

The Contractor shall submit to the Engineer for approval, a copy of the pest control company's proposal and chemical application, method/procedure including the description of the equipment to be used before start of work.

4.3.3.5 Inspection and Test

Sampling shall be done only in the presence of the Project Inspector.

Amount of sample to be taken: LENTREK TC (From Original container) 50 cc each.

4.3.3.6 Contractor's Guarantee

Upon completion of work, and on a condition for final acceptance, the Contractor shall submit to PFDA a written guarantee from the pesticide company which shall provide that:

- a) The soil poisoning treatment shall prevent subterranean termites from attacking the building on its contents for a period of not less than five (5) years.
- b) The Contractor shall thereby warrant all works in pest control that all materials and workmanship applied under the contract are of good quality in every respect and will remain as such for not less than five (5) years.

Should there be termite and "Bukbok" infestation within the one (1) year period the Contractor thereby agrees to do all necessary repairs on the damaged portions of the buildings caused by termite infestation to the satisfaction of PFDA, at the Contractor's expense. Retreatment shall also be done by the Contractor after completion of the repairs and at his expense. Such repairs and corrective works shall be done within five days after a written notice from the Owner has been received by the Contractor.

Should there be infestation after the one (1) year period up until the five (5) year guarantee, the pesticide company agrees to do all the necessary repairs at their expense. The pesticide company shall conduct annual inspection of the building and surrounding to check any infestation during the guarantee period. Notice shall be given by the pesticide company to PFDA in case there is presence of termites in the surroundings.

4.4 CONCRETE WORKS FOR BUILDINGS

4.4.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.4.1.1 Scope of Work

The work shall include reinforced concrete structures such as reinforced concrete footings with or without tie-beams, reinforced concrete columns girders, slabs, other cast-in-place and precast concrete including excavation and backfilling work.

The work shall consist of furnishing of all labor, materials, equipment and other incidentals necessary for the supply of concrete materials and the complete construction of the concrete structures for the building shown on the drawings in accordance with these specifications and as directed by the Engineer.

4.4.1.2 General Requirements

Concrete works shall conform with the requirements of Section 3.2 “Concrete Works” except noted otherwise in this Section.

4.4.1.3 Shop Drawings

Together with requirements in sub-section 3.2.1.3.c), the Contractor shall show the following in the shop drawings:

- a) Surface finish
- b) Fitting to be embedded

4.4.2 MATERIAL REQUIREMENTS

- a) Concrete shall consist of Portland cement, fine and coarse aggregates and water and shall conform with the requirements of Section 3.2, “Concrete Works”. Use ASTM C 150, Type II for general use in construction, more especially when moderate Sulfate resistance is desired.
- b) Deformed bars to be used shall conform with the reinforcement requirements in Section 3.2, “Concrete Works.” The size shall be as shown on the drawings.

4.4.3 FORMWORKS

4.4.3.1 General Requirements

Materials and construction of formwork shall be in accordance with formwork requirements in Section 3.2, “Concrete Works.”

4.4.3.2 Removal of Formwork

The minimum stripping and striking time for formwork shall be as follows unless otherwise approved by the Engineer.

Conditions	Minimum Period
Vertical sides of beams, wall, and columns, lift not exceeding 1.2m	24 hours

Vertical sides of beams and walls, lift exceeding 1.2m	48 hours
Soffits of main slabs and beams (props left under)	5 days
Removal of props from beams and main slabs and other works	10 days

4.4.4 CONCRETE

4.4.4.1 Classes of Concrete and Usage

a) Strength Requirement

Building Structures	Compressive Strength at 28 days
Columns, beams, suspended slabs, shear walls, stairs and foundation	27.6MPa (4,000 psi)
Non-Structural Reinforced Concrete Walls	20.7 MPa (3,000 psi)
Slab on grade	27.6MPa (4,000 psi)
Lean Concrete	10.3 MPa (1,500 psi)

4.4.4.2 Slump Test

Tests shall be made in conformity with ASTM C 143, and unless otherwise specified by the Engineer, slump shall be within the following limits:

Structural Element	Slump for Vibrated Concrete	
	Minimum (mm)	Maximum (mm)
Precast concrete	80	180
Wall, column and beam 25cm max. thickness	80	180
Concrete slab	80	150
Lean concrete	70	150

4.4.4.3 Concrete Cover for Reinforcement

Minimum concrete cover for reinforcement shall be as follows:

Net Concrete Cover	Location or Condition	Minimum Cover (mm)
Footing/Foundation Slab	Side	75
	Bottom	75
Footing Tie Beam	Top	50
	Side	50
	Bottom	75
Column	Above Grade Level	40
	Below Grade Level	50

Beam		40
Suspended Slab and Stair (*)	Top & Bottom	20
Wall	Non-Structural Wall	20

4.4.5 CONSTRUCTION JOINTS AND WATERSTOPS

Construction joints shall be provided where shown on the drawings or when approved with written permission of the Engineer. Special care shall be used in preparing concrete surfaces at joints where bonding between two sections of concrete is required. Unless otherwise indicated on the drawings, such bonding will be required at all horizontal joints in walls.

Waterstop material shall be an elastomeric plastic compound, the basic resin of which shall be polyvinyl chloride, and containing any additional resins, plasticizers or other materials needed for the material to comply with the requirements specified.

The waterstop shall be fabricated by an extrusion process such that it will be dense, homogeneous, free from holes and other imperfections. The cross section of the waterstop shall be uniform and symmetrical along its entire length.

Surfaces shall be prepared as follows:

The surface of concrete upon or against which the placement of contiguous concrete or masonry is later required shall be struck off true to the elevations indicated on the drawings after the concrete has been placed. Thereafter as soon as the condition of the concrete permits it, and before the concrete has hardened appreciably, i.e. normally within 2 hours after being deposited, all water, scum, laitance and loose aggregate shall be removed from the surface by means of wire or bristle brooms in such a manner that the coarse aggregate is left lightly exposed, and the surface cleaned. No raking will be permitted.

The Contractor shall then take all necessary precautions to ensure that all surfaces thus prepared shall be kept free from storage piles, drippings, staining or foreign matter, which could adversely affect the concrete or the bond between the concrete layers.

Waterstops for all joints shall be continuous around the corners and at intersections, either in horizontal or vertical direction, as indicated on the drawings. Field splices and joints shall be made in accordance with the waterstops manufacturer's instructions, using a thermostatically controlled-heating iron.

4.5 CONCRETE LOUVER BLOCKS

4.5.1 MATERIALS

a) Mortar

1) Aggregate for Mortar

(a) ASTM C144

- (b) Aggregates used in mortar for joints 6mm or less shall conform to note 1 of ASTM C144.
- 2) Portland cement: PNS 07, Type I.
- 3) Lime Putty: Slaked according to manufacturer's instructions.
 - (a) Hydrated Lime: ASTM 207, Type S.
 - (b) Pulverized Quicklime: ASTM C 5 except 100 percent shall pass the No. 20 sieve and 90 percent shall pass the No. 50 sieve.
 - (c) Lime Paste: shall be made with pulverized quicklime or hydrated lime. Hydrated lime processed by the steam method shall be allowed to soak not less than 24 hours. Quicklime and other hydrated lime shall be allowed to soak not less than 72 hours. To be used in lieu of hydrated lime paste. For use in mortar, the hydrated lime may be added in the dry foam.
 - (d) Water: potable.
- b) Mortar Mixture

Proportions: Type M in accordance with the proportion specifications of ASTM C270. The mortar shall have a flow, after suction, of 70 percent or more when tested for water retention in accordance with ASTM C91 except mortar shall be mixed to an initial flow of 125 to 135 percent.
- c) Concrete Louver Blocks

150mm thick concrete louver blocks, painted. For side wall vents as indicated in the Drawings.

4.5.2 EXECUTION

4.5.2.1 Preparation of Concrete Surface

Clean laitance, dust, dirt, organic or other foreign materials from concrete surface upon which reinforced masonry is to be placed. Use sand blasting if necessary to remove laitance from pores.

4.5.2.2 Laying of Precast Concrete

Mortar joints: Spread all bed joints with mortar for the full thickness of the face shell and place the units. Avoid fins of mortar that protrude into cells to be grouted.

4.6 MASONRY

4.6.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these Specifications and apply to this Section, whether or not referred to herein.

4.6.1.1 Scope of Work

This Section includes the furnishing of all labor and materials to complete the work as shown on the drawings and specified herein. The works shall include but not necessarily be limited to the following:

- a) Supply and installation of concrete hollow block (CHB) walls with reinforcement
- b) Plastering
- c) Installing temporary works like scaffolding, platforms, steps, etc.

4.6.1.2 General Provisions

The following publications of the issues below but referred to thereafter by basic designation only, form a part of these specifications to the extent indicated by the reference thereto:

American Society for Testing and Materials (ASTM) Publications:

- | | | |
|---|-----|---|
| A | 615 | Deformed and Plain Billet-Steel Bars for Concrete Reinforcement |
| A | 33 | Concrete Aggregates |
| C | 129 | Specification for Non-Load Bearing Concrete Masonry Units |
| C | 144 | Specification for Aggregate for Masonry Mortar |
| C | 270 | Mortar for Unit Masonry |

4.6.2 MATERIAL REQUIREMENTS

Materials shall conform to the respective specifications and other requirements specified below:

4.6.2.1 Concrete Hollow Blocks (CHB):

CHB shall be of standard manufacture, machine vibrated with fine and even texture and well-defined edges and conforming with the requirements of ASTM C 129. Unless otherwise specified on the Drawings, It shall have a minimum compressive strength of 2.40 MPa (350 psi) for interior partition walls and 4.8MPa (700 psi) for load bearing, exterior walls. CHB shall be uniform and essentially smooth as normally achieves by standard molding methods and shall be free from any cracks, flaws or other defects.

4.6.2.2 Bedding Mortar (Masonry Grout):

Mortar shall be composed of 1 part of Portland cement, 3 parts of sand and ½ part of lime. It shall have a compressive strength of 17.3 MPa (2,500 psi) at 28 days and shall comply with property specifications for type N mortar set forth in ASTM Specification C 270 and as modified herein, proportioned and tested in an approved laboratory at the expense of the Contractor. When tested for water retention, the

mortar shall have a flow after suction, of 75 percent or more when mixed to an initial flow of 125 to 140 percent. When tested for compressive strength, mortar shall be mixed to a flow of 100 to 115 percent. Aggregate for mortar shall conform to ASTM C 144.

4.6.2.3 Plaster:

Plaster shall comply with the same specification as those for bedding mortar.

4.6.2.4 Reinforcing Steel Bars and Rods:

All reinforcement used shall have a minimum yield strength of 275.8MPa (40,000 psi) for 12 mm diameter and smaller and 413.7MPa (40,000 psi) for 16 mm diameter and larger all in accordance with ASTM A615/PNS49.

4.6.3 SAMPLES AND TESTING

- a) The following shall be submitted for approval and in addition, representative samples shall be taken periodically from on-the-site stockpiles as required for testing or checking during the progress of the work.

Anchors and ties	:	Two of each type proposed for use.
Concrete Hollow Blocks	:	Shapes, sizes and kinds in sufficient numbers to show full range of quality and texture.

- b) Sampling and testing, unless otherwise specified, shall be performed by an approved independent commercial testing laboratory at the expense of the Contractor. Certified copies of laboratory test reports, including all test data, shall be submitted at least 10 days before delivery of the units or mortar materials represented by the tests to the project site.
- c) Mortar shall be laboratory-proportioned and tested. Certified copies of approved laboratory-established proportions shall be submitted with the required test reports and test data. Approved laboratory-established proportions shall not be changed and materials with different physical or chemical characteristics shall not be used in mortar for the work unless additional evidence is furnished that the mortar meets the specified requirements.

4.6.4 ERECTION

- a) General

No unit having a film of water on its surface shall be laid. Masonry shall be laid plumb, true to line, with level courses accurately spaced. Bond pattern shall be kept plumb throughout. Corners and reveals shall be plumb and true. Vertical joints shall be shoved tight. Each unit shall be adjusted to final position while mortar is still soft and plastic. Any unit that is disturbed after mortar has stiffened shall be removed and relaid with fresh mortar. Courses shall be so spaced that backing masonry will level off, flush with the face work at all joints where ties occur. Chases and rake-out joints shall be kept free from mortar or other debris.

- b) Anchorage to concrete. Anchorage to abutting columns shall be provided only where indicated. Details shall be as indicated including anchorage to underside of beams and slabs.
- c) Cutting and fitting, including that required to accommodate the work of others shall be done by masonry mechanics. Wherever possible, full units of the proper size shall be used in lieu of cut units. Cut edges shall be clean, true and sharp. Openings shall be carefully cut, formed or otherwise neatly made for recessed items and for electrical, plumbing, or other mechanical installations so that wall plates, cover plates, or escutcheons required by the installation will completely conceal the openings and will have bottoms in alignment with lower edge of masonry joints. Webs of hollow masonry units shall be cut to the minimum required for the installation. Reinforced masonry lintels shall be provided as indicated above openings over 300mm wide, for pipes, ducts and cable trays, unless steel sleeves are used.
- d) Embedded Items: Spaces around built-in items shall be filled with mortar. Openings around flush-mounted electrical outlet boxes in wet locations shall be pointed flush with mortar including flush joints above the boxes. Anchors, ties, accessories, flashing, pipe sleeves and other items required to be built-in shall be built-in as the masonry work progresses. Anchors, ties, and joint reinforcement shall be fully embedded in mortar.
- e) Unfinished work shall be stepped back for jointing with new work. Toothing may be resorted to only when specifically approved. Before laying new work, loose mortar shall be removed and the exposed joint shall be thoroughly cleaned.
- f) Protection: Surfaces of masonry not being worked on shall be properly protected at all times. At the end of each workday period and when rain is imminent, the top of exposed masonry shall be covered with a strong non-staining waterproof membrane well secured in place and in a manner that will prevent moisture. Adequate provisions shall be made during construction to prevent damages by wind.
- g) Mortar: Materials shall be accurately measured in laboratory-established proportions and mixed with as much water as may be necessary to produce the wettest workable consistency possible. Mortar shall be placed in final position within one hour after mixing. Mortar not used or that has started to set within this time interval shall be discarded.
- h) Jointing: Joints in exposed-to-view except control joints, joints to be pointed or caulked or sealed, and openings around flush-mounted electrical outlet boxes in wet locations shall be tooled slightly concave with the mortar thoroughly compacted and pressed against the edges of the units. Tooling shall be done when the mortar has been thumbprint hard. The tooled joint shall be finished to uniformly straight and true lines and surfaces, smooth and free of tool marks.

i) **Placing Reinforcing Steel**

Prior to placing grout, all reinforcement shall be cleaned of loose, flaky rust, scale, grease, mortar, grout or other coating which might destroy or reduce its bond with grout. Details of reinforcement shall be as indicated in the drawings. Reinforcing shall not be bent or straightened in a manner injurious to the steel. Bars with kinks or bends not shown on the drawings shall not be used. Placement of reinforcement shall be inspected and approved prior to placing grout. One piece vertical bars extending from floor to floor or roof above shall be provided. Vertical bars shall be spliced only where indicated.

1) **Positioning Bars**

Vertical bars shall be positioned accurately at the centerline of the wall. A minimum clearance between the bars and masonry units of 12mm and between parallel bars of one diameter of the reinforcement shall be maintained. Vertical reinforcing shall be held in place using metal supports, centering clips, spacers, ties or caging devices located near the ends of each bar and at intermediate intervals of not more than 192 diameters of the reinforcement.

2) **Splices**

Splices shall be located only as indicated. Splices shall be staggered in adjacent bars at least 600 mm. Bars shall be lapped a minimum of 40 diameters of the reinforcement.

4.6.5 PAINTING AND CLEANING

Mortar daubs or splashing, before setting or hardening, shall be completely removed from masonry unit surfaces that will be exposed or painted. Before completion of the work, all defects in joints or masonry to be exposed or painted shall be raked out as necessary, filled with mortar, and tooled to match existing joints. Masonry surfaces shall not be cleaned, other than removing excess surface mortar until mortar in joints has hardened. Masonry hardened surfaces shall be left clean, free of mortar daubs, dirt, stain and discoloration, including scum from cleaning operations and with tight mortar joints throughout. Metal tools and metal brushes shall not be used for cleaning.

4.7 STEEL AND METAL WORKS

4.7.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.7.1.1 Scope of Work

The work includes the furnishing of all labor, materials, equipment and other incidentals necessary for the fabrication and installation of structural steel and miscellaneous metal works as specified in relevant items of these specifications and as indicated on the drawings.

4.7.1.2 Submittal

- a) Before placing orders for materials for the steel and metal works, the Contractor shall submit to the Engineer for approval shop drawings for all steelwork. All project shop drawings shall show the dimension of all parts, method of construction, bolts, welding sectional areas and other details.
- b) The detail of connections shown on the shop drawings shall be such as to minimize formation of pockets to hold condensation, water or dirt. A minimum gap between abutting angles and the like shall be provided wherever possible to eliminate any traps and facilitate maintenance painting.
- c) No materials shall be ordered nor fabrication commenced until the shop drawings are approved by the Engineer.
- d) Prepare samples of each type of metal handrails & railings stainless steel hairline finish and automotive paint finish as required on GIP metal. Where finish involves normal color and texture variations, include sample sets composed of two or more units showing limits of such variations expected in completed works.
 - 1) Include 6" long samples of each distinctly different railing member including handrails, top rails and posts. Include samples of fittings and brackets if requested by Architect.
 - 2) Include sample of typical welded connection.

4.7.1.3 Storage of Materials

Structural materials, either plain or fabricated, shall be stored above the ground upon platforms, skids, or other supports. Materials shall be kept free from dirt, grease, and other foreign matter and shall be protected from corrosion.

4.7.2 MATERIAL REQUIREMENTS

- a) Unless specified herein all steel structures and metals shall conform with the requirements of Section 3.8, "Steel and Metal Works." Connections where details are not specified or indicated herein, shall be designed in accordance with the American Institute of Steel Construction (AISC), Manual of Steel Construction, latest edition.
- b) Structural steel works consisting of channels, gusset plates and other structural steel shape shall be as indicated on the drawings and shall be structural carbon steel conforming to ASTM A 36. Shapes shall be as given in AISC, Manual of Steel Construction.
- c) Purlins shall be light gage steel tubing conforming to ASTM A 500.
- d) All anchor bolts shall conform to ASTM A 325.
- e) All bolts and threaded fasteners shall conform to ASTM A 307 Carbon Steel Externally Threaded Standard Fasteners.

- f) Tubular stainless steel handrail, rail and post shall either be conform to ASTM A554, Type 316 with diameter and galvanized iron pipe. Refer to the drawings for the type of handrail/railing.
- g) Ladder shall be 38 mm diameter galvanized iron pipe support with 6mm steel plate, 10 mm x 160 bolt with epoxy anchor.
- h) Electrodes for arc welding shall be in accordance with the American Welding Society Code AWS D1.1 unless indicated otherwise. Welding electrodes shall be E70xx.
- i) Fastenings: commercial types, except where special types are shown or required. Fastenings for all exterior work shall be non-ferrous, unless otherwise shown. Fastenings for steel and aluminum and for all other interior work, where exposed, shall match the fastened metal.
- j) Miscellaneous: miscellaneous materials or accessories not listed above shall be provided as specified hereinafter the various items of work and/or indicated on the drawings, or in accordance with manufacturer's specifications.
- k) Contractor shall furnish all plates, cup angles, connectors, etc. required for completion of the structure even if every such item is not shown on the drawings.
- l) Tests are required under the ASTM Standards for steel to be used in the Works and shall be carried out in the presence of the Engineer and at least four (4) days notice must be given to him of the dates proposed for such tests. Four (4) calendar days notice on which fabricated steelwork will be ready for inspection in the Contractor's yard.

4.7.3 EXECUTION

4.7.3.1 Qualification

Qualification of steel fabricators, erectors and welders shall comply with the requirements of sub-section 3.8.3.1.

4.7.3.2 Fabrication Requirements

a) Workmanship

Fabrication shall be performed within the permissible tolerance by the approved fabricator. All workmanship shall be of the best quality with respect to internationally recognized standards of practice.

b) Cutting

Low-carbon structural steel may be cut by machine-guided torch instead of by shears or saw.

Harmful notches, burrs, irregularities, etc., shall not be developed at the cut surface.

c) Contact Faces

Contact surfaces between bases or other elements bearing directly upon bearing plates shall be ground or milled as necessary for full effective bearing.

Edges for welding shall likewise be properly prepared.

d) Bolt Holes

Bolt holes shall be according to engineering practice and as specified in these specifications.

Gas burning of holes will not be permitted.

e) High Strength Bolt Assembly Preparation

Surfaces of high strength bolted parts in contact with bolt heads and nuts shall not have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

Where the surface of a high strength bolted part has a slope of more than 1:20, a beveled washer shall be used to compensate for lack of parallelism.

High strength bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials.

When assembled, all joint surfaces including those adjacent to washers shall be free of scale except tight mill scale, and shall be free from dirt, loose scale, burrs, and other defects that would prevent solid seating of parts.

Contact surfaces of friction-type joints shall be free from oil, paint, lacquer or galvanizing.

f) Welding

All welding shall be done only by welders certified as to their ability to perform in accordance with accepted testing requirement.

Welding of parts shall be in accordance with structural standards and the Standard Code for Arc and Gas Welding in Building Construction of AWS, and shall only be done where shown, specified, or permitted by the Engineer.

Damage to galvanized areas by welding shall be thoroughly cleaned with wire brushing and all traces of welding flux and loose or cracked zinc coating shall be removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint. The paint shall be properly compounded with a suitable vehicle in the ratio of one part zinc oxide to four parts zinc dust by weight. As an alternative to the above, the Contractor may submit for approval the use of a galvanizing rod or galvanizing solder to repair damaged areas.

The welding machine shall be a stable welder, and have suitable functions for the dimension of materials to be welded. The auxiliary tools used for welding shall perform sufficiently and adequately.

The welding machine used for field welding shall be of readily adjustable for electric current.

g) Shop Assembly

Structural units furnished shall be assembled in the shop.

An inspection shall be made to determine that the fabrication and the matching of the component parts are correct.

Jigs shall be used for the assembly of units as much as possible to maintain appropriate position of mutual materials.

Approval of the Engineer shall be required when drilling temporary bolt holes or welding temporary support to the assembled structure.

The tolerances shall not exceed those allowed by codes and each unit assembled shall be closely checked to insure that all necessary clearances have been provided and that binding does not occur in any moving part.

In order to maintain accurate finished dimensions and shape, appropriate reverse strain or restraint shall be provided as required.

Assembly and disassembly work shall be performed in the presence of the Engineer, unless waived in writing by the Engineer any errors or defects disclosed shall be immediately remedied by the Contractor.

Before disassembly for shipment, component parts of the structures shall be match marked to facilitate erection in the field.

4.7.3.3 Fabrication Tolerances

a) Dimensional Tolerances for Structural Work

Dimensions shall be measured by means of an approved calibrated steel tape at the time of inspection. Unevenness of platework shall not exceed the limitation of the standard mill practice as specified in the American Institute of Steel Construction, "Manual of Steel Construction".

b) Camber

Reverse camber in any structural steel members in excess of 1/1,000 of the span length shall cause rejection. The minimum dead load camber for any structural steel member shall be as allowed by Code, or otherwise specified.

4.7.3.4 Inspection and Test Of Welding

a) Inspection of Welding

Inspection of welding shall be executed for the following work phases.

1) Before Welding

Scum, angle of bevel, root clearance, cleaning of surface to be welded, quality of end tab, drying of welding rod.

2) During Welding

Welding procedure, diameter of coil and wire, type of flux, welding current and voltage, welding speed, welding rod position, length of arc, melting, cleaning of slag of each level under surface chapping, supervision of welding rod.

3) After Execution of Welding

Assurance of bead surface, existence of harmful defects, treatment of crater, quality of slag removal, size of fillet, dimension of extra fill of butt welding, treatment of end tab.

b) Testing of Welding

Twenty percent (20%) of welds contributing in the overall strength of the structure and which will be inaccessible for the inspection in service shall be tested.

Welding shall be tested by ultrasonic test to the extent specified herein or as directed by the Engineer.

Where partial inspection is required, the ultrasonic test shall be located at random on the welds so as to indicate typical welding quality.

If ten percent (10%) of the random ultrasonic tested indicate unacceptable defect, the remaining eighty percent (80%) of the welding shall be tested.

Repair welding required shall be ultrasonic tested after the repairs are made.

4.7.3.4 Corrections

In lieu of the rejection of an entire piece or member containing welding which is unsatisfactory or which indicates inferior workmanship, corrective measures may be permitted by the Engineer whose specific approval shall be obtained for making each correction. Defective or unsound welds or base steel shall be corrected either by removing and replacing the entire weld, or as follows.

- a) Excessive convexity or overlap shall be reduced by grinding.
- b) Undercuts, lack of weld shall be repaired with necessary reinforcement of weld after removal of any foreign materials such as slag, dust, oil, etc.
- c) Any defects such as slag inclusions, incomplete fusion, or inadequate joint penetration, shall be completely removed, cleaned and re-welded.

- d) Cracks in welds or base steel, shall be removed to sound steel throughout their length and 5cm beyond each end of the crack, followed by welding. The extent of the crack, depth and length, shall be ascertained by the use of acid etching, magnetic particle inspection or other equally positive means.

The removal of welded steel shall be done by chipping, grinding, oxygen cutting, oxygen gouging, or air carbon arc gouging and in such a manner that the remaining welded steel or base steel is not nicked or undercut. Defective portions of the welding shall be removed without substantial removal of the base steel.

4.7.3.5 Installation

- a) Installation Program

- 1) Prerequisite Condition

Prior to executing steel fabrication and field installation, the Contractor shall prepare a comprehensive installation program including engineering supervision organization, fabrication procedures, field installation procedures, material application, machinery applications, inspection procedure, scope and standard of quality judgment, and submit to the Engineer for approval.

- 2) Special Technical Engineering

Special technical engineering different from contract specifications can be applied upon receiving approval of the Engineer.

- b) Installation Requirement

- 1) Setting of Anchor Bolt and Others

- (a) Anchor bolts shall be set in accurate position by using templates.
 - (b) The setting method shall be proposed to the Engineer for his approval before setting starts.
 - (c) The threads of bolt shall be cured with an appropriate method against rust and/or any damage before tightening.
 - (d) Non-shrink mortar shall be placed under base plates, well cured to obtain the sufficient strength before bearing loads are applied to base plates.

- 2) Temporary Bracing

- (a) Temporary bracing shall be installed as necessary to stay assemblies and assume loads against forces due to transport, erection operations or other work.
 - (b) Temporary bracing shall be maintained in place until permanent work is properly connected and other construction installed as necessary for support, bracing or staying of permanent work.

- (c) Extent and quality of temporary bracing shall be as necessary against wind and other loads, including seismic loads not less than those for which the permanent structure is designed to resist.

3) Adequacy of Temporary Connections

During erection, temporary connection work shall be securely made by bolting and/or welding for all dead load, wind and erection stresses.

4) Alignment

No permanent bolting or welding shall be done until the alignment of all parts with respect to each other shall be true within the respective tolerances required.

5) Field Welding

- (a) Any shop paint or surfaces adjacent to joints where field welding is to be executed shall be wire brushed to remove paint/primer.
- (b) Field welding shall conform to the requirements specified herein, except as approved by the Engineer.

6) High Strength Bolts

- (a) Final tightening of high strength bolts shall be done by using manufacturer's power operated equipment without any overstress to the threads.

7) Correction of Errors

- (a) Corrections of minor misfits by use of drift pins, and reaming, chipping or cutting will be permitted and shall be provided as part of erection work.
- (b) Any errors to be corrected or adjusted, preventing proper assembly, shall be immediately reported to the Engineer, and such corrections or adjustments shall be made as necessary and approved by the Engineer.
- (c) Cutting or alterations other than as approved will not be permitted.

8) Erection

- (a) Erection and installation shall be as per approved shop drawings.
- (b) Each structural unit shall be accurately aligned by the use of steel shims, or other approved methods so that no binding in any moving parts or distortion of any members occurs before it is finally fastened in place.

- (c) Operations, procedures of erection and bracing shall not cause any damage to works previously placed nor make overstress to any of the building parts or components. Damage caused by such operations shall be repaired as directed by the Engineer at no extra cost to the Employer.

4.7.4 GALVANIZING

4.7.4.1 Preparation

All mild steel parts exposed to weather shall be hot-dipped galvanized after fabrication in accordance with the requirements of ASTM A 123 or ASTM A 153. Prior to galvanizing, the surfaces shall be cleaned of dirt, weld splatter, grease, slag, oil, paint or other deleterious matters. The steel surfaces shall be chemically de-scaled and cleaned with the same abrasive blast or other suitable method as approved by the Engineer.

4.7.4.2 Coating

The zinc coating shall consist of uniform layers of commercially pure zinc free from abrasions, cracks blisters, chemical spots or other imperfections, and shall adhere firmly to the surface of the steel. The weight of zinc coating per square meter of actual surface shall not be less than 550 grams. Any surface damaged subsequent to galvanizing shall be given two coats of approved zinc rich paints.

4.7.5 PAINTING

This work shall consist of the preparation of the metal surfaces, the application, protection and drying of the painted surfaces, and supplying of all tools, tackle, scaffolding, labor and materials necessary for the entire work. Painting shall be applied in the field or shop as approved by the Engineer.

Unless otherwise specified or approved, all painting work for structural steel shall comply with the requirements of this Section.

4.7.5.1 Shop Painting

All structural steel shall be given a shop primer after fabrication and cleaning before delivery to the site.

All steel work shall be thoroughly dried and cleaned of all loose mill scale, rust and foreign matters by means of sand blasting or other suitable methods approved by the Engineer before shop painting shall be applied. Each individual piece shall be painted prior to assembly. Portions where field welding or field contact with concrete is required, shall not be painted.

Shop Paintings - Except for galvanized surfaces and items to be encased in concrete, clean ferrous metal surfaces shall be given one coat of Amerlock 400 Epoxy Primer at 100 Microns or approved equal. Additional coat shall be applied to surfaces that will be concealed or inaccessible for finish painting by Amerlock 400, Top Coat at 150 Microns with color or equivalent.

4.7.5.2 Field Painting

After erection, the Contractor shall thoroughly prepare and clean the entire surface of all structural steel from all dirt, grease, rust or other foreign matters. The entire surface of all members shall then be field painted.

4.7.5.3 Materials

a) Structural Steel Work

- 1) After surface preparation, steelwork shall be given one coat of approved prefabricating primer.
- 2) Before final assembly of steelwork at the fabricator's shop, two shop coats of special red lead primer shall be applied to the surface of sections to be in permanent contact, meeting faces and all other concealed surfaces. After final assembly, but before delivery to the project site, the steelwork shall likewise be given two shop coats of special red lead primer.

b) Galvanized Steelwork

All galvanized steelwork shall be treated with zinc chromate two-pack etch primer followed by one coat of non-etch zinc chromate primer.

c) Miscellaneous Metal Work

Unless otherwise specified in other Sections of the Specifications or shown on the drawing, miscellaneous metal works such as ladders, structural steel ladder rungs, etc. shall be given two shop coats of epoxy primer and two coats of epoxy enamel.

4.7.5.4 Construction Methods

a) Cleaning of Surfaces

Surfaces of metal to be painted shall be thoroughly cleaned; removing rust, loose mill scale, dirt, oil or grease, and other foreign substances. Unless cleaning is to be done by sand blasting, all weld areas, before cleaning is started, shall be neutralized with a proper chemical, after which they shall be thoroughly rinsed with water.

Three methods of cleaning are provided herein. The particular method to be used shall be as directed by the Engineer.

b) Hand Cleaning

The removal of rust, scale, and dirt shall be done by the use of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzene.

Bristle or wood fiber brushes shall be used for removing loose dirt.

c) Sandblasting

All steel shall be cleaned by sandblasting. The sandblasting shall remove all loose mill scale and other substances. Special attention shall be given to cleaning of corners and re-entrant angles. Before painting, sand adhering to the steel in corners and elsewhere shall be removed. The cleaning shall be approved by the Engineer prior to any painting which shall be done as soon as possible before rust forms.

d) Flame Cleaning

All metal, except surface inside boxed members and other surfaces which shall be inaccessible to the flame cleaning operation after the member is assembled, shall be flame cleaned in accordance with the following operations.

- 1) Oil, grease, and similar adherent matter shall be removed by washing with a suitable solvent. Excess solvent shall be wiped from the work before processing with subsequent operations.
- 2) The surface to be painted shall be cleaned and dehydrated (free from occluded moisture) by the passage of oxyacetylene flames which have an oxygen to acetylene ratio of at least 1.0. The oxyacetylene flames shall be applied to the surfaces of the steel in such a manner and at such speed that the surfaces are dehydrated; dirt, rust loose scale in the form of blisters or scabs, and similar foreign matters are freed by the rapid, intense heating by the flames. The number arrangement and manipulation of the flames shall be such that all parts of the surfaces to be painted are adequately cleaned and dehydrated.
- 3) Promptly after the application of the flames, the surfaces of the steel shall be wire brushed, hand scraped wherever necessary, and then swept and dusted to remove all free materials and foreign particles.
- 4) Paint shall be applied promptly after the steel has been cleaned and while the temperature of the steel is still above that of the surrounding atmosphere.

e) Weather Conditions

- 1) Exterior Coatings: Coatings to surface shall not be applied during foggy or rainy weather, or under the following surface temperature conditions: below 4°C, or over 35°C, unless approved by the Engineer.
- 2) Interior Coatings: Coatings shall be applied when surfaces to be painted are dry and the following surface temperatures can be maintained: between 18 to 35°C during the application.

f) Application

- 1) Paint shall be factory tinted and mixed. All paint shall be field mixed before applying in order to keep the pigments in uniform suspension.

2) Field Painting

When the erection work is complete, including all bolting and straightening of bent metal, all adhering rust, scale, dirt, grease or other foreign materials shall be removed as specified above.

As soon as the Engineer has examined and approved each steel and metal works structures, all field bolts, all welds, and any surfaces from which the top or first coat of paint has become worn off, or has otherwise come defective shall be cleaned and thoroughly covered with one coat of paint.

Surfaces to be bolted and surfaces which shall be in contact with concrete, shall not be painted. Surfaces which shall be inaccessible after erection shall be painted with such field coats as are required. When the paint applied for retouching the shop coat has thoroughly dried, and the field cleaning has been satisfactorily completed, such field coats as are required shall be applied. In no case shall a succeeding coat be applied until the previous coat is dry throughout the full thickness of the paint film. All small cracks and cavities which were not sealed in a watertight manner by the first field coat shall be filled with a pasty mixture of red lead and linseed oil before the second coat is applied.

The following provision shall apply to the application of both coats. To secure a maximum coating on edges of plates or shapes, bolt heads and other parts subjected to special wear and attack, the edges shall first be striped with a longitudinal motion and the bolt heads with a rotary motion of the brush, followed immediately by the general painting of the whole surface, including the edges and bolt heads.

The application of the second field coat shall be deferred until adjoining concrete work has been placed and finished. If concreting operations have damaged the paint, the surface shall be re-cleaned and repainted.

3) General Manners

Painting shall be done in a neat and workmanlike manner. Paint may be applied with hand brushes or be spraying, except aluminum paint which preferably shall be applied by spraying. By either method the coating of paint applied shall be smoothly and uniformly spread so that no excess paint shall collect at any point. If the work done by spraying is not satisfactory to the Engineer hand brushing shall be required.

4) Brushing

When brushes are used, the paint shall be so manipulated under the brush as to produce a smooth, uniform, even coating in close contact with the metal or with previously applied paint, and shall be worked into all corners and crevices.

5) Spraying

Power spraying equipment shall be used to apply the paint in a fine spray. Without the addition of any paint, the sprayed area shall be immediately followed by brushing, when necessary, to secure uniform coverage and to eliminate wrinkling, blistering and air holes.

6) Removal of Paint

If the painting is unsatisfactory to the Engineer the paint shall be removed and the metal thoroughly cleaned and repainted.

4.8 CARPENTRY AND JOINERY

4.8.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.8.1.1 Scope of Work

The work shall consist of furnishing all materials, tools, labor, equipment and incidentals necessary to perform and complete the carpentry works as indicated on the drawings and specified herein together with the supervision necessary to the work involved.

The work shall include the doors jambs and other wood works under various items of the specification.

4.8.1.2 Delivery and Storage

The Contractor shall protect lumber against dampness and from the weather during and after delivery.

The Contractor shall stack lumber in a manner to insure proper ventilation and drainage, at least 150 mm above ground. Lumber shall be stored under cover, not exposed to extreme temperature and humidity and in a manner to provide air circulation around all surfaces of each piece.

Interior millwork product such as doors, etc. shall not be stored or installed into the buildings until concrete masonry work and plaster are thoroughly dry.

4.8.1.3 Shop Drawing

Shop drawings for all carpentry and other woodwork items as required shall be submitted sufficiently in advance of need to allow for review and approval. Shop drawings shall indicate materials and details of construction, methods of fastening, and erection details.

Materials shall not be delivered to the site until after the approved shop drawings have been returned to the Contractor. The Contractor shall be responsible for all

errors of detailing and fabrication, and for the correct fitting of fabricated items shown on the shop drawings.

4.8.1.4 Workmanship

All wood finish works shall be true to details, clean and sharply defined. Panels must be set to allow for free movement in case of swelling or shrinkage. Means of fastening various parts together shall be concealed and as shown on the drawings or as directed by the Engineer.

4.8.2 MATERIAL REQUIREMENTS

4.8.2.1 GENERAL

- a) Lumber shall either be kiln dried or as directed by the Engineer and shall be free from imperfections that will impair its strength and finish.
- b) Lumber shall be of the best grade available of the respective kinds required for the various parts of the work, well-seasoned, thoroughly dry, sound, straight, free from warps, loose or unsound knots. Lumber with cuts, shakes or other imperfections impairing its strength, durability or appearance shall not be used. All exposed surfaces shall be smooth unless otherwise indicated on the drawings or specified.
- c) Any lumber equally good for the purpose intended may be substituted for the kind specified upon prior written approval of the Engineer.

4.8.2.2 Materials

- a) Kiln dried tanguile lumber, sound, hard and free from defects shall be used for:
 - 1) Exterior and interior millwork, siding and finish and trim, as shown on the drawings;
 - 2) Wood doors, frames and panels,
 - 3) Cabinet works;
- b) Yakal shall be used for all doors and window jambs, transom bars, wood plates and other woodwork in contact with concrete or masonry.
- c) Apitong: Sound and thoroughly seasoned, warp free, treated with pressure impregnated preservative, smooth and level on one side or whenever in contact with paneling.

Unless otherwise indicated on the Drawings, use Apitong, pressure treated for all truss members and rafters; and carpentry; except where in contact with concrete.

- d) Plywood

Plywood shall conform to Commercial Standard PSI and shall be of local manufacture.

Plywood to be varnished shall be tanguile or kalantas veneers (as indicated), ribbon grained, water resistant, Class B and of the thickness indicated.

Plywood to be painted shall be tanguile veneer ordinary rotary-cut, water resistant, Class C and of the thickness indicated.

Plywood exposed to the outside elements or where indicated shall be waterproof or marine plywood and of the thickness indicated.

The minimum number of plies required for plywood shall be as follows: 3 plies for 4mm to 9mm thick, and 4 plies for 11mm to 19mm thick. Plywood to be pressure-preservative treated shall be fully-waterproof-flue type. Grade for preservative-treated plywood shall not be less than that specified for the specific use. Plywood shall be clean and smoothly sanded on 2 sides. Shelves are considered exposed.

Wooden railing shall be hardwood.

6 mm thick tanguile plywood for ceilings on wood frame and elsewhere as shown in drawings, and for flush type marine hollow core doors for toilets as shown in drawings.

Skeletal wood framing and other woodworks not otherwise specified herein shall be coated/treated with wood preservative.

Grading of Plywood - Each sheet of plywood shall bear the mark identifying the plywood as to wood species, glue type, and grade.

e) Fastenings

Fastenings shall be common nails, glue or specified, flat-head wood screws (F.H.W.S), round-head wood screws (R.H.W.S), bolts or lag screws where specified or called for shall be used. Conceal fastenings as much as possible; where not possible, locate them in inconspicuous places. Where nailing is permitted through woodwork smooth-finished face, conceal nail heads.

Nails - shall be of the smooth shank, zinc coated, common wire nails of local manufacture, and of types and sizes best suited for the purpose.

Wood Screws - shall be brass or cadmium plated, of the best available commercial quality, and of types and sizes suited for the purpose.

4.8.2.3 Moisture Content

- a) Lumber treated with water-borne preservatives shall be dried to a moisture content not exceeding 19 percent after treatment.
- b) Interior finishing lumber shall be kiln-dried, and at the time of delivery to the building site, the moisture content shall not exceed 12 percent for material 25mm or less in thickness, and shall not exceed 15 percent for material over 25mm in thickness.

- c) Woodwork that is assembled or built-up of more than one piece at the mill, except doors, shall have a moisture content not in excess of 12 percent at time of delivery to the site.

4.8.2.4 Substitution

Any lumber equally good for the purpose intended may be substituted for the kinds specified, subject to the approval of the Engineer. Provided, however, that in the substitution of a cheaper kind of lumber to that which is specified, a reduction in the contract price equal to the difference in the cost of the two kinds of lumber will be made.

4.8.3 EXECUTION

4.8.3.1 Erection

- a) Timber construction assembled with nails and spikes.
 - 1) For wire nails, the tensile strength shall be not less than 60kg/mm² and for wrought and pressed nails not less than 40kg/mm².
 - 2) Unless otherwise specified, square spikes with countersunk square heads shall be used of a length not less than 2 ½ times the minimum dimension of the timbers to be fastened together.
 - 3) When nailing timbers together, the units to be fastened shall be butted together and be nailed perpendicularly to their surfaces. Heads of nails and spikes shall be driven flush with the surface of the timber.
 - 4) Points of spikes or nails emerging from the timber shall be turned over transversely to the wood fibers. Care shall be taken that the timbers do not split during nailing.
- b) Timber construction assembled with bolts
 - 1) The bolts used for assembling timber shall be of steel conforming to the requirements of ASTM Designation A307. The tensile strength of bolt steel shall be between 34 and 55kg/mm². Members shall be drilled accurately for bolting with suitable washers provided under heads and nuts.
 - 2) Bolts, washers, nuts, and fish-plates shall be galvanized.
 - 3) Washer plates for bolt heads and nuts shall have the following dimensions:
 - For 13mm bolts use 7.5 x 75mm washers
 - For 19mm bolts use 10 x 100mm washers
 - For 25mm bolts use 13 x 130mm washers
 - For 38mm bolts use 20 x 200mm washers
 - 4) Bolt holes in timber shall be drilled with a drill having a diameter slightly smaller than that of the bolt so that the bolt has to be forced into the hole.

The bolts shall be re-tightened several times as requested by the Engineer in order to ascertain that the bolts have obtained a suitable and stable degree of tension.

c) Timber construction assembled with screws

- 1) The screws used for assembling the timer shall comply with relevant ASTM Designations.
- 2) Undersized screw holes shall be drilled in advance. Screws shall not be hammered into holes.

4.8.3.2 Finish

The Contractor shall mill, fabricate and erect interior finish products as indicated on the drawings. Machine-sand cut joints at the mill shall be hand sand smooth.

Joints shall be made tight and in a manner to prevent shrinkage. The Contractor shall secure trim with fine finishing nails, screws, or glue where required and nails shall be set for putty topping.

4.8.3.3 Wood Doors, Jambs and Headers

Door frames shall be set plumb and level and braced until built-in.

Anchor wood frames in masonry with approved metal anchors on each side of jamb. Top and bottom anchors shall be placed 200mm from head and floor unless indicated on the drawings or directed by the Engineer.

4.8.3.4 Hardware Installation

Accurately fit and finish hardware items required.

If surface-applied hardware is fitted and applied before painting, remove all such items except butts and re-install after painting.

4.8.3.5 Pressure Treated Lumber

Preservative Treatment - All lumber indicated to be pressure treated, shall contain any of the following net retention of solid preservative.

Boliden salts	-	45.5 kg. dry chemical per cubic foot of wood.
Wolman salts	-	.31 kg. dry chemical per cubic foot of wood.
Tenalith salts	-	.34 kg. dry chemical per cubic foot of wood.

The Contractor shall submit an affidavit signed by an official of the preservative treatment company to the Engineer. This affidavit shall indicate the net retention of solid preservatives obtained and shall certify that pressure treated lumbers have a moisture content that does not exceed 17 percent upon shipment from the treatment plant.

Where it is necessary to cut or bore pressure-treated lumber on the job, two coats of prepared concentrated preservatives solution shall be applied to the end-cut or bored surfaces.

4.8.3.6 Rough Carpentry

All works shall be well fitted, accurately set, and rigidly secured in place.

Cutting and fitting to accommodate other works shall be done as required and in a neat workmanlike manner, and cut or damage works shall be patched and made good.

Framing and structural lumber shall be well-seasoned, straight, square-edged stacked, and free from loose or unsound knots, back edges or other defects that will impair its strength.

Anchors, connectors and fastenings not indicated or specified shall be of the types and size necessary to suit the conditions encountered. Size, type and spacing of nails, screws and/or bolts for installation of manufactured building materials shall be as recommended by the approved manufacturer unless indicated or specified otherwise.

All lumber surfaces in contact with concrete or masonry shall be given a brush coat of bituminous paint.

4.8.3.7 Joinery Work

All lumber used for joinery work shall be of the kinds and grades specified and shall have the contours, patterns and profiles indicated.

All joints shall be made in an approved manner, installed tight and securely fastened. Exterior joints shall be mitered and interior angles coped. Panels shall be fitted to allow for shrinkage, avoid swelling and insure that the work remains in place without warping, splitting and opening of joints.

All exposed surfaces shall be machined and hand sanded to an even smooth surface, ready for finish. No hammer marks or other unsightly marks shall be allowed on any wood panel or veneer.

4.9 ROOFING AND TINSMITHRY

4.9.1 SCOPE OF WORK

The work shall include but not limited to all labor, materials, tools, equipment and incidentals necessary to furnish and install the roofing sheets including fittings, flashing caps, ridge rolls, gutters and construction of concrete eaves and canopy excluding waterproofing, to provide completely sound water tight roof for the buildings as shown on the Drawings and specified herein.

4.9.2 MATERIAL REQUIREMENTS

4.9.2.1 uPVC Corrugated Roofing

- a) Remove existing PVC roofing and replace with new opaque 3mm thick corrugated roofing materials made from high quality virgin polyvinyl chloride

(PVC) resin. The PVC roofing system shall include stainless steel bended materials (gutters) and pre-painted bended materials (ridge rolls and fascia flashing), ridge ventilator and complete with hardware accessories.

b) Fasteners and Fixation

- 1) Use appropriate connectors as recommended by the manufacturer and approved by the Architect. Use the same metal or a metal compatible with the item fastened. Use fasteners to fasten dissimilar materials.
- 2) Paint same color as roof all exposed fixation and fastening devices. Use tekscrew cap.
- 3) Apply fasteners in a neat, consistent, even and standard manner. Apply strip of butyl rubber-based caulking compound along all end lap joints and passing over pre-drilled fixation holes.
- 4) For fixation of flashing. Use tekscrews (Steel) for roof eaves area, where roof frames are exposed.
- 5) Use tekscrew for all roofing corrugation.

c) Gutter shall be 0.60mm stainless steel ASTM A Type 302 or 304, 2D Finish, fully annealed, dead-soft temper.

d) Fascia and Flashing shall be pre-painted 0.60mm thick (Gauge 24) base metal.

4.9.2.2 Polycarbonate Roofing

- a) Solid polycarbonate sheets shall be 6 mm thick with aluminum clamping, rubber gasket, 100's steel tekscrews, silicone sealants, etc., to complete. Ultraviolet (UV) protected on both sides of the sheet.
- b) Structural Steel frame shall be in accordance with the drawing or manufacturer's standard.
- c) Fasteners: Provide U connector, end cap connectors and other accessories as per manufacturer's standard.

4.9.2.3 Fiber Tensile Fabric Canopy

- a) Provide PVC coated polyester fabric with the fire test response characteristics and able to withstand wind load and waterproof.
- b) Canopy anchorage shall be hot dipped galvanized steel pipe or stainless steel pipe including accessories.

4.9.2.4 Gutter and Flashing at Wastewater Treatment Facility (WWTF) Building

- a) Gutters and flashing shall be fabricated from Gauge 24 (0.6mm thick) prepainted cold rolled galvanized iron sheets specially tempered steel. Profile section shall be as indicated on the Drawings.

4.9.2.5 Concrete Canopy

- a) Concrete materials shall comply with the requirements in Section 3.2, Concrete Works.

4.9.2.6 Reinforcing Steel bars shall likewise conform with the requirements in Item 3.2, Concrete Works of this Outline Specification. Fasteners and Accessories

Roofing sheet fastener shall be 0.025 GI straps and units with washers and cutting screws with neoprene washers or as recommended by the approved manufacturer.

4.9.2.7 Samples

Samples shall be submitted for Engineer's approval before any order for roofing materials be made by the Contractor.

4.9.3 INSTALLATIONS

4.9.3.1 uPVC Corrugated Roofing

- a) Verification of Conditions

Examine substrate to which roofing material is to be applied to ensure that its condition is satisfactory for roofing application. Do not permit voids greater than 6 mm wide in the substrate. Concrete substrates shall be cured and free of laitance and curing compounds. Substrates for roofing materials shall be dry and free of oil, dirt, grease, sharp edges, and debris. Inspect substrates, and correct defects before application of thermoplastic sheets.

- b) Preparation

Install wood blocking at perimeters, curbs, and penetrations for use in mechanically attaching the membrane, unless recommended otherwise by the thermoplastic sheet manufacturer's printed instructions.

- c) Installation

- 1) Lay down the roofing sheet starting from the end opposite the prevailing wind.
- 2) Lay and install the first sheet with the turn down edge towards the outside of the area to be covered.
- 3) Overlay the next sheet in such a manner that the exposed edge is turned down and the covered edge is turned up.
- 4) Side-lap fasteners shall be done by the rivets and washers spaced from 305mm (12") to 457mm (18") on centers.

4.9.3.2 Polycarbonate Roofing

a) Preparation

- 1) Clean glazing channels or recesses free of obstructions, soil, debris, and other materials.
- 2) Seal porous glazing channels or recesses with primer-sealer compatible with substrate and polycarbonate sheet materials.
- 3) Cut polycarbonate sheet materials to exact sizes required, with clean edges free of notches; clean contact edges with solvent compatible with polycarbonate sheet materials, as specified or approved by polycarbonate sheet manufacturer.

b) Installation

- 1) Install plastic glazing in accordance with polycarbonate sheet manufacturer's instructions.
- 2) Do not use glazing accessories not specified or approved by polycarbonate sheet manufacturer.

c) Cleaning

- 1) Immediately after completing construction activities relating to installation of polycarbonate sheet materials, remove remainder of strippable masking from surfaces of polycarbonate sheet glazing; do not expose masking to sunlight for an extended period of time.
- 2) Immediately after removing masking, clean glazing in accordance with polycarbonate sheet manufacturer's instructions:
 - (a) Rinse surface with lukewarm water.
 - (b) Wash surface with mild soap and lukewarm water.
 - (c) Use soft cloth or sponge gently to loosen dirt and grime; scrubbing glazing surfaces, or using squeegee on glazing surfaces, is not permitted.
 - (d) Repeat rinse as above, and wipe surface dry with soft cloth until surfaces are spotless and dry.

d) Protection of Installed Products

- 1) Immediately after cleaning, cover polycarbonate sheet glazing surfaces with polyethylene sheeting, or other covering material approved by polycarbonate sheet manufacturer; secure covering in place by taping to framing members - do not tape covering to polycarbonate sheet materials.
- 2) Protect installed glazing from damage to function or finish by subsequent construction activities.

4.9.3.3 Fiber Tensile Fabric Canopy

At least 28 days before laying of roofing sheet start, the Contractor shall submit for approval of the Engineer, shop drawings indicating materials and method of installation. No roofing sheets laying work shall commence without the Engineer's approval of the shop drawings and work method.

Laying shall start from the end opposite the side from where the prevailing monsoon is coming from. The first sheet shall be laid and installed with the turned-down edge towards the outside of the area to be covered. The next sheet shall be overlapped to the previous sheet in such a manner that the exposed edge is turned down and the covered edge is turned up. The overlapped edge in the side shall be with the rib having the anti-capillary groove. End and side laps including flashing shall be as approved by the Engineer.

The straps shall be fixed and fastened with the fastener and washer as shown on the Drawings.

4.9.3.4 Gutter and Flashing at Wastewater Treatment Facility (WWTF) Building

a) Gutter

The hung type of shape indicated and supported on underside by brackets that permit free thermal movement of the gutter. Provide gutters in sizes indicated complete with mitered corners, end caps, outlets, brackets, and other accessories necessary for installation. Bead with hemmed edge or reinforce the outer edge of gutter with a stiffening bar not less than 20 by 5 mm of material compatible with gutter. Fabricate gutters in sections not less than 2400 mm. Lap the sections a minimum of 25 mm in the direction of flow or provide with concealed splice plate 150 mm minimum. Join the gutters, other than aluminum, by riveted and soldered joints. Support gutters on adjustable hangers spaced not more than 750 mm on center or as recommended by the manufacturer. Adjust gutters to slope uniformly to outlets, with high points occurring midway between outlets. Fabricate hangers and fastenings from metals compatible with the gutters.

b) Flashing

1) Bolts, Rivets, and Screws

Install bolts, rivets, and screws where indicated or required. Provide compatible washers where required to protect surface of sheet metal and to provide a watertight connection.

2) Seams

Straight and uniform in width and height with no solder showing on the face.

3) Edges

Pretin edges of sheet metals before soldering. Slowly solder with well heated soldering irons so as to thoroughly heat the seams and completely sweat the solder through the full width of the seam. Treat with soldering acid flux the edges of stainless steel to be pretinned. Solder immediately after application of the flux. Upon completion of soldering, the acid flux residue shall be thoroughly cleaned from the sheet metal with a solution of washing soda in water and rinsed with clean water.

4) Fasteners

Install fasteners at spacing recommended by the Manufacturer.

5) Cleaning

Clean exposed sheet metal work at completion of installation. Remove grease and oil films, handling marks, contamination from steel wool, fittings and drilling debris, and scrub-clean. Free the exposed metal surfaces of dents, creases, waves, scratch marks, and solder or weld marks.

6) Repairs to Finish

Scratches, abrasions, and minor surface defects of finish may be repaired in accordance with the manufacturer's printed instructions and as approved. Repair damaged surfaces caused by scratches, blemishes, and variations of color and surface texture. Replace items which cannot be repaired.

4.9.3.5 Concrete Canopy

Construction of concrete eaves and canopy shall be in accordance with Section 3.2, "Concrete Works" as shown on the Drawings and as directed by the Engineer.

Waterproofing shall be in accordance with Section 4.10, "Dampproofing and Waterproofing".

4.10 DAMPPROOFING AND WATERPROOFING

4.10.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.10.1.1 Scope of Work

The work shall cover the dampproofing and waterproofing requirements for buildings as shown on the drawings.

The work shall consist of furnishing all labor, materials, equipment and other incidentals necessary for the dampproofing and waterproofing works where required

as shown on the drawings and in accordance with the requirements of these specifications and as directed by the Engineer.

4.10.1.2 Submittal

- a) The Contractor shall submit for approval of the Engineer the name of the manufacturer nominated for the supply of materials and installation. Subcontracting documents shall be submitted to the Engineer by the Contractor.
- b) The Contractor shall submit the procedure of damproofing and waterproofing installation/construction for approval of the Engineer.
- c) All dampproofing and waterproofing materials shall be installed only by an experienced installer and shall be installed in accordance with the approved manufacturer's installation procedures or methods, approved by the Engineer.
- d) Submit mock-up samples of each damproofing and waterproofing type.

4.10.1.3 Delivery, Storage and Product Handling

Deliver and store materials in sufficient quantity to allow for uninterrupted flow of work. Materials shall be delivered to the jobsite in their original unopened packages, clearly marked with the manufacturer's name, brand name, description of contents, and shelf life of containerized materials.

Materials shall be stored in clean, dry areas, away from excessive heat, sparks, and open flame. Storage area shall be ventilated to prevent build-up of flammable gases. Maintain temperatures in the storage area below the materials' flash point and within limits recommended by the manufacturer's printed instructions.

Handle materials and containers during application work safely and in accordance with manufacturer recommendations. Store liquids in airtight containers and keep containers closed except when removing materials. Do not use equipment or containers containing remains of dissimilar materials. Do not expose foam component containers to direct sunlight for periods of time sufficient to cause contents to exceed 26 degrees C. Mark and remove from job site materials which have been exposed to moisture or that exceed shelf life limits. Not more than half the shelf life shall have expired when materials are applied.

4.10.1.4 Environmental Conditions

Do not apply roof system materials during inclement weather or when surface moisture, or visible dampness is present on the surface to be covered, or when precipitation is imminent. Use moisture-measuring methods and equipment as required to verify that the moisture conditions of substrate surfaces are in accordance with roof system materials manufacturer requirements prior to application of foam and coating materials. Substrate temperatures shall be within limits recommended by the manufacturer's printed instructions, unless specified otherwise.

4.10.1.5 Special Safety Provisions

During application, the following shall be required unless in conflict with the manufacturer's recommendations or requirements of a recognized legal authority, in which case, the manufacturer's recommendations or the legal authority's requirements take precedence:

a) Special Equipment

1) Air Masks

Wear fresh air supply masks when applying foam or when handling hazardous liquid materials. Respiratory protective devices shall be as recommended by AIHA Z88.6. Instruct personnel required to use respiratory protective devices in the use of the devices. Maintain such equipment and inspect regularly.

2) Eye and Face Masks

Use eye and face protection during materials application. Eye and face protective equipment shall meet the requirements of ANSI/ISEA Z87.1.

3) Clothing and Gloves

Wear protective clothing and gloves during materials application. Skin areas not covered by clothing shall be protected by protective creams.

b) Handling Precautions

1) Venting of Material Containers

Partially unscrew material container and drum caps to gradually vent the containers prior to opening. Do not inhale vapors. Decontaminate empty component containers by filling with water and allowing to stand for 48 hours with bung caps removed. Under no circumstances seal, stop, or close the containers which have been emptied of the foam component.

4.10.1.6 Alternative

No substitution of materials shall be made unless authorized in writing by the Engineer prior to starting the work of waterproofing.

4.10.1.7 Minimum Guarantee Period

The Contractor shall guarantee the work for a minimum guarantee period of five (5) years. The Contractor shall make sub-contract agreement with approved manufacturer in which following conditions shall be included:

- a) Minimum guarantee period of five (5) years after the issuance of Certificate of Completion.
- b) The Contractor shall transfer all the rights to the Employer, free of charge after the issuance of Certificate of Completion.

4.10.2 MATERIAL REQUIREMENTS

4.10.2.1 Damproofing

Vapour Barrier

Layer at 6 mils (0.006") polyethylene thick layer.

For slab or grade of the building interior

4.10.2.2 Roof Deck Finish – UV Protected

a) Sprayed Polyurethane Foam Insulation

Provide Sprayed Polyurethane Foam Insulation at Rood Deck is a two (2) component liquid product that uses MDI and polyol and is mixed using a high pressure proportioning equipment. Urethane foam shall be seamless insulate type and shall meet the requirements as shown in Table 4.1 below.

b) Flexible Acrylic Waterproofing

Use flexible acrylic waterproofing as protective coating approved by the foam manufacturer for use as the coating component of a sprayed polyurethane foam roof deck system.

Flexible acrylic waterproofing is single component water based liquid applied membrane inhibiting high flexibility and tensile properties.

c) Primer

Primers used shall be as required and recommended by the coating and spray foam materials manufacturer for the substrate to be covered. Rust-inhibiting primer shall be used for ferrous metal surfaces. Cut-back asphalt primers are prohibited.

d) Sealants

Sealants shall be as recommended by the coating manufacturer.

Table 7.1 - Properties of Urethane Foam

PROPERTIES	ASTM TEST	VALUE	UNITS
Density (Sprayed in Place)	ASTM D1622/ D1622M	2.2-3.6	
K-Factor (aged)	ASTM C177 ASTM C518	0.14	BTU/[(hr.)(ft ²)(in.)(°F)] F. Max. aged at 77°F
Compressive Strength Parallel to Foam Rise	ASTM D1621	52	psi
Shear Strength	ASTM C273/ C273M	46	psi
Tensile Strength Parallel to Foam	ASTM D1623	70	psi

PROPERTIES	ASTM TEST	VALUE	UNITS
Rise			
R-Value	ASTM C518	<7.14	per 1 inch thick
Water Vapor Permeability	ASTM E96/E96M or ASTM C355	1	inches
Closed Cell Content	ASTM D6226	95	Percent by volume
Water Absorption	ASTM D2842	0.08 (96 hours under 2" head)	lbs/ft ²
Flammability	ASTM E84	Flame spread of 75 or less	-
Sound Transmission Class (STC)	ASTM E90/ASTM E431	16 at 1" 18 at 2"	
Noise Reduction Coefficient 1"	ASTM C423	0.50 at 2 lbs.ft ²	

4.10.2.3 Polyurethane Waterproofing (Non-Expose Type) (for Toilets)

The polyurethane based liquid applied waterproofing is a single component pure polyurethane waterproofing membrane design to use as a conceal waterproofing system with high solid content of more than 93% pure polyurethane.

Properties	Value
Product Composition	Pure Polyurethane
Density	1.2 – 1.3 kg/m ²
Color	Black/Various Liquid
Solid Content	>95%
Tensile Strength (ASTM D412)	4.0 N/mm ²
Elongation at Break (ASTM D412)	>700%
Tear Strength	>12N/mm ²
Adhesion to concrete (ASTM D5469)	>1.5 N/mm ²
Hardness (Shore A) (ASTM D2240)	>40
Touch Dry (at 25oC at 65% R.H.)	2-3 hours
Cure Time	12-24 hours
VOC Content	>50g/L
Use	Non-exposure (Non Tar Type)
Crack Bridging Test (ASTM C836)	Pas (-250C, 2.0mm, 25 cycles)
Water Permeability (ASTM D5052)	Below 5.0g/sqm (42 hours)

4.10.3 EXECUTION

4.10.3.1 Roof Deck Finish – UV Protected

- Apply polyurethane foam only to clean, dry, sound surfaces free of loose particles or other foreign materials.
- Polyurethane foam is applied with a two-component proportioning machine. The foam is applied as a liquid and rises in a matter of seconds.
- The roof is sprayed to at 1 inch thickness. Depressions due to roof sagging can be built up by spraying to facilitate proper drainage.

- d) Cure the applied foam for a minimum of 2 hours and as otherwise recommended by the foam manufacturer prior to application of the protective coating.
- e) After curing of the foam surface, an elastomeric, weather resistant coating is applied. To ensure uniform coverage, two or more coats are normally applied.
- f) Remove overspray masking materials and coverings upon completion of the spray foam application and prior to the application of the protective coating. Do not remove the masking over air intake vents until two hours after application of the foam. Remove foam overspray found on adjacent surfaces not scheduled to application of the protective coating.

4.10.3.2 Polyurethane Based Liquid Applied Waterproofing (No-expose Type for Toilets)

a) Application

- 1) All substrates must be structurally clean, dry and free of oil, grease or other contaminants and loose particles.
- 2) Concrete substrate should have a light steel trowel finish. Porous substrate should be seal with PU Primer using brush, roller or airless spray machine at the rate of 0.2 -0.3 kg/m². Allow to cure for 2-3 hours depending on weather conditions. Penetrations, flash piping, conduit and other projection through the structural slab up stand wall and dry wall such as vent, pipe sleeves should be in place and properly mixed.
- 3) Apply 1 to 2 coats of Pure Polyurethane Waterproofing by roller, trowel, squeegee, brush or spray. Allow the first coat to dry for 2 hours depending on weather conditions before application of the second coat.
- 4) Allow it to cure in 12-24 hours. A protection layer must be used to expose to UV light.

b) Topping

Where retopping over waterproofing is required, the Contractor shall provide the topping to the thickness indicated in the drawings.

Application of Concrete Topping

c) Precautionary Measures (Health and Safety)

This Waterproofing contains solvent and is harmful to eyes and skin. Use protective personal equipment and adequate ventilation during application.

4.10.3.3 Floodtesting

Floodtest for a duration of 48 hours shall be undertaken upon completion of waterproofing installation to determine any leakage or defect on the materials and/or workmanship.

4.10.3.4 Protective Layer

The required topping as shown on the drawings, shall be made after acceptance of the floodtesting.

4.11 CEILING AND WALL INSULATIONS

4.11.1 GENERAL

Division I, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.11.1.1 Scope of Work

The work covered in this section shall include all labor, materials, tools, equipment and incidentals necessary to furnish and install decorative insulation panel system at exterior wall of the buildings and pre-fabricated insulated panels and door at new cold storage building to include aluminum coving angle, joiner mould, capping and ceiling suspension system, door hardware and other accessories to provide a completely sound watertight cold storage as shown on the Drawings and specified herein.

4.11.1.2 General Provisions

- a) Pre-fabricated insulated panels shall be a product of a single manufacturer.
- b) Trade names of the materials or components indicated in the specifications are intended only to show the standard of the materials or component on which the design of the particular work is based and also to avoid ambiguous descriptions of the materials or components on the drawings.

The indication of trade names, therefore, shall in no way be considered to limit the acceptability of other products of equal or better functions, performances, reliability and durability.

4.11.1.3 Submittals

Samples, specifications and construction procedures proposed for use shall be submitted to the Engineer for approval.

4.11.1.4 Delivery and Storage

Pre-fabricated insulated panels for ceiling and wall of Cold Storage Building shall be supplied and delivered in their finished form. They shall be stored at a place properly protected from rain and sunlight. Extended, outdoor exposure shall not be allowed. Insulation materials shall not become wet or soil. Contractor shall comply with manufacturer's recommendation for handling, storage and protection during installation.

4.11.2 MATERIAL REQUIREMENTS

a) Decorative Insulation Panel System

Decorative Insulation Panel System (DIPS) is a composite materials which is made up of three (3) parts:

- 1) Surface Coating: Fluorocarbon paint
- 2) Mortar layer (Panel Skeleton): high strength organic resin panel
- 3) Insulation Core Layer: Expanded Polystyrene Insulation (EPS).

Installation materials (auxiliary part): includes adhesive (with 0.6MPa bonding strength, auxiliary mechanical clips and panel bracket supporters (0.5kN) to provide a combination of adhesion, anchorage and supporter that ensures anchoring safety.

SYSTEM COMPREHENSIVE PERFORMANCE INDEX

TEST ITEM	PERFORMANCE INDEX	METHOD
Tensile Strength (MPa)	≥0.15, failure happens within insulation material	JG/T 287
Water Resistant Strength	≥0.15	JG/T 287
Water Absorption Amount (g/m ²)	≤500	JG/T 287
Impact/Shock resistance (joules)	10j for the first floor of Building and 3j shock test result for other floors	JG/T 287
Wind resistance (kPa)	No less than designed value for project, safety coefficient ≥1.5	JGJ 144

4.11.3 EXECUTION

a) Preparation

- 1) Protect adjoining work and property during installation
- 2) Remove foreign materials from all substrates, such as oil, dust, dirt, form-release agents, efflorescence, paint, wax, water repellants, moisture, frost, and any other condition that may inhibit adhesion.

b) Installation

- 1) Do not begin installation until substrates have been properly prepared.
- 2) Install in accordance with manufacturer's instructions.
- 3) For Decorative Insulation panel System (DIPS), use anchoring technique to install panels unto building exterior.

- 4) Install pre-fabricated insulated panels and door according to the direction of the manufacturer.

4.12 DOORS AND WINDOWS

4.12.1 GENERAL

Division I, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.12.1.1 Scope of Work

The work shall cover the fabrication, delivery and complete installation of doors and windows including glazing for the buildings.

The works shall consist of furnishing all labor, materials, tools, equipment and other incidentals necessary for the complete installation of the above mentioned doors and windows, including glazing, as shown on the drawings and in accordance with this specifications or as directed by the Engineer.

4.12.1.2 Submittal

The Contractor shall submit the shop drawings for the fabrication of the doors and windows to the Engineer for approval, twenty eight days before the start of works.

The shop drawings shall indicate the following:

- a) Elevations for each type;
- b) Details for each type;
- c) Location in the building for each item;
- d) Typical and special details of construction; and
- e) Location and installation requirements for hardware.

4.12.1.3 Handling And Storage

All doors and windows and door frames shall be delivered, stored and handled so as not to be damaged or deformed. All doors and windows and door frames stored at the site before installation shall be stocked vertically on non-absorptive strips or wood platforms and covered with suitable covering to provide weathertight protection and proper air circulation.

4.12.2 MATERIAL REQUIREMENTS

4.12.2.1 Wood Doors

- a) Wood doors shall be of the following types where indicated on the drawings with complete locksets, hinges and accessories, duco painted finish.

- 1) Flush-type marine hollow core plywood doors.
 - 2) Flush type marine plywood with fixed wood louver door
 - 3) Panel type wood tanguile doors
 - 4) Louver type wood door
- b) Frame wood block insets shall be kiln-dried tanguile, as shown on the drawings.
 - c) Facings shall be raised wood panels, ordinary plywood, marine plywood where shown on the drawings. Plywood shall be first quality, grain and color suitable for natural finish and of the thickness indicated on the drawings.
 - d) Local plywood used for fabrication of wood doors shall conform to PTS 631-02, Class 1, preservative treated, and the adhesive used for plywood manufacture shall be water-proofing grade. The Contractor shall submit compliance certificates for plywood and adhesive for approval prior to fabrication of doors.
 - e) Local lumber used for fabrication of wood doors shall conform to PTS 20. Lumber used shall be of premium select grade and in no case contain any defects or damage. Lumber shall be Tanguile or a higher class hardwood specie. Wood blocking for specified hardware shall be provided in all hollow core doors.
 - f) Adhesive and bonds shall be in accordance with NWMA Standard I.S.I. using requirements for interior doors. Adhesives shall be waterproof type.
 - g) Door jambs and headers shall be well-seasoned yakal.
 - h) Nails shall be of the smooth shank, zinc-coated, common wire nails of the types and sizes suited for the purpose and as directed by the Engineer.
 - i) Wood screws shall be brass or cadmium plated of the best available commercial quality of the types and size suited for the purpose.
 - j) Door louvers shall be fabricated from wood and shall be of the sizes indicated. Louvers shall be of the manufacturer's standard design and shall transmit a minimum of 35 percent free air. Louvers shall be the slat type. Doors shall be adequately blocked to provide solid anchorage for the louvers. Louvers shall be mounted in the door as indicated with wood lip moldings.

4.12.2.2 Steel Doors

- a) General Material Requirement
 - 1) All members shall be rolled billet steel. Frames and ventilator shall be special angle shapes not less than 25 mm (1") deep from front to back, not less than 1.2 mm in thickness. Weathering projections shall be rolled integral with the sections to provide overlapping, parallel contacts at both inside and outside points of closure on all four sides of the vent.

b) Steel Louver Door

- 1) Full Z section steel louvers on Ga. 16 jamb shall be of Ga. 18 steel blades, mill-fabricated and shall be the manufacturer's standard and stock type or modified.
- 2) The Contractor shall submit to the Architect/Engineer for approval of shop drawings constructions and assembly details. Details of anchorage, fastening for all louver blades, erection, proposed location and method of jointing and splicing of the unit to be installed shall be clearly shown. No work shall be started until these shop drawings have been approved.
- 3) Steel louver blades shall be given two (2) coats of epoxy paint primer prior to delivery.

4.12.2.3 Stainless Steel Roll-Up Door

Roll-up door shall be surfaced mounted type designed for exterior service opening as indicated on the drawings. Component parts shall conform with the following material specifications:

a) Curtains

Roll up door shutters shall be made of stainless steel manufactured from interlocking, rolled formed "C" profile slats, GA 24. The end of each alternate slat are fitted with end locks.

b) Endlocks

The end locks are made of cast malleable metal or galvanized steel, spot-welded to both ends of alternate slats, designed to prevent lateral movement of the slats and allow for a smooth operation of the shutter

c) Bottom Bar

The bottom bar is constructed from two right angled GALVALUME steel bars, each not less than 38mm x 38mm x 2.5mm thick. Between the two right angled GALVALUME steel bars is sandwiched the bottom slat of the curtain, which is securely welded into position. The bottom bar is designed to place the padlock holder, weather stripping and/or safety device

d) Guides

Guides are formed using galvalume steel channels with sufficient depth to retain the curtain in place under the horizontal pressure; it also prevents ends of curtain from de-aligning from guide slots. Top sections shall flare for smooth entry of curtains. Stops shall be provided to limit the curtains from moving beyond the guides. Guides are featured with Polyvinyl Chloride strip to act as a wear strip and to prevent steel to steel contact with the curtain and guide allowing for longevity and quiet operation.

e) Hoods

Hoods are manufactured from Galvanized Aluminum Sheet, 0.7mm thick. It is formed to fit contour of end brackets, all top and bottom edges are reinforced with rods or angle bars, and then fastened to brackets or angle bars. Hoods of more than 3.00 meters in length shall have intermediate supporting brackets.

f) Shutterlock

The roll-up door is manually operated and chain operated roll-up doors are equipped with two locking systems.

A center lock located at waist height, locking device on the inside and key operated from the outside.

In addition, two padlock holders are welded at the base of the side guide and bottom bar for added security.

g) Windlocks

Wind locks are provided for doors with wide openings to prevent curtain from de-alignment due to deflection from wind pressure or other surfaces.

a) Drum Barrel and Spring Counterbalance

Curtain shall coil on a barrel supported at end of opening on brackets and be balanced by helical springs. The drum is made from m/s tube of proper thickness and diameter corresponding to the size of the curtain and then is capped at both ends. The wall thickness is designed sufficiently to limit deflection. Within the barrel, an oil-tempered, helical, counter balancing steel spring, shall be installed which is capable of producing sufficient torque to assure easy operation of the door

b) Ventilation/Perforation

Provide fully perforated slats of 3mm in diameter, providing a see through effect as well as allowing for increased ventilation or slats punched with vent holes of 100mm x 25mm, also for the purpose of ventilation and vision.

c) Wicket Door

Wicket door is an accessory to the roll-up door, ideal as service entry, applicable to motorized or chain-block operated roll-up shutters with wide opening. Wicket door swings back when curtain is raised to give a clear, unobstructed opening. Standard wicket door dimension is 1.5mH x .60mW.

4.12.2.4 Aluminum Doors

a) General Material Requirement

All frames for aluminum door shall consist of aluminum shapes and materials extruded from alloy 6063-T5 to ASTM B 221. Frames shall be coated with

polyester powder and with shade as shown on the Drawing or as directed by the Engineer. Powder coating shall satisfy the following requirements:

Pre-treatment	:	zinc chromating and acid rinsing
Powder application	:	one operation using electrostatic gun
Oven curing temp	:	200°C for 20 min,
Coating thickness	:	min. 60 microns
Impact resistance	:	min. 20 in/lb
(ASTM D 2794)		

- b) Door panels shall either be clear or smoked glass with panel thickness as shown on the Drawings.
- c) Screws, nuts, washers, bolts, rivets and other miscellaneous fastening devices shall be non-corrosive materials such aluminum, stainless steel, etc.
- d) Hardware for fixing and locking devices shall be closely matched to the extruded aluminum section and adaptable to the type and method of opening.
- e) Vinyl weatherstrip shall be first class quality flexible vinyl forming an effective seal and without adverse deformation when installed.
- f) Pile weatherstrip shall be silicon treated and free from residual wetting agents and made of soft line hair as on wool, fur, etc.
- g) Glazing shall conform to the requirement specified Sub-section 4.12.2.9.

4.12.2.5 Wood Plastic Composite Sun Shades and Louver Doors and Louver Windows

a) Scope of Work

The work shall include the furnishing of materials and equipment and perform labor required to complete the wood plastic composite finish. For Sun shades and louver doors and louver windows

See drawings for details and location of work required.

b) Submittals

- 1) Product Data: Manufacturer's data sheets on each product to be used, including:
 - (a) Manufacturer's printed installation instructions, showing required preparation and installation procedures.
 - (b) Storage and handling requirements and recommendations.
 - (c) Installation methods.
 - (d) Cleaning and maintenance instructions.

c) Material Requirements

- 1) Wood Plastic Composite is composed of wood powder from 70% plantation forest wood (virgin spruce pine) and 30% additive and uPVC resin. Since it contains natural fiber, it has high degree of anti-UV and highly resistant to moisture/weather and termites. The wood plastic composite sun louver and louver doors shall have anti UV protection coating.

2) Physical properties of Wood Plastic Composite:

PROPERTY	STANDARD	RESULTS
Density (kg/m ³)	ASTM D2395:2007a	694 kg/m ³
Shore D hardness, median	ASTM D2240:2000	53
Water Absorption (%)	ASTM D1037:2006a Section 23 Method A	After 2 Hours -33% and After 24 hours – 0.69%
Nail Pull Resistance	ASTM D1037: 2006a Section 14	791N
Maximum Tensile Strength (MPa)	ASTM D638:2003	15.6 MPa
Elongation at Break (%)	ASTM D638:2003	2.7%
Flexural Strength (MPa)	ASTM D6109:2005	32.2MPa
Modulus of Elasticity (MPa)	ASTM D6109:2005	2102MPa
Fire Test	ASTM E84:2009c	Class B
Compressive Strength	ASTM D695-08	20.6MPa
Impact Resistance	ASTM D4495-00(2005)	47j
Moisture Content	ASTM D1037-06a Section 6	0.27%
Spread of Flame	AS/NZS 1530.3:1999	0/10

4.12.2.6 Aluminum Windows

a) General Material Requirements

Aluminum windows shall conform to the requirements of ANSI/AAMA 302.9, ANSI/AAMA A 134.1 and the specifications listed below. Provide windows of combinations, types and sizes indicated or specified. Each window shall consist of a unit including frame, sash, mullions, trim, and anchors, complete. All frame and sash extruded members shall be constructed from 6063-T5 aluminum alloy with a nominal depth of 38 mm (1-1/2") and wall thickness of 3 mm (1/8 inch) for principal members of all solid and tubular shapes. Window unit shall be prime windows of the types specified. Dimensions shown are minimum.

b) Aluminum Louver Window

The Aluminum louver windows shall be made with non-corrosive materials, including aluminum, stainless steel and UV-stabilized polypropylene and acetal plastic. This ensures a much longer life in a harsh climatic environment.

A patented sealing system at the head and seal to ensure effective sealing for maximum.

Unless otherwise indicated, aluminum louver windows shall be constructed to withstand a minimum of 200 kg/m² windload.

1) Louver Jamb Frame

The louver jamb frame shall be made of extruded channel section, 6063-T5 aluminum alloy, powder coated finish.

2) Blade Holding Clips

Blade holding clips shall be made from high strength UV-stabilized polypropylene plastic which gives the clips flexibility without sacrificing security. The louver clips shall be neatly and flush against the frame with no visible screws, giving it a smooth, neat appearance.

3) Handle

Handle shall be UV-stabilized acetal handle, designed to spring back to its normal position, even when severely bent. The operating mechanism has passed a stringent 30,000 open and close cycle test.

4) Weatherstrip

The Weatherstrip seals along the blade to prevent wind and water entering the home. Head and sill Weatherstrip are essential to ensure the highest weather resistance possible.

5) Glass Blades

The glass blades shall be 6 mm thick tempered glass with smooth edge glass.

6) Screens (Optional):

(a) Frame Material: Heavy-duty, rewirable type, 6063-T5 extruded aluminum alloy, 7/16 inch with a minimum wall thickness of 0.062 inch.

(b) Frame Construction: Corners shall be aluminum, assembled using corner reinforcement of the type recommended by the manufacturer. Screen frames 4 feet-6 inches in height and over shall have a horizontal spacer bar(s) having a similar section as that of the perimeter frame dividing the screen into equal sections. Screens shall be installed to permit quick and easy removal from the jalousie frame. No mutilation of the screen or screen frames will be permitted in mounting the window operator.

(c) Screen fabric: 14 x 18 mesh, fiberglass or aluminum alloy with an anodized finish. The mesh shall be held in place with rolled aluminum or vinyl splines as per the manufacturer's recommendation.

- (d) Screen retaining fasteners: Aluminum, single wing type with stainless steel screws. Provide fasteners near the corners and at a maximum of 18 inches on center around the periphery of the screen frame.
- c) Fixed Glass Aluminum Windows
 - 1) Type P-A2.5 of AMMA Specifications.
 - 2) Window frames shall aluminum powder coated finish conforming to Section 4.12.2.4 or as shown on the Drawings.
 - 3) Fixed glass shall be clear glass 6.0 mm thick.
- d) Awning Aluminum Windows
 - 1) Window frames shall be aluminum powder coated finish conforming to Section 4.12.2.4 or as shown on the Drawings.
 - 2) Glass shall be clear glass 6.0 mm thick.
 - 3) Provide each side hinged ventilator with one pair of non-friction-type extension hinges, one sash operator designed to hold ventilator open firmly at any angle up to 90° and one locking handle. Hinges shall have the strength necessary to permanently support the glazed ventilator without twist or sag.
- e) Casement Aluminum Windows
 - 1) Window frames shall aluminum powder coated finish conforming to Section 4.12.2.4 or as shown on the Drawings.
 - 2) Glass shall be clear glass 6.0 mm thick.
 - 3) Provide each side hinged ventilator with one pair of non-friction-type extension hinges, one sash operator designed to hold ventilator open firmly at any angle up to 90° and one locking handle. Hinges shall have the strength necessary to permanently support the glazed ventilator without twist or sag.

4.12.2.7 Overhead Braced Floor Mounted System Solid Compact Laminate Toilet Partition and Doors

- a) Panels and doors shall be 19mm thick solid compact laminates made from impregnated kraft paper with phenolic resin, compressed together with melamine impregnated decorative paper under high pressure and temperature to form high pressure laminates. Two-piece construction is not acceptable.
- b) Panels and doors shall have following characteristic:
 - 1) humidity resistant

- 2) scratch
- 3) wear resistant
- c) Pilaster shall be the same materials and construction as panels and doors. Pilasters are supported by adjustable leg and anchored to the floor by means of plug.
- d) Hardware

Refer to the Drawings for the required hardware.

4.12.2.8 Toilet Door (Frameless Frosted Glass Door)

Provide ANSI certified 12mm tempered frosted glass for toilet door at location indicated on the drawings with patch fittings, door pull and towel hanger made of stainless steel SS 304.

4.12.2.9 Glass

Glass for window sashes shall be of the best quality of its respective kind and shall be free from internal or surface defects. It shall not be clouded, cracked or imperfect.

Glass shall be provided in locations as indicated and the corresponding type specified on architectural drawings. Each glass has the manufacturer's label showing the type, thickness, and quality of glass. Labels shall not be removed until the glazing has been approved.

- a) Clear glass shall be 6.00 mm thick for doors and windows. It shall be heat-strengthened for fixed window panes with a clear rubber sealant nearly and properly installed.
- b) Tempered Glass shall be 6 mm thk for doors and windows and shall be heat strengthened tempered glass.
- c) Glazing materials and accessories such as weatherstripping, glazing sealant, gasket, channel, beads, clips, primer, masking tape, edge spacer and others shall comply with all pertinent codes and regulations and shall be as recommended by the glass manufacturer as approved by the Engineer.
- d) Hardware - All items of finish hardware shall be furnished, packaged and labeled in sets. All items of finish hardware of like kind and purpose shall be the same manufacturer and shall be made of 630 Stainless steel.

4.12.2.10 Weatherstripping

Weather strips shall be continuous wool pile, silicon treated weather stripping or any type of weatherstripping recommended by the approved door manufacturer to be fitted of stile rails and bottoms of doors.

Extruded aluminum snap-in glazing beads with vinyl inert glazing gaskets shall be provided on the exterior side of doors and windows.

4.12.2.11 Mirrors

Mirrors shall be plate glass, required thickness indicated on the Drawings, mirror glazing quality or better, free from imperfection with silvering, electro-copper plated back coating and shall be of the best commercial quality. Edges shall be ground smooth and polish. 6mm marine plywood backing shall be provided. Size shall be as shown on the drawings.

4.12.3 EXECUTION

4.12.3.1 Wood Doors

- a) Wood panel doors shall be of the designs, sizes and thickness as shown on the drawings. Frames shall be set plumbed and true and braced to prevent distortion.

Frames in concrete and masonry walls shall be secured by anchor bolts or as shown on the drawings or as directed by the Engineer.

- b) Wood panel doors shall be of the types, sizes and thicknesses as shown on the drawings. Top and bottom edges of all interior and exterior doors shall be given a coat of lead and oil priming paint or a coat of water-resistant spar varnish after cutting, fitting and prior to installation in the work. Doors shall be glazed as indicated. Doors shall be primed before glazing.
- c) Flush wood doors shall be fabricated such that the entire core and frame assembly shall be bonded to the face veneers with approved type of water resistant adhesives, and cured under controlled heat and pressure. Facing shall be waterproofed plywood or ordinary plywood as shown on the drawings. Items of finishing hardware specified in other sections of the specifications shall be fitted carefully and attached securely. Care shall be exercised so as not to mar or injure the work.
- d) Hinged doors shall be plumbed and fitted accurately allowing 1.5 mm clearance at the jambs and heads and 3.0 mm over thresholds. Clearance at the bottom of the door having no thresholds shall be 9.5 mm. Lock stiles of door 44.5 mm thick and thicker shall be beveled 3 mm. Knob locks and latches shall be installed 1.75 m from the finished floor to the center of the locks.

4.12.3.2 Steel Door

The installation of steel door and frames shall be performed by the Contractor under the supervision of the manufacturer. Frames shall be prepared to receive standard hardware, provided with anchors for building into masonry, and shall extend 63 mm (2-1/2") below finished floor lines.

All steel doors shall be checked for warps and when installed shall be hung plumb and true and when closed shall contact the joint over its entire length.

4.12.3.3 Stainless Steel Roll-up Doors

- a) Construction requirements

Doors shall be manual operated by means of hand chain. Accessories needed for the satisfactory performance of the door shall be built-in with the unit.

b) Erection/Installation

- 1) Set and install structural steel angles properly aligned, plumb, level, square true to profile section and rigidly anchored with adjacent concrete walls.
- 2) Allow all adjacent items of work to be completed before any installation work is started except the installation of structural steel angles.
- 3) Assemble roll up doors in accordance with the manufacturer's instruction manual or as indicated in the Shop Drawing approved.
- 4) All anchors and inserts for guides, brackets and other accessories shall be located accurately.

c) Locking Devices

Curtain shall be located at each end of bottom bar by concealed slide bolts which shall engage a lock wedge in each guide. A plunger type cylindrical lock is provided as standard equipment.

4.12.3.4 Aluminum Doors and Windows

a) Fabrication

All frames shall be factory prefabricated in accordance to the designs and dimensions indicated in the Drawings. Minimum metal wall thickness shall be 3mm except glazing beads, moldings, and trim which shall not be less than 1.5mm. Frames that are to receive fixed glass shall have removable glass stops and glazing beads.

Cut, join and fit rails and stiles to hairline joints securely reinforced and joined by means of concealed fastening wherever possible.

Protective Coating: Clean all surfaces and apply a protective coating of clear, water-white methacrylate-type lacquer, resistant to alkaline mortar and plaster immediately after fabrication. Covering shall not chip, peel or flake due to temperature or weather, and shall protect against discoloration and surface damage from transportation, storage, and construction activities. Covering shall be readily removable without affecting the finish. Covering shall either be adhesive paper, waterproof tape, or strippable plastic and may not be removed even after completion of installation.

b) Installation

Set and anchor frames as shown in details and in approved shop drawings.

Set frames plumb and square and brace where necessary to prevent distortion. Set frames without springing, forcing or distorting the product.

Secure frames in accordance with the manufacturer's instructions.

Wedge clear of masonry all frames set in prepared openings 4.76 mm (3/16") to 6.35 mm (1/4") to allow for caulking. Aluminum louvers can be installed flush-mounted to fit masonry or as free standing barriers or screens.

Protection of aluminum from dissimilar materials:

Aluminum to dissimilar metals: where aluminum surfaces come in contact with metals other than stainless steel, zinc or white bronze of small area, keep aluminum surfaces from direct contact with incompatible metals by the following methods:

- 1) Painting the dissimilar metal with one coat of heavy-bodied bituminous paint.
- 2) Applying good quality caulking materials between the aluminum and the dissimilar metal.
- 3) Drainage from dissimilar metals: Paint dissimilar metals used in location where drainage from them passes over aluminum as specified above, to prevent staining of aluminum.
- 4) Aluminum to masonry and concrete: Give aluminum surfaces in contact with mortar, concrete, or other masonry materials one coat of heavy-bodied bituminous paint.
- 5) Adjust all frames and attach hardware before glazing. Secure all windows and doors to be watertight and all hardware operating free and easy.
- 6) Upon completion and installation, thoroughly clean surfaces of doors and frames in accordance with the recommended procedure of the manufacturer. Do not use abrasive, caustic or acid cleaning agents.

c) Special Installation Procedure for Aluminum Glass Louver Windows

1) Examination

Examine the areas and conditions under which windows are to be installed. Do not begin installation should any condition be found unsuitable until the unsatisfactory conditions have been corrected and are acceptable to the Installer. Proceeding with work will imply acceptance of the conditions by the Installer.

2) Installation

- (a) Aluminum louver windows in accordance with the manufacturer's instructions and recommendations.
- (b) Cut frames to dimension, smooth, square, even and neat.
- (c) Shim window frames about 1/8 inch away from concrete or masonry walls. Coat aluminum surfaces in contact with concrete, masonry or

dissimilar metals with bituminous paint or a factory recommended separator to prevent galvanic action. Take care in the application of bituminous paint or separators so that coating is not visible when installation is complete.

- (d) Cut slats and vanes to exact lengths per manufacturer recommendation.
- (e) Predrill holes at the ends of vinyl slats for securement to the pivot clips perpendicular to the slat. Clean prior to insertion into the pivot clips. Do not use self drilling screws.
- (f) Drill holes accurately into the push bar for connection of connecting bar accurately.
- (g) Miter screen frame corners neatly and assemble using corner reinforcement. Frames shall be square and plumb within the jalousie window.
 - i) Cut screen fabric to size and install neatly within the frame smooth and taut, without bulges or waves, held snugly in place with the splines. Trim excess fabric.
 - ii) Roll splines neatly and uniformly rolled into the screen frame. Do not stretch vinyl splines during installation to avoid "shortening" of the spline upon relaxing.
 - Securely fasten screen retaining fasteners to the base frame to hold screen frames firmly in place.
 - Notch window frames and screen frames as required to provide drainage for entrapped moisture.

4.12.3.5 Wood Plastic Composite Sun Shades and Louver Doors

- a) Due to special manufacturing technique, there is no need of paint and glue when the wood plastic composite material is being installed.
- b) Install as per manufacturer's installation procedure.
- c) Periodic cleaning of wood plastic composite material to prevent the build-up of pollen, debris that can cause mold. Using a spray nozzle may use commercial pressure washers to remove stains, ground in dirt or mold.

4.12.3.6 Toilet Doors and Partitions

- a) Install toilet partitions on the locations and heights indicated on the drawings and according to manufacturer's recommended instructions.
- b) Hardware shall be checked and adjusted for smooth operation after installation.

4.12.3.7 Adjustments

- a) Adjust all frames and attach hardware before glazing.
- b) Secure all windows and doors to be watertight and all hardware operating free and easy.

4.12.3.8 Cleaning

Upon completion and installation, thoroughly clean surfaces of doors and frames in accordance with the recommended procedure of the manufacturer. Do not use abrasive, caustic or acid cleaning agents.

4.13 FINISH HARDWARE

4.13.1 GENERAL

Division I, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.13.1.1 Scope of Work

The work covered shall include all labor, materials, tools, equipment and incidentals necessary to furnish and install all finish hardware as shown on the drawings and as specified herein.

4.13.1.2 Submittal

A complete hardware schedule and shop drawings, together with manufacturer's catalogs, shall be submitted by the Contractor to the Engineer for approval.

The hardware schedule shall indicate the manufacturer's catalog number, function, material, finish and other information required. Samples shall be submitted upon request of the Engineer.

The hardware's furnished shall conform to the approved hardware schedule, shop drawings or samples.

4.13.2 MATERIAL REQUIREMENTS

- a) All items of finish hardware of like kind and purpose shall be of the same approved manufacturer.

The Contractor shall measure and verify all dimensions and conditions before proceeding with the work in connection with finish hardware. Hardware applied on metal shall be made to standard templates. The Contractor shall furnish and install all finish hardware to complete the work as indicated on the drawings. Finish hardware shall be suited and adopted to its required use and shall fit its respective location. Finish hardware not specified shall be as directed by the Engineer.

- b) Items of hardware shall be delivered to the job site in their original individual containers, complete with the necessary appurtenances including screws, keys and instructions. Each individual container shall be marked with the manufacturer's name and catalog number as they appear in the hardware schedule.
- c) Refer to the Drawings for the Schedule of Hardwares per location.

Thickness of Door	Width of Door	Size of Butt Hinges
21 mm or 25 mm (7/8" or 1") 28 mm (1-1/8") 35 mm (1-3/8")	0.90 m (3") or less	63 mm (2-1/2") 75 mm x 75 mm (3" x 3") 89 mm x 89 mm (3-1/2" x 3-1/2")
44 mm (1-3/4")		100 mm x 100 mm (4" x 4")
56 mm (2-1/4") and greater		125 mm x 125 mm (5" x 5")

- 1) Where the size of the butt hinges is not sufficient to allow door to clear door trim in open position, same shall be increased.

4.13.3 EXECUTION

- a) All hardware, shall be installed in a neatly, workman-like manner following the manufacturer's instructions and as shown on the drawings. Fasteners supplied with the hardware shall be used to secure the hardware in place. Wood screws shall be used for securing hardware to wood surfaces. Machine screws, set in expansion shields, shall be used for securing hardware to masonry or concrete surfaces.
- b) The bolts shall be used where specified or where necessary for satisfactory installation. After installation hardware shall be protected by the Contractor from paint, stains, blemishes and damages until issuance of Certificate of Completion of the work. All hardware shall be properly adjusted and checked-out in the presence of the Engineer to see that the hinges, locks, latches and bolts operate properly. After the hardware is checked, keys shall be tagged, identified and delivered. Any error in cutting and fittings, or any damages to adjoining work shall be replaced, as directed by the Engineer.

4.14 FINISHES

4.14.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.14.1.1 Scope of Work

The work covered by this section consist of furnishing all labor, materials, equipment, tools and incidentals necessary to undertake, complete al finishing works and painting for the buildings as indicated on the drawings and as specified herein.

Wall, floor, ceiling and other finishing works shall include but are not limited to the following:

- a) Plain cement plaster (steel trowel) finish painted with acrylic latex paint for exterior and interior CHB (Concrete Hollow Blocks) wall;
- b) Glazed tile wainscoting for toilet;
- c) Vinyl tile finish;
- d) Vitrified ceramic tiles for toilet floor;
- e) Non-skid Concrete Tiles
- f) Plain cement steel trowel floor finish with floor hardener;
- g) Rubbed concrete finish, painted with acrylic latex paint for exposed R.C. Ceiling (bottom of roof slab and beams)
- h) Granite floor slab and countertop
- i) Fiber Cement Board for Ceiling

4.14.1.2 Submittal

- a) Shop drawings for all finishing and painting works for the building shall be submitted in advance to allow twenty eight days for review and approval. Shop drawings shall indicate materials and details of finishing works. The Contractor shall be responsible for all errors of detailing and fabrication, and for the correct finishing work items shown on the shop drawings.
- b) The Contractor, before placing order for the finishing materials shall submit to the Engineer for approval representative samples of finishing materials. No placing of orders for material for finishing works shall be made without his approval.
- c) Samples of all walls finishes, measuring not less than 1000 mm x 1000 mm shall be submitted to the Engineer for approval as to its finish texture and workmanship.

4.14.2 MATERIAL REQUIREMENTS

4.14.2.1 Wall Finishes and Countertops

- a) Plain Cement Plaster Finish

- 1) Sand shall be clean and hard material. Sand shall be free from deleterious substances and conforming with the requirements of ASTM C 33.
 - 2) Cement shall be Portland cement conforming with the requirements of ASTM Designation C 150.
 - 3) Water shall be clean and potable.
 - 4) Bonding compound shall conform to ASTM C 631.
 - 5) Hydrate lime shall conform to ASTM C 206.
- b) Textured Cement Plaster Finish
- 1) Material Requirements
 - (a) Portland cement, gray color shall conform to PNS 07, type 1.
 - (b) Portland Masonry Cement, white or colored for textured finish shall be colored masonry cement conforming PNS-53 or to the best commercial standard.
 - (c) Sand shall be clean natural sand or manufactured sand passing a 3 mm screen and retained in a No. 100 mesh sieve for base coat, and a 2 mm screen for textured finish.
 - (d) Water for mixing shall be clean and potable.
 - (e) Lime shall be hydrated lime with the requirement that the unhydrated Calcium Oxide and Magnesium Oxide in the hydrated product shall not exceed 8% by weight, calculated on the “as received” basis.
 - (f) Spraying Equipment for cement texturing shall be of the approved type regularly used by the trade for providing textured finish.
 - 2) Proportioning and Mixing
 - (a) Mixing of Plaster for base coat and textured finish.

Materials shall be accurately measured in a device that will maintain the specified proportions. Mechanical mixers shall be used for the mixing of plaster and textured coating, except where hand mixing of small batches is approved. Plaster shall be thoroughly mixed with the proper amount of water, until uniform in color and consistency. For natural texture color finish, use only one brand of cement. Caked or lumped materials shall not be used. Mechanical mixers, mixing boxes and tools shall be cleaned after mixing of each batch and kept free of plaster from previous mixes. Re-tempering will not be permitted and all plaster that has begun to stiffen shall be discarded.

(b) Proportioning of Plaster

Portland cement plaster for base coat shall be a two-coat application. Each coat shall be proportioned as follows: one part Portland cement, three parts sand, and 1/5 part lime putty.

(c) Proportioning of Cement Textured Finish

Proportioning of Cement Textured Finish shall be proportioned as follows: one part white or colored masonry cement and one part fine sand.

c) Wall Ceramic Tiles

- 1) Wall tiles shall be 400 mm x 400 mm unglazed/glazed ceramic wainscoting Color as per Engineer's approval.
- 2) Trimmers and moulding shall be lustrous, glazed with size and color corresponding to wall tiles.
- 3) Portland cement, sand, bonding compound, lime and water shall conform with Sub-section 4.13.2.1.1 above.

d) Glass Wall

- 1) Surface burning characteristics as required by ASTM E-84, NFPA 235/UL 723 to be Class A (1), labeled and listed by an independent testing laboratory.
- 2) Flame spread per ASTM E-84 of 25 or less for the full depth panels and facing; Smoke development, 25 or less; labeled and listed.
- 3) Panels conform to safety standards ANSI Z97.1 and CPSC Reg.16 CFR 1201, I or II, and labeled and listed as such by an independent laboratory.
- 4) Available types include smooth and textured glass types as available.
- 5) Coatings types include solid, pear or metallic coating types as available.

4.14.2.2 Floor Finishes

a) Vinyl Tile Finish

- 1) Vinyl tiles shall be 3 mm thick x 300 mm x 300mm. Samples of the tile for color selection shall be submitted and approved by the Engineer.
- 2) Waterproof contact adhesive shall be as recommended by the tile manufacturer and approved by the Engineer.

b) Vitrified Ceramic Unglazed Tiles

- 1) Vitrified ceramic unglazed floor tiles shall be 100 mm x 100 mm, white for toilets and as shown on the drawings or to be designated by the Engineer.

- 2) Portland cement, sand and water shall conform with the requirements specified in Sub-section 4.13.2.1.1 above.
 - 3) Vitrified ceramic unglazed floor tiles shall be delivered in the manufacturer's original unbroken packages or containers that are labeled plainly with the manufacturer's name and brand. Containers shall be grade scaled. Materials shall be stored in dry weathertight enclosures, and shall be handled in a manner that will prevent the inclusion of foreign materials and damage by water or dampness.
- c) Plain Cement Floor Finish
- 1) Portland cement, sand, bonding compound and water shall conform with the requirements specified in Sub-section 4.13.2.1.1 above.
 - 2) Mortar shall be one part of Portland cement to three parts sand.
 - 3) Hardener shall be non-metallic floor hardener, delivered in cartons, cans or bags to the construction site with the labels installed and seals unbroken.
- d) Non-skid ceramic floor tiles
- 1) Non-skid ceramic tiles shall be 100mm x 200mm white ceramic tiles to be used for market hall ramp as shown on the Drawings.
- e) Granite Slab
- 1) Granite Slab shall be 19mm thick 600mm x 2400mm pre-polish granite slab and shall comply with ASTM C615.
 - 2) Shall be sound material with uniform and favorable working qualities and with very limited natural faults.
 - 3) Color and quality shall be approved by Engineer.
 - 4) Mixes:
 - (a) Bond Coat – One (1) part Portland cement, one-half to one ($\frac{1}{2}$ to 1) part lime putty, three to four (3-4) parts sand.
 - (b) Proportion for mortar setting bed – one (1) part Portland cement, three to four (3-4) parts sand.
- f) Homogeneous/ Porcelain Tiles
- 1) Material
 - (a) Homogeneous tile is a form of ceramic tiles composed of porcelain clays but fired at much higher temperature than ceramic tiles (exceeding 1,500 degrees centigrade).

- (b) Homogeneous tiles are denser, harder, less porous and less prone to moisture and stain absorption.
 - (c) Have consistent property the entire section of the tile.
 - (d) Colors of homogeneous ceramic tiles /porcelain tiles run uniformly through its entire thickness will not expose a clay base when chipped.
 - (e) Refer to the drawings for the location of its applications.
- 2) Leveling mortar bed shall consist of the following:
- (a) Cement

Ordinary Portland cement shall be used in the preparation of the mortar. Except where shown otherwise on the Drawings, the cement used meet the requirements of ASTM C 150, Type I or AASHTO M 85 Type.
 - (b) Fine Aggregates

The fine aggregate may be naturally occurring sands, manufactured sands or a mixture of both.

 - Grading: As shown below, Material retained between any two sieves shall not exceed 45 percent (ASTM C 136).
 - Fineness: Not less than 1.50 not more than 3.0. Once approved by the Engineer deviation of over 2 percent shall not be permitted (ASTM C-117).
- 3) Grouting shall be per manufacturer's standard.
- 4) Tile adhesive shall be per manufacturer's standard.

4.14.2.3 Ceiling Finishes

- a) Rubbed Concrete Finish (exposed concrete painted finish)

Portland cement, sand, bonding compound and water shall conform with the requirements specified in Sub-section 4.14.2.1 above.

- b) Fiber Cement Board

- 1) Materials

- (a) Fiber cement board on metal frame shall be auto-cleaved, single faced sheets containing Portland cement, ground sand, cellulose fiber and water. Fiber Cement sheets shall be manufactured from asbestos-free materials.
- (b) 6mm thick for internal ceiling, painted finish with 6mm wide open groove. Dimension as indicated on the Drawing.

(c) Density: 1380 kg/m³ minimum

4.14.2.4 Steel Framing

- a) Steel Studs and Runner: Ga. 25 minimum thickness of uncoated metal galvanized C-shaped or as otherwise indicated.

4.14.2.5 Fasteners

- a) Provide fasteners of type, material size, corrosion resistance, holding power and other properties required for fastening furring and framing members to substrates indicated.
- b) Trim Accessories: Provide metal trims accessories of profile and materials as shown on the drawings, or as otherwise required by the Architect/manufacturer.

4.14.2.6 Miscellaneous Framing and Supports

- a) General: Provide steel framing and supports for applications indicated.
- b) Fabricate units to sizes, shapes, and profiles indicated and required to receive adjacent other construction retained by framing and supports. Fabricate from structural steel shapes, plates and steel bars of welded construction using mitered joints for field connection. Cut, drill, and tap units to receive hardware, hangers, and similar items.
 - 1) Equip units with integrally welded anchors for casting into concrete or building into masonry. Furnish insert, if units must be installed after concrete is placed.
 - 2) Except as otherwise indicated, space anchors at 600 mm O.C. and provides minimum anchor units in the form of steel straps 32 mm wide by 6 mm by 200 mm long.

4.14.2.7 Miscellaneous Materials

- a) General: Provide auxiliary materials for fiber cement board construction, which comply with reference standards and the recommendations of the manufacturer of the fiber cement board.
- b) Fastening Adhesive for Metal: Special adhesive recommended by manufacturer.
- c) Screws: As per recommendation by manufacturer.
- d) Bedding and Topping Cement: As per recommendation by manufacturer.
- e) Perforated Paper Reinforcing Tape: As per recommendation by manufacturer.
- f) Trim Accessories: Provide galvanized steel edge corner and joint trims as shown or otherwise required by the Architect/manufacturer as standard details.

g) Aluminum Ceiling Panel (Clip-in and Perforated)

- 1) 300mm x 300 aluminum clip-in ceiling panel (round mould) in suspended light steel frame with fiber cement board border painted.
- 2) 600 x 600mm aluminum square perforated ceiling panel with concealed suspension grid with fiber cement ceiling board border, painted finish.
- 3) Aluminum panel ceiling consisting of panels made of powdercoated aluminum alloy, panel length up to approximately 6 meters, colors for Architect's approval.
- 4) Panel Carriers and Panel Clips made of light steel as required by the Architect.
- 5) Panel Clips - as per manufacturer's standards.
- 6) Aluminum Ceiling Panel shall comply with the following properties:

Sound Absorption α_w	Up to 0.45 (L)
Sound Absorption Class	D, E, not rated
Sound attenuation D_{nfw}/D_{ncw} (dB)	Up to 44
Sound Reduction Index R_w (dB)	Up to 8
Sound Absorption NRC	Up to 0.55
Light Reflectance	Up to 85%
Recycled Content	30%
Humidity Resistance (RH %)	95
Clean Room Classification	ISO 3, ISO 5
Cleanability Types	Damp sponge, High pressure water spray

h) Aluminum Cell Ceiling Module

Cell ceiling system are manufactured from aluminum alloy HD5050 or equal (EN 1396).

- 1) Panel: 0.5mm thick aluminum strip with the following dimension:
 - (a) 600mm x 600mm cell module at 20mm cell depth
 - (b) 150mm x 150mm cell module at 50mm cell depth.

Panels are assembled from aluminum U-profiles and create perfect detailing of the connecting U-profiles.

- 2) Finish: Two layer polyester finish in nominal thickness of 20 microns is stoved enameled in a continuous coil-coating process to ensure uniform thickness and absolute adhesion.
- 3) Profile size: 22mm and 50mm

- 4) Suspension: The panels feature an integrated system with main and cross runners constructed from the same profiles as the panels. The panels are easily (de)mounted with the siding clip
- 5) Physical Properties

Seismic Rating	Zones A, B,C,D,E,F
Fire Rating	Class A Fire Rated per ASTM E84 -Painted or anodized metal: Frame Spread: ≤25; Smoke: ≤50
Light Reflectance (LR) Coefficient per ASTM E1264 & ASTM E1377	LR = 0.81

4.14.3 EXECUTION

4.14.3.1 Wall Finishes

- a) Plain Cement Plaster Painted Finish

- 1) Preparation of Surfaces

All surfaces shall be cleaned and projections, dust, loose particles and other materials, which would prevent good bond, shall be removed.

Plaster shall not be applied directly to concrete and masonry surfaces coated with bituminous compounds and surfaces previously painted or plastered.

All surfaces shall be thoroughly wetted before plastering.

- 2) Trial Mix

A trial mix of at least three (3) different water-cement ratios for a proposed mix shall be prepared under full scale conditions and adequate workability. The proportions by weight of cement to the weight of sand shall not be less than one part of Portland cement to two parts of sand.

The proportion of cement-sand and water necessary to produce the cement plaster of the required consistency shall be subject to the approval of the Engineer. Such approval may be withdrawn at any time and a change in proportions may be required. Based on the approved mix proportions, the Contractor shall prepare a list showing the number of kilograms of the various materials to be used in the cement plaster finish mix.

No cement plaster finish shall be started without an approved trial mix by the Engineer.

3) Cement Plaster Finish Application

A brown coat with sufficient pressure shall be applied to fill the gaps, and to secure a good bond. Moistened for 48 hours, each coat of cement plaster shall be kept after application and allow to dry.

A finish coat shall be applied after the brown coat has set. The brown coat shall be moistened before application of the finish coat. Finish coat shall be floated to plumb, even planes and surfaces.

Final plaster finishes shall be rubber sponged.

4) Tolerance

The Contractor shall finish plaster work plumb, level, square and true within tolerance of 3 mm in 3 meters, without cracks and other imperfections.

5) Patching and Cleaning

Upon completion of the building, and when directed, all loose, cracked, damaged or defective plastering shall be cut out and replastered in a satisfactory and approved manner.

b) Textured Cement Plaster Finish

1) Workmanship

Base coats shall be applied with sufficient pressure and the plaster shall be sufficiently plastic to provide good bond on masonry base or uneven concrete surface. Plaster work shall be finished level, plumb, square, and true, within a tolerance of 3 mm in 3 m, without eaves, cracks, blisters, pits, grazing, discoloration, projections, or other imperfections. Plasterwork shall have no visible junction marks. Finished work shall be covered and protected to prevent damage.

2) Textured Cement Plaster Finish

Textured Cement Plaster Finish shall be spray-applied to a thickness of not less than 6 mm thick. Application shall be done to provide uniform thickness and texture.

3) Repair of Defective or Damaged Work (Patching and Pointing)

Upon completion of the finishing and when directed, all loose, cracked, damaged or defective texturing work shall be cut out and repaired. Exposed textured surfaces shall be left in an unblemished condition, ready to receive paint or other finish. All pointing and patching of textured surfaces shall be done in a neat and workmanlike manner. Plaster droppings shall be removed from all surfaces. Protective coverings shall be removed from floors and other surfaces, and all rubbish and debris removed from the building.

c) Wall Ceramic Tiles

1) Mortar Preparation

All mortar setting beds shall be mixed by volume in the proportion of 1 part Portland cement and 3 parts dry sand and not more than 1/10 part hydrated lime.

Mortar materials shall be measured in approved containers, which will insure that the specified proportions of materials will be controlled and accurately maintained during the progress of the work. Measuring materials with shovels, "shovel count", will not be permitted. Unless specified otherwise, mortar shall be mixed in proportions by volume, in an approved mortar box.

The quantity of water shall be controlled accurately and uniformly. The aggregates shall be introduced and mixed in such manner that the materials will be distributed uniformly throughout the mass. A sufficient amount of water shall be added gradually and the mass further mixed until a mortar of the elasticity necessary for purpose intended is obtained. Mortar boxes, pans and wall surfaces shall be kept clean and free from debris or dried mortar. The mortar shall be used before the initial set of the cement has occurred. Re-tempering of mortar in which cement has started to set will not be allowed.

2) Application of Wall Tile

Interior masonry shall be clean, thoroughly dry, sound and sufficiently rough to provide strong mechanical bond. Surfaces shall be evenly damped immediately prior to the application of the scratch coat.

Scratch coat shall be applied to masonry, as backing for wall tile, not less than 24 hours or more than 48 hours before starting the tile setting. The scratch coat shall not be less than 6 mm from the face of the masonry. The scratch coat shall be applied with sufficient pressure to ensure a proper bond with the base for the setting bed. While the mortar is still plastic, the scratch coat shall be cut with a trowel at all internal vertical angles for the depth of the coat with the full height of the tile bed and shall be cross-scratched, in 25 mm centers for the extent of the tile bed.

Immediately before the application of mortar setting bed, the scratch coat shall be moistened thoroughly but not saturated. Temporary screeds shall be applied to the scratch coat with mortar to provide a true and plumb surface, the proper distance back from the finished wall line. The setting bed shall be applied, rodded and floated flush with the screeds over an area not greater than the area to be covered with the tile while the bed remains plastic. The thickness of the setting bed shall not exceed 15 mm and the mortar shall not be retempered. The setting bed shall be cut with a trowel at all internal corners as specified for the scratch coat.

Mounted tiles shall be soaked in clean water a minimum of one hour before they are set. Absorptive mounted tiles shall be damped by placing sheets on a wetted cloth in a shallow pan before setting. A skim coat of

neat Portland cement mortar, mixed with water to the consistency of a pasty, thick cream, shall be applied 0.8 mm to 1.6 mm thick to the mortar setting bed, or to the back of each tile as laid. The tiles shall then be pressed firmly on the setting bed and tamped until flush and in the plane of the other tiles. The tiles shall be applied before the mortar bed has taken its initial set.

Intersections and returns shall be formed accurately. Where cutting of tiles is necessary it shall be done at the internal angles of the walls or wainscots. Cutting and drilling tiles shall be done neatly without marring the surfaces. The cut edges of tiles against trim, built-in fixtures, and similar surfaces shall be ground and jointed carefully. The tiles shall fit closely with plumbing fixtures and around electric outlets, pipes and fittings, so that the plates or escutcheons will properly overlap the tiles. Wainscots shall be within one half of the heights indicated without cutting of the tiles.

Bases, caps, bull-nose corners, and all other trimmers moulded or shaped features, and accessories shall be backed thoroughly with mortar and set firmly into place. All lines shall be kept straight and true, and all finished surfaces brought to true and even planes, straight and plumb, and internal corners squared and external corners rounded.

Horizontal joints shall be maintained level and vertical joints plumb and in alignment. The completed work shall be free of broken, cracked, damaged or otherwise faulty tiles.

Joints shall be parallel and uniform in width, plumb, level and in alignment. End joints in broken-joint work shall be made as far as practicable, on the center line of adjoining tiles. Except in special arrangement and design, as indicated or specified, square tiles shall be set with straight joints, and oblong tiles shall be set with broken joints.

Joint widths shall be uniform and spaced to accommodate the tile in the given spaces with a minimum of cutting. Tiles shall be wetted, if they have become dry, before applying grout. Joints 3 mm or less in width shall be grouted with a neat Portland cement grout of the consistency of thick cream. Other joints shall be pointed with mortar consisting of one part Portland cement and two parts pointing sand. The grout for walls and other vertical surfaces shall contain non-staining white Portland cement. Grout and pointing mortar shall be forced into joints by using trowel, brush or finger application.

Before the grout or mortar sets, the joints of cushion edge tiles shall be struck or tooled to the depth of cushion, filling all skips or gaps, and the joints of square edge tiles shall be filled completely flush with their surface. Dark cement shall not show through grouted white joints. Care shall be taken to avoid scratching glazed finishes. All mortar or grout shall be removed before it has set or hardened.

3) Cleaning and Curing

All completed tile work shall be thoroughly sponged and washed diagonally across joints, and finally polished with clean, dry cloth. Acid cleaning of unglazed tile, when necessary, shall not be done within ten days after setting tile. All metal shall be covered with an approved grease and the tile shall be wetted with clean water, before tile is cleaned with 10% muriatic acid solution. After acid cleaning, the tile shall be flushed with clean water, and the grease coating on metal shall be removed. Acid cleaners shall not be used on glazed tile.

4) Protection

Tiled walls outside corners (external angles) shall be protected with board corner strips in areas used as passage ways by workmen. Extreme care should be taken not to disturb walled tiled until mortar has fully set.

d) Colored Glass Wall

1) Examination

- (a) Do not begin installation until substrates have been properly prepared.
- (b) If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

2) Preparation

- (a) Clean adjoining and supporting surfaces thoroughly prior to installation. Remove dust from drywall.
- (b) Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3) Installation

- (a) Install in accordance with manufacturer's instructions.
- (b) Install materials in accordance with manufacturer's printed instructions and submittals. Installation shall start only after all other work on the adjoining walls, base, and floor has been completed. Insure that perimeter details and opening sizes are correct before starting.
- (c) Panels shall be installed, accurately and in the required locations, as indicated on the drawings. Surfaces shall be plumb, level, aligned and flush, with uniform joints, and with the proper patterns, textures and colors.
- (d) Manufacturer's protective film on the face of the panels shall not be removed until all work is complete.

4) Wall Installation

(a) Adhesive installation: Construction adhesive as recommended by the glass manufacturer with no acetoxic silicone. Adhesive manufacturer's requirements shall be followed. Always wipe dust off walls thoroughly.

(b) Frame Installation

- Wall panel trim shall be installed in a plumb, level and square manner. The face of the trim shall be on a flat and plumb plane. Maximum variation 3 mm in 4572 mm.
- Exception: When the design intent is for the wall plane to not be plumb and/or not be a continuous flat plane. Joints shall be flush and tight with the maximum tolerance +0.5 mm.
- Wall panels shall be flat and on a consistent plane with adjacent panels. Tolerance + 0.8 mm.
- The plane of the trim face and the plane of the panel face shall have a constant and parallel relationship.
- Bonding adhesives shall be applied to a sealed and contaminant free bonding surface. No adhesive shall be visible.

4.14.3.2 Floor Finishes

a) Vinyl Tiles

No vinyl tile work shall start until the Engineer has approved the time when such work shall start.

The Contractor shall furnish and install all vinyl tiles and base where and as shown on the drawings or as specified. The temperature shall be maintained at 22°C for 48 hours before, during and 48 hours after the application of tiles.

Vinyl tile shall be laid in accordance with the approved manufacturers recommended method of laying.

Waterproof contact adhesive shall be applied both on the floor and tile, spread evenly and allowing 10 minutes drying time prior to installation.

Tiles shall be laid with close, straight joints, bedded in contact adhesive in accordance with method approved and rolled with roller of sufficient weight to press tile firmly in place and provide smooth, plush surfaces at the joints. Tiles shall be fitted close to all pipes, base and other intersection surfaces.

All finished floors shall be protected in a manner that will prevent the finish from any damage. The Contractor shall remove and replace any defective materials and/or workmanship or damage of the finished floors.

b) Plain Cement Floor Finish with Floor Hardener

1) Trial Mix

No plain cement floor finish work shall be started without the approval of the Engineer of the trial mix.

2) Application

The concrete sub-floor shall be cleaned and projection, dust, loose particles and other materials which would prevent good bond shall be removed. The sub-floor surface shall be moistened but not soaked, dry cement shall then be sprinkled over it and the mortar shall be spreaded on the setting bed. The surface shall be tamped to assure a good bond over the entire area and screeded to provide a smooth and level bed at proper height.

Mortar mix shall be one part Portland cement to three parts sand. Following the placing of leveling concrete on the floor and after the concrete is free from excess water, a dry mixture of 2 parts of floor hardener and 1 part Portland cement shall be uniformly dusted over the floor. Three kilograms of floor hardener shall be used for every square meter of flooring or in accordance with approved manufacturer's specifications. The dry mixture shall be floated thoroughly into the surface which shall be finished by steel trowelling and cured by water or curing compound for seven (7) days.

c) Vitrified Ceramic Tiles

1) Mortar Preparation

Mortar mix proportion and preparation shall be in accordance with the requirements in paragraph b of sub-section 4.14.3.1.c)

2) Surface Preparation

Surfaces to receive the tiles shall be clean, free of dust, dirt, oil, grease, and other deleterious substances. Floor tile operations in spaces receiving wall tile shall not be started until wall tile installation has been completed. Before tile is applied with a dry-set mortar bed, the structural floor shall be tested for levelness or uniformity of slope by flooding it with water. Areas where the water ponds shall be filled and leveled with mortar and shall be retested before the setting bed is applied.

3) Placing of Setting Beds and Floor Tile

Mortar setting beds shall have a minimum thickness of 20 mm for floors. The structural concrete slab shall be soaked thoroughly with clean fresh water on the day before the setting bed is to be applied. Immediately preceding the application of the setting bed, the structural slab shall again be wetted thoroughly, but no free water shall be permitted to remain on the surface.

A skim coat of neat Portland cement mortar shall then be applied not more than 4 mm thick. The mortar shall be spread until its surface is true and even and thoroughly compacted, either level or sloped uniformly for drainage, as the case requires. A setting bed, as large as can be covered with tile before the mortar has reached its initial set, shall be placed on one operation; but in the event that more setting mortar has been placed than can be covered, the unfinished portion shall be removed and cut back to a clean beveled edge.

All mounted tiles shall be soaked in clean water a minimum of one hour before they are set. Absorptive mounted tile shall be dampened by placing sheets on a wetted cloth in a shallow pan before setting. No free water shall remain on the tiles at the time of setting. Before the initial set has taken place in the setting bed, a skim coat of neat Portland cement mortar, 0.7 mm to 1.6 mm thick, shall be trowelled or brushed over the setting bed and/or the back of the tile, or a thin layer of Portland cement, 0.79 mm to 2 mm thick, may be hand-dusted uniformly over the setting bed and worked lightly with a trowel or brush until thoroughly damp.

The tiles shall then be pressed firmly upon the setting bed, and beaten into the mortar until true and even with the plane of the finished floor line. Beating and leveling shall be completed within one hour after placing tiles or sheets. Borders and defined lines shall be laid before the field or body of the floor. Where floor drains are provided, the floors shall be sloped to drain properly to the drains. Intersections and returns shall be formed accurately.

Cutting of tile, where necessary, shall be done along the outer edges of the floor. As far as practicable, no tiles of less than half size shall be used. Cutting and drilling of tiles shall be done neatly without marring the tile surfaces. The cut edges of tile against trim, bases, thresholds, pipes, built-in fixtures, and similar surfaces shall be ground and jointed carefully. Tile shall fit closely and neatly at all plumbing fixtures and around electrical outlets, pipes and fittings so that cover plates or escutcheons will overlap the tiles properly. Tiles shall be secured firmly in place and loose tiles or tiles sounding hollow shall be removed and replaced. All lines shall be kept straight, parallel, and true, and all finished surfaces brought to true and even planes. The inner edges of borders shall be kept straight and, where practicable, shall form right angles at all returns. The paper and glue shall be removed from mounted tile, without using excess water, within one hour after installing the tiles.

Joints shall be parallel and uniform in width, plumb, level and in alignment. End joints in broken-joint work shall be made as far as practicable, on the center lines of adjoining tiles. Except in special arrangement and design, as indicated or specified, square tiles shall be set with straight joints, and oblong tiles shall be set with broken joints.

Joint widths shall be uniform and spaced to accommodate the tile in the given spaces with a minimum of cutting. Tiles shall be wetted, if they have become dry, before applying grout. Joints 3.2 mm or less in width shall be grouted with a neat Portland cement grout of the consistency of thick

cream. Other joints shall be pointed with mortar consisting of one part Portland cement and two parts pointing sand.

The grout or mortar for joints on floors shall be white Portland cement or as specified by the Engineer. Grout pointing mortar shall be forced into joints by using trowel, brush or finger application. Before the grout or mortar sets, the joints of cushion edge tile shall be struck or tooled to the depth of the cushion, filling all skips or gaps, and the joints of square edged tiles shall be filled completely flush with their surface. Dark cement shall not be seen through grouted white joints.

All surplus mortar or grout shall be removed before it has set or hardened.

4) Cleaning and Curing

Floors shall be covered with waterproofed paper with all joints lapped at least 96 mm and allowed to damp cure for at least 72 hours before foot traffic is permitted thereon.

All completed tile work shall be thoroughly sponged and washed diagonally across joints, and finally polished with clean, dry cloth. Acid cleaning of unglazed tile, when necessary, shall not be done within ten days after setting the tile. All metal shall be covered with approved grease and the tile shall be wetted with clean water, before tile is cleaned with 10% muriatic acid solution. After acid cleaning, the tile shall be flushed with clean water, and the grease coating on metal shall be removed.

Finished tile floors shall be covered with clean building paper before foot traffic is permitted on them. Board walkways shall be placed on floors that are to be continuously used as passage ways by workmen. Thresholds shall be covered with boards. Tiles vertical outside corners (external angles) shall be protected with board corners strips in areas used as passage by workmen.

d) Granite Slab

- 1) Before spreading the setting bed, establish lines of borders and center the fieldwork on both directions to permit the pattern to be laid with a minimum of cut slab.
- 2) Place mortar onto only as large an area as can be covered with the tile before mortar reaches its initial set. When more setting mortar is spread that can be covered, the unfinished portion shall be cut back to a clean, leveled edge and removed.
- 3) Tamp mortar bed to ensure a good bond over the entire area, and screed to provide a smooth level bed at proper height and slope.
- 4) Wet slab prior to installation. Lay slab from centerline outward and make adjustments at walls and keep tile joints parallel and straight over the entire area.

- 5) Fill in voids with approved joint filler and machine-sand slab using the wet method.
 - 6) Machine-sand slab to a shiny finish after the application of the wet method three to four (3-4) times.
- e) Homogeneous /Porcelain Tiles
- 1) Setting

Set floor tile firmly in setting bed, for a true surface. Joints should be straight, level and of even width not exceeding 15mm. Joint depth is approximately 6mm to 8mm.
 - 2) Grouting Method

Grout float method (adaptable to small paving-stone series). Force a maximum amount of grout (1 part cement to 2 parts fine graded sand) into joints.
 - 3) Cleaning

Clean homogeneous ceramic tiles /porcelain tiles surface as thoroughly as possible within 10 minutes after completion of grouting with sponge rubber or brush.

4.14.3.3 Ceiling Finish

a) Rubbed Concrete Finish

After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of holes, honeycomb spots, broken corners or edges and other defects to thoroughly set. Surfaces to be finished shall be rubbed with a minimum coarse carborundum stone using a small amount of mortar on each face. The mortar shall be composed of cement and fine sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids have been filled, and a uniform surface has been obtained. The face produced by this rubbing shall be left in place at this time.

After all concrete above the surface being created has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of smooth texture and uniform color.

After the final rubbing is completed and the surface has dried, it should be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

b) Fiber Cement Board

- 1) Install fiber cement board in accordance with approved layouts on metal grid supports not more than 50 cm apart. When structural supporting members are set at such spacing that the above requirements cannot be complied with, adequate intermediate supports shall also be provided.
- 2) Each board shall be tightly and rigidly secured in place and free from unnecessary movement.
- 3) Each board shall be set square, straight, plumb and/or level, accurately positioned at locations and to layouts required, with adjacent like units or members accurately aligned.
- 4) Board joints shall be tightly abutting and flush across adjacent units.
- 5) The installation shall be free from exposed fastenings, unnecessary cuts or holes, other than as particularly shown, specified or approved.
- 6) Exposed surfaces shall be completely clean and free from dust, dirt, smudges, fingerprints, scratches, dents, warping, waviness, buckling, broken parts or units, chips, cracks, misaligned or improperly fitted joints, stains, discoloration or other defects or damage.

c) Aluminum Ceiling Panel (Clip-in, Perforated and Cell Ceiling)

- 1) Installation shall be performed only by qualified installer of the manufacturer.
- 2) Provide final protection and maintain conditions, in a manner suitable to installer which ensures Aluminum ceiling panels installation being without damage or deterioration at time of substantial completion.

4.15 PAINTING

4.15.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.15.1.1 Scope of Work

This Section covers the surface preparation, coating materials and application of coatings systems required for the Works.

The work shall consist of furnishing of all labor, materials, equipment and other incidentals necessary for the supply of painting materials and the complete painting of surfaces as shown on the drawings in accordance with this Specification and as directed by the Engineer.

The term paint as hereinafter used includes emulsion paints, varnishes, oils, pigments, thinner and dryers.

All exposed metal surfaces, except metal surfaces embedded in concrete, shall be painted unless otherwise specified.

4.15.1.2 Standard

The following publications listed below, but referred to thereafter by basic designation only, forms a part of these Specifications to the extent indicated by the reference thereto:

Steel Structures Painting Council (SSPC) U.S. Specification
JIS K 5628 Red-lead Zinc Chromate Anti-Corrosive Paint.

4.15.1.3 Submittal

- a) The Contractor shall submit work method statements with lists of materials to the Engineer for approval twenty eight days before the starting of works. This statement shall include following items:
 - 1) Type of paint and manufacturer
 - 2) Manufacturer's specifications
 - 3) Storage and delivery of materials
 - 4) Surface preparation
 - 5) Finish painting and drying
 - 6) Touch-up painting, if any
 - 7) Equipment
- b) The Contractor, before placing order for the painting materials, shall submit to the Engineer for approval samples of materials. No placing of orders for material shall be made without his approval.

4.15.1.4 Storage and Delivery

- a) The Contractor shall deliver all material to the site in the original labeled sealed cans and containers, with labels intact and seal unbroken.
 - 1) Seals shall remain unbroken until after inspection and acceptance of material by the Engineer.
 - 2) The Contractor shall deliver materials in ample quantities sufficiently in advance of the need to avoid any delay or interruptions in the works.
- b) Paint in thinner shall be stored in accordance with the approved manufacturer's instructions.
 - 1) All regulations required for storage of paint shall be observed and all necessary safety signs required by governing codes shall be posted.

- 2) Any damage caused by failure to exercise proper precautions in paint storage shall be repaired.

4.15.2 Material Requirements

4.15.2.1 Paint

Paints for the protective coating system shall be the product of a manufacturer approved by the Engineer.

All paint materials shall meet the requirements of the standard specifications of the Standardization Committee on supplies and shall be in accordance with the latest Classification Class “A” of the Institute of Science, Manila, Philippines, and shall be delivered on the work in the original containers, with labels intact and seals unbroken.

Boysen Paint or Davies Paint or equivalent shall be used on all surfaces and certificate of origin and quality shall be submitted to the Owner for inspection and approval before using any of the paint materials.

The use of ready mixed paint may be allowed in this project, provided, however, that such paint is in accordance with the standard Specification No. 13 of the Philippine Government and that ready mixed plants shall be those listed under “Good Substitutes” only.

Tinting colors for latex shall be the highest grade obtainable. Tinting colors for oil paint shall be color in oil ground in pure linseed oil. Color shall be non-fading. Color pigments shall be used to produce the exact shades of paint which shall conform to the approved color scheme of the building. Except as otherwise noted, color of priming coat shall be white.

All materials to be used in the work shall be stored in a place to be designated by the Owner, and such place shall be kept neat and clean at all times. Any damage on this place and its surroundings shall be rectified. All precautions to avoid danger of fire must be observed by removing oil rags, wastes, etc. from the building at the end of daily work.

4.15.2.2 Schedule of Painting

Paint manufacturers shall be BOYSEN, DAVIES or approved equal.

4.15.3 EXECUTION

4.15.3.1 Surface Preparation of Steel

- a) Steel surfaces shall be cleaned as follows:
 - 1) All round welds, burrs and sharp surface projections shall be ground smooth and all weld splatter shall be removed prior to blast cleaning.
 - 2) Sand abrasives, if used, shall be clean, and free from salt and extraneous matter. The sand shall pass through a 2.0 mm test sieve, and be

substantially retained on a 0.18 mm test sieve, with at least 25 percent retained on a 0.355 mm test sieve.

- 3) Metallic abrasive, if used, shall be sharp, hard and free from dust, and shall pass through a 1.8 mm test sieve.
- 4) Blast cleaning operations shall not be conducted on surfaces that will be wet after blasting and before coating, or when the surfaces are less than 10°C above degree points, or when the relative humidity of the air is greater than 95 percent.
- 5) Any oil, grease, soil, dust or other foreign matter deposited on the cleaned surfaces shall be removed prior to painting. In the event that rusting occurs after completion of the surface preparation, the surfaces shall be cleaned again in accordance with the specified method.
- 6) Particular care shall be taken to prevent the contamination of other corrosive chemicals before the application of the paint. Such contamination shall be removed from the cleaned surface by flash blasting and the paint applied immediately.
- 7) Care shall be taken to prevent contamination of cleaned and painted surfaces by cleaning operations in an adjacent area.
- 8) Surfaces not to be painted shall be suitably protected from the effects of cleaning and painting operations.

4.15.3.2 Surface Preparation of Wood

- a) Wood surfaces shall be sanded to a fresh surface. Surface mould where present, shall be removed by washing, rubbing down and burning off as necessary. Resinous exudation and large knots shall be removed and replaced with filler or other materials approved by the Engineer.
- b) Parts of timber to be enclosed in walls shall always be primed unless already impregnated. Priming shall be brushed on and a minimum of two coats applied to end grain. When the priming paint is hard, all cracks, holds, open joints, etc. shall be made good with hard stopping and rubbed down with fine abrasive paper. Priming of joinery shall be applied only on site after the Engineer has approved such joinery and before it is fixed. For internal surfaces primer coats shall be carefully flattened.

4.15.3.3 Surface Preparation of Concrete And Plaster

Concrete and cement plaster surfaces to be painted shall be prepared by removing efflorescence, dust, dirt, grease, oil, asphalt, tar, excessive mortar and mortar dropping and by roughening to remove glaze. A zinc sulfate solution shall be applied before prime coat.

4.15.3.4 Surface Preparation for Fiber Cement Surfaces

Shall be dry and clean prior to application of the specified first-coat material. Oil, grease, or rust stains shall be carefully removed by the use of suitable solvent. Wire

brushing will not be permitted. After the first coat has become dry and prior to application of finish coats, touch-up coats shall be applied to suction spots.

4.15.3.5 Additional Requirements for Preparation of Surfaces with Existing Coatings

- a) Before application of coatings, perform the following on surfaces covered by soundly-adhered coatings, defined as those which cannot be removed with a putty knife:
- b) Wipe previously painted surfaces to receive solvent-based coatings, except stucco and similarly rough surfaces clean with a clean, dry cloth saturated with mineral spirits, ASTM D 235. Allow surface to dry. Wiping shall immediately precede the application of the first coat of any coating, unless specified otherwise.
- c) Sand existing glossy surfaces to be painted to reduce gloss. Brush, and wipe clean with a damp cloth to remove dust.
- d) The requirements specified are minima. Comply also with the application instructions of the paint manufacturer.
- e) Previously painted surfaces, specified to be repainted or damaged during construction shall be thoroughly cleaned of all grease, dirt, dust or other foreign matter.
- f) Blistering, cracking, flaking and peeling or other deteriorated coatings shall be removed.
- g) Chalk shall be removed so that when tested in accordance with ASTM D 4214, the chalk resistance rating is no less than 8.
- h) Slick surfaces shall be roughened. Damaged areas such as, but not limited to, nail holes, cracks, chips, and spalls shall be repaired with suitable material to match adjacent undamaged areas.
- i) Edges of chipped paint shall be feather edged and sanded smooth.
- j) Rusty metal surfaces shall be cleaned as per SSPC requirements. Solvent, mechanical, or chemical cleaning methods shall be used to provide surfaces suitable for painting.
- k) New proposed coatings shall be compatible with existing coatings.

4.15.3.6 Existing Coated Surfaces with Minor Defects

Sand, spackle, and treat minor defects to render them smooth. Minor defects are defined as scratches, nicks, cracks, gouges, spalls, alligatoring, chalking, and irregularities due to partial peeling of previous coatings. Remove chalking by sanding so that when tested in accordance with ASTM D 4214.

4.15.3.7 Removal of Existing Coatings

- a) Remove existing coatings from the following surfaces:

- b) Surfaces containing large areas of minor defects;
- c) Surfaces containing more than 20 percent peeling area; and
- d) Surfaces designated by the Engineer, such as surfaces where rust shows through existing coatings.

4.15.3.8 Substrate Repair

- a) Repair substrate surface damaged during coating removal;
- b) Sand edges of adjacent soundly-adhered existing coatings so they are tapered as smooth as practical to areas involved with coating removal; and
- c) Clean and prime the substrate as specified.

4.15.3.9 Surface Preparation for Concrete And Masonry - For Old or Previously Painted Surfaces

- a) Scrape off loose, scaling and peeling old paints. Sand the whole surfaces including those where old paint still adheres very well.
- b) For areas with extreme chalking problems, steel brush, blow air from a compressor or wipe with a clean rag pre-wetted with water. Let dry, then apply one (1) coat of concrete scaler. Dry for at least 4 hours before applying subsequent coats.
- c) For areas affected by molds and mildew, wash the whole surface with water or with hypochlorite washing solution. Scrub using a stiff nylon brush, then rinse with water. Apply fungicidal washing compound. Leave overnight.
- d) For areas with mapping problems, properly prepare the surface then apply concrete sealer. Dry for at least 4 hours.
- e) Putty hairlines cracks.

4.15.3.10 Steel/Aluminum Doors and Windows

All metal surfaces shall undergo pre-treatment process which includes: desmutting, water-rinsing, degreasing/etching, water rinsing, zinc phosphating, water rinsing and acid rinsing.

Powder coating application, shall be factory applied and shall be done in one operation using an electro-static powder gun. The materials to be coated should be well connected to earth. Coating thickness should be kept to a minimum of 60 microns for exposed areas. On details which are to be treated mechanically after coating (drilling, sawing, etc.), the coating film must not exceed 100 microns.

The powder coating shall be oven cured in the range of 20 minutes at 220° Centigrade (metal temperature measured on the area with greatest metal thickness). The temperature variation in the oven should not exceed +/- 10° Centigrade.

Handling: Coated items should be cooled to no less than 40° Centigrade before handling. Precautions should be taken to avoid damages on the finished coating during stacking, storing and transportation.

Storage and Delivery: Inspect materials delivered to the site for damage. Unload and store with minimum handling. Provide storage space in dry location with adequate ventilation, free from dust or water and easily accessible for inspection and handling. Store materials neatly on the floor, properly stacked on non-absorptive strips or wood platforms. Protect finished surfaces during shipping and handling using manufacturer's standard method.

4.15.3.11 Mixing and Thinning

Mixing and thinning of paint shall be done in accordance with the approved manufacturer's printed instructions. The pot life of each paint as stated by the manufacturer shall not be exceeded.

4.15.3.12 Weather Condition

The paint shall not be applied when the relative humidity is above 85 percent. The paint shall not be applied in rain, wind, fog, dust or mist.

4.15.3.13 Application

Workmanship shall be first class in every respect. All work shall be done in a workmanship manner so that the finished surfaces shall be free from runs, chop, ridges, waves, laps and unnecessary brush marks. All coats shall be applied in such manner as to produce an even film of uniform thickness. Edges, corners, crevices, welds and rivets shall receive special attention to ensure that they receive an adequate thickness of paint.

All painting shall be done by thoroughly experienced workmen.

Safety regulations shall be adhered to at all times, including the wearing of respirators by persons engaged on assisting in spray painting. Adjacent areas and installation shall be protected by the use of cloths or other approved precautionary measures.

Plain enamel and varnish shall be applied carefully with good clean brushes or approved spraying equipment, except that the initial coat on any surface shall be applied with brush. Sufficient time shall be allowed between coats to assure thorough drying and each coat shall be in proper condition before receiving the next coat.

Sanding and dusting as required shall be performed between coats in varnishing work. Finish coat shall be smooth and free from runs, sags, and other defects. Exterior paint shall not be applied during rainy days.

All paint when applied shall provide a satisfactory film and smooth, even surface. Paint shall be thoroughly stirred and kept at a uniform consistency during application. Powdered metallic pigments added at the time of use shall be mixed by adding the powder in small increments to about one-third of the base paint or vehicle, with thorough mixing to obtain a smooth paste. The remainder of the base paint shall then be thoroughly stirred in.

Different brands of emulsion paints shall not be mixed prior to application of the materials.

Where necessary to suit conditions of surface temperature, weather and method of application, the package paint may be thinned immediately prior to application in accordance with the approved manufacturer's directions, but not in excess of 125 cc of suitable thinner per liter (one pint per gallon). Before using, the paint shall be mixed to a uniform consistency and shall be stirred frequently during application.

Paints other than water-thinned paints shall be applied only to surfaces which are completely free of moisture as determined by sight or touch and only such combinations of humidity to be painted as will cause evaporation rather than condensation.

Surfaces which have been cleaned, pretreated and/or otherwise been prepared for painting shall be primed or painted with one coat of finish paint as soon as practicable after such preparation has been completed, but in any event prior to any deterioration of the prepared surfaces.

The first coat of paint on all exterior surfaces shall be applied by brush. Interior prime coats and all other subsequent coats on either exterior or interior surfaces may be applied by brush or spray. Whenever spraying is permitted all areas inaccessible to spray painting shall be coated by brushing or other suitable means. Brushes to be used for application of water-emulsions shall be soaked in water for a period of 2 hours prior to use.

All cloths and cotton waste which might constitute a fire hazard shall be placed in closed metal containers or destroyed at the end of each day.

Upon completion of the work, all staging, scaffolding, and containers shall be removed from the site or destroyed in a manner approved by the Engineer. Paint spots, or stains upon adjacent surfaces shall be removed and the entire job left clean and acceptable to the Engineer.

No smoking shall be permitted in the vicinity where painting is going on.

4.15.3.14 Touch-Up Painting

Touch-up painting shall be done with the same paint as used for the original coat. The resulting minimum dry film shall be the same as for the original coat.

Touch-up painting shall include cleaning and painting of field connections, welds and all damaged or defective paint and rusted areas.

During touch-up painting, only loose, cracked, brittle or non-adherent paint shall be removed during cleaning. All exposed edges shall be feathered. Touch-up painting shall be performed in a manner which will minimize damage to sound paint. Rust spots shall be thoroughly cleaned and edges of the existing paint shall be scraped back to sound material.

4.15.3.15 Drying

- a) No primer or paint shall be forced to be dried under conditions which will cause cracking, wrinkling, blistering, formation of pores which would detrimentally affect the condition of the paint.
- b) No drier shall be added to the paint unless specified in the approved manufacturer's instructions.
- c) Painted surfaces shall be protected from dust, dirt, and the elements of the weather until dry to the fullest extent practicable.
- d) After drying, any areas of paint damaged from any cause shall be removed, the surface again prepared and then touched-up with the same paint and to the same thickness as the undamaged areas as specified in sub-section 4.15.3.7 above.

4.15.3.16 Handling

- a) Precautions shall be taken to minimize damage to paint films resulting from stacking for drying.
- b) Paint which is damaged in handling shall be scraped off and touched-up with the same paint and in the same thickness as was previously applied to the damaged area at Contractor's expense.

4.15.3.17 Inspection

- a) All works and materials supplied under this Specification shall be subject to inspection by the Engineer.
- b) The Contractor shall correct such works or replace such materials found defective under these Specifications at his own expense.

4.16 SPECIAL COATINGS TANK LINING – FOOD GRADE

4.16.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.16.1.1 Scope of Work

This specification covers the furnishing and supply of materials including equipment and performing labor necessary to complete the installation of food grade tank lining as shown on plans and as specified herein.

4.16.2 MATERIALS

Materials shall conform to the respective specification and standards and to the requirements specified herein.

- a) Food grade internal tank lining, coating shall be applied and coat with three (3) coats of grade high solid epoxy coating with polyester cloth mesh reinforcement and shall be used as follows:

- 1) Primer

- The primer shall be of food grade type and high solid. The volume solids shall be 100% and solvent free epoxy. It shall be applied on one (1) full coat with a dry film (DFT) of 8-10 mils. (200-850 microns). Apply the polyester cloth mesh reinforcement.

- 2) Topcoat

- The topcoat shall be of food grade type, high build and gloss finish. The volume solids shall be 100% and solvent free epoxy. It shall be applied in two (2) full coats with a total dry film thickness (DFT) of 16-20 mils (400-500 microns).

4.16.3 EXECUTION

- a) Surface Preparation

- Cement bound surfaces must be dry, firm, offer good traction, free from grout, dust, dirt and additionally free of oil, grease and other impurities which can adversely affect uniform adhesion. If considered necessary, the surface should be sand blasted, milled or grinded.

- b) Adjusting, Cleaning and Protection

- 1) Upon completion of the work, repair surface that have been permanently stained, marred, or otherwise damage. Replace work which is damage or cannot be adequately cleaned as directed.
 - 2) Upon completion of the work, removed unused materials, debris, containers and equipment from the site. In addition to the initial cleaning procedure required, clean the work before acceptance by the Owner.
 - 3) Protect the work during the construction period so that it will be without any indication of use or damage at the time of acceptance.
 - 4) Until the applied tank lining is fully cured and protected with a temporary protection during the construction period keep the coating areas free from traffic and other trades. Contractor shall provide necessary temporary protection to prevent damage such as caused by traffic, gouging, scraping, and spillage of deleterious substances, excessive heat, or other matter.

4.17 EPOXY COATING

4.17.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these Specifications; and apply to this section, whether or not referred to herein.

4.17.1.1 Scope of Work

This specification covers the furnishing of materials including equipment and performing labor necessary to complete the installation of epoxy flooring as shown on the drawings and as specified herein.

4.17.1.2 Quality Assurance

a) Single Source Responsibility

Obtain primary chemical-resistant seamless, epoxy coating materials including primers, resins, hardening agents, finish or sealing coats from a single manufacturer with not less than 3 years of successful experience in supplying principal materials for work of type described in this section. Provide secondary materials only of type and from source recommended by manufacturer of primary materials.

b) Prime Coat

Apply primer over prepared substrate at manufacturer's recommended spreading rate. Coordinate timing of primer application with application of topping mix to insure optimum adhesion between chemical-resistant epoxy coating materials and substrate.

c) Finish or Sealing Coat

After topping mix has cured sufficiently, apply finish or sealing coat of type required by the manufacturer to produce required finish indicated and in number of coats and spreading rates recommended by manufacturer.

4.17.2 MATERIALS

Epoxy coating shall conform to the respective specification and standards and to the requirements specified herein.

a) Epoxy coating shall be two component epoxy resins and polyamide curing agent and shall be used as follows:

b) Epoxy coating shall be solvent-free two components colored epoxy for self-smoothing screeds.

1) Self-smoothing floor: (2-3mm layer thickness)

- Primer
- Self-smoothing floor

Color and texture shall be as approved by the Architect / Engineer and Owner.

4.17.3 EXECUTION

a) Installation

Comply with epoxy coating manufacturer's written instructions for installation of epoxy coating system, including surface preparation, joint treatment, flashing, reinforcement, accessory items and surfacing. Apply materials by methods as instructed by epoxy manufacturer to provide uniform thickness.

1) Coordination

Proceed with epoxy work only after substrate construction, including curbs; spill dams and equipment pads, and penetrating work through substrate have been completed. No phased construction will be permitted.

b) Adjusting, Cleaning and Protection

1) Upon completion of the work, repair surfaces that have been permanently stained, marred, or otherwise damaged. Replace work that is damaged or cannot be adequately cleaned as directed.

2) Upon completion of the work, remove unused materials, debris, containers and equipment from the project site. In addition to the initial cleaning procedure required, clean the work before acceptance by the Owner.

3) Protect the work during the construction period so that it will be without any indication of use or damage at the time of acceptance.

(a) Until the epoxy coating is fully cured and protected with a temporary covering during the construction period, keep the coating areas free from traffic and other trades. Construction Manager shall provide necessary temporary protection to prevent damage, such as caused by traffic, gouging, scraping, spillage of deleterious substances, excessive heat, or other manner.

4.18 PLUMBING AND SANITARY WORKS

4.18.1 SCOPE OF WORK

The work covered for this section shall consist of furnishing all labor, tools, equipment, materials and incidentals necessary for the complete installation, testing and operation of the plumbing and sanitary system within the buildings and premises in accordance with these Specifications and as shown on the drawings or as directed by the Engineer. The septic tank and their effluent and discharge pipelines shall be part of other section of these specifications.

4.18.2 MATERIAL REQUIREMENTS

4.18.2.1 Submittal

- a) The Contractor shall submit his work method statement with necessary shop drawings to the Engineer for approval twenty eight (28) days before the start of the works.

Shop drawings shall be dated and shall contain the name of the project and location of the subject item in the shop drawing which is to be installed.

The Engineer will review and approve or return for correction all shop drawings with reasonable promptness. The Contractor shall make any corrections required and file with the Engineer three (3) corrected copies of the shop drawings.

- b) The drawings shall indicate the general arrangement of all pipings, however, where actual conditions necessitate re-arrangement in opinion of the Contractor and/or the Engineer, the Contractor shall prepare and submit to the Engineer for approval, twenty eight (28) days before placing the order for materials, shop drawings of the proposed re-arrangement. Because of the small scale of the drawings, shop drawings to indicate all offsets, fittings and accessories shall be prepared. The Contractor shall carefully examine the drawings and shall carefully investigate actual structural and finish conditions affecting all his work.
- c) The Contractor shall be responsible for the proper fitting of materials, equipment and accessories without substantial alteration and at no cost to the Employer.
- d) The Contractor shall be responsible for the proper coordination of the work and shall provide all necessary clearance where necessary.

4.18.2.2 Standards

Use of materials shall further be governed by other requirement imposed on other sections of these Specifications. Materials shall be subject to tests necessary to ascertain their fitness if the Engineer so requires. All works shall comply with the pertinent provisions of the Plumbing Code of the concerned city or town, the Code on Sanitation of the Philippines, and/or the National Plumbing Code of the Philippines.

4.18.2.3 Materials

- a) Identification of Materials

Each length of pipe, fittings, traps, fixtures and devices used in the plumbing work shall have cast, stamped or indelibly marked on it, the approved manufacturer's trademark or name, the weight, type and class of product when so required by the standards mentioned above.

b) Alternative Materials

Use of any material not specified in this Specification may be allowed provided such alternate has been approved by the Engineer and provided further that a test, if required, shall be done by an approved agency in accordance with generally accepted standards.

c) Soil, Waste, Drain, Vent Pipes and Fittings

Soil, waste and vent pipes shall be unplasticized Polyvinyl Chloride (uPVC) pipes. Diameter shall be as indicated on the Drawings. It shall conform to ASTM D 1784 or ASTM D 2729.

Drainage Pipes shall be reinforced concrete pipe (300 mm diameter and larger) and polyvinyl chloride (PVC) pipes (250 mm diameter and smaller) conforming to ASTM C76-85 Class II and ASTM D1784, respectively.

d) Jointing Material

The joint material for uPVC pipes shall be PVC solvent cement as recommended by the approved pipe manufacturer.

e) Water Supply Pipes

1) Galvanized Iron (G.I.) Pipe and Fittings

ASTM A-120/A-53 Schedule 40 G.I. Pipes and Accessories (elbow, union, nipple, etc.). Fittings shall be malleable iron, class 150, used screwed connection from 12mm dia. to 65 mm dia. and flanged connection from 75mm dia. and larger. Apply seal tape, or paint with red oxide paint at all joint lengths. When buried underground, the GI pipe shall be coated with coal tar and wrapped with burlap for corrosion protection.

(a) Polypropylene (PP-R) Pipe and Fittings

Polypropylene (PP-R) Random (Type 3) pipe and fittings PN 20, high resistance to pressure and temperature, conforming to DIN specifications DIN 8077 and DIN 8078 or ASTM 2389, forming polyfusion homogeneous joint. All threaded inserts should be made of nickel-plated brass conforming to DIN 2999.

(b) High Density Polyethylene (HDPE) Pipes and Fittings (for Market Building)

High Density Polyethylene (HDPE) Water Pipes and Fittings shall conform to PNS ISO 4427:2002, PE 100, SDR 17 (PN 10) with socket fusion joint.

2) Sea Water Piping (for Market Hall)

(a) High Density Polyethylene (HDPE) Pipes and Fittings (for Market Building only)

- (b) High Density Polyethylene (HDPE) Water Pipes and Fittings shall conform to PNS ISO 4427:2002, PE 100, SDR 17 (PN 10) with socket fusion joint.

- f) Cleanouts, Plugs and Tee

Cleanouts shall be of the same material as the pipe to be fitted. Cleanouts installed in connection with uPVC hubs and spigot pipes shall consist of a long sweep quarter bend of $\frac{1}{4}$ as shown on the drawings.

- g) Pipe Sleeves

Pipe sleeves shall be installed and properly secured in place at all points where pipes pass through masonry or concrete. Pipe sleeves shall be uPVC pipe, Schedule 40.

- h) Downspout

All downspout shall be unplasticized polyvinyl chloride (uPVC) pipe class DWV conforming to ASTM D2729 or ASTM D1784 for sanitary pipes, Series 1000.

- i) Splash Block

Provide splash blocks at the outlet of downspout emptying at grade which shall be made of pre-cast concrete, with smooth finished counter sunk dishes sloped to drain away from the building. Dimensions as shown on the Drawings.

- j) Roof Strainers

Provide basket strainers in brass or in $\frac{1}{8}$ diameter stainless steel wires construction on slotted holes on brass or stainless steel Ga. # 12 ring with secondary strainer to ensure continuous flow of water.

- k) Roof Drains

ANSI A112.21.2M; provide hot-dip galvanized cast-iron or ductile-iron drains, with minimum of 250 mm diameter body, non-puncturing flashing clamp device with integral gravel stop and deck clamp, and removable cast-iron or ductile-iron or polypropylene locking dome. Free area of dome shall be not less than two times the free area of drain outlet. Provide drain flashing ring seat flush with adjacent roof deck, and secure rigidly in place with deck clamp.

- l) Shower, Floor and Urinal Drain

Shower and floor drains shall be made of stainless steel non-tilting grate, perforated or slotted. Urinal drains shall be cast iron dome type drain.

- m) Pipe hangers, Inserts and Support

- 1) Pipe hangers shall be wrought iron, malleable iron pipe hangers spaced not over 1.5meters apart for uPVC pipes and 3.0meters apart for iron pipes. Chain straps, perforated bars or wire hangers will not be permitted.

- 2) Hangers shall have short turnbuckles or other approved means of adjustment. Turnbuckles may be omitted on hangers where space does not permit their use. Trapeze hangers may be used in lieu of separate hangers for pipes running parallel to each other and close together.
- 3) Inserts shall be of cast iron or cast steel and shall be of a type to receive a machine bolt head or nut after installation.
- 4) Wrought iron clamps or collars shall be used to support vertical runs of pipes.

n) Unions

Union pipe 50 mm in diameter and smaller shall be malleable iron. Union on water piping 63mm in diameter and larger shall be flanged pattern and shall be of galvanized (zinc coated) cast iron. Gaskets for flange unions shall be of best quality fiber plastic or leather.

o) Valves

Valves shall be cast bronze or brass body. Chrome plated finish for all fixture taps and faucets and natural finish for all others, like hose bibbs, gate valves and which are not tapped directly to a plumbing fixture. Concrete valve boxes shall be installed where required and will be of sufficient size for operating the valve.

p) Septic Tank

The Septic tank shall be provided as shown on the plans and shall be 21 MPa (211 kg/cm²) reinforced concrete with all pipe vents and fittings. Inlet and outlet pipes shall conform to the latest edition of the National Plumbing Code.

q) Plumbing Fixtures and Accessories

Materials and schedule of plumbing fixtures, fittings and accessories shall be as specified by the Architectural Specifications.

r) Concrete, Reinforcing Steel, Pipe and Steel Plate

Materials for wash pits, catch basins and manholes shall conform to the requirements as follows:

- 1) Concrete materials shall conform with the requirements of Section 3.2, "Concrete Works" and shall be Class C concrete with a 28-day minimum compressive strength of 20.7 MPa (3,000 psi).
- 2) Reinforcing steel shall be as shown on the drawings and shall conform with the requirements of reinforcing steel bars in Section 3.2, "Concrete Works."
- 3) Pipes shall be as shown on the drawings and shall comply with the relevant item of the particular pipe.

- 4) Steel plates shall be as shown on the Drawings and shall comply with Section 4.7, "Steel and Metal Works".

s) Non-reinforced Concrete Pipe

Non-reinforced concrete pipe shall be as shown on the Drawings and shall conform with the requirements of non-reinforced concrete pipes AIC latest edition. Concrete shall be with a 28-day minimum compressive strength of 20.7 MPa.

4.18.3 EXECUTION

All installation works shall be in conformity with the National Plumbing Code of the Philippines (NPCP).

4.18.3.1 Excavation, Trenches and Backfilling

- a) Trenches for all underground pipelines shall be excavated to the required depth. The bottom of trenches shall be tamped hard and graded to secure the required fill. Bell holes shall be excavated so that pipes will rest on solid ground for their entire length.

Rocks where encountered, shall be excavated to a depth of 150 mm below the bottom of the pipe and before the pipe is laid, the space between the bottom of the pipe and the rock shall be filled with sand. Sewer and water pipes shall be laid in separate trenches.

- b) After pipelines have been tested, inspected and approved by the Engineer and prior to backfilling, all forms shall be removed and the excavation shall be cleaned of all trash and debris.

Materials for backfilling shall consist of acceptable excavated soil, borrow of sand, gravel or other materials approved by the Engineer and shall be free from trash, lumber or other debris. Backfilling shall be placed in horizontal layers not exceeding 150 mm in thickness and properly moistened to approximate optimum requirements. Each layer shall be compacted by hand or machine tamper or by other suitable equipment to a density that will prevent excessive settlement or shrinkage.

Backfilling shall be brought to a suitable elevation above grade to provide for anticipated settlement and shrinkage thereof.

Water pipes shall have a sand cushion 150 mm below and above the pipes.

4.18.3.2 Installation of Soil, Waste Drains or Vent Pipes

- a) Horizontal Drainage Pipe and Vent Piping

Horizontal waste pipes 75 mm in diameter and smaller shall have a minimum grade of 6.5 mm per 0.30 m and for 100 mm diameter and larger, 3.2 mm per 0.30 m. All main vertical soil and waste stacks shall be extended full size above the roof line as vents, except where otherwise specifically shown.

Where practicable, two (2) or more vent pipes shall be connected together and extended as one pipe through the roof. Vent pipes in roof spaces shall be run as close as possible to the underside of roof with horizontal piping pitched to stacks using fittings as required without forming traps in pipes.

Vertical pipe vents may be connected to a vent line carrying other fixtures. The connection shall be at least 1.20 m above the floor on which the fixtures are located to prevent the use of vent lines as waste. Horizontal waste lines receiving the discharge from two (2) or more fixtures shall be provided with vents, unless separate venting of fixtures is noted.

b) Fittings

All changes in pipe sizes on soil waste lines shall be made with reducing fittings or recessed reducers. All changes in direction shall be made by the appropriate use of forty five (45) degree wyes. Long sweep quarter bends or elbows may be used in soil and waste lines where the change in direction of flow is from the horizontal to the vertical and on the discharge from water closets.

Where it becomes necessary to use short radius fittings in any location, the approval of the Engineer shall be obtained before they are installed.

c) Joints

1) PVC Soil Pipe

All joints in uPVC soils, waste and vent pipe shall be accomplished by the use of PVC solvent cement.

2) All joints for uPVC shall be accomplished by applying the manufacturer's recommended solvent before connection to the pipe.

d) Cleanouts

Cleanouts at the bottom of each soil stack, waste stack and where else indicated shall be the same size at the pipe.

Cleanouts on floors shall be by uPVC plug adapter fit into the hub and fitted with uPVC screw plugged flush with the floor.

Cleanout shall be provided at every change in direction greater than 45 degrees.

e) Flashings

All pipes passing through the roof shall be provided with lead flashings. All flashings shall be built to 40 lbs. bituminous felts and shall extend up to the pipe and down-over to top of pipe at least 150 mm and along the roof not less than 300 mm and shall lap over flashing to make a weatherproof joint.

f) Traps

Each fixture and piece of equipment requiring connections to the drainage system, except fixtures with continuous waste shall be equipped with a trap. Traps shall be specified to be supplied with the fixtures. Each trap shall be placed as near to the fixtures as possible. Traps installed on threaded pipes shall be recessed drainage pattern.

g) Pipe Sleeves, Hangers and Supports

Pipe sleeves shall be installed and properly secured in place at all points where pipes pass through masonry or concrete except unframed floors on earth.

Pipes shall not be permitted to pass through footings or beams unless noted on the drawings.

Pipe sleeves in floors shall extend not less than 25 mm and not more than 50 mm above the finished floor. After installation of the pipe, the space around the pipe shall be packed with plastic material and made watertight. Flashing shields for sleeves passing through waterproofing membrane shall be thoroughly mopped into the membrane. The space between the pipe and sleeves shall be made watertight by inserting approved sealing and caulking materials.

4.18.3.3 Installation of Water Pipes, Fittings and Connections

a) Gate Valves and Outlets

Gate valves shall be installed close to the point of connection to the existing service line outside the building. The piping shall be extended to all fixture outlets and equipment from the gate valves. Outlets where indicated shall be capped or plugged and left ready for future connections.

b) Mains, Branches and Runouts

All runs of piping shall be installed as shown on the drawings. The piping shall be cut accurately to measurements, and installed at the building site by the Contractor and shall be worked into place without springing or forcing. Care shall be taken not to weaken the structural portions of the buildings.

All pipes above ground shall be run parallel with the lines of the building unless otherwise shown on the drawings. Branch pipes from service lines may be taken off on top of mains, bottom of mains or side of mains, using such cross over fittings as may be required by structural or installation conditions.

All service pipes, valves and fittings shall be kept at sufficient distance from the other work to permit finished covering not less than 6.5 mm from such other work and not less than 13 mm between finished covering on different services. No water piping shall be buried in floors unless specifically indicated on the drawings or approved. Changes in pipe sizes shall be made with reducing fittings.

The use of long screws and bushings is prohibited.

c) Joints

- 1) Polypropylene - socket fusion and brass fittings and joints shall be used.
- 2) Polyethylene - socket fusion and butt fusion joints.
- 3) G.I. Pipes and Fittings - Carefully reamed threaded joints. Apply seal tape, or paint with red lead paint at all joints lengths. Screwed connection from 12mm dia. to 65 mm dia. and flanged connection from 75mm dia. and larger.
- 4) Dissimilar Pipes - Adaptor fittings shall be used.

d) Unions

Where required unions shall not be concealed in walls, ceilings or partitions.

e) Tests

The following tests shall be conducted by the Contractor at his expense under the supervision of the Engineer.

1) Tests for Drainage and Venting System

The entire drainage and venting system shall have necessary openings plugged to permit the entire system to be filled with water to the level of the highest vent stack above the roof. The system shall hold the water for 30 minutes with a drop not greater than 100 mm.

2) Disinfection of Water Distribution System and Water Tank

- (a) The entire water system shall be thoroughly flushed and disinfected with chlorine before it is placed on operation. Water tank shall be washed and swabbed.
- (b) Chlorination materials shall be liquid chlorine or hypochlorite, as specified and shall be introduced into the water lines in a manner approved by the Engineer. The tank shall be thoroughly cleaned of all debris, dirt or dust before swabbing.
- (c) The chlorine dosage shall be such as to provide not less than fifty parts per million (50 ppm) available chlorine.
- (d) Following a contact period of not less than sixteen (16) hours, the heavily chlorinated water shall be flushed from the system with clean water until the residual chlorine content is not greater than two tenth parts per million (0.20 ppm). All valves in water lines being sterilized shall be opened and closed several times during the 16-hour chlorinating period.

3) Pressure Test for Water Lines

- (a) After the pipe have been installed, the joints completed and with joints exposed for examination, all newly installed pipe or any valve section, thereof, shall be subjected to hydrostatic pressure one and one half (1½) the designed working pressure of the system or as specified by the Engineer.
- (b) The duration of each pressure test shall be at least 20 minutes unless otherwise specified by the Engineer.
- (c) Each section of pipeline shall be slowly filled with water and the specified test pressure, measured at the point of lowest elevation, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer. During the filling of the pipe and before applying the test pressure, all air shall be expelled from the pipeline. To accomplish this, tap shall be made if necessary, at the highest point of the pipe under test and after completion of the test, the taps shall be tightly plugged unless otherwise specified. During the test, all exposed pipes, fittings, valves, joint and couplings will be carefully examined. If found to be cracked or defective, they shall be removed and replaced by the Contractor with sound materials at his expense. The test shall then be repeated until satisfactory results are obtained.

4) Leakage Test for Water Lines

- (a) Leakage test shall be conducted after satisfactory completion of the pressure test and shall consist of an examination of all exposed joints for leakage as well as an overall leakage test of the completed pipeline.
- (b) The pressure to be maintained during the test shall be the designed working pressure of the system.
- (c) Leakage test shall be made only after a minimum of 24 hours after the pipe to be tested has been filled with water.
- (d) The duration of each leakage test shall be two hours unless otherwise specified by the Engineer.
- (e) Each section of pipeline shall be slowly filled with water and the specified test pressure, measured at the point of lowest elevation shall be applied by means of a positive displacement type pump and reservoir connected to the pipe in a manner satisfactory to the Engineer.
- (f) Before starting the leakage test, all air shall be expelled from the pipe. All exposed pipes, fittings, valves and joints shall be examined for leakage during the test.
- (g) Allowable leakage rate per 100 joints per inch of Pipe Diameter at Pressure Stipulated.

PRESSURE		LEAKAGE RATE	
psi	kg/cm ²	liters/hr	liters/2 hrs
50	3.5	1.45	2.90
75	5.3	1.75	3.50
100	7.0	2.05	4.10
125	8.8	2.30	4.60
150	10.5	2.50	5.00
200	14.0	2.90	5.80

5) Defective Work

- (a) If the inspection or test shows any defect, such defective work or material shall be replaced and the test shall be repeated until satisfactory to the Engineer.
- (b) All repairs to piping shall be made with new materials at the expense of the Contractor.
- (c) No caulking of screwed joints or holes will be accepted.

4.18.3.4 Assembly, Installation and Connection of Fixtures

Fixtures shall be supported and fastened in a satisfactory manner. Where secured to concrete or masonry work walls, fixtures and equipment shall be fastened with brass bolts or machine screws in lead-sleeve type anchorage units or with brass expansion bolts. Expansion bolts shall enter 7.5 cm into solid concrete or masonry works and shall be fitted with loose tubing or sleeves of proper length to bring expansion sleeves into the solid concrete masonry walls.

Where wood screws are used, screws shall go into solid pieces set between studs. Where through-bolts are used, bolts shall be provided with plates or washers at back set, so that they will be concealed by plaster. Bolts and nuts shall be hexagonal and exposed nuts, cap nuts, and screw heads shall be provided with chromium plated brass washers.

4.18.3.5 Protection of Fixtures

Pipe openings shall be closed with caps or plugs during installation. Fixtures shall be tightly covered and protected against dirt, water and chemical injury. At the completion of all works, all fixtures shall be thoroughly cleaned and delivered in a condition satisfactory to the Engineer.

4.18.3.6 Fixtures and Fastening

All fixtures shall be supported and fastened in a satisfactory manner as follows:

- a) Where secured to concrete or concrete hollow block walls, they shall be fastened with one quarter inch brass bolts with twenty threads to the inch and of sufficient length to extend at least 7.5 cm into solid concrete or hollow block work, fitted with loose tubing or sleeve insert and shall be securely anchored

and installed flush with the finished wall and shall be completely concealed when the fixtures are installed.

- b) Where through-bolts are used, they shall be provided with plates or washers back set so that heads, nuts and washers will be concealed by plaster. Bolts and nuts shall be hexagonal. Exposed bolts, nuts, capnuts and screw heads shall be provided with chromium plated brass washers.

4.18.3.7 Guarantee

Upon completion and before final acceptance of the equipment installation, the Contractor shall furnish the Engineer a written guarantee stating that all equipment installed under this Section free from defects. The guarantee shall be for a period of one (1) year from the date of final acceptance of the work. Any part of the equipment that becomes defective during the term of the guarantee shall be replaced, renewed and/or made good by the Contractor, at his own expense and in a manner satisfactory to the Engineer.

Guarantees made by the approved manufacturers or suppliers beyond one year, shall be transferred to PFDA without any expense on his part.

4.18.3.8 As-Built Drawings

Upon completion of and before final acceptance of the work, the Contractor shall prepare, at his own expense, and submit to the Engineer as-built drawings showing conditions of the work actually performed.

Where as-built drawings are required for a submission to enforcing authorities, same shall be submitted first to the Engineer for verification and checking. One (1) set of the drawings duly approved by the proper enforcing authorities shall be submitted to the Engineer together with the reproducible originals.

4.18.3.9 Cleaning Up

- a) All exposed metal surfaces shall be free of grease, dirt of other foreign materials.
- b) All plumbing fixtures shall be properly protected from use and damage during the construction stage. The fixtures shall be cleaned to the satisfaction of the Engineer upon completion and prior to acceptance of work.
- c) All equipment, pipes, valves and fittings shall be cleaned of grease and sludge which may have accumulated. Any clogging, discoloration or damage to other parts of the building due to the system shall be repaired by the Contractor.

4.18.3.10 Plumbing, Fixtures and Toilet Accessories Installation

All installation works shall be as shown on the drawings and shall conform to the applicable standards set forth by the Philippine National Plumbing Code. All fixtures shall be fastened and/or supported in accordance with the given requirements.

4.19 SIGNAGES

4.19.1 GENERAL

4.19.1.1 Scope of Work

Furnish materials and perform labor to include miscellaneous works required for the installation of room identification for the toilets.

4.19.1.2 Sample and Shop Drawings

The Contractor shall submit samples for approval by the Engineer. For the room I.D. full size lettering layout and installation method shall be submitted to the Engineer for approval before start of work.

4.19.2 MATERIAL REQUIREMENTS

Room Markers: Black acrylic letters, 38 mm (1-1/2") high on white acrylic background, 63 mm (2-1/2") high, with clear acrylic cover. Lengths shall be as required by the full notation therein.

4.19.3 EXECUTION

4.19.3.1 Workmanship

Workmanship shall be executed in high quality comparable with artworks.

4.19.3.2 Mounting

For all mounted assemblies, appropriate mounting hardware and connectors which are concealed shall be sufficiently used.

Assemblies shall be mounted plumb, straight, level, and at prescribed heights.

4.19.3.3 Installation

Installation shall be done in a secure and permanent manner at prescribed heights and/or layout. The backwall shall not be mutilated. After the dowels are positioned, fill with expanding grout, or other approved fillers, and retouch, flashed to the backwall surface.

4.20 FACILITIES AND DEVICE FOR DISABLED PERSONS

4.20.1 GENERAL

4.20.1.1 Scope of Work

The work shall consists of furnishing materials, tools, labor and incidentals necessary for the construction/installation of facilities and device for disabled persons as shown on the Drawings and in accordance with the Implementing Rules and Regulations of Batas Pambansa Bilang 344 and this Specification.

4.20.2 MATERIAL REQUIREMENTS

4.20.2.1 Graphic Signs

Graphic signs like the International Symbol of Access shall be fabricated from plastic materials, white color with either dark blue background. Letters and symbols shall be laminated and raised from the background.

4.20.2.2 Handrails

Handrail for ramp shall be 50mm diameter tubular stainless steel 316. It shall be provided with a small hole as of a Braille system.

4.20.2.3 Concrete Materials for Ramps

- a) Portland cement shall conform with the requirement of Section 3.2, "Concrete Works"
- b) Aggregates shall conform with the requirements of Section 3.2, "Concrete Works".
- c) Temperature bars shall have diameter of 10mm conforming with the requirements of Section 3.2, "Concrete Works".
- d) Non-skid tiles shall conform to Section 4.14 of these Specifications.

4.20.3 EXECUTION

4.20.3.1 Graphic Signs

- a) Directional and information signs, indicating the location of the ramp for physically handicapped persons, shall be installed/placed at the front of the main entrance of the Terminal Building. The signed board shall be 300mm x 300mm mounted on a 50mm Ø, schedule 40, signpost and the text and arrow shall be in accordance with the International Symbol of Access "B".
- b) Signs shall be placed at the entrance and exits of the ramps and toilets, installed at conspicuous locations. The signboards shall be 150mm x 150mm and the text shall be in accordance with the International Symbol of Access "A".

4.20.3.2 Ramp

The ramp shall be constructed as shown on the Drawings and with a non-skid surface.

4.20.3.3 Railing

Lavatories, urinals and water closets where indicated on the Drawings shall be provided with railings. The position and distance from the floor shall be as shown on the Drawings.

4.21 PLUMBING FIXTURES AND ACCESSORIES

4.21.1 GENERAL

Division 1, "General Requirements," contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

4.21.1.1 Scope of Work

- a) Furnish materials and equipment and perform labor required to complete toilet and bath accessories.
- b) See drawings and details for sizes, location, extent and other requirements.

4.21.1.2 Samples

Submit catalog cuts and color samples for approval of the Architect.

4.21.1.3 Delivery and Storage

Schedule delivery of materials such that it is near time of installation. Materials shall be protected against damage during delivery and storage at the site. Toilet and bath accessories shall be delivered in their original containers bearing manufacturer's name and brand.

4.21.1.4 Contractor's Responsibility

The Contractor shall be responsible for providing those portions of the fixtures fittings (as trims) which are not provided with the fixtures but are required for the complete installation. All fixtures shall be carefully checked to determine the portions which must be provided to complete the installation.

4.21.2 MATERIAL REQUIREMENTS

Refer to the drawings.

Note: Color, type and model as selected by the Engineer.

4.21.3 INSTALLATION

- a) Install toilet and bath accessories on the locations and heights indicated on the drawings and according to manufacturer's recommended instructions
- b) Surfaces/areas damaged during the installation of toilet and bath accessories shall be repaired/rectified.

4.22 OUTDOOR LED DISPLAY UNIT (FIXED TYPE)

4.22.1 MATERIAL

Provide outdoor video display unit, fixed type with the following requirements:

Feature	Requirements
Video Display:	
Pixel Pitch (mm)	5.21
Module Resolution	48x96 = 4608dots
Module Dimension	250mmx500mmx26
Panel Dimension (LxWxH) (mm)	500x100x90
Panel Material	Aviation Aluminum
Panel Weight (kg/panel)	13.8
Brightness (nit)	≥ 5000
Contract ratio	3000:1
Viewing Angle (H/V)	120/120
LED lifetime	≥ 100,000 Hours
Digital Signage Player	
	Equipped with 2 HDMI & 1 VGA outputs for 2 concurrent displays
	Provide 3 playback modes to show zone-type displays, individual programs, or playlists
	Support 4K UHD video, Flash®, HTML5, CSS3, weather, social media, etc.
	Unlimited Video zones, Image zones, and Ticker zones
	Support 4 signal output modes: Single, Clone, Extended, Distinct Modes
	Offer flexible task scheduling based on once, daily, weekly, monthly, or yearly timescales
	Allow self-designed template creation either directly on SMP player or on your PC
	Make rich Library and cloud resources freely available
	Support 2 LAN ports for advanced management & network security
PC Set with LED Software	
Power Distribution Box	

Complimentary Parts	Spare Framing	
Structured (Stand Alone)		I Beam, Tubular and Angle Bars
Includes also the following:		
		Installation and Configuration
		Free training (Operation and Maintenance)
		Warranty for LDE Display : 2 years and Digital Signage Player : 1 year

4.22.2 INSTALLATION

- a) Install in accordance with manufacturer's instructions.
- b) Where visual display boards must be partly assembled at project site, use factory-supplied H-bar to maintain proper alignment.
- c) Install visual display unit level and plumb, keeping perimeter trim aligned in accordance with manufacturer's recommendations.

DIVISION 5

ROADS & PAVEMENTS

DIVISION 5 ROADS AND PAVEMENTS

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5.1 SURVEY AND LAYOUT

5.1.1 GENERAL

- a) Division 1, "General Requirements" of these Specifications and shall apply to this Section whether herein referred to or not.
- b) Applicable requirements under Section 2.2, "Surveys, Soundings, Soil Investigations and Installation of Markers" and Section 4.1 "Survey and Layout" for building works shall apply to this section.

5.1.2 SCOPE OF WORK

This Section covers survey and layout work.

5.1.3 SURVEY AND SETTING OUT OF WORKS

- a) The Contractor shall carry out the survey by means of transversing and leveling connected to the approved established reference points.
- b) The stations shall be established in accordance with Sub-section 2.2.5.
- c) The Contractor shall establish at least three (3) permanent monuments and three (3) benchmarks in the port area on locations approved by the Engineer that can serve conveniently as reference points of future construction.

5.2 CONCRETE WORKS FOR ROADS AND PAVEMENTS

5.2.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.2.2 SCOPE OF WORK

- a) This Section includes all cast in-situ concrete under roads and pavement work.
- b) Applicable provisions and requirements under Section 3.2 "Concrete Works" shall apply to this Section.

5.2.3 CLASSES OF CONCRETE AND USAGE

- a) Strength Requirements

Classes of Concrete shall conform with the applicable requirements in Sub-section 3.2.7.a).

- b) Usage: The classes of concrete to be used shall be as follows:

- 1) Class B2 Concrete : For Road Improvement
- 2) Class C Concrete : For Road/ Pavement Utility RC works
- 3) Class D Concrete : Leveling concrete

5.3 DEMOLITION/BREAKING OF EXISTING PAVEMENT AND DISPOSAL OF MATERIALS

5.3.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.3.1.1 Description

This work shall consist of the breaking of existing pavement and disposal of unsuitable or excess materials including the removal of all superficial obstructions on the site in the way of or otherwise affected by the works as shown on the drawings. The Contractor shall clear each part of the site at times and to the extent required or approved by the Engineer.

The Contractor shall submit his proposed method of breaking of existing pavement and disposal of materials including materials, equipment, and all related works for the approval of the Engineer.

5.3.2 DEMOLITION AND CLEARING

a) Demolition

Where shown on the drawings or directed by the Engineer, dilapidated pavement and structures, or part of structures, masonry, and like material within the roadway and sidewalk shall be demolished by the Contractor. Where only a part of a structure has to be demolished, the Contractor shall take all possible care to ensure that only such part is demolished and shall make good at his own expense any damage beyond that part. During demolition, the Contractor shall take every precaution to protect the unaffected roadway, structure, embankment and all other existing works from damage and likewise ensure the safety of his workmen and the general public.

When the area on which an embankment is to be placed has been cleared, the Engineer may order the surface of the existing ground to be scarified so that the filling material will bind into the original ground. The cost of such work, if so required, shall be included in other items of work and shall not be paid for separately.

b) Disposal of Materials

All demolished materials shall be removed or deposited off the site in dumps to be provided by the Contractor in a manner approved by the Engineer. If however, in the opinion of the Engineer, the demolished material is suitable for filling, the Engineer will direct that the material be used. The Contractor may, with the written approval of the Engineer, use for the purposes of the works any cleared materials which are at his disposal.

5.4 CLEARING AND GRUBBING

5.4.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.4.2 DESCRIPTION

This Item shall consist of clearing, grubbing, removing and disposing all vegetation and debris as designated in the Contract, except those objects that are designated to remain in place or are to be removed in consonance with other provisions of this Specification. The work shall also include the preservation from injury or defacement of all objects designated to remain.

All combustible materials from clearing operation shall be completely burned or removed from site of work or otherwise disposed of as directed by the Engineer.

Stumps shall be removed entirely. Roots and matted roots shall be grubbed out to at least 450 mm below the existing surface and shall be backfilled with suitable material and compacted to the required density.

5.4.3 CONSTRUCTION REQUIREMENTS

5.4.3.1 General

The Engineer will establish the limits of work and designate all tree, shrubs, plants and other things to remain. The Contractor shall preserve all objects designated to remain. Paint required for cut or scarred surface of trees or shrubs selected for retention shall be an approved asphaltum base paint prepared especially for tree surgery.

Clearing shall extend one (1) meter beyond the toe of the fill slopes or beyond rounding of cut slopes, as the case maybe, for the entire length of the project unless otherwise shown on the plans or a directed by the Engineer and provided it is within the right of way limits of the project, with the exception of trees under the jurisdiction of the Forest Management Bureau (FMB).

5.4.3.2 Clearing and Grubbing

All surface objects and all trees, stumps, roots and other protruding obstructions, not designated to remain, shall be cleared and/or grubbed, including mowing as required, except as provided below:

- a) Removal of undisturbed stumps and roots and nonperishable solid objects with a minimum depth of 1 meter below subgrade or slope of embankments will not be required.
- b) In areas outside of the grading limits of cut and embankment areas, stumps and nonperishable solid objects shall be cut off not more than 150 mm (6 inches) above the ground line or low water level.
- c) In areas to be rounded at the top of cut slopes, stumps shall be cut off flush with or below the surface of the final slope line.
- d) Grubbing of pits, channel changes and ditches will be required only to the depth necessitated by the proposed excavation within such areas.
- e) In areas covered by cogon / talahib, wild grass and other vegetation, top soil shall be cut to a maximum depth of 150 mm below the original ground surface or as designated by the Engineer, and disposed outside the clearing and grubbing limits as indicated in the typical roadway section.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted to the required density.

If perishable material is burned, it shall be burned under the constant care of competent watchmen at such times and in such a manner that the surrounding

vegetation, other adjacent property, or anything designated to remain on the right of way will not be jeopardized. If permitted, burning shall be done in accordance with applicable laws, ordinances, and regulations.

The Contractor shall use high intensity burning procedures. (i.e. incinerators, high stacking or pit and ditch burning with forced air supplements) that produce intense burning with little or no visible smoke emission during the burning process. At the conclusion of each burning session, the fire shall be completely extinguished so that no smoldering debris remains.

In the event that the Contractor is directed by the Engineer not to start burning operations or to suspend such operations because of hazardous weather conditions, material to be burned which interferes with subsequent construction operations shall be moved by the Contractor to temporary locations clear of construction operations and later, if directed by the Engineer, shall be placed on a designated spot and burned.

Materials and debris which cannot be burned and perishable materials may be disposed off by methods and at locations approved by the Engineer, on or off the project. If disposal is by burying, the debris shall be placed in layers with the material so disturbed to avoid nesting. Each layer shall be covered or mixed with earth material by the land-fill method to fill all voids. The top layer of material buried shall be covered with at least 300 mm (12 inches) of earth or other approved material and shall be graded, shaped and compacted to present a pleasing appearance. If the disposal location is off the project, the Contractor shall make all necessary arrangements with property owners in writing for obtaining suitable disposal locations which are outside the limits of view from the project. The cost involved shall be included in the unit bid price. A copy of such agreement shall be furnished to the Engineer. The disposal areas shall be seeded, fertilized and mulched at the Contractor's expense.

Woody material may be disposed off by chipping. The wood chips may be used for mulch, slope erosion control or may be uniformly spread over selected areas as directed by the Engineer. Wood chips used as mulch for slope erosion control shall have a maximum thickness of 12 mm (1/2 inch) and faces not exceeding 3900 mm² (6 square inches) on any individual surface area. Wood chips not designated for use under other sections shall be spread over the designated areas in layers not to exceed 75 mm (3 inches) loose thickness. Diseased trees shall be buried or disposed off as directed by the Engineer.

All merchantable timber in the clearing area which has not been removed from the right of way prior to the beginning of construction, shall become the property of the Contractor, unless otherwise provided.

Low hanging branches and unsound or unsightly branches on trees or shrubs designated to remain shall be trimmed as directed. Branches of trees extending over the roadbed shall be trimmed to give a clear height of 6 m (20 feet) above the

roadbed surface. All trimming shall be done by skilled workmen and in accordance with good tree surgery practices.

Timber cut inside the area staked for clearing shall be felled within the area to be cleared.

5.4.3.3 Individual Removal of Trees or Stumps

Individual trees or stumps designated by the Engineer for removal and located in areas other than those established for clearing and grubbing and roadside cleanup shall be removed and disposed off as specified under Subsection 5.4.3.2 except trees removed shall be cut as nearly flush with the ground as practicable without removing stumps.

5.5 EXCAVATION

5.5.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.5.1.1 Description

This Item shall consist of roadway and drainage and borrow excavation and the disposal of material in accordance with this Specification and in conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

5.5.1.2 Roadway Excavation

Excavation will include excavation and grading for roadway, parking areas, intersections, approaches, slope rounding, benching, waterways and ditches; removal of unsuitable material from the roadway and beneath embankment areas; and excavating selected material found in the runways as ordered by the Engineer for specific use in the improvement. Roadway excavation will be classified as "unclassified excavation", "rock excavation", "common excavation", or "muck excavation," as indicated in the Bill of Quantities and hereinafter described.

- a) **Unclassified Excavation.** Unclassified excavation shall consist of the excavation and disposal of all materials regardless of its nature, not-classified and included in the Bill of Quantities under other pay items.
- b) **Rock Excavation.** Rock excavation shall consist of igneous, sedimentary and metamorphic rock which cannot be excavated without blasting or the use of rippers, and all boulders or other detached stones each having a volume of 1 cubic meter or more as determined by physical measurements or visually by the Engineer.
- c) **Common Excavation.** Common excavations shall consist of all excavation not included in the Bill of Quantities under "rock excavation" or other pay items.

- d) Muck Excavation. Muck excavation shall consist of the removal and disposal of deposits of saturated or unsaturated mixtures of soils and organic matter not suitable for foundation material regardless of moisture content.

5.5.1.3 Borrow Excavation

Borrow excavation shall consist of the excavation and utilization of approved material required for the construction of embankments or for other portions of the work, and shall be obtained from approved sources, in accordance with the following:

- a) Borrow, Case 1. Borrow Case 1 will consist of material obtained from sources designated on the Plans.
- b) Borrow, Case 2. Borrow, Case 2 will consist of material obtained from sources provided by the Contractor.
- c) The material shall meet the quality requirements determined by the Engineer unless otherwise provided in the Contract.

5.5.2 CONSTRUCTION REQUIREMENTS

5.5.2.1 General

When there is evidence of discrepancies on the actual elevations and that shown on the Plans, a pre-construction survey referred to the datum plane used in the approved Plan shall be undertaken by the Contractor under the control of the Engineer to serve as basis for the computation of the actual volume of the excavated materials.

All excavations shall be finished to reasonably smooth and uniform surfaces. No materials shall be wasted without authority of the Engineer. Excavation operations shall be conducted so that material outside of the limits of slopes will not be disturbed. Prior to excavation, all necessary clearing and grubbing in that area shall have been performed in accordance with Subsection 5.4, Clearing and Grubbing.

5.5.2.2 Conservation of Topsoil

Where provided for on the Plans, suitable topsoil encountered in excavation and on areas where embankment is to be placed shall be removed to such extent and to such depth as the Engineer may direct. The removed topsoil shall be transported and deposited in storage piles at locations approved by the Engineer. The topsoil shall be completely removed to the required depth from any designated area prior to the beginning of regular excavation or embankment work in the area and shall be kept separate from other excavated materials for later use.

5.5.2.3 Utilization of Excavated Materials

All suitable material removed from the excavation shall be used in the formation of the embankment, subgrade, shoulders, slopes, bedding and backfill for structures, and for other purposes shown on the Plans or as directed.

The Engineer will designate as unsuitable those soils that cannot be properly compacted in embankments. All unsuitable material shall be disposed off as shown on the Plans or as directed without delay to the Contractor.

Only approved materials shall be used in the construction of embankments and backfills.

All excess material, including rock and boulders that cannot be used in embankments shall be disposed off as directed.

Material encountered in the excavation and determined by the Engineer as suitable for topping, road finishing, slope protection, or other purposes shall be conserved and utilized as directed by the Engineer.

Borrow material shall not be placed until after the readily accessible roadway excavation has been placed in the fill, unless otherwise permitted or directed by the Engineer. If the Contractor places more borrow than is required and thereby causes a waste of excavation, the amount of such waste will be deducted from the borrow volume.

5.5.2.4 Prewatering

Excavation areas and borrow pits may be prewatered before excavating the material. When prewatering is used, the areas to be excavated shall be moistened to the full depth, from the surface to the bottom of the excavation. The water shall be controlled so that the excavated material will contain the proper moisture to permit compaction to the specified density with the use of standard compacting equipment. Prewatering shall be supplemented where necessary, by truck watering units, to ensure that the embankment material contains the proper moisture at the time of compaction.

The Contractor shall provide drilling equipment capable of suitably checking the moisture penetration to the full depth of the excavation.

5.5.2.5 Presplitting

Unless otherwise provided in the Contract, rock excavation which requires drilling and shooting shall be presplit.

Presplitting to obtain faces in the rock and shale formations shall be performed by: (1) drilling holes at uniform intervals along the slope lines, (2) loading and stemming the holes with appropriate explosives and stemming material, and (3) detonating the holes simultaneously.

Prior to starting drilling operations for presplitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor's methods are

satisfactory. The Engineer may order discontinuance of the presplitting when he determines that the materials encountered have become unsuitable for being presplit.

The holes shall be charged with explosives of the size, kind, strength, and at the spacing suitable for the formations being presplit, and with stemming material which passes a 9.5 mm (3/8 inch) standard sieve and which has the qualities for proper confinement of the explosives.

The finished presplit slope shall be reasonably uniform and free of loose rock. Variance from the true plane of the excavated back slope shall not exceed 300 mm (12 inches); however, localized irregularities or surface variations that do not constitute a safety hazard or an impairment to drainage courses or facilities will be permitted.

A maximum offset of 600 mm (24 inches) will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern.

5.5.2.6 Excavation of Ditches, Gutters, etc.

All materials excavated from side ditches and gutters, channel changes, irrigation ditches, inlet and outlet ditches, toe ditches, furrow ditches, and such other ditches as may be designated on the Plans staked by the Engineer.

Ditches shall conform to the slope, grade, and shape of the required cross-section, with no projections of roots, stumps, rock, or similar matter. The Contractor shall maintain and keep open and free from leaves, stick and other debris all ditches dug by him until final acceptance of the work.

Furrow ditches shall be formed by plowing a continuous furrow along the line staked by the Engineer. Methods other than plowing may be used if acceptable to the Engineer. The ditches shall be cleaned out by hand shovel work, by ditcher, or by some other suitable method, throwing all loose materials on the downhill side so that the bottom of the finished ditch shall be approximately 450 mm (18 inches) below the crest of the loose material piled on the downhill side. Hand finish will not be required, but the flow lines shall be in satisfactory shape to provide drainage without overflow.

5.5.2.7 Excavation of Roadbed Level

Rock shall be excavated to a depth of 150 mm (6 inches) below subgrade within the limits of the roadbed and runway bed, and the excavation backfilled with material designated on the Plans or approved by the Engineer and compacted to the required density.

When excavation methods employed by the Contractor leave undrained pockets in the rock surface, the Contractor shall at his own expense, properly drain such depressions or when permitted by the Engineer fill the depressions with approved impermeable material.

Material below subgrade, other than solid rock shall be thorough scarified to a depth of 150 mm (6 inches) and the moisture content increased or reduced, as necessary, to bring the material throughout the 150 mm layer to the moisture content suitable for

maximum compaction. This layer shall then be compacted in accordance with the following paragraph.

The Contractor shall compact the material placed in all embankment layers and the material scarified to the designated depth below subgrade in cut section, until a uniform density of not less than 95 mass percent of the maximum determined by AASHTO T 180 (ASTM D 1557) is attained, at a moisture content determined by Engineer to be suitable for such density. Layer 50 cm or less below subgrade level shall be compacted to 98 mass percent of the maximum by AASHTO T 180 (ASTM D 1557)

5.5.2.8 Borrow Areas

The Contractor shall notify the Engineer sufficiently in advance of opening any borrow areas so that cross-section elevations and measurements of the ground surface after stripping may be taken, and the borrow material can be tested before being used. Sufficient time for testing the borrow material shall be allowed.

All borrow areas shall be bladed and left in such shape as to permit accurate measurements after excavation has been completed. The Contractor shall not excavate beyond the dimensions and elevations established, and no material shall be removed prior to the staking out and cross-sectioning of the site. The finished borrow areas shall be approximately true to line and grade established and specified and shall be finished. When necessary to remove fencing, the fencing shall be replaced in at least as good condition as it was originally. The Contractor shall be responsible for the confinement of livestock when a portion of the fence is removed.

5.5.2.9 Removal of Unsuitable Material

Where the Plans show the top portion of the runway-bed to be selected topping, all unsuitable materials shall be excavated to the depth necessary for replacement of the selected topping to the required compacted thickness.

Where excavation to the finished graded section results in a subgrade or slopes of unsuitable soil, the Engineer may require the Contractor to remove the unsuitable material and backfill to the finished graded section with approved material. The Contractor shall conduct his operations in such a way that the Engineer can take the necessary cross-sectional measurements before the backfill is placed.

The excavation of muck shall be handled in a manner that will not permit the entrapment of muck within the backfill. The material used for backfilling up to the ground line or water level, whichever is higher, shall be rock or other suitable granular material selected from the roadway excavation, if available. If not available, suitable material shall be obtained from other approved sources. Unsuitable material removed shall be disposed off in designated areas shown on the Plans or approved by the Engineer.

5.6 FILLING

5.6.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.6.1.1 Description

This work shall consist of the construction of embankments and other areas of fill not specified elsewhere by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with the specifications and to the lines, level, grades, dimensions and cross section shown on the drawings and as required by the Engineer. Unless otherwise stated, the term "embankment" shall include all areas of fill.

The Contractor shall submit his proposed method of filling including materials, equipment, and all related works for the approval of the Engineer.

5.6.2 MATERIAL REQUIREMENTS

a) General

All sources of filling materials shall be approved by the Engineer.

Appropriate quantities of sample of all materials to be used in the Works shall be submitted for acceptance and approval by the Engineer thirty (30) days before the commencement of work.

General filling shall consist of approved material from approved sources of suitable grading obtained from excavation, quarries or borrow pits, without excess fines, clay or silt, free from vegetation and organic matter.

Sample of approved materials shall be kept/stored in the field for ready reference/comparison of the delivered materials.

The Contractor shall insure that adequate quantities of required materials that comply with the specifications and quality approved by the engineer are available at all times.

b) Fill Materials other than Dredged Materials

Fill materials for reclamation purposes other than dredged materials shall be pit sand, quarry run, gravel or mine tailings. The fill material shall be of the same quality or better, as approved by the Engineer and called for in dredged material specification.

c) Dredged Materials

Hydraulic fill shall be well-graded gravel.

d) Types of Filling Materials

1) Selected Fill Materials

The material shall not have high organic content and shall meet the following requirements:

- (a) Not more than 10 percent by weight shall pass the No. 200 sieve (75 microns).
- (b) Maximum particles size shall not exceed 75 mm.
- (c) The fill materials shall be capable of being compacted in the manner and to the density of not less than 95%.
- (d) The material shall have a plasticity index of not more than 6 as determined by AASHTO T 90.

2) Sand and Gravel Fill:

The materials shall be composed of 50% sand and 50% gravel and shall be free from rocks, wood, scrap, vegetables, and refuse. The materials shall not have organic content and the maximum particle size shall not exceed 100mm. Source of materials shall be river or mountain quarry.

5.6.3 EXECUTION

a) General

The Contractor shall be responsible for all ancillary earthworks that are necessary for the reception of the fill material and including, all spout handling, temporary dike or shoring construction where necessary, temporary protection to dikes in the sea and drainage of excess water.

The arrangements of these ancillary earthworks shall be laid out in consultation with the Engineer and to the Engineer's satisfaction and care shall be taken to minimize the loss of fill.

- b) Replacement, backfilling and reclamation may be done by any method acceptable to the Engineer. Prior to start of Work, the Contractor shall submit his method and sequence of performing the works to the Engineer for approval. However, the Engineer's approval of the method and sequence of construction shall not release the Contractor from the responsibility for the adequacy of labor and equipment.
- c) The Engineer shall approve the type of material to be used as fill prior to its placement. If the material is rejected, such material shall be deposited into areas designated or as directed by the Engineer.
- d) When suction dredges are used, discharge pipework shall be arranged in conjunction with the Engineer's instructions and shall be such that by means of operating valves, material can be deposited to several places without altering the pipework or interrupting dredging. Where necessary vehicle overpasses shall be constructed by the Contractor.
- e) Fill material shall be placed in horizontal layers not exceeding 200mm (8 inches), loose measurement, and shall be compacted as specified before the next layer is placed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to assure

uniform density. Water shall be added or removed, if necessary, in order to obtain the required density. Removal of water shall be accomplished through aeration by plowing, blading, dicing, or other methods satisfactory to the Engineer.

Even though the thickness of layers is limited as provided above, the placing of individual rocks and boulders greater than 600 mm in diameter will be permitted provided that when placed, they do not exceed 1200mm (48 inches) in height and provided they are carefully distributed, with the interstices filled with finer material to form a dense and compact mass.

Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spalls and finer fragments of earth. Lifts of material containing more than 25 mass percent of rock larger than 150mm in greatest dimension shall not be constructed above an elevation 300mm (12 inches) below the finished subgrade. The balance of the reclamation work shall be composed of suitable material smoothed and placed in layers not exceeding 200mm (8 inches) in loose thickness and compacted as specified for embankments.

Dumping and rolling areas shall be kept separate, and no lift shall be covered by another until the necessary compaction is compacted.

Hauling and leveling equipment shall be so routed and distributed over each layer of the fill in such a manner as to make use of compaction effort afforded thereby and to minimize rutting and uneven compaction.

f) Field Compaction Test

Field Density tests to determine the percent of compaction of the material shall be conducted at elevation + 1.60 from MLLW. Compaction of each layer thereafter shall continue until a field density of at least 98 percent of the maximum dry density in accordance with AASHTO T/180. Method D has been achieved. In place density determination shall be made in accordance with AASHTO T191.

g) Permissible Tolerance

Elevation: plus 5 cm

5.7 SUBGRADE PREPARATION

5.7.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.7.1.1 Description

The subgrade preparation shall be the part of the work which is the preparation for the support of the subbase or, if there is no subbase, the surfacing of the pavement structure. It shall extend to the full width of the road including the shoulders as shown in the drawings or as specified herein. Unless otherwise agreed by the

Engineer subgrade preparation of a section of road shall not commence unless the Contractor is able, after the completion and acceptance of the work, to commence immediately pavement construction.

5.7.2 MATERIAL REQUIREMENTS

Unless otherwise stated in the Contract and except when the subgrade is in rock cut, all materials below subgrade level to a depth of 150 mm or to such greater depth as may be specified shall meet the requirements of selected borrow for topping, e.g., soil of such gradation that all particles will pass a sieve with 75 mm (3 inches) square openings and not more than 15 percent will pass the 0.075 mm (No. 200) sieve, as determined by AASHTO T 11. The material shall have a plasticity index of not more than 6 as determined by AASHTO T 90 and liquid limit of not more than 30 as determined by AASHTO T89.

5.7.3 EXECUTION

a) Prior Works

Prior to commencing the preparation of the subgrade all culverts, ditches, drains and drainage outlets shall be completed. No work shall be started on the preparation of the subgrade before the prior works are herein approved by the Engineer.

b) Where the new pavement is to be constructed immediately over an existing gravel surfaced pavement and if so specified in the Contract the pavement shall be scarified, thoroughly loosened, reshaped and recompactd in accordance with item 3 below.

c) Unless otherwise ordered by the Engineer a variable load pneumatic tired roller shall be used to proof roll the subgrade. The roller shall have a load variable within the range of at least from 15 to 45 tons, on an overall width not greater than 3.2 m and shall have tires whose pressures are variable up to not less than 620 KN/sq.m. The wheels shall be in row and shall be capable of considerable vertical movement relative to each other without appreciable variation in loading either by each supporting a separate ballast unit, or by virtue of an efficient interconnecting suspension system. The ballast shall be in a form which permits rapid adjustment of loads. The total loaded weight and tire pressure used at any time shall be as directed by the Engineer. The pneumatic tired roller shall not be towed over completed sub-bases or surfacings without the prior approval of the Engineer on each occasion. The proof rolling shall consist of one pass of the roller along the center of each lane of the traveled way.

The subgrade shall be compacted to a depth of 150 mm to the requirements of Table 5.1. This work shall comply with all the specified requirements for compaction of earthwork.

Table 5.1
Compaction Requirements

Soil Classification According to AASHTO M 145	Type to	Test Method for Determining Moisture Density Relations	Minimum Relative Density Field Dry Density as % of Maximum Dry Density as Determined by the Specified Test Method
A - 1 A - 2 - 4 A - 2 - 5 A - 3		AASHTO T 180 (4.54 kg rammer) Method D	90%
A - 2 - 6 A - 2 - 7 A - 4 A - 5 A - 6 A - 7		AASHTO T 99 (4.54 kg rammer) Method D	95%

d) Protection of Completed Work

Any part of the subgrade that has been completed shall be protected and any damage resulting from default of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the subgrade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and recompacting. He shall limit the amount of subgrade preparation to an area that can be maintained with the equipment available. He shall arrange for subgrade preparation and subbase or base placing to follow each other closely. The subgrade, when prepared too soon in relation to the laying of the sub base, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the subgrade as may be necessary restore it to the state specified herein.

e) Tolerances

The finished compacted surface of the subgrade shall conform to the allowable tolerances as specified below:

Permitted variation from design level of surface	+20 mm -30 mm
Permitted surface irregularity measured by 3m straightedge	30 mm
Permitted variation from design crossfall or camber	±0.5%
Permitted variation from design longitudinal grade over 25m length	±0.1%

5.8 AGGREGATE SUBBASE COURSE

5.8.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these Specifications; and apply to this Section, whether or not referred to herein.

5.8.1.1 Description

This Section shall consist of furnishing, placing and compacting an aggregate subbase course on a prepared subgrade in accordance with these Specifications and the lines, grades and cross sections shown on the Drawings, or as directed by the Engineer.

5.8.2 MATERIAL REQUIREMENTS

Aggregate for subbase shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. The composite material shall be free from vegetable matter and lumps or balls of clay, and shall be of such nature that it can be compacted readily to form a firm, stable subbase.

The subbase material shall conform to Table 5.2, Grading Requirements.

Table 5.2
Grading Requirements

Sieve Designation		Mass Passing	Percent
Standard (mm)	Alternate US Standard		
50	2"	100	
25	1"	55-85	
9.5	3/8"	40-75	
0.075	No. 200	0-12	

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and plasticity index not greater than 12 as determined by AASHTO T 89 and T 90, respectively.

The coarse portion, retained on a 2.00 mm (No. 10) sieve, shall have a mass percent of wear not exceeding 50 by the Los Angeles Abrasion Tests as determined by AASHTO T 96.

The material shall have a soaked CBR value of not less than 25% as determined by AASHTO T 193. The CBR value shall be obtained at the maximum dry density and determined by AASHTO T 180, Method D.

5.8.3 EXECUTION

a) Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Section 5.7, "Subgrade Preparation", before placing the subbase material.

b) Placing

The subbase material shall be placed as a uniform mixture on a prepared subgrade in a quantity which will provide the required compacted thickness. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

The placing of material shall begin at the point designated by the Engineer. Placing shall be from vehicles especially equipped to distribute the material in a continuous uniform layer or windrow. The layer or windrow shall be of such size that, when spread and compacted the finished layer be in reasonably close conformity to the nominal thickness shown on the Drawings.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

c) Spreading and Compacting

When uniformly mixed, the mixture shall be spread to the plan thickness, for compaction.

Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, the aggregate subbase material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

The moisture content of subbase material shall, if necessary, be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required in order to obtain the required compaction.

Immediately following final spreading and smoothing, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling shall progress gradually from the sides to the center, parallel to the centerline of the road and shall continue until the whole surface has been rolled. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Along curbs, headers, and walls, and at all places not accessible to the roller, the subbase material shall be compacted thoroughly with approved tampers or compactors.

If the layers of subbase material, or part thereof, does not conform to the required finish, the Contractor shall, at his own expense, make the necessary corrections.

Compaction of each layer shall continue until a field density of at least 100 percent of the maximum dry density determined in accordance with AASHTO T 180, Method D has been achieved. In-place density determination shall be made in accordance with AASHTO T 191.

d) Trial Sections

Before subbase construction is started, the Contractor shall spread and compact trial sections as directed by the Engineer. The purpose of the trial sections is to check the suitability of the materials and the efficiency of the equipment and construction method which is proposed to be used by the Contractor. Therefore, the Contractor must use the same material, equipment and procedures that he proposes to use for the main work. One trial section of about 500 m² shall be made for every type of material and/or construction equipment/procedure proposed for use.

After final compaction of each trial section, the Contractor shall carry out such field density tests and other tests required as directed by the Engineer.

If a trial section shows that the proposed materials, equipment or procedures in the Engineer's opinion are not suitable for subbase, the material shall be removed at the Contractor's expense, and a new trial section shall be constructed.

If the basic conditions regarding the type of material or procedure change during the execution of the work, new trial sections shall be constructed.

e) Tolerances

Aggregate subbase material shall be spread with equipment that will provide a uniform layer which when compacted will conform to the designed level and transverse slopes as shown on the Drawings. The allowable tolerances shall be as specified hereunder:

Permitted variation from design thickness of layer	+20 mm
Permitted variation from design level of surface	+10 mm -20 mm
Permitted surface irregularity measured By 3 m straightedge	20 mm
Permitted variation from design crossfall or camber	+0.3%
Permitted variation from design longitudinal grade over 25 m length	+0.1%

5.9 AGGREGATE BASE COURSE

5.9.1 GENERAL

5.9.1.1 DESCRIPTION

This Section shall consist of furnishing, placing and compacting aggregate base course on a prepared subgrade in accordance with this Specification and the lines, grades, thickness and typical cross sections shown on the Plans, or as established by the Engineer.

5.9.2 PRODUCTS

5.9.2.1 MATERIAL REQUIREMENTS

Aggregate for base course shall consist of hard, durable particles or fragments of crushed slag or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. The composite material shall be free from vegetable matter and lumps or balls of clay, and shall be of such nature that it can be compacted readily to form a firm, stable base.

The base course material shall conform to Table 5.3,

Table 5.3
Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard mm	Alternate US Standard	Grading A	Grading B
50.0	2"	100	
37.5	1 1/2"	-	100
25.0	1"	60-85	
19.0	3/4"	-	60-85
12.5	1/2"	36-65	-
4.75	No. 4	20-50	30-55
0.425	No. 40	5-20	8-25
0.075	No. 200	0-12	2-14

The fraction passing the 0.075 mm (No.200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No.40) sieve shall have a liquid limit not greater than 25 and plasticity index not greater than 6 as determined by AASHTO T 89 and T 90, respectively.

5.9.3 EXECUTION

5.9.3.1 Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Section 5.7, "Subgrade Preparation", before placing the base material.

5.9.3.2 Placing

The aggregate base material shall be placed as a uniform mixture on a prepared subgrade in a quality which will provide the required compacted thickness. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

The placing of materials shall begin at the point designated by the Engineer. Placing shall be from vehicles especially equipped to distribute the material in a continuous uniform layer or windrow. The layer or windrow shall be of such size that when spread and compacted the finished layer shall be in reasonably close conformity to the nominal thickness shown on the Plans.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

5.9.3.3 Spreading and Compacting

When uniformly mixed, the mixture shall be spread to the plan thickness, for compaction. Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, the aggregate base shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

The moisture content of base material shall, if necessary, be adjusted prior to compaction by watering with approved sprinkler mounted on trucks or by drying out, as required in order to obtain the required compaction.

Immediately following final spreading and smoothing, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling shall progress gradually from the sides to the center, parallel to the centerline of the road, and shall continue until the whole surface has been rolled. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Along curbs, headers, and walls, and at all places not accessible to the roller, the base material shall be compacted thoroughly with approved tampers or compactors.

If the layer of base materials, or part thereof, does not conform to the required finish, the Contractor shall, at his own expense, make the necessary corrections.

The field density required of each layer is not less than 98 percent of the maximum dry density determined in accordance with AASHTO T 180 (ASTM D1557).

5.10 CRUSHED AGGREGATE BASE COURSE

5.10.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.10.1.1 Description

This work shall consist of furnishing, spreading and compacting crushed aggregate base material of crushed gravel, crushed stone or crushed rock, constructed over a prepared subgrade or subbase in one or more layers, in accordance with these specifications and shown in the drawings.

5.10.2 MATERIAL REQUIREMENTS

- a) Material for crushed aggregate base course shall consist of crushed or partly crushed hard, durable gravel stone or rock fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm stable base.
- b) The base material shall conform to the grading requirements of Table 5.4, whichever is called for in the Bill of Quantities.

Table 5.4
Grading Requirements

Sieve Designation		Mass Percent Passing
Standard Mm	Alternate US Standard	
37.5	1 1/2"	100
25.0	1"	-
19.0	3/4"	60-85
12.5	1/2"	-
4.75	No. 4	30-55
0.425	No. 40	8-25
0.075	No. 200	2-14

The portion of the material passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40 sieve).

The portion of the material passing the 0.425 mm (No. 40) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 as determined by AASHTO T 89 and 90, respectively.

The material passing the 19 mm (3/4 inch) sieve shall have a minimum soaked CBR-value of 80% tested according to AASHTO T 193. The CBR-value shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.

If filler, in addition to that naturally present, is necessary for meeting the grading requirements or for satisfactory bonding, it shall be uniformly blended with the crushed base coarse material on the road or in a pugmill unless otherwise specified or approved. Filler shall be obtained from sources approved by the Engineer, free from hard lumps and not contain more than 15 percent of material retained on the 4.75 mm (No. 4) sieve.

5.10.3 EXECUTION

a) Placing

Crushed aggregate base shall be delivered to the site of the works as a uniform mixture. No material shall be spread on a soaked surface.

b) Compaction Requirement

The compacted dry density of each layer of the compacted base shall not be less than 100 percent of the maximum dry density determined according to AASHTO T 180, Method D. The field density shall be determined according to AASHTO T 191.

c) Tolerances

The base shall be laid to the designed level and transverse slopes as shown in the Drawings. The allowable tolerances shall be in accordance with Table 5.5.

Table 5.5
Tolerances for Base

Variations	Base
Permitted variation from design thickness of layer	+10 mm -10 mm
Permitted variation from design level of surface	+5 mm -10 mm
Permitted Surface Irregularity measured by 3m straightedge	5 mm
Permitted variation from design crossfall or camber	+0.2 %
Permitted variation from design longitudinal grade over 25 m length	+0.1 %

5.11 AGGREGATE SURFACE COURSE (FOR SIDEWALK)

5.11.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.11.1.1 Description

This Section shall consist of a wearing or top course composed of gravel or crushed aggregate and filler material, whichever is called for in the Bill of Quantities, constructed on a prepared base in accordance with these Specifications and in conformity with the lines, grades and typical cross-sections shown on the drawings.

5.11.2 MATERIAL REQUIREMENTS

The aggregate shall consist of hard, durable particles or fragments of stone or gravel and sand or other fine mineral particles free from vegetable matter and lumps or balls of clay and of such nature that it can be compacted readily to form a firm, stable layer. It shall conform to the grading requirements shown in Table 5.6 when tested by AASHTO T 11 and 27.

Table 5.6
Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard mm	Alternate US Standard	Grading A	Grading B
25.0	1"	100	100
9.5	3/8"	50-85	60-100
4.75	No. 4	35-65	50-85
2.00	No. 10	25-50	40-70
0.425	No. 40	15-30	25-45
0.075	No. 200	5-20	5-20

The coarse aggregate material retained on the 2.00 mm (No. 10) sieve shall have a mass percent of wear by the Los Angeles Test (AASHTO T 96) of not more than 45.

When crushed aggregate is called for in the Bill of Quantities, not less than fifty (50) percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one (1) fractured face.

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two-thirds of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and a plasticity index range of 4 to 9, when tested by AASHTO T 89 and T 90, respectively.

5.11.3 EXECUTION

5.11.3.1 Placing

Aggregate surface course shall be placed in accordance with the requirement of Section 5.10, Crushed Aggregate Base Course.

5.11.3.2 Compacting Requirements

Aggregate surface course shall be compacted in accordance with the requirements of Section 5.10, Crushed Aggregate Base Course.

5.11.3.3 Trial Sections

Trial sections shall be carried out for aggregate surface course in accordance with the requirements of Sub-section 5.8.3.d).

5.11.3.4 Surface Course Thickness and Tolerances

The aggregate surface course shall be laid to the designed level and transverse slopes shown on the drawings. The allowable tolerances shall be as specified hereunder:

Permitted variation from design thickness of layer	+15 mm -5 mm
Permitted variation from design level of surface	+15 mm -5 mm
Permitted surface irregularity measured by 3 m straightedge	5 mm
Permitted variation from design crossfall or camber	+0.2%
Permitted variation from design longitudinal grade over 25 m length	+0.1%

5.12 PORTLAND CEMENT CONCRETE PAVEMENT

5.12.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.12.1.1 Description

This work shall consist of constructing pavement of Portland cement concrete on a prepared base for roads and parking area in accordance with the Specifications and the Drawings.

The Contractor shall submit his proposed method of construction of cement concrete pavement including materials, equipment, and all related works for the approval of the Engineer.

5.12.2 MATERIAL REQUIREMENTS

5.12.2.1 Concrete

The class of concrete for the cement concrete pavement shall be Class B2, as specified in Section 3.2, "Concrete Works".

5.12.2.2 Concrete Materials

Portland cement and fine and coarse crushed aggregates shall conform to the requirements of Section 3.2, "Concrete Works".

The aggregate shall unless otherwise ordered by the Engineer be combined in properties to produce a mixture within the grading limits for combined aggregates shown in the Table 5.7.

Table 5.7
Grading of Combined Aggregates

US Standard Sieve		Percent Passing by Weight
mm	Alternative	Class C
50.0	(2")	80-95
37.5	(1 1/2")	65-87
25.0	(1")	50-75
19.0	(3/4")	45-66
9.5	(3/8")	38-55
4.75	(No. 4)	30-45
2.36	(No. 8)	23-35
1.18	(No. 16)	17-27
0.600	(No. 30)	10-17
0.300	(No. 50)	4-9
0.150	(No. 100)	1-3
0.075	(No. 200)	0-2

5.12.2.3 Storage of Cement and Aggregates

The storage of cement and aggregates shall conform with the requirements of Section 3.2, "Concrete Work".

5.12.2.4 Admixtures

Admixtures shall only be used with the written permission of the Engineer. If air entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer.

5.12.2.5 Tie Bars and Dowels

Tie bars for joints and dowels shall be deformed steel bars conforming to the requirements specified in AASHTO M 31. Sizes shall be as indicated on the drawings. The deformed steel bars shall be Grade 40 and shall be shipped in standard bundles, tagged and marked in accordance with the code of Standard Practice of the Concrete Reinforcement Steel Institute.

5.12.2.6 Joint Filler

Preformed joint filler shall conform to the requirements of AASHTO M 153 or M 213. It shall be punched to admit the dowels where called for on the drawings. The filler

for each joint shall be furnished in a single piece for the depth and width required for the joint.

5.12.3 EXECUTION

5.12.3.1 Proportioning, Consistency and Mixing of Concrete

The proportioning, consistency and mixing of concrete shall conform with the requirements of Section 3.2.

5.12.3.2 Transporting and Delivery of Mixed Concrete

Transporting and delivery of mixed concrete shall be in accordance with the requirements of Section 3.2.

5.12.3.3 Preparation

The base shall be watered and thoroughly moistened prior to the placing of the concrete.

5.12.3.4 Formwork Construction

- a) Formwork shall comply with the requirements of Section 3.2 under the title "Formwork" and with the requirements below.

Forms shall be of steel, of an approved section, and shall be straight and of a depth equal to the thickness of the pavement at the edge. The base of the forms shall be of sufficient width to provide necessary stability in all directions. The flange braces must extend outward on the base not less than 2/3 the height of the form.

- b) All forms shall be rigidly supported on a bed of thoroughly compacted material during the entire operation of placing and finishing the concrete. They shall be set with their faces vertical so as to produce a surface complying with the tolerance requirements in Table 5.8.

Table 5.8 Tolerances for Cement Concrete Pavement

Item	Tolerance
Permitted variation from design thickness of layer	+5 mm
Permitted variation from design level of surface	+5 mm
Permitted surface irregularity measured by 3 m straightedge	5 mm
Permitted variation from design crossfall or camber	+0.2%

- c) Except for the concreting of short sections, the length of formwork erected, checked and approved by the Engineer shall not be less than 150 m at the time of commencement of concreting on any one day.
- d) Adjacent lanes may be used in lieu of forms for supporting finishing equipment provided that proper protection is afforded to the concrete of the adjacent lanes to prevent damage, and further provided that the surface of the concrete carrying the finishing equipment does not vary more than 3 mm in each 3 m length. Adjacent lanes in lieu of forms may not be used until the concrete is at least 7 days old. Flanged wheels of the finishing equipment shall not be operated on the concrete surface. The inside edge of supporting wheels of the finishing machine shall not operate closer than 100 mm from the edge of the concrete lane.
- e) Alternative to placing forms, slip-forming may be used. Slip-form paving equipment shall be equipped with the travelling side forms of sufficient dimensions, shape, and strength to support the concrete laterally for a sufficient length of time during placement to produce pavement of the required cross section. No abrupt changes in longitudinal alignment of the pavement will be permitted. The horizontal deviation shall not exceed 20 mm from the proper alignment established by the Engineer.

5.12.3.5 Joints

All joints, longitudinal, transverse, etc. shall be constructed as shown on the drawings and shall be clean and free of all foreign material after completion of shoulder work and prior to acceptance of the work, and in accordance with the following provisions:

- a) Contact Joints

Contact joints are those joints made by placing fresh concrete against hardened concrete.

- b) Contraction Joints (Weakened Plane Joints)

Contraction joints shall be formed by cutting a groove in the pavement with a power driven saw at the locations shown on the drawings. The grooves shall be cut to a minimum depth of 50 mm and the width shall be cut to a minimum width possible with the type of saw being used, but in no case shall the width exceed 5 mm. Every fourth planned transverse weakened plane joint in the initial lane of concrete and also the first joint immediately after the transverse contact joint shall be sawed within 24 hours after the concrete has been placed, the exact time to be determined by the Engineer. Every second planned transverse weakened plane joint shall be sawed within 48 hours after placing the concrete, the exact time to be determined by the Engineer. The remaining longitudinal and transverse weakened plane joints may be sawed at such time, after 24 hours, as the Contractor may elect, except they shall be completed before placing concrete in succeeding adjacent lanes and before permitting the Contractor's traffic or public traffic to use the pavement.

In succeeding lanes of concrete pavement, the transverse joints opposite those which have opened in the initial lane shall be sawed within 24 hours after the concrete has been placed, the exact time to be determined by the Engineer, but

in all cases not more than 3 consecutive planned transverse weakened plane joints shall be omitted. The remaining longitudinal and transverse weakened plane joints may elect, except they shall be completed before placing concrete in the succeeding adjacent land and before permitting the Contractor's traffic of public traffic to use the pavement.

No sawing shall be done where transverse cracks exist. If a transverse crack falls within 1.52 m of the location of a proposed sawed joint, the sawed joint shall be omitted. Joints sawed in violation of the provisions in this paragraph will not be paid for. At the discretion of the Engineer transverse weakened plane joints may be formed by placing a continuous strip of plastic or other material which will not react adversely with the chemical constituents of the concrete. The strip shall have a minimum thickness of 0.4 mm and a width of not less than 50 mm or more than 55 mm. After placement, the vertical axis of the joint material shall be within 10 degrees of a plane normal to the surface of the pavement. The top of the strip shall not be above nor more than 5 mm below the finished pavement surface. Final alignment of the strip shall conform to that shown on the transverse weakened plane joints and shall not vary more than 20 mm from the edge of a 3 m straightedge. The strip shall be placed by means of a mechanical installation device which shall vibrate the plastic concrete sufficiently to cause an even flow of concrete above the joint material. After installation of the joint material, the concrete shall be free of segregation, rock pockets or voids and the finished concrete surface on each side of the joint shall be in the same plane. Splices in the joint material shall not be permitted.

The Contractor shall maintain a standby multiple-bladed power joint saw, in operating condition, at the project site at all times while concrete paving operations are underway, regardless of the type of weakened plane joint being constructed.

At the discretion of the Engineer, longitudinal weakened plane joints at traffic lanes in multi-lane monolithic concrete pavement may be formed by placing a continuous strip of plastic or other material which will not react adversely with the chemical constituents of the concrete. The joint insert material shall be of such width and character that when placed vertically in the concrete it will not bond with the concrete and will form an effective weakened plane joint of 50 minimum depth. The joint material shall be inserted with a mechanical device that places the material in a continuous strip, except where intervening structures break the continuity of paving. Splices in the joint material will be permitted provided that they are effective in maintaining the continuity of the joint material as placed. The joint material shall be placed in such manner that the top of the strip is not more than 3 mm below the finished surface of the concrete. The joint material shall not be deformed from a vertical position, either in the installation or in subsequent finishing operations performed on the concrete. The alignment of the finished joint shall be uniformly parallel with the center line of the pavement and shall be free of any local irregularity which exceeds 10 mm. The mechanical installation device shall vibrate the concrete during placing the strip sufficiently to cause the concrete to flow evenly about the joint material producing homogeneous concrete free of segregation and rock pockets or voids.

c) Expansion Joints

Expansion joints shall be formed at structure approaches as shown on the drawings.

Joints with Joint Sealant

At expansion joints in concrete slabs to be exposed, and at other joints indicated to receive joint sealant, pre-molded expansion-joint filler strips shall be installed at the proper level below the elevation with a slightly tapered, dressed and oiled wood strip temporarily secured to the top thereof to form a groove, which when surface dry, shall be cleaned of foreign matter, loose particles, and concrete protrusions, then filled approximately flush with joint sealant so as to be slightly concave after drying.

Jointing materials shall be as specified in Sub-section 3.2.2.6.

Finish of concrete at joints

Edges of exposed concrete slabs along expansion joints shall be neatly finished with a slightly rounded edging tool.

5.12.3.6 Placing Concrete

The concrete shall be so deposited and spread that segregation will not occur, and a uniform layer of concrete whose thickness is approximately 20 mm greater than that required for the finished pavement. Rakes shall not be used for handling concrete.

In order to prevent the introduction into the concrete of earth and other foreign materials, the men whose duties require them to work in the concrete, shall in general, confine their movements to the area already covered with fresh concrete. Whenever it becomes necessary for these men to step out of the concrete, their footwear shall be washed or otherwise thoroughly cleaned before returning to the concrete. During the operation of striking off the concrete, a uniform ridge of concrete at least 70 mm in depth shall be maintained ahead of the strike-off screed for its entire length. Except when making a construction joint, the finishing machine shall at no time be operated beyond that point where this surplus can be maintained in front of the strike-off screed.

After the first operation of the finishing machine, additional concrete shall be added at all low places and honeycombed spots and the concrete rescreeded. In any rescreeding, a uniform head of concrete shall be maintained ahead of the strike-off for its entire length. Honeycombed spots shall not be eliminated by tamping or grouting.

Workers on the job shall have mobile footbridges at their disposal so that they need not walk on the wet concrete.

In conjunction with the placing and spreading, the concrete shall be thoroughly spaded and vibrated along the forms, bulkheads, and joints.

The internal vibrators shall be pneumatic, gas-driven, or electric type, and shall operate at a frequency of not less than 3,200 pulsations per minute.

Whenever the placing of the concrete is stopped or suspended for any reason, for a period of 30 minutes or longer, a suitable bulkhead shall be placed so as to produce a vertical transverse joint. If an emergency stop occurs within 2.5 meters of a contraction or an expansion joint, the concrete shall be removed back to the joint. When the placing of the concrete is resumed, the bulkhead shall be removed and new concrete placed and vibrated evenly and solidly against the face of previously deposited concrete. Any concrete in excess of the amount needed to complete a given section, or that has been deposited outside the forms, shall not be used in the work.

The Contractor must provide suitable equipment for protecting the fresh concrete in case of rain, such as screens which will cause the rain water to run off beyond the edges of the paving, rain proof tarpaulins or other methods approved the Engineer. The equipment must be sufficient to shelter from rain an area equal to that paved in two hours of work.

5.12.3.7 Finishing Concrete

The concrete shall be compacted and finished by a mechanical, self-propelled finishing machine of approved type, having two independently operated screeds. If a machine possessing only one screed is adopted, the screed will not be less than 450 mm wide, and shall be equipped with compensating springs to minimize the effect of the momentum of the screed on the side forms. The number of driving wheels, the weight of the machine, and the power of the motor shall be so coordinated as to prevent slippage. The top of the form and the surface of the finishing machine wheels shall be kept free of concrete or dirt.

The machine shall at all times be in first-class mechanical condition, and shall be capable of compacting and finishing the concrete as herein described. Any machine which causes displacement of the side forms from the line or grade to which they have been properly set, or causes undue delay due to mechanical difficulties, shall be removed from the work and replaced by a machine meeting the Specifications.

The finishing machine shall be operated over each section of pavement two or more times and at such intervals as will produce the desired results. Generally, two passes of the finishing machine are considered the maximum desirable.

The concrete shall be vibrated, compacted, and finished by a vibratory finishing machine. The vibratory machine shall meet the requirements for ordinary finishing, and shall be one of the following types:

- a) The machine shall have two independently operated screeds, the front screed shall be equipped with vibratory units with a frequency of not less than 3,500 pulsations per minute. There shall be not less than one vibratory unit for each 2.5 meters length, or portion thereof, of vibratory screed surface. The front screed shall be not less than 300 mm wide, and shall be equipped with a "bull nose" front edge built on a radius of not less than 50 mm. This type of vibratory finishing machine shall be operated in such manner that each section of pavement will receive at least one vibratory pass, but not more than two passes, unless otherwise directed, or;

- b) The machine shall be equipped with an independently operate vibratory "pan" (or pans) and two independently operated screeds; the "pan" shall be mounted in a manner that will not permit it to come in contact with the forms, and will permit vibration of the full width of the lane simultaneously. There shall be not less than one vibratory unit for each 2 m length, or portion thereof, of vibrating pan surface. The vibratory units in any individual pan shall be synchronized and have a frequency of not less than 3,500 pulsations per minute. The front screed shall be capable of operating in a position that will strike off the concrete at a sufficient height above the top of the forms to allow for proper compaction with the vibrating pan. This type of vibratory finishing machine shall be operated in such manner that each section of pavement will receive at least on vibratory pass but not more than two passes, unless otherwise directed the Engineer.

After the final pass of the finishing machine, and when the concrete has started to dry, the surface of the pavement shall be finished with an approved longitudinal float. The float may be operated either manually or by mechanical means. The float may be either of wood or metal, shall be straight and smooth and light in weight so as not to displace or sink into the concrete surface.

To be effective, the float shall be at least 300 mm wide and 3 m long. When manually operated, the float shall be moved from edge to edge with a wiping motion and advanced 1 meter or more.

The succeeding trip shall overlap the previous trip. A light smoothing float at least 3 meters long may be used provided approved by the Engineer.

The surface of the pavement shall be tested by the Contractor, before the final belting, with an approved standard straightedge 3 m in length. Irregularities so detected shall be corrected immediately. Special attention must be given to the concrete adjacent to transverse joints to insure that the edges therefore are not above the grade specified, or the adjacent concrete below grade. All depressions or projections discovered shall be corrected before any initial set has developed in the concrete.

After the concrete has been brought to the required grade, contour, and smoothness, it shall be finished by passing over the concrete a drag of one or two burlap cloths, which give the surface the required roughness. The vehicle used to carry these clothes may be independent of the concrete laying machine or may be incorporated with it, and may be operated either by hand or mechanically.

Hand finishing will be permitted only on variable width sections of the pavement and other places where the use of the finishing machine would be impracticable. Hand finishing shall be accomplished by means of the hand operated strike-off template of either steel or steel-shod wood construction.

The striking template shall be operated forward with a combined longitudinal and transverse motion, and shall be so manipulated that neither end will be raised off the side forms. A similar tamper shall be used for tamping the concrete.

As soon as the concrete has attained its initial set, the edges of the pavement, the longitudinal joints, the construction dummy, and expansion joints not sawn shall be

carefully finished with an edging tool having a radius of at least 5 millimeters. The tools, the special accessories for cutting impressed joints, and methods of workmanship shall be such as they will produce a joint whose edges are of the same quality of concrete as the other portions of the pavement. Methods and workmanship which make use of excess mortar or grout in this area shall be eliminated. Unnecessary tool marks shall be eliminated during construction, and the edges left smooth and true to line.

5.12.3.8 Striking Forms

Forms shall remain in place at least 12 hours after the concrete has been placed. When working conditions are such that the early strength gain of the concrete is delayed, the forms shall remain in place for a longer period, as directed by the Engineer. Bars or heavy loads shall not be used against the concrete when still in the forms. Any damage to concrete resulting from removal shall be repaired promptly by the Contractor as directed by the Engineer without any additional payment.

5.12.3.9 Curing Concrete

Unless otherwise ordered by the Engineer, curing concrete shall be done by the curing compound method in accordance with the curing concrete requirements in Section 3.2.

Curing concrete by the other curing concrete methods shall conform with the curing concrete requirements in Section 3.2.

5.12.3.10 Cleaning and Sealing Joints

After completion of the required curing and before opening of the pavement to traffic, all joints shall be thoroughly cleaned of all concrete aggregate fragments or other material.

After removal of side forms, the ends of transverse expansion joints at the edges of the pavement shall be carefully cleaned of any concrete within the expansion spaces for the entire depth of slab, care being taken not to injure the ends of the joints. Expansion and contraction joints shall then be poured with a hot joint sealer to the depth as indicated on the drawings. Joint sealer shall be poured using approved hand pouring pots, with liquid at a temperature not less than that recommended by the manufacturer.

5.12.3.11 Opening to Traffic

The pavement shall be closed to traffic, including the vehicles of the Contractor, for a period of 21 days after the concrete is placed, or longer if, in the opinion of the Engineer, the weather conditions make it necessary to extend this time. The Contractor shall furnish, place and maintain satisfactory barricades and lights as directed, to exclude all traffic from the pavement. Any damage resulting to the pavement due to traffic shall be repaired or replaced at the expense of the Contractor. Paving mixers, mechanical concrete spreaders and finishers and other heavy paving equipment shall not be operated on completed concrete lanes in order to construct alternate lanes until after the regular curing period is completed. Even

then, planks shall be laid on the finished pavement or other precautions taken to prevent damage to the concrete slab.

5.12.3.12 Pavement Smoothness, Thickness and Tolerance

The cement concrete pavement shall be laid to the designed level and transverse slope shown on the drawings. The allowable tolerance shall be in accordance with tolerance for cement concrete pavement under Table 5.8.

5.13 CONCRETE WALK

5.13.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.13.1.1 Description

This section shall consist of the construction of Portland Cement Concrete Walk with Concrete Block in accordance with this specification and to the lines, grades, levels and dimensions shown on plans, or as required by the Engineer.

5.13.2 MATERIAL REQUIREMENTS

5.13.2.1 Portland Cement Concrete

The concrete walk inclusive of concrete block (0.2 m x 0.4 m) shall be Class B2 concrete. The concrete shall satisfy the following requirements:

- a) Concrete materials shall conform with the requirements of Section 3.2, "Concrete Works."
- b) Maximum 28th day compressive strength shall be 24.1 MPa (3,500 psi).
- c) Maximum aggregate size is 19 mm.
- d) Maximum water cement ratio is 0.52.

5.13.2.2 Expansion Joint Filler

Unless otherwise specified, the preformed joint filler shall have a thickness as indicated on the drawings and shall conform with the requirements of Section 5.12, "Portland Cement Concrete Pavement."

5.13.2.3 Forms

Forms shall be of wood or metal approved by the Engineer and shall extend to the full depth of the concrete. All forms shall be straight, free from warps and of adequate strength to resist distortion.

5.13.2.4 Bed Course Material

Bed course material shall be crushed aggregate conforming to the requirement in Section 5.10, "Crushed Aggregate Base Course."

5.13.3 EXECUTION

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to a firm even surface conforming to the section shown on the Drawings. All material from soft areas shall be removed and replaced with suitable material.

The bed course material shall be compacted in layers not exceeding 100 mm, to the depth, line and levels shown on the drawings.

All forms shall be staked securely in position at the correct line and level. Preformed joint filler shall be set in the position shown on the drawings before the placing of the concrete is started.

The mixing, placing, finishing, and curing of concrete shall be as specified in Section 3.2, "Concrete Works." The concrete shall be placed to the total depth shown on the drawings.

The surface shall be cut through to a depth of 25 mm with a trowel at intervals of 3 m, or where required, in straight lines perpendicular to the edge of the concrete walk. Expansion joints shall be provided not more than 15 m of the length of the concrete walk.

The surface shall then be brushed. The edges of the concrete walk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges as shown on the drawings.

5.14 CURB

5.14.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.14.1.1 Description

This Section shall consist of construction of curb in accordance with these specifications and in conformity with the lines and grades shown or established by the Engineer.

5.14.2 MATERIAL REQUIREMENTS

5.14.2.1 CLASS OF CONCRETE

The concrete for the curb shall be Grade B2. The concrete shall satisfy the following requirements.

Concrete material shall conform with the requirements of Section 3.2, "Concrete Works."

Minimum 28 day compressive strength shall be 24.1 MPa (3,500 psi).

Maximum aggregate size 25 mm.

Maximum Water-Cement Ratio 0.52.

5.14.2.2 Mortar Base

Cement mortar shall be composed of one part Portland cement and three parts fine aggregate by volume and sufficient water to make the mortar of such consistency that can be handled easily and spread with a trowel.

5.14.2.3 Base Course

Base course material shall be crushed aggregate conforming to the requirements in Section 5.10, "Crushed Aggregate Base Course."

5.14.2.4 Joint Filler

Expansion joint filler shall be preformed conforming to the requirements of AASHTO M 153 or M 173.

5.14.3 EXECUTION

Excavation shall be made to the required depth and the base upon which the curb is to be set shall be compacted to a firm, even surface. All material from soft areas shall be removed as directed and replaced with suitable material.

A layer of crushed aggregate as shown on the drawings shall be placed to form a bed for the curb.

Forms to hold the concrete shall be built and set in place as described in Section 3.2, "Concrete Works." Forms for at least 50 m of curb shall be in place and checked for alignment and grade before concrete is placed. Curbs constructed on curves shall have forms of either wood or metal and they shall be accurately shaped to the curvature shown on the drawings. Mixing, placing, and curing of concrete shall be as described in Section 3.2 and in accordance with the requirements given below.

The top of the curb shall be floated smooth and the edges rounded to the radii shown on the drawings. In finishing concrete, only the mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

The curb shall be constructed in uniform sections of not more than 15 m to 10 m in length except where shorter sections are required to coincide with the location of expansion or contraction joints of the concrete pavement or for closures but no section shall be less than 2 m long. The sections shall be separated by sheet templates set perpendicular to the face and separated by sheet templates set perpendicular to the face and top of the curb. The templates shall be approximately

5 mm in thickness, of the same width as that of the curb and not less than 50 mm greater than the depth of the curb. Templates shall be set carefully and held firmly during the placing of the concrete and shall remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. The preformed joint filler may be used in place of the sheet template referred to above, on the approval of the Engineer. In this event the fiber board shall be pre-cut to the shape of the curb so that its outer edge will be flushed with the abutting curb.

Expansion joints shall be formed in the curb at intervals of 15 m to 18 m to coincide with the expansion joints of cement concrete pavements or as shown on the drawings.

Contraction joints will be executed at 3 m intervals.

The forms may be removed within 24 hours after concrete has been placed. Minor defects shall be repaired with cement mortar. Plastering shall not be permitted on the face of a curb and all rejected curbs shall be removed and replaced by the Contractor without additional cost. All surfaces which will be exposed in the finished construction of the curb shall be finished, while the concrete is still "green" by wetting a wood block or float and rubbing the surfaces until they are smooth.

Immediately upon the completion of the rubbing down operation the surface shall be moistened and kept moist for 3 days or cured by other approved method.

After the concrete has set sufficiently so as not to be damaged, spaces at the back of the curb excavated for placing the curb shall be refilled to the required elevation with suitable earth or granular material, which shall be tamped in layers of not more than 150 mm each until firm and solid.

5.15 SECURITY FENCE AND GATE

5.15.1 GENERAL

Volume I, preceding these Technical Specification and Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.15.2 DESCRIPTION

The work consist of furnishing of all labor, materials, equipment and incidentals necessary for the manufacture and installation of fences and gates as well all other accessories in accordance with the lines, grades, and dimensions shown in the drawings.

5.15.2.1 DETAILED SHOP DRAWINGS

Before materials for the fence are ordered, the Contractor shall submit to the Engineer for approval complete shop drawings, including details of the security fence and gate.

5.15.2.2 DELIVERY, HANDLING AND STORAGE

Handle, store and protect the concrete hollow blocks both in transit and on jobsite to avoid chipping, breaking or contact with soil. Materials shall not be delivered unduly long before it is required for the proper conduct of work.

5.15.3 MATERIAL REQUIREMENTS

5.15.3.1 Cyclone Wire Fence

Cyclone wire fence shall be fabricated from 10 gauge galvanized iron (G.I.) wire conforming to AASHTO M 181. The Cyclone wire fence shall be welded to 16mm diameter round bar frame as indicated on the drawings. Forge welding is a process of metal fusion using a combination of high temperature and high pressure.

Tubular post shall be 50mm diameter galvanized iron pipe, Schedule 40 embedded on reinforced concrete pedestal with concrete footing having minimum 28-day compressive strength of 20.7MPa (3,000 psi). Reinforcing steel shall be Grade 40, conforming to ASTM A615.

Provide anchor bar welded to G.I. Pipe.:

Welding Electrodes: Approved for manual shielded metal arc welding as required E - 6013 for general welding and the attachment of the fence wire fabric to the frame body/ assembly.

5.15.3.2 Additional Concrete Hollow Blocks (CHB) in existing CHB Fence

Concrete hollow blocks shall be standard machine vibrated, and shall have fine and even texture and well defined edges. Units shall be load bearing and shall conform to the requirements of ASTM Specification C 90, Grade A or Philippine National Standard (PNS) 16, Type I, Class A, minimum compressive strength of 4.80 MPa (700 psi).

Mortar shall be mixed in proportions by volume of one part Portland cement and three parts sand. Mortar materials shall conform to Item 4.5 "Masonry".

5.15.3.3 Movable Fence

Tubular post shall be 50mm diameter hot dipped galvanized iron pipe, Schedule 40.

Hot dipped galvanized square tubular members shall conform to ASTM A36 and zinc coating conforming to ASTM A123.

5.15.3.4 Concertina Wire

Concertina wire is fabricated with razor sharp steel blades, made of galvanized steel strip with four hook barbs, die cut every 25mm and cold clenched around a high tensile spring steel core wire.

Coil diameter	600 mm
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No. of turns	50
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Approx. Wt. of coil	8.25 kgs
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Full straight length (RBT)	94 m
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No. of clips	5
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Reinforced Barbed Tape (RBT) is used to hold the concertina coils to angles during installation.

The hot dipped galvanized concertina wire is formed by clipping adjacent loops of a single coil to one another at regular points around the circumference.

Quality of hot-dipped galvanizing shall be in accordance with requirements of AASHTO M 111 or ASTM A 123.

5.15.3.5 Barbed Wire

Barbed wire shall conform to the requirements of ASTM A121, Class 1. The barbed wire shall consist of 3 strands of 12.5 gauge wire, twisted with 2 points, 14 gauge barbs spaced 100mm apart.

5.15.3.6 Steel fence and gate with wire mesh (@ solid Waste Facility-2)

Provide steel gate with 50 mm dia. tubular steel and Ga. 10 wire mesh 1" x 1" opening including painting and incidentals to complete.

5.15.4 EXECUTION

5.15.4.1 Erection of Post

The post shall be erected vertically in position inside the formwork of the foundation block prior to the placing of concrete and shall be adequately supported by bracing to prevent movement of the post during the placing and setting of the concrete. The posts shall be erected to the height and location shown on the Plans, or as ordered by the Engineer.

5.15.4.2 Installation of Chain Link Fence Fabric

The chain link fence fabric shall be set to line and elevation and pulled out between each post before spot welding, or other method of fixing, is carried out. Where splicing of the fence fabric is necessary, or at joints, the lapping of the chain link fence fabric shall be for a minimum of 100mm. No horizontal splicing will be permitted. The fence fabric shall be fixed to the posts as shown on the Plans. Any surface protective layer damaged during welding and/or construction shall be restored properly.

The Contractor shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment. Fence shall generally follow the contour of the ground. Grading shall be performed where necessary to provide a neat appearance.

5.15.4.3 Laying of Concrete Hollow Blocks

Concrete hollow blocks shall be set plumb and true to line with level horizontal joints. Cells of concrete hollow block shall be laid with full mortar coverage on horizontal and vertical face shells. Joints of exterior concrete hollow blocks that will be exposed shall be cut flush and tooled finish with a 6.0 mm deep "V" joint for horizontal and vertical joints.

5.15.4.4 Concertina Wire

- a) First check the concertina coil material and ensure no rust and damage. Also carefully check the quality of razor barded tape and make sure there is no cut, bend or twist.
- b) Generally concertina coil wires are made of high tensile strength therefore It should not be cut with help of pliers.
- c) Straight wire should be clamped to support provided on the wall where concertina coil to be laid.
- d) Straight wire needs to be tighten and clamped properly with the support.
- e) Concertina coil needs to be fixed properly on the support and ensure proper alignment. However concertina coil should not be clamped loose otherwise it will hang at some of the locations due to self weight.
- f) Fencing Coil support span should not be more than 5 meters.
- g) Trained and skill manpower should be deployed for job and should be worn proper PPE – helmet, safety shoes, cut resistance hand gloves and safety glasses.
- h) Concertina coil can be installed manually therefore quality supervision is needed to avoid any loop hole in security.

5.15.4.5 Repair and Cleaning

Damaged galvanized surface shall be repaired as follows:

- a) Damaged surfaces shall be cleaned with steel brush removing loosened and cracked spelter coatings and two coats of approved zinc pigment paint shall be applied on damaged areas.
- b) Areas disturbed by the operations shall be cleaned and trimmed.

5.16 REINFORCED CONCRETE RETAINING WALL

5.16.1 GENERAL

Volume I, preceding these Technical Specification and Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.16.1.1 Description

This work shall consist of constructing reinforced concrete retaining wall in accordance with these Specifications and in conformity with the dimensions, lines, and grades shown on the Plans, or as directed by the Owner.

5.16.2 MATERIAL REQUIREMENTS

- a) Concrete Materials: Concrete materials shall meet the requirements of Specification Subsection 3.2, Concrete Works, with Minimum Compressive Strength 27.6 MPa (4,000 psi) at 28 days.
- b) Reinforcing Steel: Reinforcing steel, unless otherwise specified shall be billet steel bars conforming to the requirements of ASTM A 615.
- c) Equipment, tools, and form materials necessary for the satisfactory performance of this construction shall be on the Project and approved before work will be permitted to begin.

5.16.3 EXECUTION

5.16.3.1 Final Grade Preparation

All major excavation for retaining walls, coping walls, and steps shall be performed under other Sections of these Specifications. Only the final grade preparation for this Work shall be included in this Section. It shall be performed to the satisfaction of the Owner and will be considered incidental to the Work.

5.16.3.2 Forming for Retaining Walls

Forming for retaining walls, either reinforced or gravity, shall be in accordance with the applicable provisions of Section 3.2 or as directed by the Engineer.

5.16.3.3 Reinforcement for Retaining Walls

Reinforcement for retaining walls shall be in accordance with the applicable provisions of Section 3.2, Concrete Works.

5.16.3.4 Placing and Consolidating Concrete

Placing and consolidating concrete shall be performed in accordance with the applicable provisions of Section 3.2, Concrete Works.

5.16.3.5 Exposed Surfaces

Exposed surfaces of retaining walls, coping walls, and steps shall be given a Rubbed Finish and surfaces to be backfilled shall be given an Ordinary Surface Finish.

5.16.3.6 Testing Concrete

Concrete for retaining walls, coping walls, and steps shall be tested by test specimens made and cured in accordance with AASHTO Designation T 23 for cylinders at the frequency stipulated in the Plans or as directed by the Owner. The Contractor shall furnish the concrete necessary for casting test specimens in the field. The City will supply all molds and labor necessary to cast and test specimens.

5.16.3.7 Curing Concrete

Concrete for retaining walls, coping walls, and steps shall be cured in accordance with the applicable provisions of Section 3.2, Concrete Works.

5.16.3.8 Drainage System for Concrete Retaining Walls

Provide 100 mm diameter Polyvinyl Chloride (PVC) pipe weepholes space at 2,000 mm on center and staggered with gravel pack (300mm length of the PVC shall be perforated and embedded on the gravel pack with geotextile wrap.

5.17 STONE MASONRY BARRIER

5.17.1 GENERAL

Volume I, preceding these Technical Specification and Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.17.1.1 Description

This Section shall consist of stone masonry barrier installed at the location called for on the Drawings, constructed on the prepared foundation bed, in accordance with this Specification and in conformity with the lines, grades, sections, and dimensions shown on the Plans or as ordered in writing by the Engineer.

5.17.2 MATERIAL REQUIREMENTS

5.17.2.1 Stone

Boulder shall be clean, hard and durable stones and shall be subject to the approval of the Engineer. Unless otherwise specified on the plans or directed by the Engineer, boulders shall range in size in minimum thickness of 150mm by 250 mm and 350 mm in its widest and longest dimensions, respectively with roughly similar blunted ends. Sound pieces of broken concrete obtained from the removal of bridges, culverts, and other structures may be substituted for stone with the approval of the Engineer. Visual evaluation of the quarry may be used to determine the acceptability of the stone.

The stone shall be dressed to remove any thin or weak portions. Face stones shall be dressed to provide bed and joint lines that do not vary more than 20 mm from the true lines and to ensure the meeting of bed and joint lines without the rounding of corners of the stones in excess of 30 mm in radius. Bed surfaces of the face stones

shall be approximately normal to the face of the stones for about 80 mm and from this point may depart from a normal plane not to exceed 50 mm in 300 mm.

Finish for exposed faces shall be pitched to line along the beds and joints. The maximum projection of rock faces beyond the pitch lines shall not be more than 50 mm.

5.17.2.2 Mortar

Cement, fine aggregate, and water shall conform to the respective requirements for those materials as specified under Section 3.2, Concrete Works, except as to the grading of fine aggregate which shall all pass the 2.36mm (No. 8) sieve, not less than 15 nor more than 40 percent shall pass the 0.3mm (No. 50) sieve, and not more than 10 percent shall pass the 0.15mm (No. 100) sieve.

The mortar for the masonry shall be composed of one part of Portland cement and two parts of fine aggregate by volume and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel. Mortar shall be mixed only in those quantities required for immediate use. Unless an approved mortar mixing machine is used, the fine aggregate and cement shall be mixed dry in a tight box until the mixture assumes a uniform color, after which, water shall be added as the mixing continues until the mortar attains the proper consistency. Mortar that is not used within 90 minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

5.17.2.3 Filter Materials

Grading of filter materials shall be required that D15 of the filter is at least four (4) times the size D85 for the embankment, where D15 percent and 85 percent, respectively, passing in a grain size analysis (by mass). Filter material shall be placed to prevent fine embankment materials to be washed out through the voids of the face stones.

5.17.3 EXECUTION

5.17.3.1 Selection and Placing

When the masonry is to be placed on a prepared foundation bed, the bed shall be firm and normal to, or in steps normal to, the face of the wall, and shall have been approved by the Engineer before any stone is placed.

Care shall be taken to prevent the bunching of small stones or stones of the same size. Large stones shall be used in the corners.

All stones shall be cleaned thoroughly and wetted immediately before being set. The bed that is to receive them shall be cleaned and moistened before the mortar is spread. Stones shall be laid with their longest faces horizontal in full beds of mortar and the joints shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set.

The stones shall be handled so as not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. The rolling or turning of stones on the walls will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone re-laid with fresh mortar.

5.17.3.2 Beds and Joints

Beds for face stones may vary from 20 mm to 50 mm in thickness. They shall not extend in unbroken line through more than 5 stones. Joints may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than two stones. They may be at angles with the vertical from 0° to 45°. Face stones shall bond at least 150 mm longitudinally and 50 mm vertically. At no place shall corners of four stones be adjacent to each other.

Cross beds for vertical faced walls shall be level, and for battered walls may vary from level to normal to the batter line of the face of the wall.

5.17.3.3 Cleaning Exposed Faces

Immediately after being laid, and while the mortar is fresh, all face stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

5.17.3.4 Curing

If hot or dry weather, the masonry shall be protected satisfactorily from the sun and shall be kept wet for a period of at least three days after completion.

5.17.3.5 Templates and Batterboards

All masonry works shall be provided with templates or batterboards to ensure plumbness and alignment prior to construction. Templates and batterboards shall not be removed without the consent of the Engineer and such shall remain in place until the completion of the work.

5.18 LANDSCAPING

5.18.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.18.1.1 Description

The work shall consist of furnishing, placing and compacting topsoil, laying grass sods and planting of shrub in accordance with the Specifications where shown on the Drawings, or ordered by the Engineer.

5.18.2 MATERIAL REQUIREMENTS

5.18.2.1 Topsoil

Topsoil furnished by the Contractor shall consist of a natural friable surface soil without mixture of undesirable subsoil, refuse, or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 50 mm in diameter, noxious wood, tall grass, brush, sticks, stubble, or other litter and shall be subject to the approval of the Engineer.

5.18.2.2 Grass Sod

The sod shall consist of a healthy, dense and well rooted growth of living grass.

The grass sod shall be cut into uniform squares approximately 300 mm and shall have a minimum thickness of 50 mm (excluding grass blades). Sods shall be subject to the approval of the Engineer.

5.18.2.3 Shrub




The shrub shall be healthy and well rooted seedling of selected plants for this Project.


5.18.2.4 Trees, Palms, Shrubs and Groundcover Specification

Below are the proposed types of plantings for landscape.



a) Plants





REF	BOTANICAL NAME	COMMON NAME
FP	<i>Wodyetia bifurcate</i>	Foxtail Palm
AN	<i>Saribus rotundifolius</i>	Anahaw
AR	<i>Muntingia calabura</i>	Aratiles
YB	<i>Tecoma stans</i>	Yellow Bell
SA	<i>Ixora coccinea</i>	Santan
RA	<i>Rhapis excelsia</i>	Rhapis
SL	<i>Crinum asiaticum</i>	Spider Lily
PA	<i>Excoecaria cochichinensis</i>	Picara
PS	<i>Philodendron seloum</i>	Selloum
BG	<i>Bougainvillea glabra</i>	Bougainvillea

	<p>FOXTAIL PALM <i>Wodyetia bifurcate</i></p> <p>The foxtail palm trunk is smooth, thin, and self-cleaning. It grows a single, double, or triple trunk that is slightly spindle-shaped to columnar reaching heights of about 30 ft.</p> <p>The trunk also has a closely ringed, dark grey to light gray color which slowly turns more and more white. The crownshaft of the foxtail palm is light to bright green and slightly swollen at the base.</p>
	<p>ANAHAW <i>Saribus rotundifolius</i></p> <p>Size : This palm is an erect, solitary, and grows at a height ranging from 1-5 m and diameter thickness of about 25 cm.</p> <p>Physical : Its trunk is smooth and straight with a shallow rings of leaf scars.</p> <p>Growth : Overharvesting of leaves of wild plants have reduced leaf size. The leaves do grow faster after harvest but tend to be smaller.</p> <p>Use: The leaves are used for thatching and food wrapping.</p>
	<p>ARATILES <i>Muntingia calabura</i></p> <p>Size : A small, fast-growing tree with spreading branches to 10 m in height. The leaves are hairy, and can grow up to 12 cm long.</p> <p>Physical : Calabura is a rapidly growing, small, evergreen shrub or a tree with a short, broad, spreading crown; it can grow from 3 - 12 metres tall. The lower branches often touch the ground.</p> <p>Growth : It flowers over a long period, even on young plants. There are both red and yellow fruited forms. It is also sometimes grown as an ornamental and amenity shade tree.</p> <p>Use : The tree is occasionally cultivated for its edible fruits.</p>


	<p>YELLOW ELDER <i>Tecoma stans</i></p> <ul style="list-style-type: none"> • Commonly referred to in the Philippines as ‘Yellow Bell’; this tree is drought-tolerant and grows well in warm climate. • Physical : The plant produces pods containing yellow seeds with papery wings. • Growth : It is a ruderal species, readily colonizing disturbed, rocky, sandy, and cleared land and occasionally becoming an invasive weed. • Use : The flowers attract bees, butterflies, and hummingbirds.
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c) **SHRUBS**

	<p>SANTAN <i>Ixora coccinea</i></p> <ul style="list-style-type: none"> • Size : Santan is an erect and smooth ornamental shrub, growing to a height of 2 to 3 meters. • Physical : Leaves are stalkless or on very short stalks, oblong, 5 to 9 centimeters long, heart-shaped or rounded at the base and blunt-tipped. • Use : Flowers are many, pink or red, and borne in terminal, stalkless or shortly stalked, hairy cymes. Bears fruit that is reddish, almost round, about 5 millimeters in diameter.
	<p>RHAPIS <i>Rhapsis excelsa</i></p> <ul style="list-style-type: none"> • Size : Rhapsis excelsa grows up to 4 m in height and 30 mm in diameter but can be controlled through regular trimming. • Physical : Leaf segments are single or few in young plants and increase to a dozen or more in mature plants; segments are divided to the petiole. Leaf-ends are saw-toothed unlike most other palms, occurring on slender petioles ranging from 20 to 60 cm in length. new foliage emerges from a fibrous sheath which remains attached to the base. • Growth : Often in multi-stemmed clumps with glossy, palmate evergreen leaves divided into broad, ribbed segments. As the plants age, the

	sheaths fall, revealing the bamboo-like trunks.
	<p>SPIDER LILY <i>Crinum asiaticum</i></p> <ul style="list-style-type: none"> • <i>Size</i> : A perennial herb which may grow 1 m tall. • <i>Physical</i> : it has a spherical leaf base, the upper part of the bulb is cylindrical, and the base is laterally branched, with a diameter of about 6-15 cm. • <i>Growth</i> : Leaves with 1 sharp point, dark green, grows up to 1 m long, width 7-12 cm or wider; leaves 20-30 à piece. Flower stem erect, as long as the leaf.
	<p>PICARA <i>Excoacaria cochichinensis</i></p> <ul style="list-style-type: none"> • <i>Size</i> : A subtropical evergreen shrub with a woody stem, growing up to 1–2 meters (3.3–6.6 ft) high. • <i>Physical</i> : Its leaves are opposite, their texture shiny and papery, the upper surface dark green or variegated and the underside a deep maroon. The leaves measure 6–14 cm by 2–4 cm.
	<p>SELLOUM <i>Philodendron seloum</i></p> <ul style="list-style-type: none"> • <i>Growth</i> : A tropical plant that is usually grown in full sun, but can tolerate and adapt to deep shade. It grows best in rich, moisture-retentive soil that can be slightly alkaline. However, it cannot tolerate high salt concentration in soil. Given this condition, this plant should be placed farther away from the shore.
	<p>BOUGAINVILLEA <i>Bougainvillea glabra</i></p> <ul style="list-style-type: none"> • <i>Physical</i> : The thorns are tipped with a black, waxy substance. They are evergreen where rainfall occurs all year, or deciduous if there is a dry season. The leaves are alternate, simple ovate-acuminate, 4–13 cm long and 2–6 cm broad. • <i>Growth</i> : The vine species grow anywhere from 1 to 12 m (3 to 40 ft.) tall, scrambling over other plants with their spiky thorns

d) Groundcovers

	<p>CARABAO GRASS <i>Paspalum Renggeri</i></p> <ul style="list-style-type: none"> • <i>Physical</i> : Coarse, with pale green leaves that are narrow, flat and thin. • <i>Growth</i> : This is widely used because, unlike the other two types, it survives in semi-shaded areas. The downside is that it grows rapidly and needs frequent mowing, especially during the rainy season.
	<p>BERMUDA GRASS <i>Cynodon dactylon</i></p> <ul style="list-style-type: none"> • <i>Physical</i> : Carpet-like quality. • <i>Use</i> : Used to control soil erosion in steep, sloping terrain. • <i>Growth</i> : The bright green leaves are slender, creeping, and can grow up to two to three centimeters.
	<p>BLUE GRASS <i>Zoysia matrella</i></p> <ul style="list-style-type: none"> • <i>Physical</i> : compact, has shallow roots, and makes for fine cover. Its pointy leaves are finer and denser than bermuda. • <i>Growth</i> : Bluegrass can thrive in areas fully exposed to sunlight.

Planting design was based on the above proposed species to ensure suitability for the respective landscape zones described on the landscape plans.

5.18.2.5 General Landscape Zones

a) Gender and Development (GAD) Center

The GAD will have landscaped areas focused on creating an inviting and natural garden setting with seating and leisure space.

TREES	Anahaw, Aratiles
SHRUBS	Santan, Spider Lily
GROUND COVER	Carabao grass, Bermuda grass

Circular concrete seating provides the GAD with an activity space for its users, as well as added aesthetic value through colors that complement the building and parallel materials.

b) Market

The landscape design for the market consists of manicured planters along the front corners of the building, balancing a visual focal point and a pleasing entry.

TREES	Anahaw, Foxtail Palm
SHRUBS	Santan, Spider Lily, Selloum, Picara, Rhaps
GROUND COVER	Carabao grass, Bermuda grass

c) Commercial Building

Landscape design for the commercial building revolves around complimenting the architecture and emphasizing the focal point (entryway) of the structure. Its alternating shrubbery and rows of palm trees aim to add to the vibrancy of the area.

TREES	Foxtail Palm, Yellow Bell
SHRUBS	Santan, Spider Lily, Selloum, Picara, Rhaps
GROUND COVER	Carabao grass, Bermuda grass, Mulch

d) Toilet Building

Contained planters guide the access towards the toilet building and provide visual and olfactory screening.

TREES	Anahaw
SHRUBS	Selloum, Rhaps, Picara
GROUND COVER	Carabao grass, Bermuda grass, Mulch

e) Solid Waste Facility

Planters for the SWF are focused on creating screening for the operation through high shrubs and trees.

TREES	Yellow Bell, Aratiles
SHRUBS	Selloum, Rhaps

f) Administration Building

Landscaping for the administration building revolves around creating garden amenities for its users and visitors of the port, all the while preserving the existing trees in the area.

TREES	All existing trees, Anahaw
SHRUBS	Santan, Selloum, Rhapis, Spider Lily, Bougainvillea, Picara
GROUND COVER	Carabao grass, Bermuda grass, Mulch

g) Streetscape

The sidewalks can be provided with significant upgrading in the form of paving treatment. Detail design treatments of street trees and footpaths have been considered in the proposals and will be detailed in full in the design development of the streetscapes.

5.18.3 EXECUTION

5.18.3.1 General

All materials to be installed are to be new and or of the best possible quality fit for its purpose. The whole of landscape works is to be carried out with a qualified Landscape Contractor or tradesman who is experienced in horticultural practice, landscape construction, and planting techniques.

5.18.3.2 Topsoil

Topsoil shall be obtained from approved sources. The Contractor shall notify the Engineer at least seven (7) days before he intends to start stripping operations. After inspection and approval by the Engineer and prior to stripping any topsoil the Contractor shall remove noxious weeds and tall grass, brush, roots and stones larger than 50 mm in diameter.

The topsoil shall be evenly spread on the areas indicated on the Plan to the line and level shown on the Drawings and compacted with a light roller to a depth of not less than 100 mm. Spreading shall not be done when the ground topsoil is excessively wet, or otherwise in a condition detrimental to the work. The roadway surfaces shall be kept clean during hauling and spreading operations.

After spreading has been completed, large clods, stones, roots, stumps and other loose lying material shall be raked up and removed. Any erosion, irregularities of grade or other incidental damage to the surface of topsoil prior to the laying of grass sods shall be repaired to the Engineer's satisfaction.

5.18.3.3 Sodding

The areas to be sodded shall be as shown on the Drawings. The surface of the area to be sodded shall be loosened and brought to a reasonably fine texture to a depth of approximately 20 mm. The bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after having been cut.

Unless otherwise required, the sod on slopes shall be laid horizontally, beginning at the bottom of the slopes and working upwards, when placing sod scour checks or

similar constructions, the length of the strips shall be laid at right angles to the direction of flow of the water.

As the sod is being laid it shall be lightly tamped with suitable wooden tampers, sufficiently to set the sod into the underlying soil.

At points where it is anticipated that water may flow over a sodded area, the highest edge of each sod shall be turned into the soil to be below the adjacent area, and a layer of earth shall be placed over this juncture, and thoroughly compacted. At the limits of sodded area, the end strips shall be turned in and treated similarly.

On all slopes steeper than one vertical to three horizontal the sod shall be pegged with stakes, 200-300 mm in length, spaced as required by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until flush with the bottom of the grass blades.

After the staking has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer of top soil shall be scattered over the sod as top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

The Contractor shall regularly water and maintain sodded areas in satisfactory condition for the duration of the Contract and until final acceptance of the work by the Engineer.

5.18.3.4 Shrugging

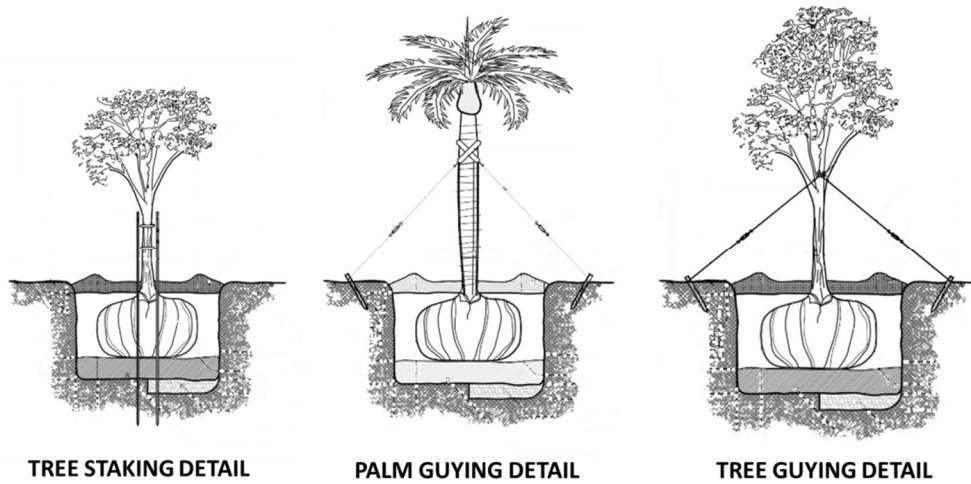
Shrubs seedling shall be planted in location shown on the Drawing or as directed by the Engineer. Distance between plants shall be 150 mm.

After planting of shrubs, the area planted shall be protected from foot and other traffic by temporary barricade until such time that the plant has already established roots in the surrounding soil.

The Contractor shall likewise water and maintain shrubs for the duration of the Contract and until final acceptance of the work by the Engineer.

5.18.3.5 Trees

As preferred by the IFPC, all trees within the site shall be conserved. In the event of a needed uprooting/transferring of trees, the following planting procedure shall be followed.



5.18.3.6 Landscape Lighting

Landscape lighting will emphasize features of the design as well as provide ambient light source to illuminate garden areas, all optional to the decision of the IFPC.

DIVISION 6

WATER, SEWER & DRAINAGE SYSTEMS INCLUDING WASTEWATER TREATMENT FACILITIES & SEAWATER TREATMENT FACILITY

DIVISION 6 WATER, SEWER & DRAINAGE SYSTEMS INCLUDING WASTEWATER TREATMENT FACILITIES & SEAWATER TREATMENT FACILITY

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6.1 WATER SUPPLY SYSTEM

6.1.1 GENERAL

6.1.1.1 Description

The work shall consist of furnishing all labor, materials, equipment and other incidentals necessary to complete the water supply system in accordance with the specification. The construction of the water supply system shall composed of the following components, namely:

a) **Elevated Water Tank for Storage of Potable Water**

The work to be undertaken in this component includes the supply and installation on elevated stainless steel water tank with structural steel support, complete delivery and installation of pipes, fittings and valves as shown on the drawings.

b) **Rainwater Tanks**

1) **For Market and Commercial Building**

The work to be undertaken in this component includes the supply and installation of reinforced concrete water tanks attached to the building and complete delivery and installation of pipes, fittings and valves as shown on the drawings. The work includes excavation, backfilling, reinforced concrete construction, waterproofing and the delivery and installation of complete pipes, fittings and valves for the rainwater tank as shown on the drawings.

2) **For Administration building**

The work to be undertaken in this component includes the supply and installation of cylindrical stainless steel water tanks with saddle supports and complete delivery and installation of pipes, fittings and valves as shown on the drawings.

c) Rehabilitation and Expansion of Water Supply and Distribution Lines

The work involves the excavation and backfilling of pipe trenches, furnishing, laying and jointing of pipes, valves and fittings and the construction of thrust blocks and concrete saddles. The work will also include the furnishing and installation of water meters, including accessories to the water distribution line at the locations and elevations indicated on the drawings, or as maybe directed by the Engineer and in accordance with the requirement of the Specifications.

d) Pumping Equipment

The work involves the furnishing of labor, materials, equipment, tools and incidentals necessary to provide and install pumping equipment and appurtenances in accordance with the approved drawings and specifications.

6.1.1.2 Submittal

The Contractor shall prepare and submit shop drawings and construction methodology he proposes to employ and the list of all materials he intends to use including the name of the manufacturer for the Engineer's approval twenty eight (28) days before the start of any work described in this Section.

The Contractor shall not place any order for materials without prior approval of the Engineer.

6.1.2 MATERIAL REQUIREMENTS

6.1.2.1 Reinforced Concrete Rainwater Tanks

a) Reinforced Concrete Materials

Concrete for the cistern shall be cast in-place and shall be Class C with 28 days compressive strength of 27.68 MPa (4,000 psi).

b) Waterproofing Materials

- 1) For exterior walls and top slab of cistern use Integral waterproofing.

The dosage shall be per manufacturer's recommendations.

- 2) For Interior lining of the reinforced concrete water tank use epoxy tank lining waterproofing to be applied on top of capillary type waterproofing.

(a) Cementitious Type Waterproofing

Cementitious powder consisting of active chemicals wherein crystals are formed once in contact with water. These crystals will follow the water through 38.1 cm of solid concrete structure thus filling the voids and capillary tracts resulting in the prevention of seepage of water in the area while still allowing the substrate to breathe. This is applied in the interior of the cistern with the application of epoxy tank lining waterproofing.

(b) Epoxy Tank Lining Waterproofing

The number of coatings to be applied on top of cementitious type of waterproofing shall be per manufacturer's recommendations.

Refer to Section 4.9, "Concrete Waterproofing" for the requirements on submittals, product handling, alternative and minimum guarantee period.

c) Mortar Materials

Portland cement, sand and water for mortars shall comply with the requirements in Section 3.2 "Concrete Works."

d) Valves and Fittings

1) General

(a) All valves and fittings to be installed may be inspected at the site of manufacture.

(b) In the presence of the Engineer, the pipes, valves and fittings shall be subjected to an internal hydraulic pressure bursting test which shall not be less than 2.07 N/mm². Checking of dimension and weights shall likewise be done. The necessary certificate as to acceptance to satisfactory compliance with the above-mentioned test shall be issued by the Engineer.

(c) The Contractor shall submit a list of materials to be furnished, the name of suppliers, and the date of delivery on site to the Engineer for approval twenty eight (28) days before the commencement of work.

2) Gate Valves

(a) Gate valves shall be the outside screw and yoke flanged type.

(b) Gate valves shall conform to Standard Specification AWWA C500, insofar as applicable. Valves shall have flanged joint ends, and shall be of iron body, bronze mounted, disc, parallel seat, non-rising stem type.

(c) Extension stems shall be provided where required, of sufficient length so that the operating nuts are within 25 mm of finished grade. Valves shall open to the left or counterclockwise. The stuffing box construction shall be of the "O-Ring" type. Operating nuts shall be 50 mm square. Furnish 2 valve wrenches each in 1.2 m, 2 m, and 2.5 m lengths. Valve wrenches shall be standard steel "T" wrenches with socket for 50 mm square operating nut.

3) Float Valve

Float valves shall conform to AWWA C500 or ISO Specifications.

4) Fittings

All fittings shall be cast iron fittings, with a minimum working pressure of 1.04 N/mm² and shall conform to AWWA Specifications for cast iron fittings.

6.1.2.2 Stainless Steel Rainwater Tanks

- a) The materials and fabrication requirements of horizontal cylindrical stainless steel water tanks on steel saddle supported on 20.7 MPa (3,000 psi) reinforced concrete pads as indicated on the drawings shall conform to Section 4.7, "Steel and Metal Works" and Section 3.2, "Concrete Works."
- b) Piping, fittings and miscellaneous metal works.
 - 1) Furnish and install all pipes, fittings, valves, pipe supports, miscellaneous metal works and all required appurtenances as shown on the drawings and as required to make the entire piping system operable.
 - 2) All materials furnished and installed shall be new and guaranteed free from defects in design, materials and workmanship.
 - 3) Adequate protective measures shall be provided to protect pipes, fittings, valves and all other materials from damage or injury during storage and installation.

6.1.2.3 Elevated Stainless Steel Water Tank for Potable Water

- a) The structural steel and steel plates for elevated stainless steel water tank shall conform to ASTM A36.
- b) The materials and fabrication requirements of the elevated stainless steel water tank shall conform to Section 4.7, "Steel and Metal Works" and Section 3.2, "Concrete Works."
- c) All structural design analysis shall conform to the latest Building Code and National Structural Codes for Building (NSCB) and AWWA-D-100.
- d) Piping, fittings and miscellaneous metal works
 - 1) Furnish and install all pipes, fittings, valves, pipe supports, miscellaneous metal works and all required appurtenances as shown on the drawings and as required to make the entire piping system operable.
 - 2) All materials furnished and installed shall be new and guaranteed free from defects in design, materials and workmanship.

- 3) Adequate protective measures shall be provided to protect pipes, fittings, valves and all other materials from damage or injury during storage and installation.
- e) Flanges, gaskets and bolts
 - 1) Flanges shall conform in dimensions and drilling to ANSI B-16.1 Class 125.
 - 2) Gaskets shall be ring-type.
 - 3) Bolts shall be standard square head machine bolts with heavy, hot, pressed hexagon nuts. Threads shall conform to ANSI B-1.1, coarse thread series, Class 2 fit.
- f) Steel ladder, railings and platform shall be hot-dip galvanized structural steel which shall conform to Section 4.7, "Steel and Metal Works" of this Specification. Inside tank ladder shall be made of stainless steel with dimension indicated on the drawings.

6.1.2.4 Galvanized Iron (G.I.) Pipes and Fittings

a) Pipes and Fittings

G.I. pipes and fittings shall be hot-dip galvanized iron (G.I.) conforming to ASTM A 53 subject to the specific exceptions or additional requirements noted in this Section. All G.I. pipes shall be schedule 40. Ends shall be threaded according to ANSI B 2.1.

The pipe shall meet the requirement of the National Sanitation Foundation for potable water use as tested by the Department of Science and Technology or other testing laboratories authorized by the Government and shall be made from non-toxic materials.

b) Jointing

Galvanized iron pipe shall be furnished with flanged joints. At the option of the Contractor, a mechanical joint may be substituted on all galvanized iron pipe and fittings. The mechanical joint shall conform to the requirements of the AWWA C 110 and AWWA C 115.

6.1.2.5 High Density Polyethylene (HDPE) Pipe and Fittings

- a) HDPE Pipes and Fittings shall be PE 10, SDR 17 (PN10), conforming to ASTM D 3350 or may be post-industrial polyethylene.
- b) The pipe manufactured must certify compliance with the above requirements.
- c) Manufacturing Method and Tolerance
 - 1) Pipes extrusions shall be produced utilizing a Vacuum Extrusion system to ensure uniformity.

- 2) Extrusions shall be spirally wound to form a uniform round cross section pipe.
 - 3) For Internal Diameters (ID) up to and including 1000mm, extrusion profile shall be rectangular.
 - 4) Pipe wall design shall be monolithic to the welding that becomes an I-beam structure for resistance to external loads.
 - 5) Inner wall shall be generally smooth to reduce flow resistances.
 - 6) Wall thickness tolerance shall be maintained within +/-8%.
- d) Fittings/ Couplers
- Butt fusion welding shall be used to join HDPE pipe into one continuous pipeline.

6.1.2.6 Water Meters

- a) Submittal
- 1) At least twenty eight (28) days prior to the start of the work, the Contractor shall submit a manufacturer's test data and material certification that the water meters including accessories meet the requirements specified herein. Together with this certificate, the Contractor shall submit manufacturer's drawings, information, shop drawings, brochures, descriptions and manufacturer's specifications.
 - 2) For each consignment the Contractor shall submit, in triplicate a certificate certifying that water meters have been inspected, tested and accepted from the approved manufacturer's in accordance with these Specifications.
 - 3) Shop testing and inspection of water meters shall be as indicated in accordance with respective reference standard.
 - 4) The equipment together with accessories shall be made by a reputable firm with at least five (5) years of experience in the field and having maintenance and repair facilities in Iloilo City, Philippines.
- b) General

The meters to be supplied in 3 m³ and 10 m³ size shall be the multi-jet type. They shall be suitable for domestic cold water use, with magnetic coupling and a register, that will continually ensure a day dial lens and these shall be complete with couplings and tail pieces. They shall be able to withstand shock during transport, handling, delivery and installation.

The multi-jet meter shall have a revolving element in the form of a bladed rotor mounted on a spindle within a cylindrical measuring chamber. The liquid enters the chamber through a number of tangential openings around the circumference of one level and leaves through similar openings of another level. The basic

principle of design is that over the working range of the meter, the speed of rotation of the rotor bears a linear relationship to the velocity of flow through the meter.

c) Materials and Workmanship

Unless otherwise specified, all materials and components for multi-jet meters under this Contract shall be suitable for and where necessary or desirable, specially treated and processed for delivery, storage and service under tropical conditions of high temperature, high humidity, heavy rainfall, and mildew and fungus-conductive environment. The material and processes used for tropicalizing shall be in accordance with the best commercial and industrial practices.

All materials shall be new and free from all imperfections. Materials shall be carefully selected for their suitability in the intended application.

d) Meter Body

The meter body (or case) shall be cast from copper alloy containing not less than 75% copper, or a copper alloy containing not less than 57% copper with an anti-corrosion treatment. Castings shall be smoothly finished free from defects. Castings which have been repaired are not acceptable.

Meter bodies shall have a common inlet-outlet axis and shall be suitable for horizontal installation.

All external fasteners and seals shall be designed for easy disassembly, after long in-service use, without the need for special tools or equipment.

Meter bodies shall have integral connection spuds which shall be threaded parallel, right hand external in accordance with ISO Recommendation R228, as follows:

Meter Size	Meter Spud Required Thread ISO R228 Designation Nominal Size
3 m ³ & 5m ³ 7 m ³ 10 m ³	19 mm (¾") 25 mm (1") 32 mm (1 ¼")

e) Register Bonnet

The register bonnet (or box ring) shall be made of copper alloy containing not less than 57% copper or of a suitable synthetic polymer that will neither warp nor deform when exposed to temperatures of up to 50°C.

f) Dial Lens

The lens covering the register dial shall be securely fastened and shall be of clear glass of 5 mm minimum thickness, tempered or otherwise hardened such as to be resistant to impact and abrasion.

Impact resistance shall be such as to resist the impact of a 25 mm diameter steel ball dropped from a height of one (1) meter, without sustaining any evident damage.

Meter lenses shall be covered by a hinged lid or similar protective device or a suitable synthetic polymer.

g) Register

The type of register compartment shall be such that there will be no occurrence of moisture condensation on the dial lens that will make meter reading difficult or obscure the meter register when placed in service under conditions stipulated in Sub-section 6.1.2.6.2.c).

The meter register shall be straight reading in cubic meters (m³) that is, with an in-line row numerals appearing on number wheels revolving on a common horizontal axis and framed in a rectangular shaped aperture.

h) Measuring Chamber Assembly

The measuring chamber shall be a self-contained unit cast independently of the meter body either in copper alloy containing not less than 75% copper with suitable amounts of tins, lead and zinc, or in a suitable synthetic polymer, to withstand all normal conditions of operation without change in form or dimension. It shall be smoothly finished, firmly seated and easily removed, and be secured so that the meter's accuracy will not be adversely affected by any distortion of the meter body.

Multi-jet adjustable rotors shall be smoothly finished, of vulcanized hard rubber or suitable synthetic polymer.

Rotor spindle or pivot shall be of phosphor bronze, stainless steel, nickel or nickel alloy or suitable synthetic polymer with nut for adjusting rotor.

Diaphragms, thrust roller and thrust roller bearing plates shall be of phosphor bronze, monel, stainless steel or a suitable synthetic polymer.

The movement of the measuring element shall be transmitted to the register magnet by means of a permanent drive magnet on the upper end of the elements spindle. The magnet shall be of graphite or other suitable non-corrosive magnetic material. The entire magnetic coupling shall be protected from external magnetic fields by suitable shielding on all the sides of the meter.

No part of the measuring chamber assembly should be deformed when exposed to 50 °C.

i) Strainer

Each meter shall have a rigid strainer screen on the inlet. The screen shall be a snug fit and yet easy to remove. The effective open straining area of the screen shall be at least twice that of the meter inlet bore. Screen shall be on stainless steel, a suitable synthetic polymer or other approved material. Strainer shall conform to AWWA C708.

j) Tailpieces

Each meter shall have a pair of tailpieces. Tailpieces shall be of copper alloy containing not less than 57% copper.

The end of the tailpiece joining the meter spud shall have a shoulder and gasket. The opposite end of the tailpiece shall be threaded right hand external taper in accordance with ISO Recommendation R7, as follows:

Meter Size	Required Thread ISO R228 Designation Nominal Size
3 m ³ & 5 m ³ 7 m ³ 10 m ³	19 mm (½") 25 mm (¾") 32 mm (1")

The length of tailpieces shall be to suit the meter length (face to face of spuds) such that the overall length of the assembly (meter plus two tailpieces) will be equal to the present meter assemblies in the system, which are based on AWWA dimensions as follows:

Meter Size	Overall Length of Assembly
3 m ³ & 5 m ³ 7 m ³ 10 m ³	12 ¼ inches = 311.15 mm 14 inches = 355.60 mm 16 inches = 406.40 mm

k) Coupling

Coupling nuts for joining the body spuds and tailpieces shall be made of a copper alloy containing not less than 57% copper, and shall have internal parallel pipe threads conforming to the meter spud threading.

The coupling shall have sealing wire holes of not less than 2 mm diameter.

Coupling gaskets shall be made of paraffined leather, rubber, composition fiber, or a suitable synthetic polymer.

l) Sealing

Each meter shall be supplied with copper wire and lead seal system to discourage unauthorized opening or removal of the meter and also to indicate if

such unauthorized action has occurred. All elements of the sealing system, including length of wire, location of wire holes, etc., shall be suitable for covering all possible means of tampering, in particular disturbance of the coupling nuts, accuracy of the adjustments device or of the register assembly. The lead seal shall be blank and suitable for sealing by a compression tool, supplied by others, containing a unique embossing symbol.

m) Tamper-Resistant Device

Each meter shall incorporate a tamper-resistant device which shall function separately from the wire and lead seal, and which is intended to deter entry into the register assembly.

n) Shop Testing

The approved manufacturer shall perform the following test for every water meter.

- 1) After machining each body, casing and each tailpiece shall be subjected to air or water hydrostatic pressure of 200 meters of water column for one (1) minute. Should any leakage be observed, the body or tailpiece shall be rejected.
- 2) After assembly, each completed meter shall be subjected to a hydrostatic pressure of 200 meters of water column for one (1) minute. Should any leakage be observed the necessary adjustments shall be made to stop the leakage or the meter shall be rejected.
- 3) Each assembled meter shall be tested for accuracy and adjusted as necessary to meet the guaranteed performance. Test results of each meter shall be certified by the manufacturer as correct and submitted to the Engineer.

6.1.2.7 Valves, Hydrants and other Appurtenances

a) General

Valve ends shall be at the Contractor's option except as specified by the Engineer and where specifically called for on the drawings. Caulked-typed bell ends shall not be allowed for 200 mm and larger valves.

All valves shall have the direction arrow for opening, the name for manufacturer and the working pressure for which they are designed, cast in raised letters upon an appropriate part of the body. In addition, valves designed for one-way flow only shall have a direction arrow cast on the body.

All interior part of valves manufactured of bronze (except valve stems) shall conform to the requirements of ASTM B62 unless otherwise stated.

Gate and check valves shall be suitable for use under operating conditions of 100 meter water column. Operating nuts and valve operators shall turn counterclockwise to open.

The Contractor shall submit manufacturer's certified drawings showing the principal dimensions, construction details and materials used for all parts of the valve and full details of valve stem extensions, including materials, dimensions, fabrication, torque limits, method of connection to the valve and box and stem guides when required to avoid buckling.

b) Gate Valves

Gate valves with a diameter of 75 mm above shall be flanged type and made of cast iron in accordance with AWWA C 500. The waterway shall be unobstructed and of a diameter not less than full diameter of the valve when in the open position.

The valves shall have a 50 mm square operating nut with the work "OPEN" and an ARROW cast on showing that the valve opens by turning the operating nut counterclockwise.

Valves shall be of the non-rising stem type, with a minimum of two (2) "O" ring seals, of which at least one (1) shall be above the stem collar and replaceable under full working water pressure while the valve is in the fully open position.

Gate valves with a diameter of 75 mm below shall be bronze type with threaded connection designed for a water working pressure not less than 1.0 MPa (150 psi) in accordance with Grade 1 of ASTM B62 and threaded to ANSI B2.1.

c) Stand-up Type Fire Hydrant (Commercial Type)

Fire hydrant assemblies shall be designed to withstand a minimum water working pressure of 1.0 MPa (150 psi).

The component materials and protective coating of fire hydrant assemblies shall be free from toxic substances and shall not foster microbiological growth nor give rise to taste, color, cloudiness or discoloration of the water which they come into contact with.

Hydrant head shall have a 150 mm (6 in.) flanged inlet, a 100 mm (4 in.) hose pumper outlet, and a 63 mm (2-1/2 in.) hose outlet. The outlets shall have National Standard Hose Threads with bronze or plastic caps with chains. The hydrant head shall have a heavy duty body of grade A bronze conforming with ASTM Specification B-62 or gray or ductile cast iron in accordance with AWWA C503 and shall meet Underwriters National Standard Specifications of fire hydrant heads. The bury section shall be made of cast iron or steel while all working parts (valve mechanisms) shall be made of bronze. The stem shall be provided with at least two (2) O-rings. Hydrant heads made of C.I. shall be thoroughly machined and cleaned on the inside and the outside. The inside surface shall be coated with epoxy paint or approved equal, while the outside surface shall be painted with at least two (2) coats of paint or approved substitute. Hydrant heads made of bronze may be coated with a suitable clear sealer. The bury section shall be applied with the required protection for C.I. or steel (as the case may be). The design, materials of construction, and fabrication shall be in accordance with AWWA Standard for Wet-Barrel Fire Hydrants (AWWA C503).

d) Check Valves

The check valve shall be of the swing type and shall be borne as brass with screwed connection designed to prevent the reversal flow of water. The swing type check valve shall be designed for a water working pressure of not less than 1.04 N/mm².

e) Air Release Valves

Air release valves up to and including 75 mm (3-in) in diameter shall have threaded connections, except where otherwise shown on the drawings and shall be designed for a water working pressure of 1.0 MPa (150 psi). The body shall be of high strength cast iron and the float shall be of stainless steel. All internal parts, except the seat shall be of stainless steel or bronze. The seat shall be of material insuring water tightness with a minimum of maintenance. The valve shall be designed to automatically permit the escape of accumulated air under pressure while the pipe is in operation. The valves shall be either direct or lever operating.

6.1.2.8 Pumping Equipment

a) General

- 1) All equipment shall be supplied from reputable firms engaged in the manufacture of each particular item. The entire assembly as installed shall be given a start-up and test run to prove that all the Specifications have been met before acceptance by the Engineer. The test duration shall be 24 hours. Submittal of the Certificate of Test to the Engineer shall be a condition of final payment.
- 2) The Specifications stated herein are basic guides only. Other items not so indicated but which are obviously necessary for the proper operation of system as intended shall be supplied in accordance with accepted engineering standards.
- 3) The equipment shall be guaranteed for a period of at least one year of trouble free operation. The Supplier of equipment shall certify to the availability of spare parts locally and service in case of system breakdowns within a period of at least three years. Manuals of operation and maintenance and lists of spare parts shall be supplied together with the equipment. Submittal of warranty certificates shall be a condition for final payment.
- 4) The Supplier shall submit at least two copies of pump performance curves showing, among others, the pump rating and pump efficiency properly marked thereon.
- 5) Pump and motor installation dimension drawings shall be submitted and verified in the site.

- 6) The brands, names and place of manufacture of pump and motor, and all accessories where applicable shall be indicated in the quotation. Also, a description of pump impellers being offered shall be included.
- 7) A metal nameplate indicating in indelible letters the correct Specifications of the pump and motor shall be properly attached to the assembly at a location such that the information written thereon can be conveniently read by all concerned.
- 8) Preparation and submittal of As-built drawings.

b) Booster Pumps for Seawater Intake

The pumps shall consist of 2 units of horizontal multistage centrifugal pump with a capacity of 50 gpm driven by 2.2 kilowatts electric motor. Pump and motor shall be mounted on a common steel base.

1) Pump Operation – Automatic with Alternative Manual Operation

Electric Motor Pump

- | | | |
|------------------------|---|-----------------|
| (a) Design Capacity | : | 50 gpm |
| (b) Total Dynamic head | : | 120 ft |
| (c) Electric Motor | : | 2.2 kW (3.0 Hp) |
| (d) Pump Speed | : | 3480 rpm |

2) Priming

All pumps shall be self-priming.

3) Electric Motor

The pump shall be driven by a 2.2 kilowatts, 220/440 volts, 60 Hz, 3-phase electric motor.

4) Material

- | | |
|------------------|-----------------|
| (a) Casing - | Stainless Steel |
| (b) Impeller- | Stainless Steel |
| (c) Shaft - | Stainless Steel |
| (d) Shaft Seal - | Mechanical Seal |
| (e) Rubber - | EPDM |

c) Submersible Pump for Deepwell

The pump shall be of the low head high capacity type that should satisfy the operational requirements described herewith.

1) Design Requirements

The pump shall be a single suction submersible pump with integrated submersible motor and the discharge nozzle to be installed in the valve box sump. The maximum rated speed of the pump shall not exceed 3600 rpm.

The guaranteed terms shall include continuous operation of the pump in groundwater with 25 ppm sand content by weight. The guaranteed operating range shall involve all operating conditions of the sump that are assigned between the minimum head point and the maximum head point.

Pump and motor though coupled shall be designed as separate units. All rotating parts of the pump and motor shall be statically and dynamically balanced.

The pump shall be provided with an integrated foot strainer. The check valve at the discharge side of the pump shall be of the streamline disc or drop pipe. The sealing faces shall be of corrosion and erosion resistant material.

Diaphragm check valve types of certified performance are also acceptable. The strainer shall have a minimum net inlet area of three times the smaller suction inlet area. The pump shall be sufficiently resistant against sand contents of the groundwater to be suitable for the application.

The pump shall have a nameplate showing the serial number of the equipment and the name of the manufacturer. The nameplate shall show the capacities in cu.m./hr, total head in meters and the rated speed in revolution per minute. Such other information as the manufacturer may consider necessary may be shown on the plate. The nameplate of the distributing agent will not be acceptable. The nameplate shall be securely attached to the equipment to the location affording easy viewing when delivered and installed. Installation of winding temperature sensors may be offered separately.

The motor shall withstand operation of the pump against closed discharge valve for a minimum of six (6) minutes without damage from overheating.

The thrust bearings shall be designed for sustained operation against closed discharge valves (disregarding motor requirements) and shall be shock and water-hammer proof.

The lifetime of the thrust bearings shall be guaranteed for five (5) years' continuous operation under actual site conditions considering various heads, throttled flow, power failures, etc.

2) Pump Operation – Automatic with Alternative Manual Operation

Electric Motor Pump

- | | | |
|------------------------|---|--------|
| (a) Design Capacity | : | 50 gpm |
| (b) Total Dynamic head | : | 200 ft |

- (c) Electric Motor : 3.7 kW (5.0 Hp)
(d) Pump Speed : 3480 rpm

3) Electric Motor

The pump shall be driven by a 3.7 kilowatts, 230 volts, 60 Hz, 3-phase electric motor.

4) Material Requirement

All coupled materials shall be selected to avoid electro-chemical corrosion. The material of the well casing and well screen shall be of low carbon steel and stainless steel respectively. For protection against wear and corrosion the following minimum material requirements shall be met.

<i>Parts</i>	<i>Minimum Requirements</i>
Pump Bowls	Stainless steel, minimum ultimate strength 200N/mm ²
Impellers	Stainless steel
Strainer	Stainless Steel
Pump Shaft	Stainless Steel 16% Cr, 1.5% Ni

5) Spare Parts Requirements

The Contractor shall give a complete specification of all spare parts compatible to his pump and motor design, which shall be illustrated by a sectional drawing. The following spare parts shall be supplied for each type of motor and pump assembly delivery:

- (a) 1 set of bearings and thrust bearings including shaft sleeved and thrust rings.
- (b) 1 set of impellers including lock collars, clamping devices or sleeves
- (c) 1 set of wear rings
- (d) 2 motor shaft seals and sleeves

6.1.3 EXECUTION

6.1.3.1 Reinforced Concrete Rainwater Tanks

a) Excavation and Backfilling

All excavation and backfilling to be undertaken shall be in accordance with Section 4.2, "Excavation and Backfilling for Buildings."

b) Reinforced Concrete Work

Cutting, bending and fixing of reinforced steel shall conform with the requirements of Section 3.2, "Concrete Works" and as shown on the drawings.

Concrete work shall conform with the requirements of Section 3.2, "Concrete Works" and as shown on the drawings.

Concrete cover to reinforcement nearest to the surface shall be as shown on the drawings, but in no case shall be less than 75 mm.

c) Waterproofing

1) Application for Cementitious Waterproofing:

Application procedure shall be in accordance with the manufacturer's recommended system of work.

Manufactured materials shall be delivered to the site in their original packages or containers bearing the manufacturer's name and brand designation.

2) Surface Preparation/Application of Cementitious Type Waterproofing and Epoxy Tank Lining Waterproofing:

(a) Surface Preparation for Cementitious Type Waterproofing

All concrete to be treated must be structurally sound. Remove all forms of scale, oil, form release agents, laitance and any foreign materials which will impair the bond, penetration and performance of the waterproofing. Rout out visible cracks exceeding 0.01" in size, 19 mm deep, also honeycombed pockets and faulty construction joints. Form tie holes shall be left approximately 25 mm back of surface. Rinse all surfaces thoroughly with water the day prior to the capillary type waterproofing application.

(b) Application of Cementitious Type Waterproofing

The manner of installation shall be as per manufacturer's standard procedure.

(c) Surface Preparation for Epoxy Tank Lining Waterproofing

All waterproofing treated surfaces to receive epoxy coating must be neutralized with a solution of capillary type waterproofing cleaner. The capillary type waterproofing application has to age for a minimum period of two (2) weeks before application of epoxy.

(d) Application of Epoxy Tank Lining Waterproofing

Moisture must be present in the concrete strata to assure maximum chemical penetration. Surfaces shall be moist only, not wet when coatings are applied.

Mixing : Mixing proportions and procedures as recommended by the Manufacturer.

Curing : Moisture cure waterproofing treated surfaces for a period of three (3) days starting with water fog spraying the day following the completion of waterproofing application. Backfill materials can be placed on the application after moisture curing has been completed and no protection boards are required.

The waterproofed water tank shall be flood tested in accordance with Sub-section 6.1.3.1.f)

d) Installation of Valves and Fittings

- 1) Valves shall be inspected in opened and closed position to ensure that all parts are in good working condition and interiors cleaned of all matters before installation.
- 2) Valves and fittings shall be installed at the points and manner as shown on the drawings and in accordance with the requirements of the approved installation instructions recommended by the approved manufacturer.

e) Installation of Pipes

- 1) All pipes shall be carefully placed and supported at the proper lines and grade where possible shall be sloped to permit complete draining.
- 2) Piping runs shown on the drawings shall be followed as closely as possible, except for minor adjustments to avoid adverse-effect on architectural and/or structural features. If major relocations are required, they shall be subject to the approval of the Engineer.
- 3) Carefully inspect all pipes and fittings before installation. Inspection of pipe shall include light tapping with a hammer to detect cracks or defects. No pipe fittings or valves which are cracked or showing defects shall be used.
- 4) Piping shall be properly supported by suitable anchor, brackets or hangers. Vertical pipes shall be anchored by suitable galvanized steel straps. Pipe supports shall be provided as shown on the drawings.

f) Test for Watertightness and Disinfection of Reinforced Concrete Rainwater Tanks

- 1) The water tank shall be subjected to leakage test after concrete has attained a compressive strength of 27.6 MPa (4,000 psi) and waterproofing process has been completed. After cleaning out all debris and dirt from the inside tank, the cistern shall remain filled with clean water for a minimum of 24 hours reckoned from the time the free-board line was reached during filling up. After the 24-hour period there shall be no drop in water level in the tank more than 40 mm, otherwise the leak shall be located and plugged properly and the test for watertightness is repeated. Should the test disclosed any leakage the Contractor shall correct the defect at his own expense.

- 2) Before the water tank can be placed in service, the structure shall first be chlorinated to avoid pollution of the potable water supply. The cistern shall be continuously flushed and scrubbed with clean water so that all solid pollutants or pollutants of any physical form shall be washed away.

After flushing, such that the flushing water runs clear, the water tank shall be flushed and scrubbed with HTH solution (High Test Hydrochlorite) of at least 50 parts per million available chlorine strength. After flushing with HTH solution and after solution has been removed by flushing with potable water, samples of new water stored in the water tank shall be taken and tested bacteriologically.

6.1.3.2 Stainless Steel Cylindrical Rainwater Tanks

- a) Horizontal stainless steel cylindrical water tanks for Administration Building shall be installed on the reinforced concrete pad after the concrete has attained its design compressive strength. The tank shall be fastened to the R.C. pad by means of 25 mm G.A. 18 stainless steel strap bolted on the R.C. pad. Refer to the drawings for the details.

- b) All the necessary pipes, fittings and valves shall be installed at the points and in a manner shown on the drawings.

- c) Test for Watertightness of Completed Stainless Steel Tanks

The completed stainless steel water tanks shall be tested for watertightness by filling it up with clean water after cleaning out all dirt and debris from inside the tank. The water shall be allowed to stand for a minimum period of 24 hours reckoned from the time the maximum water level line was reached during filling up. After the 24 hour period there shall be no drop in water level in the tank more than 40 mm, otherwise, the leaks shall be located and plugged properly and the test for watertightness repeated.

- d) Defective Work

- 1) If the inspection and test show any leaks, such leaks shall be repaired by welding. The tank shall be re-tested and repaired until satisfactory results are obtained and no leaks occur.
- 2) All repairs shall be made with new material at the expense of the Contractor.
- 3) No caulking of screwed joints or holes will be accepted.

A test certificate shall be filled out and signed by the Engineer's and Contractor's representative.

- e) Disinfection of Stainless Steel Water Tank

Before the elevated stainless steel water tank is placed in service, the tank shall be disinfected in the same manner as that discussed in Sub- section 6.1.3.1.f.

6.1.3.3 Stainless Steel Water Tank for Potable Water

- a) Concrete, reinforcing steel and metal structures shall be in accordance with appropriate sections of the Specifications.
- b) Piping, fittings and miscellaneous metal works.
- c) Furnish and install all pipe fittings, valves, pipe supports, miscellaneous metal work and all required appurtenances as shown on the plans and as required to make the entire system operable. The following shall be complied:
 - 1) Provide access manhole cover as shown on the drawing.
 - 2) The water tank shall be provided with a water level indicator device.
 - 3) Air vent shall be fitted with wire-mesh insect screen as shown on the drawings.
 - 4) Water tank shall be fitted with approved access and servicing ladders. Inside ladder rungs shall be stainless steel.
- d) Test for Watertightness of Completed Stainless Steel Water Tank

The completed stainless steel water tank shall be tested for watertightness by filling it up with clean water after cleaning out all dirt and debris from inside the tank. The water shall be allowed to stand for a minimum period of 24 hours reckoned from the time the maximum water level line was reached during filling up. After the 24 hour period there shall be no drop in water level in the tank more than 40 mm, otherwise, the leaks shall be located and plugged properly and the test for watertightness repeated.

- e) Defective Work
 - 1) If the inspection and test show any leaks, such leaks shall be repaired by welding. The tank shall be re-tested and repaired until satisfactory results are obtained and no leaks occur.
 - 2) All repairs shall be made with new material at the expense of the Contractor.
 - 3) No caulking of screwed joints or holes will be accepted.

A test certificate shall be filled out and signed by the Engineer's and Contractor's representative.

6.1.3.4 Distribution Lines

- a) Handling and Protection
 - 1) Care shall be taken in loading, transporting, and unloading to prevent injury to the pipes or coatings. Pipes or fittings shall not be dropped. All pipes or

fittings shall be examined before laying, and no piece which is found to be defective shall be installed.

- 2) If any defective pipe is discovered after it has been laid, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractors at his own expense. All pipes and fittings shall be thoroughly cleaned before laying, and shall be kept clean until used in the completed work, and shall be laid to conform to the lines and grades required.
- 3) After installation, all pipes shall be protected from damage during subsequent construction activities.

b) Trench Excavation and Backfilling

- 1) The minimum width of excavation for all pipes shall be 300 mm. The ground adjacent to all excavations shall be graded to prevent water from running in. The Contractor shall remove, by pumping or by other means approved by the Engineer, any water that has accumulated in the excavation. Pumping shall be at the expense of the Contractor. All other excavation related to the work shall comply with the requirements of structural excavation under Section 4.2 "Excavation and Backfilling for Buildings."
- 2) Backfilling shall be done only after leakage test on the installed pipelines have been completed, inspected and approved by the Engineer.

Sand bedding materials shall be placed evenly and carefully around and over the pipe, hand tamped in 100 mm maximum layers up to 300 mm cover over the pipe, then followed by 600 mm minimum cover of ordinary well compacted materials unless otherwise shown on the drawings.

c) Installation of G.I. Pipes and Fittings

The pipes shall be accurately installed to the line, levels, grades and positions set out by the Contractor based on survey to be conducted by the Contractor and referred from data shown on the drawings, under the direction and approval of the Engineer.

Prior to installation of a pipe, adequate inspection of the pipe body for cracks or other defects shall be performed. The inside of the pipe shall be thoroughly cleaned prior to installation.

Straight piping shall not be inclined more than a definite angle limit as directed by the Engineer.

At any place where the pipe is to cross an existing buried structure, there will be a separation of at least 300mm.

Pipes, valves and fittings shall be carefully examined on defects at the time of installation. Any defective material discovered before, during or after being installed shall be permanently marked, removed from the jobsite, and replaced with sound material.

Where it is required to join pipes, valves, or fittings of different type, size, or joint combination, adapters shall be used of a class and type appropriate to the connecting ends as shown on the drawings.

All pipe joint preparation and jointing operations shall comply with the instructions and recommendations of the approved pipe manufacturer.

Piping shall be properly supported by suitable anchor, bracket or hangers. Vertical pipes shall be anchored by suitable galvanized steel straps. Pipe supports shall be provided as shown on the drawings.

The Contractor shall be responsible for taking the measurements required to determine the lengths of cut portions of pipes for insertion as closing lengths in pipelines. The pipe and methods of jointing shall be such that the locations of fittings and lengths of pipe can be adjusted in the field to suit field conditions and variations in stationing and not extra payment will be made for such adjustments. The Contractor shall make all closures with suitable pipe and approved connections to compensate for cumulative errors in pipeline installation. The Contractor shall take every precaution to ensure that both the measurement and the cutting of pipes are to the accuracy required and should any errors occur the Contractor shall remedy same at his own expense and to the satisfaction of the Engineer.

d) Installation of HDPE Pipes and Fittings

Pipes are to be laid carefully onto the sand bed and joined using the specified couplers. Fill and compact both sides with good quality selected filling material up to two-thirds (2/3) of the pipe diameter. Compact the filling material in successive lifts of 150mm each. Note: The layers must pass compaction dry density test at minimum 95%.

Using a shovel to 'slice' the material under and around the pipe with subsequent compaction until 50% of outside diameter of pipe.

e) Valve Box

Valve boxes shall be cast iron or concrete as shown in the drawings, except that concrete boxes may be installed only in locations not subjected to vehicular and with flared base. The minimum thickness of metal shall be 5mm (3/16 inch). Concrete boxes shall be the standard product of a manufacturer of precast concrete equipment. The work "WATER" in English shall be cast on the cover. The boxes shall be of such length as will be adapted, without full extension to the depth of cover required over the pipe at the valve location.

f) Thrust Blocks

- 1) Longitudinal thrust along pipelines of bends, tees, reducers, and caps or plugs shall be counteracted by thrust blocking, pipe harnesses or other suitable means approved by the Engineer.

Where bends are in a vertical plane, the thrust shall be counteracted by enough weight of concrete to counterbalance the vertical thrust forces. Where undisturbed trench walls are not available for thrust blocking, the Contractor shall furnish and install suitable pipe harnesses or ties designed and manufactured specifically for this purpose. Harnesses and/or ties shall be approved by the Engineer.

- 2) In lieu of thrust blocking and with the approval of the Engineer, the Contractor may elect to provide pipe harnesses and/or ties or restrained push-on or restrained mechanical joints.
- 3) Concrete for thrust blocking shall conform to provision of Section 3.2, "Concrete Works."

g) Field Testing

1) General

- (a) The Contractor shall furnish all necessary equipment and labor for carrying out a pressure test and leakage test on the pipelines. The procedures and methods for carrying out the pressure and leakage test shall be approved by the Engineer.
- (b) The Contractor shall make any taps and furnish all necessary caps, plugs, etc., as required in conjunction with the testing of a portion of the pipe between valves. The Contractor shall also furnish a test pump, gauge, and any other equipment required in conjunction with carrying out the hydrostatic test.

2) Pressure Test

- (a) Pipeline tests shall be made on a portion of the pipeline between valves but shall not exceed 300 meters of the length of pipelines.
- (b) After the pipes have been laid, the joints completed and the trench partially backfilled but the joints exposed for examination, all newly laid pipes or any valve section thereof shall be subjected to hydrostatic test pressure not less than 1.04 N/mm^2 for any and all kinds of pipes, fittings and valves, for at least 30 minutes unless otherwise directed by the Engineer.
- (c) Pressure tests shall be made only after completion or partial backfill and at least seven (7) days after the last concrete thrust block has been cast.
- (d) Each length of pipeline to be tested shall be slowly filled with water and the specified test pressure measured at the point of lowest elevation shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer. During the filling operation of the pipe and before applying the test pressure, all air shall be expelled from the pipeline. To accomplish this, taps shall be made, if necessary

at points of highest elevation, and after completion of that test, the taps shall be tightly plugged.

- (e) During the test, all exposed pipes, fittings, valves joints and couplings will be examined. If found to be cracked or defective, they shall be removed and replaced by the Contractor at his expense. The test shall then be repeated until satisfactory results are obtained.

3) Leakage Tests

- (a) Leakage tests shall be conducted after satisfactory completion of the pressure tests and shall consist of an examination of all exposed joints for leakage as well as an overall leakage test of the completed pipeline.

The pressure to be maintained during the test shall be the average pressure to which the pipe will be subjected under normal conditions of service for at least two hours unless otherwise directed by the Engineer. The length of pipeline to be tested shall not exceed 300 meters. Each length of pipeline to be tested shall be slowly filled with water and the specified test pressure, measured at the point of lowest elevation, shall be applied by means of a pump connected to the pipe in a manner satisfactory to the Engineer.

Before starting the leakage test, all air shall be expelled from the pipe as specified under paragraph 2, "Pressure Test" above.

- (b) All exposed pipes, fittings, valves and joints shall be examined for leakage during the test. Any pipeline found with leakage in excess of the allowable rate specified in the following table shall be rejected.

Allowance Leakage Rate per 100 Points per Inch of Pipe Diameter at Pressure Stipulation

Pressure (N/mm ²)	Leakage Rate	
	Liters/Hours	Liters/2 Hours
0.31	1.36	2.72
0.34	1.44	2.88
0.41	1.57	3.14
0.44	1.65	3.30
0.48	1.70	3.40
0.51	1.76	3.52
0.55	1.82	3.64
0.69	2.04	4.08
0.86	2.29	4.58
1.04	2.52	5.04

- (c) Should any test of a section of pipeline disclosed joint leakage greater than that permitted, the Contractor shall at his expense repair or

replace the defective joints until the leakage is within the permitted allowance.

4) Disinfecting Pipelines

- (a) Before being placed in service, all potable water pipelines shall be chlorinated in accordance with AWWA 601, "Standard Procedure for Disinfecting Water Mains" unless otherwise specified herein. The procedure shall be approved by the Engineer.
- (b) The location of the chlorination and sampling points will be determined by the Engineer at the site. Taps for chlorination and sampling shall be uncovered and backfilled by the Contractor as required.
- (c) The general procedure for chlorination shall be first to flush all dirty or dissolved matter from the lines, for at least an hour to assure that all solid pollutants shall have been washed away. After flushing, and after flushing water runs, clear chlorine shall be introduced in approved dosages through a tap at one end, while water is being withdrawn at the other end of the line. The dosages of chlorine should provide an HTH solution (High Test Hydrochlorite) of at least 50 parts per million available chlorine strength. The chlorine solution shall remain in the pipeline for about 24 hours.
- (d) Following the chlorination period, all treated water shall be flushed from the lines at their extremities and replaced with water from the distribution system.

Bacteriological sampling and analysis of the replacement water shall be made by the Engineer in full accordance with the AWWA Manual C601. The Contractor will be required to rechlorinate, if necessary, and the line shall not be placed in service until approved by the Engineer.

- (e) Special disinfecting procedures shall be used where the method outlined above is not practicable.

6.1.3.5 Water Meters

Water meters shall be installed in accordance with AWWA specifications and as shown on the drawings or as directed by the Engineer.

6.1.3.6 Installation of Pumps

The booster pumps including accessories/appurtenances shall be installed in accordance with the approved manufactured recommended installation.

6.2 SANITARY SEWER SYSTEM

6.2.1 DESCRIPTION

The work covered by this Section involves the construction of the reinforced concrete septic tanks, sewer collecting pits and installation of sewer lines from the buildings to the point of discharge in accordance with these specifications and in conformity with the lines and grades shown on the drawings or as established by the Engineer.

The work includes the furnishing of labor, materials, tools, equipment and incidentals necessary for the construction of the reinforced concrete septic tank, sewer collecting pit and installation of sewer lines to the point of discharge.

6.2.2 MATERIAL REQUIREMENTS

6.2.2.1 Concrete Material

- a) Concrete for reinforced concrete septic tanks and sewer collecting pits shall be Class A and shall have a minimum 28 days compressive strength of 27.6 MPa (4,000 psi).
- b) All concrete materials shall conform with the requirements in Section 3.2, "Concrete Works."

6.2.2.2 Reinforcing Steel

Reinforcing steel bars shall conform with the requirements in Section 3.2. "Concrete Works" and sizes as shown on the drawings.

6.2.2.3 Sewer Pipes and Fittings

Exposed gravity sewer pipelines shall be Polyvinyl Chloride (PVC) pipes and fittings and shall be in accordance with ASTM D 3034, Type PSM with minimum SDR of 34.

Exposed gravity and pressurized sewer lines (If Applicable) shall be cast iron pipe and fittings with cement mortar lining conforming to AWWA C108/C115, pressure Class 150.

6.2.2.4 Jointing Materials

The joint for PVC pipes shall be push-on type with rubber O-ring. Rubber gaskets for push-on joint shall be of the continuous ring type made of special composition rubber, synthetic rubber or a suitable combination thereof.

6.2.2.5 Cleanouts

Cleanouts shall be PVC cleanout cover and plug fitted to PVC hubs and spigots.

6.2.3 EXECUTION

6.2.3.1 Septic Tanks

- a) R.C. septic tanks and sewer collecting pits shall be constructed as shown on the drawings and in accordance with Section 3.2, "Concrete Works."
- b) Excavation and backfilling shall conform with the requirements of Section 4.2, "Excavation and Backfilling for Buildings."
- c) Proportioning, mixing, placing and curing of concrete shall be in accordance with Section 3.2, "Concrete Works."
- d) Cutting, bending, and placing of reinforcing steel bars shall be in accordance with Section 3.2, "Concrete Works" and as shown on the drawings.

6.2.3.2 Installation of Pipes and Fittings

- a) Trench excavation shall be in accordance with Section 4.2, "Excavation and Backfilling for Buildings."
- b) Each pipe will be carefully inspected before and after it is installed. Defective pipes will be rejected. Pipes shall be laid with the bell pointing up grade. Spigots shall be adjusted in bells to give a uniform space all around. Blocking or wedging between bells and spigots will not be permitted. Pipes which does not allow sufficient space for proper fitting and installation of joint material shall be replaced by one of the proper dimensions. Open ends of pipes at the end of each day's work shall be closed temporarily with wood blocks or bulkhead.

Where indicated on the drawings, some pipes are laid discontinuous with no joint.

- c) After cleaning the spigot ends and socket, PVC pipe shall be jointed in accordance with the manufacturer's instruction and recommendations.
- d) All work shall be proved to be first class condition and constructed properly in accordance with the drawings and specifications. All defects and leaks disclosed by the tests shall be remedied. No piping shall be covered until it has been inspected, tested and approved.

6.3 DRAINAGE SYSTEM

6.3.1 DESCRIPTION

This work shall consist of the construction of drainage pipes, box culverts and ditches in accordance with these Specifications and to the lines, grades and dimensions shown on the drawings or ordered by the Engineer. It shall include the excavation and backfilling works, furnishing and laying of the pipes and the construction of such joints and connections to discharge outflow and/or accessories required to complete the work as shown on the drawings or as required by the Engineer.

6.3.2 MATERIAL REQUIREMENTS

6.3.2.1 Reinforced Concrete Pipe (RCP)

a) General Requirements for RCP

The drainage pipes shall be tongue and groove and shall conform to the requirements of ASTM C 76, Class II, Wall B or AASHTO M 170.

b) Compressive Strength of Concrete for RC Pipe

Concrete to be used shall conform to the requirements of Section 3.2, "Concrete Works" and shall have a 28 days compressive of 20.7 MPa (3,000 psi).

c) Concrete Materials

The concrete materials for reinforced concrete pipe shall be as follows:

- 1) Portland cement shall conform to the requirements of ASTM C 150.
- 2) The fine aggregates shall consist of sand, stone screening or other approved inert materials with similar characteristics, or combination thereof, having a clean, hard, strong, sound, durable and uncoated grains, free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances, and shall not contain more than three percent of materials passing the 0.075 mm (No. 200) sieve by washing nor more than one percent of clay lumps or one percent of shale. The use of beach sand is prohibited.

The fine aggregates shall be tested for sodium sulphate soundness in accordance with AASHTO T 104 five (5) cycles and shall show a maximum loss of not more than 10 percent.

The fine aggregates shall be uniformly graded and when tested in accordance with AASHTO T11 and AASHTO T27 shall meet the grading requirements shown below:

REQUIREMENTS FOR FINE AGGREGATE

US Standard Sieve mm	Alternative	Percent Passing by Weight %
9.5	(3/8 in)	100
4.75	(No. 4)	95-100
1.18	(No. 16)	45-80
0.30	(No. 50)	10-30
0.15	(No. 100)	2-10

Fine aggregates shall be such quality that mortar specimens, prepared with standard Portland cement and tested in accordance with AASHTO T 71,

shall develop a compressive strength at 7 days of not less than 90 percent of the strength developed by a mortar prepared in the same manner with the same cement and graded sand having a fineness modulus of 2.40 ± 0.10 . Natural aggregates shall be thoroughly and uniformly washed before use.

- 3) Water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer. It shall be free from oil and shall not contain more than 1,000 parts per million of chlorides as Cl, nor more than 1,300 parts per million of sulphates as SO₄. In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of more than 25 percent nor a reduction in the compressive strength of mortar at 14 days of more than 5 percent when compared to the results obtained with distilled water.
- 4) When required by the Engineer, the quality of the mixing water shall be determined by the Standard Method of Test for Quality of Water to be Used in Concrete, AASHTO T26.

d) Reinforcement

Steel Bar Reinforcement for RC Pipes and RC Collar shall be deformed billet-steel bars Grade 40, and with a minimum yield strength of 276 MPa, conforming to the requirements specified in ASTM A 615 unless otherwise shown on the drawings or required by the Engineer. The use of cold twisted bars is not permitted.

e) Inspection before laying

All reinforced concrete pipes shall be approved by the Engineer prior to installation. Pipes will be subject to rejection on failure to conform to any of the minimum requirements, and units may also be rejected for reasons as follows:

- 1) Fractures or cracks passing the shell (except that which does not exceed the depth of the joint).
- 2) Defects that indicate imperfect proportioning, mixing and moulding.
- 3) Damage indicating honeycomb or open texture.
- 4) Damage ends that prevent a satisfactory joint.
- 5) Warp or misalignment greater than 1 ½ percent of the true form; however, a wall thickness greater than that specified will not be a cause for rejection.

f) Repair of pipes

Pipes may be repaired, if necessary, and will be acceptable if in the opinion of the Engineer, the repairs are sound and properly finished and cured, and the repaired portion otherwise conforms to the requirements of this Section.

6.3.2.2 Mortar Material

- a) Cement mortar shall consist of one part of Portland cement and two parts of fine aggregates with water added as necessary to obtain the required consistency.
- b) Portland cement, sand and water shall be in accordance with Section 3.2, "Concrete Works."

6.3.2.3 Polyvinyl Chloride (PVC) Pipe

Polyvinyl chloride (PVC) pipes for drain lines shall conform to ASTM D 1784, Class II.

6.3.2.4 Reinforced Concrete Headwall

Concrete and reinforcing bars shall be in accordance with Section 3.2, "Concrete Works." Concrete shall have a 28 day compressive strength of 20.7 MPa (3,000 psi).

6.3.2.5 Open Trench (U-Ditch) With Steel/Cast Iron Gratings

Excavation and backfilling works shall conform to the requirements of Section 4.2, "Excavation and Backfilling for Building" of these specifications.

Concrete with steel reinforcement shall conform to the requirements of Section 3.2, "Concrete Works" of these specifications.

Gravel bedding shall be of maximum size of 19mm conforming to the requirements of Section 3.2, "Concrete Works."

Steel gratings shall be pre-fabricated hot-dip galvanized structural steel forge welded/machine made gratings and shall conform to the requirements of Section 4.7, "Steel and Metal Works." Refer to the drawings for the details.

6.3.2.6 Concrete Bedding

Concrete bedding when required by the Engineer shall have a 28-day minimum compressive strength of 17.2 MPa (2,500 psi). Concrete bedding materials such as Portland cement, aggregates and water shall conform with requirements of Section 3.2, "Concrete Works."

6.3.2.7 Manholes

- a) Cement

Portland cement shall conform to the requirements of ASTM C 150 Type 1.

- b) Fine Aggregate

Fine aggregate shall be in accordance with Section 3.2, "Concrete Works" and shall conform with ASTM C 33.

c) Coarse Aggregate

The coarse aggregate shall consist of crushed or uncrushed stone, gravel or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable uncoated particles, free from injurious amount of soft, friable, thin, elongated, or laminated pieces, alkali, organic or other deleterious matter and conforming to the requirements of Section 3.2, "Concrete Works," of these Specifications and ASTM C 33.

The coarse aggregate shall be of uniform grading with maximum sizes of 19 mm.

d) Water

Water for washing, mixing and curing shall be in accordance with Section 3.2, "Concrete Works."

e) Steel Reinforcement

Steel reinforcement shall conform to the requirements of Section 3.2, "Concrete Works," and as shown on the drawings.

f) Concrete

Concrete for cast in place shall be Class C with 28 days compressive strength of 20.7 MPa (3,000 psi)], unless otherwise indicated in the drawings or directed by the Engineer.

g) Gravel Base

Gravel base shall be of a maximum size of 19 mm conforming with the requirements of Section 3.2, "Concrete Works."

h) Manhole Cover

Refer to Sub-section 6.3.2.5 for the material requirements of steel gratings.

6.3.2.8 Bedding Materials

- a) Bedding where required shall conform to one of the classes specified. When no bedding class is specified requirements for Class C bedding shall apply for concrete pipe.
- b) Class A bedding shall consist of a continuous concrete cradle conforming to details on drawing.
- c) Class B bedding shall consist of bedding with a depth of not less than 30 percent of vertical outside diameter of pipe.
 - 1) Minimum thickness of bedding beneath pipe shall be 100 mm.

- 2) Bedding material shall be sand or selected sandy soil all of which passes a 9.5 mm sieve and not more than 10 percent of which passes a 7.5 mm sieve.
- 3) Layer of bedding material shall be compacted and shaped to fit pipe for at least 15 percent of its total height. Recesses in trench bottom shall be shaped to accommodate bells or other projections.
- d) Class C bedding shall consist of bedding with a depth of not less than 10 percent of its total height with foundation surface shaped to pipe contour.

6.3.3 EXECUTION

6.3.3.1 Excavation

- a) A trench shall be excavated to the line, depth and grade necessary for the pipe to be laid as shown on the drawings. Except where bedding is required, the bottom of the trench shall be shaped to conform to the shape of the pipe for at least 30 percent of its outside circumference. The width of the trench shall be as shown on the drawings but not be greater than 2 times the pipe diameter, to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe.
- b) All soft unsound material underlying the proposed pipework shall be removed to the depth required by the Engineer and shall be replaced by suitable material in layers not exceeding 200 mm in depth and compacted.

6.3.3.2 Bedding

- a) The trench shall be excavated to the depth required for the gravel or sand bedding as shown on the drawings and in accordance with Section 4.2, "Excavation and Backfilling for Building."
- b) Soft, spongy, or otherwise unstable materials encountered that will not provide a firm foundation for the pipe shall be removed for the full width of the trench and replaced to a depth of not less than 30 percent of the vertical outside diameter of the pipe.
- c) After excavating, gravel or sand bedding shall be laid to the dimensions shown on the drawings or as may be directed by the Engineer.
- d) Bedding, unless shown otherwise in the drawings, shall be provided for depth of not less than 10 percent of total length of pipe; with sufficient additional bedding placed and shaped to pipe profile to provide continuous support for not less than 25 percent of pipe circumference.
- e) Proportioning, mixing, placing and using concrete bedding shall be in accordance with Section 3.2, "Concrete Works."

6.3.3.3 Placing RC Pipe

- a) Pipe trenches shall be inspected and approved by the Engineer prior to start of work. RC collar and grout joints shall be properly cured, dried and approved by the Engineer prior to start of backfilling.
- b) The pipe shall be laid carefully with bells at the higher end and with ends fully and closely jointed, and true to the elevations and grades given. Proper facilities shall be provided for lowering the sections when they are to be placed in a trench.
- c) Pipe shall not be installed when subgrade material is in muddy or soggy condition.
- d) Under no circumstances shall pipe be laid in water, and no pipe shall be laid when the trench conditions or the weather are unsuitable for such work, except with specific approval of the Engineer.
- e) Any pipe which is not in true alignment or which shown any undue settlement after being laid, or is damaged, shall be taken out and relaid or replaced without additional cost to the Employer.
- f) Tongues shall be adjusted in grooves to give a uniform space all around. Blocking or wedging between tongues and grooves shall not be permitted. Pipe that does not allow sufficient space for proper caulking and installation of jointing material shall be replaced by one of the proper dimensions. Open side of pipes at the end of each day's work shall be closed temporarily with wood blocks or bulkheads.
- g) The first unit shall be properly bedded. A shallow excavation for the concrete saddle with dimensions as shown on the drawings, shall be made underneath the unit at the joint and filled with mortar to provide a bed for the second. The mortar shall consist of 1 part Portland cement to two parts of clean sand by volume with sufficient water to obtain the workability required. The grooved end of the first unit shall be carefully cleaned with a wet brush, and a layer of soft mortar shall be applied to the lower half of the groove.

The tongue of the second pipe shall be cleaned carefully with a wet brush, and while in a horizontal position, a layer of soft mortar shall be applied to the end of the first, until mortar is squeezed out on the interior and exterior surfaces. Sufficient mortar shall be used to completely fill the joint and to form a collar on the outside (refer to the drawings for the construction of RC collar). The interior surface of the units at the joint shall then be brushed smooth. The collar on the outside shall immediately be protected from the air and sun with a cover of wet burlap or wet earth, and shall be kept protected until the mortar is satisfactorily cured.

- h) Movement of any construction equipment or machinery over any drain shall be at the Contractor's risk, and any damage resulting from such operations shall be repaired, as directed at the Contractor's expense.

- i) No pipeline shall be placed in service for which it is intended until terminal end is provided with suitable structure or outlet; and until approved and ready for service. The upper end shall be maintained plugged or blocked against entry of any water.

6.3.3.4 Construction of Drainage System

- a) Formworks

Formwork shall be supplied and fixed in the position as required by the concrete to be cast as shown in the drawings or required by the Engineer and shall be supplied, erected and removed as specified in Section 3.2, "Concrete Works."

- b) Concrete

Proportioning, mixing, placing and curing of concrete shall be in accordance with Section 3.2, "Concrete Works."

Steel reinforcement and steel for grating shall be furnished, bent and fixed in accordance with Section 3.2, "Concrete Works" and where shown in the drawings.

- c) Connections

Sections of connections pipes shall be incorporated into the construction of the manholes, catch basins and outlet structures and placed at the elevation, direction and grade structure and placed at the elevation, direction and grade required. The inner ends of the pipe shall be flush with the inner face of the walls in manholes and outside face of the wall in case of outlet structures.

- d) Cleaning

Upon completion, each manhole, catch basin and outlet structure shall be thoroughly cleaned of any accumulation of silt, debris, or other foreign matter of any kind and shall be kept clean of such accumulation until final acceptance of the work.

6.3.3.5 Backfilling

- a) After the pipe has been installed and the mortar joints sufficiently set, selected suitable material shall be placed alongside the pipes in layers not exceeding 200 mm in depth and compacted so that on each side of the pipe there shall be thoroughly compacted material of the same height. This method of filling and compacting shall be continued until the fill has reached an elevation of 300 mm above the top of the pipe.
- b) Backfilling for manhole and concrete lined drains shall be in accordance with Section 4.2, "Excavation and Backfilling for Buildings."

6.4 DEEPWELL

6.4.1 GENERAL

6.4.1.1 Scope of work

The work includes the furnishing of all labor, material, transportation, tools, supplies, plant equipment and appurtenances, necessary for the complete and satisfactory construction, development, testing and disinfection of the proposed one (1) production well.

6.4.2 MATERIAL REQUIREMENTS

6.4.2.1 Well Casing

The Contractor shall, before commencement of work, submit for approval of the Engineer the following details of all casing:

- a) Type of Material
- b) Internal and External Diameters
- c) Wall Thickness
- d) Method of Jointing

All permanent casing material shall be spiral welded low-carbon steel pipe with minimum wall thickness of 6mm. Casing shall be of new stock and shall be water-tight. The outside diameter of the casing shall be as indicated on the Preliminary Well Design Drawing. Pipe ends shall be beveled to facilitate welding and shall precisely match the diameter of abutting well components including the stainless steel screens.

Reducing cone and tapered sump pipe shall be factory or workshop manufactured from low-carbon steel to the dimensions indicated on the Drawing or as approved by the Engineer and shall precisely match abutting pipe or screen.

The Contractor shall assume responsibility for any casing failure and shall correct, as approved by the Engineer, any casing failure at no extra cost. In the event that the Contractor cannot correct a casing failure, the Contractor shall replace the casing with material complying with the specifications, or if necessary, better casing as approved by the Engineer at no extra cost.

6.4.2.2 Well Screens

- a) Type of Screen

The screen to be furnished and installed hereunder shall be Stainless Steel AISI Grade 304 SS or equivalent continuous slot wedge wire-wound with slot size 1.5 mm (slot 60), 3 meter length per piece, diameter as that of the well casing. Provide well screens as manufactured by "Superscreens" or "Johnson Screens" or approved equal.

Each piece of screen shall be marked with an indelible marker with a unique identification mark. Stainless steel screens shall be of new stock and shall comply with the following criteria:

SCREEN DETAILS

Nominal Diameter (mm)	150
Outside diameter (mm)	170
Length - including weld ring (m)	3
Minimum open area (%)	30
Slot opening tolerance (mm)	+/- 0.1
Collapse Pressure (K Pascal) (minimum)	1662
(psi)	241
Tensile strength (Kg) (minimum)	8,000
Transmitting capacity (lps/m of screen) using 0.03m/sec entrance velocity	6.0

Details of the screen to be supplied by the Contractor shall be submitted together with the bid. The Contractor shall submit to the Engineer for approval the shop drawing for the stainless steel screen. A certificate stating the detailed specification of the screen materials shall accompany the screens on delivery to the Site.

b) Screen Accessories

All fittings, packers, couplings, joints, plugs and seals used during installation of well screen together with the installation procedure, shall be to the approval of the Engineer.

6.4.2.3 Formation Stabilizer/ Gravel Pack

The formation stabilizer/gravel pack material shall consist of well rounded, water-worn siliceous grains. (Under no circumstances may angular chippings or road stone be used as formation stabilizer/gravel pack material.)

Graded gravel pack materials shall have grain size 4 - 7 mm with a uniformity coefficient (Cu) less than 2 where,

$$Cu = \frac{D_{60}}{D_{10}}$$

The Contractor shall, during the mobilization period, submit to the Engineer for his approval, samples of the formation stabilizer he proposes to use, stating the source, quantities available, rate of delivery and any other information requested.

6.4.2.4 Grouting Material

Cement grout shall consist of a mixture of 95% Portland cement, 5% bentonite and clean water, mixed in the proportion of 52.5 kg of Portland cement/bentonite to a maximum of 30 liters of water.

All cement shall, unless otherwise specified in the Contract Documents, conform to the "Specifications for Portland Cement" (ASTM C150-latest revision).

6.4.2.5 Clay Seal or Basket

A layer of bentonite or clay about 1 m thick should be placed on top of the gravel filter pack as shown on the Final Well Design.

6.4.2.6 Well Details

Well Number	Total Depth (m)	Borehole Diameter (mm)	Screen/Casing Diameter (mm)	Discharge Pipe Diameter (mm)
PBH 01	100	300	150	50

6.4.3 EXECUTION

6.4.3.1 Borehole Drilling

a) Equipment

The rig shall have sufficient capacity to drill the specified borehole at the diameter specified and to a depth which is a minimum 25% deeper than that indicated on the Preliminary Well Design.

b) Drilling Method

The drilling shall be performed with the rotary drilling method.

The Contractor shall drill the hole to such depth and with such a diameter which shall enable easy installation of casing and screen and placement of gravel envelope with a uniform thickness as specified. During drilling of the hole, the Contractor shall ensure that the natural permeability of the yielding strata near the well bore is not irreversibly reduced due to the drilling method employed.

Except where ordered in writing by the Engineer, no over-drilling will be measured for payment. Any over-drilling required by the Contractor to facilitate installation of casing/ screen shall be done subject to the prior approval of the Engineer at the Contractor's expense.

c) Strata Sampling

Strata samples shall be taken at 1 meter intervals or more frequent if the formation penetrated changes. Samples shall be placed in plastic or other appropriate bags on which or in which the sampling depth and the date of sampling is written in such a manner that it is permanently readable. The sampling procedure must provide that all the fractions of the penetrated strata are present in the sample.

d) Drilling Mud

Bentonite, if used, shall be of premium quality in accordance with API Standard 13A with 150 kg/m³ of make-up water yielding a mud with a viscosity of between 35 and 40 seconds using a Marsh Funnel and a mud weight of less than 1.10 kg/l (9.2 lb./US gal.).

Make-up water for drilling mud shall be treated with caustic soda (soda ash) to maintain the pH between 8.0 and 9.0 prior to mixing mud.

During drilling with mud, the Contractor shall perform measurements of the following mud characteristics:

- pH value
- Funnel viscosity
- Specific gravity
- Sand content
- Filtration loss
- Filter cake thickness

The recorded mud characteristics shall not exceed the following values, without the prior approval of the Engineer:

- | | | |
|--------------------|---|-----------|
| - Specific gravity | : | 1.10 kg/l |
| - Sand content | : | 4% |
| - Filtration loss | : | 10 ml |
| - Filter cake | : | 1.5 mm |

e) Working Hours

All work from start of drilling of the borehole until completion of well development shall be on a round the clock basis.

6.4.3.2 Geophysical Logging

The Contractor shall perform geophysical logging of the unlined portions of the pilot hole.

a) Equipment

The geophysical logs may be recorded either by automatic recording on a chart strip or by manual reading of recorded values. In case the logs are recorded by the manual method, readings shall be taken at minimum intervals of 0.33 m of borehole length.

The recorded logs shall be submitted to the Engineer immediately upon completion of logging as plots of recorded characteristics versus depth for his approval. In case of disapproval of the Engineer, the logs shall be repeated immediately. The Contractor shall submit the interpretation of the log together with data recorded on CD within 5 days of the completion of logging.

Geophysical logging shall comprise the following logs:

- caliper log
- resistivity log (400 mm & 1600 mm)
- gamma ray log
- self-potential log (SP).

6.4.3.3 Casing Installation

The Contractor shall provide and install well casings as shown on the Final Well Design and any temporary casing required during construction.

a) Temporary Casing

The Contractor shall provide such temporary casing as may be necessary to prevent the collapse of any formation during the drilling operation to allow the well to be sunk to the specified depth and to allow the installation of permanent lining material as required. The Contractor shall remove the temporary casing before completing the well, unless otherwise specified.

b) Lining Installation

Lining material shall be assembled and located in the well at the required depth in a continuous operation. The lining material shall be set concentric within the borehole by centralizing bars unless otherwise agreed with the Engineer.

If the lining jams or is lost before it is set to the specified depth, the Contractor shall endeavor to remove the lining material from the well or, if unable to effect removal, shall abandon the well and drill a replacement well. No payment shall be due for the abandoned well nor for any lining installed therein.

c) Lining Material Accessories

The Contractor shall provide as necessary the following accessories to set the lining material to the required depth:

- 1) Centralizers to be affixed to the lining material at intervals of 12 m to locate the lining material in the center of the borehole;
- 2) Supporting clamps, equipment and tools;
- 3) Reducing cones and connecting pieces;
- 4) Casing hangers;
- 5) All other necessary equipment.

6.4.3.4 Installation of Well Screens

The Contractor shall provide and install the well screens specified and shown on the Final Well Design.

a) Responsibility for Malfunction

The Contractor shall assume full responsibility for any malfunction of the screen caused by inadequate installation procedure and shall undertake any correction as approved by the Engineer at no extra cost to the Owner.

The screen must have no change of alignment at any of its joints after installation. If requested, the Contractor shall submit for approval by the Engineer the design and method of fabrication of the screen.

In the event that the Contractor cannot correct a screen failure, the Contractor shall replace the screen with material complying with the Technical Specification at no extra cost to the Owner.

6.4.3.5 Gravel Pack Installation

The Contractor shall provide and install formation stabilizer, or gravel pack specified and shown on the Final Well Design.

a) Method of Installation

The method of placing the formation stabilizer/gravel pack in the annulus shall be such that separation of the gravel and bridging is avoided.

The formation stabilizer/gravel pack shall immediately upon completion of lining installation, be placed in the annulus between the borehole and the lining, in the screened section(s) of the lining, as indicated on the Final Well Design.

Installation of formation stabilizer/gravel pack shall be done by circulation of the drilling mud.

6.4.3.6 Well Development

a) Scope

1) The Contractor shall furnish compressors, surge plungers, jetting tools, electric generators, chemicals and any other equipment required for satisfactory well development and shall undertake the development as directed by the Engineer.

2) Development shall comprise deflocculation, high velocity jetting for continuous slot screens, surging with plunger for slotted screens, airlifting, and overpumping, unless otherwise specified in the Special Provisions.

3) Expected Yield

The Contractor shall develop the well to its maximum expected yield of 3.15 lps (50 gpm), by the methods specified.

b) Deflocculation

1) Upon completion of installation of lining or formation stabilizer/gravel pack, the drilling mud shall immediately be displaced from the well by pumping clean water into the sump pipe.

2) Mud displacement shall immediately be followed by injection and/or jetting through the screened sections with a polyphosphate solution to deflocculate the mud cake on the borehole wall. The concentration of the

polyphosphate solution shall be 3 percent by weight of the quantity of the water in the borehole. The well shall then be left for 12-24 hours to allow the polyphosphate to react, before developing is continued.

c) High Velocity Jetting

- 1) After the deflocculation material has been allowed to react for 12-24 hours all sections screened with continuous slot screens shall be developed by high velocity jetting.
- 2) The jetting tool shall be equipped with two or four nozzles. The nozzle design shall be such that it produces a concentrated jetting action. The tool shall be presented to the Engineer for approval before the start of the drilling operation.
- 3) The jetting tool shall be supplied with water through a high-pressure pump capable of producing a nozzle velocity of 50-70 m per second. The pump shall be equipped with a suitable pressure gauge on the discharge side to facilitate monitoring of nozzle velocity.
- 4) The development shall be carried out by slowly rotating the jetting tool and gradually lowering it in order to cover the entire surface of the screen.
- 5) At the same time as the high velocity jetting is performed, the well shall be discharged with a discharge rate slightly higher than the discharge rate from the jetting tool.
- 6) Each section of the screen shall be jetted until the return water is free from drilling mud, but no section shall be jetted less than 20 minutes per meter of screen.

d) Development by Airlifting

- 1) Upon completion of high-velocity jetting, the well shall be discharged by the airlifting method.
- 2) The compressor used for pumping by airlifting shall be capable of developing a pressure not less than 100 psi. The delivery shall be no less than 7 m³ air per minute.
- 3) The quantity of water discharged from the well and the drawdown in the well at the commencement of the development shall be limited and shall be gradually increased only as the water clears. From time to time the air flow shall be stopped to facilitate loosening of trapped sand grains. The well may also be backwashed by pumping clean water into the well.
- 4) During the airlifting operation the position of the air pipe and conductor pipe, drawdown in well, approximate yield and time for each change in position shall be recorded by the Contractor.

- 5) The development shall be completed with a conductor pipe not more than 0.5 m above the bottom of the well to ensure that all sand has been removed from the sump pipe.
- e) Development by Overpumping
 - 1) Upon completion of development by the airlifting method, the well will be further developed by overpumping.
 - 2) Overpumping will consist of pumping the well at a rate of 1.5 times the expected discharge for about 12 hours.
 - 3) Starting and stopping the pump intermittently will be required to allow the rising water in the well pipe to fall back into the well.
- f) Well Cleaning

Upon completion of the development operations, the Contractor shall demonstrate to the satisfaction of the Engineer that the bottom of the well is clear of all sand, mud and other foreign materials.
- g) Freedom from Sand
 - 1) The Contractor shall develop the well by the methods specified until the water pumped from the well is substantially free from sand and until the turbidity is less than 5 on the Silica Scale described in Standard Methods of Water Analysis (latest edition as published by AWWA, APHA and WPCT).
 - 2) The water pumped from the well shall not contain an amount of fine material in excess of 1.0 mg per liter when the well is pumped at its maximum expected yield. The equipment for measurement of the sand content shall be furnished by the Contractor.
- h) Acceptance of Development
 - 1) The development by the specified methods shall be repeated and continued until the well is thoroughly developed in accordance with the criteria specified in Clause (g).
 - 2) If the yield after the well has been confirmed sand-free is below the yield considered acceptable for the penetrated aquifer, then the Works Engineer may instruct the Contractor to perform further development.

6.4.3.7 Well Testing for Yield and Drawdown

a) Scope

The Contractor shall provide and operate a pumping unit for the following purposes:

- 1) Step-drawdown pumping tests on the constructed well;

- 2) Constant discharge pumping and recovery tests on the constructed well.

b) Equipment Capacity

- 1) The Contractor shall provide and operate pumping machinery capable of carrying out the specified pumping and shall provide adequate controls to allow discharge rates to be kept constant at varying pumping water levels and to permit pumping with a variation of not more than 5% of the designated discharge rate during any period of yield or aquifer testing.
- 2) The pumping unit set shall be able to deliver a discharge rate, which is a minimum of 50% higher than the expected yield of the well and a minimum discharge, which is a maximum of 15% of the expected yield of the well when suitably throttled by use of a gate valve.
- 3) Suitable pumping machinery will be deemed to be:
 - (a) Submersible electric pump unit together with generator and such accessories needed to run the pump.
 - (b) Line-shaft pump and internal combustion prime mover together with all accessories needed to run the pump.

c) Equipment Operation

- 1) The Contractor shall supply and operate all equipment and accessories necessary for installation and removal of pumps.
- 2) The Contractor shall maintain on Site sufficient fuels, lubricants, spares and other accessories needed to run the pumping unit for whatever period may be specified by the Engineer.
- 3) The Contractor shall provide sufficient competent personnel including a qualified fitter and electrician, as may be necessary to install and operate the pumping unit.

d) Control of Discharge Rate

The Contractor shall, during the pumping tests, provide a suitable gate valve on the discharge pipeline, to facilitate control of the discharge rate.

e) Discharge Rate Monitoring

Discharge rates up to 15 lps (54 m³/hr) may be measured by drum filling. Discharge rates in excess of 15 lps shall be recorded with a water meter or by a V-notch weir. All items are subject to the Engineer's approval before the start of drilling.

f) Suspension of Pumping

If the condition of any equipment, personnel, fuel, lubricants or accessories may prejudice the quality of data obtained from any pumping test the Engineer may suspend the work.

g) Equipment Breakdown During Pumping

- 1) Pumping must be continuous and at a constant rate during the tests. The Works Engineer will instruct the Contractor as to the expected maximum duration of each pumping test before the start of each test.
- 2) If pumping is interrupted or the discharge rate fluctuates by more than 5% of the designated discharge rate, the test shall be repeated after a period of recovery as determined by the Engineer.
- 3) If any pumping test is interrupted because of equipment breakdown or inadequate supervision or discharge control, no payment will be made for any pumping period before recommencing the test.

h) Duration of Tests

- 1) The step-drawdown pumping tests shall be performed in 5 steps with a duration of 2 hours each.
- 2) The constant rate drawdown tests shall be performed for a period of 2-3 days, unless otherwise instructed by the Engineer.
- 3) The recovery test shall be performed for not more than 24 hours or until the original static water level position is reached, whichever occurs first.
- 4) The pumping test once started shall not be stopped until finally finished or unless directed by the Engineer.

i) Procedure for Pumping Tests

1) Step Drawdown Test

- (a) After well development, the water shall be allowed to recover to its static level prior to the initiation of the step drawdown test.
- (b) The test shall consist of 5 steps at 2 hours duration each to be carried out in succession with discharge rate increased in equal fractions. A constant discharge shall be maintained through out each step.
- (c) Discharge readings shall be taken at the start of each step and every half-hour thereafter, and the discharge adjusted to the required value, noting down changes made, if any.
- (d) Depth to water measurements shall be taken simultaneously with every change in discharge rate according to the schedule below.

2) Constant Rate Drawdown Test

- (a) The constant-rate drawdown test should not commence until the water level in the well has fully recovered from the step drawdown test.
- (b) The pump rate for the constant rate test shall be as determined from the step drawdown test or equal to the expected well yield.
- (c) The test shall consist of continuously pumping the well at a constant rate for 48-hours. The rate of discharge shall be measured at the start of the test and every hour thereafter.
- (d) Depth to water measurements shall be taken according to the schedule below.

3) Recovery Test

When the pump is stopped, water level recovery readings shall be immediately taken according to the same schedule employed during the pumping test until recovery is attained but not to exceed 24 hours.

4) Water Level Measurements

- (a) Depth to water in wells shall be measured according to the following schedule:
 - (1) Every minute until the tenth minute, then
 - (2) Every two minutes until the 20th minute, then
 - (3) Every five minutes until the first hour, then
 - (4) Every ten minutes until the second hour, then
 - (5) Every half hour until the sixth hour, then
 - (6) Every hour until the end of the test.
- (b) Water level measurements shall be taken to the nearest half centimeter or 1/8 inch.

- 5) The Contractor shall measure the hole depth after he has completed his recovery readings.
- 6) The Contractor shall bail and clean the well until the original well depth is reached. The well may be accepted by the Engineer provided the depth of silt accumulated in the sump pipe does not exceed 0.3 m. Silt in excess of 0.3m shall be removed by the Contractor.

Note: Requisition for an alternative procedure or addition not specified in the above specifications may be allowed provided that such alternative/addition is necessary for the successful operation of the test and has been approved, in writing, by the Engineer.

j) Temporary Pipeline

- 1) The Contractor shall provide a temporary pipeline as directed by the Engineer for the discharge of water from the well during the pumping tests and for disposal to a suitable water course or drain.

6.4.3.8 Grouting and Sealing

The Contractor shall provide the cement and equipment required for the mixing and placing of the grout as indicated on the Final Well Design and shall place the cement grout as specified.

a) Method of Placing Grout Material

- 1) The method and equipment for placing the grout shall be to the approval of the Engineer. No method will be approved that does not provide for the forcing of grout from the bottom of the casing/hole/annulus to be grouted, to the surface. Flushing of the annular space with fluid to assure the space is open and to remove loose material will be required before grouting is commenced.
- 2) Any grouting operation shall be continuous and before starting, sufficient grout shall be mixed to complete the whole operation. During the grouting operation, the mixed grout shall be continuously stirred.

b) Setting Time

No work will be allowed on the well within a period of 72 hours after completion of grouting unless a quick setting cement is used. In such case, the idle period may be reduced to 24 hours subject to the Resident Engineer's prior approval.

6.4.3.9 Testing for Plumbness and Alignment

a) Requirement to Test

All boreholes shall be constructed and casing and screens set around, plumb and true to line as defined herein. To demonstrate the compliance of his work with this requirement the Contractor shall furnish all labor, tools and equipment and shall make the tests described hereby, and to the satisfaction of the Engineer. Tests for plumbness and alignment must be made after the complete construction of the well and before its acceptance. Additional tests, however, may be made by the Contractor during the performance of the work. No specific payments shall be made by the Owner for making these tests.

b) Description of Test

Plumbness and alignment shall be determined by lowering into the well to the depth of the lowest anticipated pump setting a section of pipe 12 meters long, or a dummy of the same length. The outer diameter of the plumb shall not be more than 13 mm smaller than the diameter of the part of the casing of hole being tested. If a dummy is used, it shall consist of a rigid spindle with three rings, each ring being 0.30 M wide. The rings shall be truly cylindrical and shall be spaced one at each end of the dummy and one ring in the center thereof. The center member of the dummy shall be rigid so that it will maintain the alignment of the axes of the rings.

c) Requirements for Plumbness and Alignment

Should the plumb bob or dummy fails to move freely throughout the length of the casing or hole to a depth of the lowest anticipated pump setting or should the well vary from the vertical in excess of two-thirds of the smallest inside diameter of that part of the well being tested per 30 meters of depth, or beyond the limitations of this test, the plumbness and alignment of the well shall be corrected by the Contractor at his own expense and, should he fail to correct such faulty alignment for plumbness, the Engineer may refuse to accept the well. The Engineer may waive the requirements of this paragraph for plumbness if, in his judgement, (a) the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond his control; (b) the utility of the completed well will not be materially affected; (c) the cost of necessary remedial measures will be excessive. In no event will the provisions of this paragraph with respect to test for alignment be waived.

6.4.3.10 Well Disinfection and Cleaning

a) Time of Disinfection

After the well has been completely constructed and pump tested, it shall be thoroughly cleaned of all foreign substances, including tools, timbers, rope, debris of any kind, cement, oil, grease and scum. The casing pipe shall be thoroughly swabbed, using alkalis if necessary, to remove oil, grease or joint dope. The well shall then be disinfected with a chlorine solution.

b) Procedure

The required quantities of calcium hypochlorite powder (HTH) or other approved disinfectant shall be mixed with water in a suitable container of sufficient capacity to ensure complete sterilization of the well water with the application of a solution giving a concentration of 100 mg/l of free chlorine in all parts of the well. The solution shall be introduced to the well taking care to apply disinfectant solution to all areas of casing above the static water level. The Contractor shall provide reliable means for ensuring that the disinfectant agent is uniformly applied throughout the entire water depth of the well. Any mechanical or surging action adopted for agitation of the disinfectant shall be carried out under careful control to avoid risk of screen damage to the approval of the Engineer.

All accessible portions of the well above the static water level shall be maintained in a damp condition with water containing the required concentration of disinfecting agent for a period of not less than 20 minutes. The disinfecting agent shall remain in the well for a period of 8 hours.

Measurement of the chlorine residual in a water sample taken from the well shall be done at the end of the shown contact period using a suitable chlorine comparator test kit procured by the Contractor to the approval of the Engineer. The test kit shall be retained by the Owner. The procedure shall be accepted as complete provided there is a detectable chlorine residual in the water sample.

If ordered water shall be pumped from the well until the chlorine residual is less than 10 ppm. The disposal point for the purged water shall be selected so as to minimize potential damage to the population, aquatic life and vegetation.

The following table gives the amount of calcium hypochlorite (70%) available chlorine required to provide a dosage of 100 mg/l of available chlorine.

Table 1 - Chlorine Compound Required to Dose
1 m Depth of Water-Filled Well

Diameter of Casing (mm)	Volume per m of Depth (litres)	Amount of Calcium Hypochlorite in gms per m of Depth at 100 mg/l of Free Chlorine
150	18	2.5
200	32	4.5
250	49	7.0

c) Requirements for Disinfection of Test Pump

In the event that the test pump will be installed after the well has been disinfected, all exterior parts of the test pump coming in contact with the well water shall be swabbed with a chlorine solution as directed by the Engineer.

6.4.3.11 Samples, Records, Protection of Water Quality, Capping and Abandonment of Well

a) Sample of Formation

The Contractor shall keep an accurate record of the location of the top and bottom of each stratum penetrated and shall save and keep in the field a sample of material taken from each meter (3 feet) of drilling and at every change of formation. Material samples should be contained in a plastic bag labeled with pertinent data/ information and properly placed in a box designed and intended only for this purpose. The Engineer shall have access to these samples and information during field inspections.

b) Records of Casing Pipe

The Contractor shall keep an accurate record (as assembled) of the order, number, size and lengths of the individual places of screens and liners installed

in the well as well as the amount of grouting used. Installation of pipes, screens and liners should be done in the presence of the Engineer.

c) Liquidated Damages

Failure on the part of the Contractor to obtain, preserve and deliver such samples or records to the Engineer, shall be considered an actual damage to the Owner and shall authorize the Owner to retain from moneys due or to become due the Contractor the sum of FIVE HUNDRED PESOS (500.00) as liquidated damages for each sample that the Contractor shall fail to obtain, preserve and deliver, or for each length of pipe not properly measured and recorded in the order in which it was placed in the well. In the event that, in the opinion of the Engineer, the failure of the Contractor to take and preserve the samples may affect the proper design of the screen, the Contractor may be required to perform such work as the Engineer deems necessary to remedy such failure.

d) Daily Reports

The Contractor shall also submit a daily report describing the nature of material encountered, the work done during each day, including the items of work accomplished, such as depth drilled, casing set, etc., the water level in the well at the beginning and end of each shift and such other pertinent data as he is requested to make a record of by Engineer.

e) Precautions to be Taken

The Contractor shall take such precautions as are necessary or as may be required permanently to prevent contaminated water or water having undesirable physical or chemical characteristics from entering, through the opening made by the Contractor in drilling the well, the stratum from which the well is to draw its supply. He shall also take all necessary precautions during the construction period to prevent contaminated water, gasoline, and other deleterious substances from entering the well either through the opening or by seepage through the ground surface.

f) Corrective Work

In the event that the well becomes contaminated or that water having undesirable physical or chemical characteristics does enter the well due to the negligence of the Contractor, he shall at his own expense, perform such work or supply such casings, seals, sterilizing agents or other material as may be necessary to eliminate the contamination or shut-off the undesirable water from the well.

g) Temporary Capping

At all times during the progress of the work, the Contractor shall protect the well in such manner as to effectively prevent either tampering with the well or the entrance of foreign matter into it and, upon its completion, he shall provide and set a substantial screwed, flanged or welded cap satisfactory to the Engineer.

h) Abandonment of Well

In the event that the Contractor shall fail to sink the well to the depth specified or to such lesser depth as ordered by the Engineer, or should he abandon the well because of loss of tools or for any other cause, if requested and as directed by the Engineer, he shall fill the abandoned hole with clay or clays and concrete, and remove the casing. Salvaged material furnished by the Contractor shall remain his property. Payments shall then be based on the accepted well.

6.4.3.12 Chemical Tests Required

At least one physico-chemical test and one bacteriological test in laboratory acceptable to the Owner shall be performed on samples of water to be taken during the well development stage of Construction and another on a water sample to be taken towards the end of the Pumping Test for Yield and Drawdown. Results of said tests shall be submitted to the Owner. Expenses relevant to these tests shall be borne by the Contractor.

6.4.3.13 Well Completion

The site shall be restored to a condition as nearly possible to that which existed before the well drilling and testing activities commenced. This work shall include, but not be limited to restoration of fences and structures, removal of drill cuttings, leveling of the disturbed ground surfaces and replacement or compensation for the destroyed plants and landscaping.

6.4.3.14 Submittal of Reports and Borehole Data

At the end of the well construction and tests performance, and before final payment is made, the Contractor shall submit to the Owner at least three (3) certified copies of the Detailed Report containing the following well information, among others:

- a) Date of Start and Completion of Well Construction;
- b) Total Depth of Well;
- c) Description of Strata Encountered;
- d) Geophysical Log together with Interpretation;
- e) Sizes and Lengths/Specifications of casings installed;
- f) Locations and description of well screens and recommended location of pump setting;
- g) Locations of gravel pack, the gravel pack grading and the amount of cement grout installed;
- h) Records of discharge rates and drawdown during well development together with description of the methods of the development;
- i) Well capacity or yield (expressed as discharge rate and drawdown), dates and length of tests;
- j) Methods of measuring yield and drawdown;
- k) Drawdown and recovery data;
- l) Plumbness test results; and
- m) Water sample analyses results.
- n) Total Cost of Construction;
- o) Difficulties Encountered During Construction/Drilling (if any); and

- p) Any further technical information pertinent to the well and their construction as required by the Engineer.

The data shall be compiled and bound in a hardbook folder to the approval of the Engineer.

6.5 SEAWATER TREATMENT FACILITY

6.5.1 SCOPE OF WORK

The Scope of Work shall include but not limited to the following:

- a) Design, supply and installation of Mechanical and Electrical/ Instrumentation equipment;
- i. Multimedia Filter
 - ii. Carbon Filter
 - iii. UV Sterilizer
 - iv. Booster/Transfer Pump
 - v. Piping, valves, controls and other accessories for complete operation.
- b) Commissioning, performance testing and training of operators.

6.5.2 SITE AND AREA AVAILABLE FOR THE SEAWATER TREATMENT SYSTEM

The site and area available for the Water Treatment System are shown in the Drawing. The general arrangement of the filtration system shall fit into the available area of about 15 sq.m. located adjacent to the Market Building, Ground Floor.

6.5.3 DESIRED TREATMENT PLANT AND PERFORMANCE EFFICIENCY

The seawater treatment system shall have a design flowrate of 50 gallon per minute.

The raw water characteristics is shown in Table 1 below. Verification must be conducted by the Bidders to satisfy themselves as the accuracy of the data.

Table 1 – Raw Water Characteristics

Parameters	Unit	Water Analysis Results	
		Average	Maximum
Color	TCU	13	50
pH		8.0	8.0
Total Suspended Solids	mg/L	145	250
Total Coliform	MPN/ 100mL	3,672	10,059
Fecal Coliform	MPN/ 100mL	2,318	8,502

The desired water treatment system shall produce water quality conforming to the minimum quality standards as shown in Table 2 below.

Table 2 – Minimum Water Quality Standards

Parameters	Units	Concentration
Total Coliform Bacteria	cfu/100mL	<1
Fecal Coliform Bacteria	cfu/100mL	<1

cfu - colony forming units

TCU – True Color Units

NTU – Nephelometric Turbidity Units

The volumes, dimensions, or capacities of the different parts of the Treatment System shall be designed by the Contractor. The desired treatment process shall have the 100% capacity even undergoing backwashing. Accumulated backwash water shall be provided with holding tank and discharged to the drainage system.

6.5.4 TECHNICAL SPECIFICATIONS

a) Multimedia Filter

The Pre-Filtration Treatment System shall be composed of a Fiberglass or Composite Media Tank, Bronze or Plastic Control Valve (top-mount), PVC Control Valves (front-mount) and timer motor/controls. The system may be composed of Gravel, Pebbles, Coarse Sand and Silica Sand or may use an Activated Filter Media (AFM) from pure green and brown glass and manufactured under ISO 9001:2008 quality system. It must exhibit a self-sterilizing property. It must be compliant with the international standard NSF/ANSI 61 (NSF-61), and must bear a Water Quality Association (WQA) Gold Seal Certification for Drinking Water System Components.

b) Activated Carbon Filtration

The Filter Tanks shall be made of Fiber Glass Reinforced Plastic (FRP or GRP) and the Activated Carbon Filters shall be Certified Food Grade compliant. It shall be equipped with an automated valve of approved rated capacity based on the actual need and conditions, flow meter and pressure gauges. Its control system shall be soft start Human Machine Interface (HMI), Programmable Logic Controller (PLC), and its backwash pump shall have a rated capacity based on actual design requirements.

The automatic controller shall have a maximum flow rate of 10 cu.m/hr and can service an automatic 3 cycles of backwash-rinse service.

c) Sea Water UV

The UV System shall have 3 sets of UV Sterilizer lamps with extremely durable construction. It is manufactured with PVC Schedule 80 material. The system can operate on low temperature and shall have an excellent sealing efficiency.

6.5.5 INSTALLATION, TESTS AND WARRANTY

6.5.5.1 Installation Requirements

All components of the water treatment system such as tanks, pumps, valves, motors/controls and other similar equipment and appurtenances shall be located and so installed to meet the requirements for sanitary protection of water quality, hydraulics of the system and protection against interruption of service by fire, flood or any other hazard. In this case, all equipment shall be elevated at least 16 cm above finished grade and all floors shall drain in such manner that the quality of the potable water will not be endangered. Electrical controls shall be located above grade.

Plug-and-play of individual parts shall be done in good workmanship. Installation shall be watertight.

Supervision by a representative of the manufacturer shall be provided as to the assembly of all mechanical equipment/ appurtenances at the time of installation and initial operation.

6.5.5.2 Water Quality Output Testing Requirements

The water treatment system shall deliver the required water quality based on the standard parameters set forth in the Philippine National Standards (PNS) for Drinking Water as shown above.

The Water Quality Test or Water Analyses shall be conducted duly by a Department of Health (DOH) Accredited Testing Laboratory to verify compliance to PNS.

6.5.5.3 Warranty and Guarantee

The Contractor shall provide a warranty for the equipment for a period of one (1) year and shall submit a guarantee for the installation of the system for a period of five (5) years from the date of acceptance. In addition, the Contractor shall offer free service for a period of one (1) year from the date of acceptance including annual maintenance and training visits by the Contractor.

6.6 WASTEWATER TREATMENT FACILITIES

6.6.1 SCOPE OF WORK

The Scope of Work shall include but not limited to the following:

- a) Design, manufacture, supply, installation and commissioning of two (2) Wastewater Treatment Facilities (WWTFs) and all ancillary equipment and works required for the proper installation, operation and performance.
- b) All related civil and architecture works.
- c) All related mechanical works, such as mechanical ventilation, plumbing/ sanitary and fire protection works, etc.

- d) All related electrical works such as power supply, controls and alarm work, etc.
- e) Settings, operation and performance tests.
- f) Instruction, operating, servicing and maintenance manuals.

6.6.2 APPLICABLE STANDARDS AND REGULATIONS

Wastewater treatment works shall comply with all the relevant Philippines Standards and all National and Local Code and Regulations governing such plants.

Applicable codes and standards for the civil, architectural, and electrical works for wastewater treatment plant shall refer to their respective Specifications.

6.6.3 DESIGN LIFE

Unless stated elsewhere in these Specifications, components shall be designed for a service life of 15 years without replacement of major parts based on an operation time of 24 hours per day, seven days per week considering the climatic condition in the Philippines.

6.6.4 SPARE PARTS

The list of spare parts for two (2) years operation shall be submitted to the Engineer for approval prior to placing order.

6.6.5 MATERIAL REQUIREMENTS

6.6.5.1 Design Criteria and Parameters

The design of the WWTFs shall adopt the Advanced Oxidation Treatment Process (AOTP). The following are the design criteria and parameters:

(1) DESIGN FLOW RATE

Parameter	Unit	Value
Market Hall	m ³ /day	25
Refrigeration Building	m ³ /day	10

(2) DESIGN CRITERIA

Parameter	Unit	Value	DENR Set Standards “ Class SC Marine Water”
Biochemical Oxygen Demand	mg/L	2,500	≤ 100

Chemical Oxygen Demand	mg/L	4,000	≤200
Total Suspended Solids	mg/L	2,000	≤ 100
pH		6.0 – 9.0	6.0 – 9.0
Ammonia	mg/L	25	0.5
Oil and Grease	mg/L	100	< 10
Total Coliform	MPN/100 mL	> 10 ⁴	< 10,000

6.6.5.2 Service Requirements

a) Preliminary Treatment

1) Screening

The raw influent passes through a manual bar screen prior to its entry into the Sedimentation Tank or Equalization Tank. The plant operator shall check the bar screen and collect any accumulated debris at least twice daily. All debris collected shall be wrapped and disposed with other solid waste

2) Pre-Treatment Tanks

The sedimentation tank or equalization tank receives the screened wastewater. It must be designed to collect grit and sand prior to moving the collected wastewater to the Anoxic/Ozonation chamber. The function of the tank is to regulate the inflow of influent into the Anoxic/Ozonation chamber to maintain proper both hydraulic and organic loading. There shall be two basins. The sedimentation tanks shall have enough holding capacity to accommodate peak flows without compromising the performance of the treatment process.

Prior to transfer of wastewater to Anoxic/Ozonation chamber, it will pass through a multi-media filter to remove initially the odor, color, and suspended solids.

b) Anoxic/Ozonation

The pre-treated wastewater will now be treated in a non-biological treatment system called Advance Oxidation Process (AOP). A programmable controller controls the operation of the AOP based on the demand of the influent to be treated. AOP includes hydraulic control features that allow to operate the system, basic process mode: filtration and ozonation. The process overview includes:

- 1) Filling – wastewater is moved from pre-treatment tanks and pass through multi-media filter to Anoxic/Ozonation chamber by a transfer pump.

- 2) Ozone Generator – ozone is a strong oxidant that will be used to remove microorganisms, organic pollutants, reduce concentrations of nitrate, phosphate, ammonia, surfactants and coliform. Also, breakdown of the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) takes place during the ozonation process.
- 3) Filtration – the filtration process will be done simultaneously with the ozonation process using 2 sets of filter media to remove total suspended solids, odor and color. Fats, Oil and Grease Filter (FOGF) will be used to remove oil and grease of wastewater. Micron Filter (MF) will be used to remove remaining total suspended solids up to 5 microns. The process will take up 15 minutes to 30 minutes together with the Ozone Generator.
- 4) Effluent Discharge – treated wastewater from the Anoxic/Ozonation chamber shall be pumped to the disinfection tank prior to discharge.

c) Disinfection

The treated wastewater from the Anoxic/Ozonation chamber shall be transferred to the disinfection tank. The effluent shall be disinfected using submersible Ultraviolet (UV) lamps. The UVL disinfection will instantaneously neutralize micro-organisms as they pass through the UV lamps submerged in the effluent.

Disinfected effluent shall be discharged via storm water drain directly to the receiving water body by gravity or by pumping.

d) Sludge Digestion

The excess sludge requires treatment to reduce its water and organic content and to obtain a stabilized product suitable for end use or final disposal. Waste sludge generated from Anoxic/Ozonation chamber and sedimentation tanks will take within 2 to 3 years before it will be pumped out using sludge pump and dewatered. The dewatered sludge shall be discharged to a drying bed prior to final disposal or re-use as organic fertilizer for plants.

e) Pumping

Pumping system is necessary for the treatment process to be complete. It includes the following pumps:

- 1) Transfer pump – transfer the raw wastewater from the pre-treatment tanks to anoxic tank.
- 2) Anoxic pump – will be used to complete the filtration process prior to disinfection.
- 3) Discharge pump – will be used if the discharge tapping point is below the level of disinfection tank.
- 4) Sludge pump – collect the sludge generated from the sedimentation tanks and anoxic tank and conveyed to a drying bed or sludge tank for future collection and disposal.

f) Odor Control

The anticipated odor management shall comply with government regulations. Using the close-type chamber, filtration process and ozonation process, there is no foul odor being generated even during the actual process. However, installation of exhaust fan is recommended if the pump room is totally close or no ventilation.

g) Mechanical Piping, Valve, Fittings and Supports

The corresponding mechanical piping, valves and fittings and structural and mechanical support shall be provided to complete the proper process flow of the system. All piping materials associated with the pumping units shall be PN 10 or greater. Disconnection of the major items of the plant shall use sufficient flanges and unions in order not to disturb the main piping works. Adequate clamping support and hanger shall be provided to allow for the removal of any section of pipework during maintenance.

h) Electrical, Programmable Logic Computer (PLC) Programming and Instrumentation

The design of the electrical power supply will be properly layout for the entire system within the capacity of the Building requirements.

A Hydraulic Control Panel shall be provided that will allow the system to operate automatically or in manual mode. The programmable logic controller will be prepared as BMS ready.

6.6.6 INSTALLATION, TESTS AND WARRANTY

6.6.6.1 Installation

- a) Install wastewater treatment plant including related and associated work per approved Shop Drawings and per applicable requirements specified or referenced.
- b) Install components at times required; in advance where necessary; all fixed items shall be accurately positioned and rigidly secured to structure.

6.6.6.2 Testing Requirements

The system and equipment shall be tested and commissioned in accordance with the manufacturer's recommendation and subject to the approval of the Engineer.

6.6.6.3 Warranty and Guarantee

The Contractor shall provide a warranty for the equipment for a period of one (1) year and shall submit a guarantee for the installation of the system for a period of five (5) years from the date of acceptance. In addition, the Contractor shall offer free service for a period of one (1) year from the date of acceptance including annual maintenance and training visits by the Contractor.

DIVISION 7

ELECTRICAL WORKS

DIVISION 7 ELECTRICAL WORKS

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7.1 ELECTRICAL GENERAL REQUIREMENTS

7.1.1 GENERAL

7.1.1.1 Application

This section applies to all sections of "Electrical Division" of this project except as specified otherwise in each individual section.

7.1.1.2 Work Included

The work to be done under this division shall include the furnishing of all tools, labor, supervision, equipment, fixtures and all necessary materials, each complete and in proper working condition unless one or other is specifically excluded or stated otherwise in this specifications but not limited to the following items of works.

- a) All works and material for a complete lighting and power systems including cables and conduits, circuit breakers, panelboard and connection to all lighting fixtures and power outlets, motor appliances, switches, supports and accessories.
- b) All excavation works, backfilling, dewatering, removal of surplus earth, preparation of formworks and pouring of concrete envelopes as indicated on the drawings or as required to complete the installation.
- c) All steel support for conduits, wires, panelboard, boxes, lighting fixtures, etc. as indicated or as required to complete the installation.
- d) A complete grounding system as required by the governing codes.
- e) A complete testing of all electrical systems.
- f) Where material are furnished and supplied by the Engineer, the Contractor shall receive, unload, handle and transport to the site, assemble and install

completely. This Contractor shall be responsible for safekeeping and warehousing of such materials/equipment from the time of his acceptance.

- g) All items incidentals to and or required for the proper completion such as painting of boxes, conduits and the likes.
- h) Coordination with other trade Contractors.
- i) Coordination with other companies/offices including handling of all material related to material testing and application of electrical permits.
- j) Preparation of necessary shop drawings required for the proper execution of the works subject to the approval of the Engineer.
- k) Preparation of "As-Built" drawings.

7.1.1.3 Work Not Included Under Electrical Works

The work excludes the furnishing of the following:

- a) Supply and installation of all motors, pumps and their associated control equipment.
 - 1) All electrical system installation beyond the motor branch circuit breakers.
 - 2) All motor controllers as indicated to be supplied with equipment.
 - 3) Structural foundation of the above.

7.1.1.4 Submittals

Obtain approval before procurement, fabrication or delivery of items to the job site. Partial submittals will not be entertained and will be returned without review. Submittals shall include the manufacturer's name, trade name, place of manufacturer, catalogue model of number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference and technical society publication references, and other information necessary to establish contract compliance of each item to be furnished.

a) Shop Drawings

In addition to the requirements of the contract clauses, shop drawings shall meet the following requirements:

- 1) Drawings shall be a minimum of 210 mm x 297 mm in size or in A3 size, except as specified otherwise.
- 2) Drawings shall include wiring diagrams and installation details indicating the proposed location layout and arrangement, control panels, accessories, and other items that must be shown to assure a coordinated installation.

- 3) Wiring diagrams shall identify circuit termination and the internal wiring for each item of equipment and its interconnection.
 - 4) Drawings shall indicate adequate clearances for operation, maintenance and replacement of equipment devices. If the layout is disapproved, revise the layout and resubmit.
- b) Manufacturer's Data

Submittal for each manufactured item shall be current descriptive literature of cataloged products.

- c) Publication Compliance

Where equipment or materials are specified to conform to industry and technical society publications of organizations such as American National Standard Institute (ANSI), American Society for Testing and Materials (ASTM) and Underwriters Laboratories, Inc. (UL), submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In each of the publications referred to herein, consider the advisory provisions to be mandatory as though the word "shall" had been substituted for "should" wherever it appears. Interpret reference in these publications to the authority having jurisdiction, or words of similar meaning, to mean the Engineer. In lieu of the label or testing, submit a certificate from an approved independent testing organization, adequately equipped and component to perform such services, organization's test methods and not the item conforms to the specified organizations publications.

The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

7.1.1.5 Certificates of Compliance

Submit manufacturer's certifications as required on products, materials, finish and equipment indicated in the Technical Sections. Certifications shall be documents prepared specially for the contract. Preprinted certifications and copies of previously submitted documents are not acceptable. The manufacturer's certification shall name the appropriate products, equipment or materials and the publication specified as controlling the quality of the item. Certification shall not contain statement to imply that the item does not meet requirements specified such as "Good As", "Achieves the same end use and results as materials formulated in accordance with referenced publications" or "Equal or exceeds the service and performance of the specified materials". Certifications shall simply state that the item conforms to the requirements specified; and shall be printed on the manufacturer's letterhead and shall be signed by the manufacturer's official, authorized to sign certificates of compliance.

7.1.1.6 Operation and Maintenance Manuals

Submit as required for systems and equipment indicated in the Technical Sections. Furnish three (3) copies, bound in hardback binders or an approved equivalent.

Furnish one complete manual prior to performance of system or equipment tests, and furnish the remaining manual prior to contract completion. Inscribe the following identification on the cover: the word "Operation and Maintenance Manual", the name and location of the system equipment, building, name of Contractor and contract number. Include in the manual the names, addresses and telephone numbers of each sub-Contractor installing the system or equivalent and the local representatives for the system or equipment. Include a table of contents and assemble the manual to conform to the table of contents with the tab sheets placed before instruction covering the subject. The instructions shall be legible and easily read with large sheets of drawings folded in the manual shall include the following:

- a) Internal and interconnecting wiring and control diagrams with data to explain detailed operation and control of the system or equipment.
- b) A control sequence describing start-up, operation and shut-down.
- c) Description of the function of each principal item of equipment.
- d) Installation and maintenance manual.
- e) Safety precaution
- f) Diagrams and illustrations
- g) Testing methods
- h) Performance data
- i) Lubrication schedule including type, grade, temperature range and frequency
- j) Part list
- k) Appendix

List qualified permanent servicing organization for support of the equipment, including addresses and certified qualifications.

7.1.1.7 Posted Operating Instructions

Furnish approved operating instructions for systems and equipment indicated in the technical sections for use by operation and maintenance personnel. The operating instructions shall include diagrams, control diagrams and control sequence for each principal system and equipment. Print or engrave operating instructions and frame under glass or in approved laminated plastic. Attach or post the operating instructions adjacent to each principal system and equipment including start-up, proper adjustment, operating, lubrication, shutdown, safety precautions, procedure in the event of equipment failure, and other items of instruction recommended by the manufacturer of each system for operating instruction exposed to the weather. Operating instructions shall not fade when exposed to the weather and shall be secured to prevent easy removal or peeling.

7.1.1.8 Instructions to Personnel

Where indicated in the technical sections, furnish the services of competent instructors to give full instructions to personnel in the adjustment, operation and maintenance of systems and equipment, including safety precautionary measures. Each Contractor shall be thoroughly familiar with all parts of the installation and shall be trained in operating theory as well as practical operation and maintenance work, instructions shall be given during the first regular work week after the equipment or system has been accepted and turned over to the Engineer for regular operation. The number of man-days (8 hours) of instruction shall be as specified in each individual section.

7.1.1.9 Delivery and Storage

Handle, store, and protect equipment and materials in accordance with the manufacturer's recommendations and with the requirements of NFPA 70B, Appendix 1, titled "Equipment Storage and Maintenance during Construction". Replace damaged or defective items with new one.

7.1.1.10 Catalogue Products/Service Availability

Materials and equipment shall be current products by manufacturers regularly engaged in the production of such products. Products shall have been in satisfactory commercial or industrial use for two (2) years prior to bid opening. The two (2) year period shall include applications of equipment and materials under similar circumstances and of similar size. The two (2) year period shall be satisfactory completed by a manufacturer's catalog or brochures. Products having less than two (2) year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturer's factory or laboratory tests is furnished. The equipment item shall be supported by service organization, which are reasonably convenient to the equipment on a regular and emergency basis during the warranty period of the contract.

7.1.1.11 Manufacturer's Recommendations

Where installation procedures or any parts thereof are required to be in accordance with manufacturer's recommendations, furnish printed copies of the recommendation prior to installation. Installation of the items shall not proceed until recommendations are received. Failure to furnish recommendations shall be cause for rejection of the equipment or materials.

7.1.1.12 "As-Built" Drawings

The cost of as-built drawings shall be borne by the Contractor. Submittal of such drawings shall be a condition to final payment.

7.1.1.13 Materials/Substitution/Tests

All materials to be installed shall be brand new and shall conform with specifications except as otherwise noted on the drawings. All materials where not specified shall be of the best of their respective kind. Samples of said material including its manufacturer's data shall be submitted for approval. Necessary tests on the installations shall be made by the Contractor in the presence of the Engineer. These

tests shall include but not limited to ground test, performance test, phase sequence test, etc. Records of approved tests result shall be relayed to the Engineer in writing. This Contractor shall within ten (10) days after the award of the contract, submit a list of materials he proposes to use. All materials installed without prior approval shall be at the risk of the Contractor.

7.1.1.14 Coordination/Guarantees/Suspension or Delay

The Contractor shall be familiar with the specifications of the other trades and coordinate with them thoroughly so that he can arrange his work and dispose his materials without interfering the work of other Contractors. The Contractor shall guarantee that the electrical systems shall be free from all defects of workmanship and of materials, and that it will remain so for a period of one year from the date of acceptance by the Engineer. Any remedy to correct defects deemed to be caused by such shall be made at the expense of the Contractor.

The Contractor shall not suspend or delay the work without justifiable cause. Subsequent delays shall be deemed as a sufficient cause for penalties or termination of contract in which the Engineer shall have the right to take-over the work and all materials on the site and make arrangements necessary to complete the work. It shall be the sole responsibility of the Contractor to ensure that the Electrical sub-contractor conducts coordination of his activities to other trades.

7.1.1.15 Sleeves/Inserts/Cutting/Patching/Backfill

The Contractor shall provide all openings, sleeves, also inserts in walls, floors, and beams as required for his work. All unused openings shall be grouted in. the Contractor shall do all patching requirements necessary and these shall be done so as to exactly match the surrounding area without the evidence of alteration or patching. The Contractor shall provide all necessary backfill on all excavation works of his doing.

7.1.1.16 Temporary Light and Power

The Contractor shall make all arrangements and pay for the provisions of the necessary electrical power of the type and capacity required for the performance of the work of all trades engaged in the construction of the building.

7.1.1.17 Cleaning Up

The Contractor shall remove all dirt, debris, and rubbish and waste materials caused by him in the process of his work. He shall also remove all tools, temporary power installation, scaffolding and surplus materials after completion and acceptance of work.

7.1.1.18 Electrical Characteristics

The electrical characteristics for this project shall be 400/230V, 4- wire, three phase and 60Hz or as per system requirements.

7.1.2 MATERIAL REQUIREMENTS

7.1.2.1 Nameplates

Provide laminated plastic nameplates for each panelboard, equipment enclosure, relay, switch, and device. Each nameplate inscription shall identify the function and when applicable, the position. Nameplate shall be melamine plastic, 3.2mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the black core. Minimum size of nameplates shall be 25mm x 38mm. Lettering shall be a minimum of 6mm, high normal block style.

7.1.3 EXECUTION

7.1.3.1 Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

7.1.3.2 Painting of Equipment

- a) **Factory Applied:** Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA ICS 6 corrosion-resistance test, except equipment specified to meet requirements of ANSI C37.20 shall have a finish as specified in ANSI C37.30.
- b) **Field Applied:** Paint electrical equipment as required to match finish or to meet safety criteria.

7.2 DIESEL ENGINE GENERATOR SET

7.2.1 GENERAL

Work under this Contract shall be in accordance with Section 7.1 "Electrical General Requirements" of these Specifications and shall be applicable to this Section, whether herein referred to or not.

7.2.1.1 Scope of Work

The Work covered shall include but not be limited to all labor, materials, tools, equipment and incidentals necessary for the Contractor to furnish/provide diesel electric generating unit with accessories, auxiliary equipment, and associated work as specified and indicated.

7.2.1.2 Applicable Publications

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

- c) American National Standards Institute, Inc. (ANSI)
 - B15.1-72 Safety Standard for Mechanical Power Transmission Apparatus.
 - C50.10-77 General Requirements for Synchronous Machines
- d) American Society of Mechanical Engineers (ASME) Publication:
 - PTC 26-62 Speed-Governing Systems for Internal Combustion Engine-Generator Units.
- e) Diesel Engine Manufacturers Association (DEMA) Publications:
 - (Sixth Edition 1972) Standard Practices for Stationary Diesel and Gas Engines
- f) Institute of Electrical and Electronics Engineers (IEEE) Publication:
 - 126-59 Recommended specification for Speed Governing of Internal Combustion Engine-Generator Units
- g) Institute of Integrated Electrical Engineer (IIEE)
 - PEC (2002) Philippine Electrical Code
- h) Philippine National Standard (PNS)
 - BS (2002) Bureau of Standard
- i) Underwriter's Laboratories, Inc. (UL) Publications:
 - (AM 85) Steel Above ground Tanks for flammable and Combustible Liquids
 - (1999) Electric Battery Charges

7.2.1.3 Quality Assurance

Engines installed shall meet all of the operating experience requirements listed below:

- a) Only electrical generation service is considered as equivalent experience. Engine driving pumps or compressors, or those in marine propulsion or railroad service, are not acceptable.
- b) Only experience on the same engine model is acceptable. Engine model is considered to be a given series or class of identical bore and stroke and of the same type of engine, such as in-line or Vee. In-line and Vee engines with identical bore and stroke are considered as two separate models of engines.

- c) Only experience at the identical rotative speed as that which is offered is acceptable.
- d) Only experience at the identical or higher brake mean effective pressure as that which is offered is acceptable.
- e) Only experience with fuel oil is acceptable.

7.2.1.4 Submittal

The Contractor shall furnish certificate(s) within twenty eight (28) days after commencement of works certifying that no less than two engines of identical number of cylinder size, identical rotative speed, and identical or higher Brake Mean Effective Pressure (BMEP), and of the same basic configuration (in-line or Vee) as the engine to be furnished, shall have driven generators which have produced in satisfactory operation not less than 500 KWH of electricity for each KW of generator nameplate capability within a two (2) year period. Certificate(s) shall include:

- a) A list of at least two engine installation meeting the experience requirements set forth in Sub-section 7.2.1.3 entitled "Quality assurance".
- b) Owner and location of each such installation.
- c) Date of initial operation of each such installation.
- d) Number of KW hours produced per KW of generator rated capability of each installation.
- e) Horsepower rating, KW rating, and rotative speed of each unit.
- f) Brake Mean Effective Pressure (BMEP) rating of each engine.
- g) Design characteristics of each unit, such as bore and stroke, number of cylinders, and configuration (in-line or Vee).

7.2.1.5 Shop Drawings and Calculations

The Contractor shall submit shop drawings and calculation for diesel engine generating unit and auxiliary equipment, including the following:

- a) Certified outline, general arrangement (setting plan), and anchor bolt details. Drawings shall show the total weight and center of gravity of the assembled equipment of the mounting skid.
- b) General arrangement drawings showing location of all auxiliary equipment in relation to the diesel generating unit.
- c) Piping schematic for compressed air starting, fuel oil, lubricating oil, jacket water, and cooling water integral with diesel engine.
- d) BMEP calculations.

- e) Air Starting and Cranking time calculations.
- f) Battery sizes.
- g) Critical speed calculations.
- h) Electrical elements, schematics and wiring diagrams, including details of the safety shutdown systems and main generator circuit breaker trip system.

7.2.1.6 Certified Test Reports

- a) Diesel engine shop tests
- b) Generator shop tests
- c) Diesel engine driven electric generator set shop test tests
- d) Radio-interference suppression.

7.2.1.7 Manuals

The Contractor shall provide three (3) sets of operation and maintenance manuals for equipment. Identification symbols for all replaceable parts and assemblies shall be included. Information in manuals shall be comprehensive and specific.

7.2.1.8 Safety Requirements

Safety requirements shall comply with ANSI B15.1 or with the manufactured recommendation.

7.2.2 MATERIALS REQUIREMENTS

7.2.2.1 Materials

- a) Standard Commercial Product

Generator set shall, as a minimum, be in accordance with the requirements of this specification and shall be the manufacturer's standard commercial product with any added features needed to comply with the requirements. Additional or better features which are not specifically prohibited by this specification, but which are apart of the manufacturer's "standard commercial product " is defines as a product which has been or will be sold on the commercial market through advertisement or manufacturer's catalogs, or brochures, and represents the latest production mode(s).

- b) Materials and Equipment

The Contractor shall furnish new materials of high quality which will give long life and reliable operation. Equipment shall not have been in prior service except as required by factory tests. Workmanship shall be of highest quality in every detail.

7.2.2.2 Diesel-Electric Generator Set and Auxiliary Equipment

Each generator set shall consist of a diesel engine connected to an alternating current generator with brushless excitation system mounted on a steel subbase and provide with all necessary accessories, auxiliaries, and control equipment resulting in a complete self-contained unit people capable of operation.

Set shall be arranged for manual starting. Generator set must be capable of providing full rated power within 10 seconds after starting.

a) Equipment Rating and Capability

Diesel-electric generating set shall have a net continuous rating as indicated at 0.8 power factor for 3-phase unit. Both the engine and generator of the generator set shall be capable of satisfactorily carrying a load 10% in excess of the net continuous rated generating capacity at 0.8 power factor for a period of 2 continuous hours out of any 24 consecutive hours.

Gross kW rating of each diesel generating set shall be not more than the figure obtained by multiplying the delivered shaft horse power rating of the engine by 0.746 and by the overall efficiency of the generator at the corresponding load. Overall efficiency of the generator shall allow for power required to operate the exciter, including power consumed in losses and in windage and friction for generator and rotating exciter.

Rated net capacity of each generating set is defined as gross electrical power output of generator minus total electrical power requirements of "engine assemble," as defined in NEMA publication "Standard Practices for Stationary Diesel and Gas Engine". All auxiliary equipment furnished shall be designed for continuous duty at 110% of rated net capacity of generating set.

The generating set shall be as follow:

150kVA (120kW), 0.8 power factor, 3Ø, 400/230V
500 kVA (400kW), 0.8 power factor, 3Ø, 240V

b) Critical Speeds

Each complete diesel-electric generating set shall be free of electrical speeds of either a major or minor order that will endanger satisfactory operation will be considered endangered if torsional vibration stresses exceed 390 kg/cm² with 10% above or below rated engine speed. The Contractor shall submit three (3) copies of a summary of computations of critical speeds to the Engineer.

7.2.2.3 Design and Construction

Rotating or reciprocating parts, or other parts that may present a hazard to operating personnel shall be isolated or shielded to minimize danger. Design characteristics shall limit operating temperatures at critical points of maximum wear at full-load operating conditions.

7.2.2.4 Diesel Engine and Accessories

a) Type and Requirements

The diesel engine to be furnished shall drive the A/C generator and shall be base mounted.

The diesel engine shall be of vertical, single acting, solid injection, 4-stroke cycle, cold starting, water cooled diesel engine.

Main parts shall possess excellent properties against heat, pressure, erosion and wear. All parts shall be manufactured to ensure the highest accuracy and precision by means of limit gages, special jigs, fixtures, etc., so that they are entirely interchangeable with each other.

The diesel engine shall be furnished with a cooling water pump to circulate the cooling water for the diesel engine. The pump shall be driven by the main diesel engine. The requirements of the cooling water pump shall be of the engine manufacturer's standard.

b) Manufacturing and Materials

1) Cylinder Block Head and Crankcase

The cylinder block, head and crankcase shall be made of cast iron.

Replaceable wet type cylinder liners shall be made of high grade cast iron.

2) Crankshaft

The crankshaft shall be of the forged, one piece-type, made of carbon steel. Bearing surfaces shall be of sufficient size to safely sustain all bearing loads imposed, and shall be heat-treated to provide resistance against shocks and wear.

3) Camshaft

The camshaft shall be made of carbon steel, driven by gears from the crankshaft. The hard-wearing surfaces shall be treated by high frequency induction hardening.

4) Piston and Piston-Pin

Pistons shall be of trunk type and made of special cast iron or high grade heat treated light alloy, and shall have sufficient resistance against heat and pressure. Piston rings shall consist of two or three compression rings and one or two oil scraping rings. The piston-pins shall be of full floating type and completely carbonized.

5) Connecting Rods

Connecting rods shall be made of forged steel and designed for using replaceable and precision insert type crank pin bearings. A drilled passage

for piston-pin lubrication shall be incorporated.

6) Bearings

The bearings for both main and crank pin journals shall be of precision insert bearings and readily replaceable. The piston-pin metals shall be of the special phosphorous bronze.

7) Fuel Injection Nozzle

Each one set of fuel pump with plunger, for adjusting injection volume and timing, shall be provided for each cylinder.

The injection nozzle shall be pin hole type and designed to adjust the needed injection pressure automatically and to meet with any load conditions immediately.

8) Governor

The governor is of mechanical and/or hydraulic type and so sensitive in operation that it is able to adjust the fuel injection volume at any sudden change of loads automatically and immediately. Engine speed variation is calculated not more than 10% (instantaneous) and 5% (steady).

9) Exhaust System

The diesel engine exhaust gas shall be released to atmosphere outside the house through exhaust pipe works and silencers. All exhaust pipe work inside the house shall be lagged by thermal insulation materials with aluminum sheet.

Each silencer shall be positioned as shown on the Drawings. The exhaust system shall be complete with expansion below, support structures and brackets where necessary.

c) Accessories

The accessories of the diesel engine to be furnished shall be as follows:

1) Gauges

Tachometer, lubrication oil pressure, cooling water pressure, suction air pressure, fuel oil pressure, etc.

2) Thermometer

Lubrication oil, cooling water, exhaust gas, etc.

3) Auxiliary Priming Pump

Wing type lubrication oil pump.

4) Strainer and Cooler

Fuel oil strainer, lubrication oil strainer, lubrication oil cooler, suction air cooler, etc.

5) Safety Devices

Lubrication oil pressure relay, cooling water high temperature relay, over and under speed relay, cooling water flowsight glass, etc.

6) Miscellaneous

Exhaust system has turbo-supercharger, pressure indicator cock for each cylinder, flywheel and dual air reservoir tanks, flexible pipe joints, installation bolts, etc.

d) Fuel Oil System

Conform to NFPA 30 and NFPA 37 and the requirements herein. Provide motors and flange connections in accordance with paragraphs entitled "Motors" and "Flange Connections."

1) Tanks

Tanks may be standard design as recommended or used by the engine manufacturer or shall be constructed as specified in paragraph entitled "Tank Construction."

(a) Fuel Oil Day Tanks

Provide tanks with a minimum capacity of 8 hours of engine-generator unit operation at full rated load for the engine-generator unit. Provide tanks with a level gage and makeup control valve. Include connections of the indicated size for inlet, outlet, overflow, drain, vent, and level controller, and a high and low level alarm switches.

(1) Fuel Oil Drip Tank

Provide tank to receive dirty fuel oil drips from the engine. Working capacity of tank shall be not less than 38 L per engine. Include connections of the indicated size for inlet, outlet, overflow, drain, vent, and level gage, and high level alarm switch. Locate high level alarm switch 150 mm below the top of the tank.

(2) Level Alarm Switches

Provide tank-top mounted or external float cage, single-pole, single-throw type designed for use on fuel oil tanks. Arrange high level alarm switches to close on rise of liquid level, and low level alarm switches to close on fall of liquid level. Mount float cage units with isolating and drain valves. Contacts shall be suitable for the station battery voltage. Contact ratings shall be A150 in accordance with NEMA ICS 2.

(3) Tank Gages

Provide tank gages conforming to CID A-A-50568. Gages for fuel oil day tanks shall be buoyant force type, with dial indicator not less than 100 mm in size and arranged for side mounting. Each reading dial or scale shall be calibrated for its specific tank to read from empty to full, with intermediate points of 1/4, 1/2, and 3/4.

(b) Fuel Oil Pumps

Each pump unit shall consist of a horizontal, positive-displacement, rotary pump driven by a three-phase electric motor. Direct connect each pump to its driving motor through a flexible coupling. Mount pump and motor on a common steel or cast-iron base plate and provide a coupling guard. Equip each pump with a bypass relief valve. Each pump shall conform to CID A-A-50561. Pumps shall be capable of pumping the following quantities of fuel oil at a temperature of 32°C.

(c) Duplex Fuel Oil Strainer

Provide the type having two straining chambers and arranged to divert the flow from one chamber to the other without interruption at any point of the changeover. Design shall allow for cleaning, by permitting removal of the strainer basket not in use while the other strainer basket is in use. Construct strainer baskets of corrosion-resistant metal. Strainer mesh, type, and size shall be as recommended by the engine manufacturer. Construct body of cast iron suitable for 861 kPa (gage) working pressure. Provide a remote differential pressure gage between inlet and outlet of duplex-strainer to indicate the pressure drop of strainer chamber on line.

(d) Fuel Oil Meters

Provide positive displacement type. Maximum variation from absolute accuracy measurement over entire range of meter shall be not greater than plus or minus five-tenths of one percent. Provide meters with horizontal setback registers calibrated to read in liters and tenths of liters. Construct meters with cast-iron bodies, with working parts made of material to resist wear, friction, and corrosion and can handle oil containing a small percentage of sulphur.

(e) Day Tank Makeup Control Valve

Provide one control switch and solenoid type control valve for each fuel oil day tank as indicated. Valve body shall have a minimum working pressure rating of 1033.5 kPa (gage) at 93°C. The level control switch shall energize to open the solenoid control valve and start the fuel oil transfer pump at low level conditions and close the valve and stop the transfer pump at high level conditions. For multiple day tank installations, the level control switches shall actuate their respective solenoid valves and the selected fuel pump through the necessary relays and control switches. The day tank system control shall be

controlled by an "OFF-AUTO" switch on the engine control panel with a contact rating of not less than A150 in accordance with NEMA ICS 2.

(f) Fuel Oil Filters

Provide two filters of the throwaway filter element type, consisting of shell, filter elements, drains, and necessary connections and fittings. Equipment and component parts shall be the standard product of the filter manufacturer to ensure prompt and continuing service and delivery of repair or maintenance parts and shall be standard with the engine manufacturer. Component parts of the unit need not be the product of the same manufacturer. Each filter shall be capable of removing not less than 95 percent of all particles larger than 5 microns. Filter elements shall be factory-assembled type, with compression type end seal gaskets at top and bottom and with suitable pullout device. Filter material shall be cellulose, laminated fiber discs, or acid resistant textile material. Elements shall be designed for an initial pressure drop not in excess of 35 kPa at a flow rate of 0.0972 L/s per element. Construct filters with sides having double walls. Install insulating material between the inner and outer walls. Inner shell shall be pressed steel or welded steel construction enclosing, supporting, and protecting all elements. Filters shall have flanged, removable bolted top cover for access to all components without disconnecting any connections or fittings. Provide compartments for clean and dirty oil. Provide supports for base mounting. There shall be tie-bolts, or equivalent means, for holding down the filter elements and cover, and recesses or other means for receiving and locating the elements. Design and construction shall conform to the ASME BPVC SEC VIII D1. Filter cover shall be steel and secured to the shell by swing-type bolts with hex nuts. Use lifting devices with integral supports for covers weighing over 14 kg. Arrange connections so that filter elements may be removed without breaking outside connections. Mount pressure gages on filter shell to indicate pressure before and after the filter elements. Provide a tapped drain and exterior valved pipe connection. A duplex gage may be provided. Gages shall conform to ANSI/ASME B40.1 and shall be pressure detecting class, 108 mm size, and 0 to 689 kPa range. Provide a needle valve and fittings for mounting each gage and differential pressure switch. Equip each unit with instruction plates and diagrams, suitably located, describing special or important procedures to be followed in operating and servicing the equipment. Plates shall be copper or zinc base alloy, adequately secured to the unit. Provide an adjustable pressure switch with contacts suitable for the starting battery voltage to indicate high differential fuel-oil filter pressure.

(g) Fuel Oil Centrifuges

Provide two identical fuel oil centrifuges. Centrifuges shall be capable of removing and discharging water and sludge from incoming fuel oil. Each centrifuge shall be of the unit type, including inlet and outlet oil transfer pumps with integral bypass relief valves, interconnecting piping, sight flow indicators, thermometer, sampling cocks, and three-phase electric motor all mounted on a common steel or cast-iron base

plate. Bowls shall be corrosion-resistant construction and arranged for self draining. Provide each centrifuge with an air-tight cover hinged to the frame of the unit, locking it in either the open or closed position. Arrange check valve to automatically shut off the oil when cover is raised. Provide each unit with a friction clutch to ensure that the machine will be properly and automatically brought up to speed without danger of overloading either motor or gears. Provide safety shutdown interlocks for dangerous vibration, open bowl, low-flow operation, low-water pressure, and bowl completely stopped before cover can be opened.

7.2.2.5 Generators and Excitation Systems

a) Generators

The generator for the unit shall be as indicated, 60 Hertz, 0.8 power factor, 3-phase, alternating-current type with revolving field. The speed of the generator shall be that of the engine. The generator shall be capable of carrying continuously a 0.80 power factor load equal to the gross kilowatt rating of the diesel generating unit and to carry a 0.80 power factor load 10% in excess of the gross kilowatt rating of the diesel generating unit for 2 continuous hours out of any period of 24 consecutive hours at normal voltage and with a temperature rise of not more than 80°C as measured by resistance based on 40°C ambient temperature. Enclosures shall be the general-purpose open type with ventilating openings covered with removable screens having a mesh not larger than 12 mm.

The generator shall conform to ANSI C50.10 and to NEMA MG-1. The generator shall have form-wound coils and Class H sufficient flywheel effect to meet the requirements of regulation and operation as specified. The rotor shall be mounted on an extended shaft which shall be coupled rigidly to the engine. Crankshaft. Impellers shall be mounted on the rotor for cooling the generator. The rotor shall be capable of safe operation at a speed 25% in excess of its rated synchronous speed. The generator armature, field, and ground leads shall clamp or crimp-type lugs or connectors for electrical connections. Terminal markings shall conform to NEMA MG-1.

b) Excitation and Voltage Regulation System

The excitation system shall be integral brushless-type consisting of a rotating AC exciter and rectifier diode assembly together with a static-type voltage regulating system and including surge protection and the required accessories. The system shall serve as an individual excitation and regulation system for the generator specified herein, and there is no requirement for parallel operation with other exciters.

The excitation system shall have a continuous current rating of not less than the generator excitation current required when the generator operates at 105% rated voltage under the condition of continuous rating requiring maximum field current. The voltage rating of the system shall be as required to match the generator field requirements. The excitation system response ratio shall not be less than 0.5 and the ceiling voltage shall not be less than 120% of rated voltage.

c) Exciter

The exciter shall be a rotating AC generator having a rotating armature on the rotor spider and a stationary field on the stator frame. The exciter insulation shall be Class B and the temperature rise shall not exceed 70°C when measured by resistance based on a 40 °C ambient temperature.

d) Rectifiers

Rectifiers shall be full-wave silicon diode type, with each diode protected by individual fuses. The rectifiers shall be mounted on the rotating part of the exciter to convert AC exciter output to DC for the main generator excitation. Connection shall be provided between, the exciter, rectifier, and generator field without uses of brushes or slip rings.

e) Voltage Regulator

The voltage regulator shall be completely solid-state type for control of generator voltage by control of the exciter field. The regulator shall be suitable for mounting in the generator control panel. The regulator shall control the generator exciter field as required to maintain a constant and stable generator output voltage within plus or minus $\frac{1}{4}$ of 1% of nominal for all steady-state loads from no load to full load including a 5% variation in frequency and the effects of field heating. The regulator shall be designed for single-phase voltage sensing. Electromagnetic interference suppression shall be an integral part of the regulator. Thermal protection for power semi-conductors, inherent overvoltage protection, and fuse protection shall be provided internally in the regulator. No electrolytic capacitors, vacuum tubes, or electro-mechanical relays shall be used in the voltage regulator. The regulator shall have provisions for switching to manual control to allow the generator voltage to be controlled either manually or automatically. The following regulator components shall be mounted on the front of the generator control panel.

1) Voltage adjusting rheostat

2) Manual voltage control with adjusting rheostat

f) Engine Generator Instruments and Controls

NEMA ICS 1,2,3,4, and 6 shall be applied.

g) Engine Instrument

Engine instruments shall include the following as minimum components:

1) Lubricating Oil Pressure Gauge

Lubricating oil pressure gauge shall be indicating dial type utilizing a Bourdon tube for confining the pressure medium. The Bourdon tube shall be seamless and made of phosphor bronze. Gauge shall be accurate to within 2 percent of full scale reading. Gauge subject to rapid pressure surges shall be properly suppressed

2) Coolant temperature Indicators

Coolant temperature indicators shall be indicating dial type. Capillary tubing shall be covered with a protective casing throughout its entire length and reinforced with an additional casing at the connection to the bulb or socket. The temperature indicator shall be accurate to within 2 percent of full scale reading.

3) Generator Controls and Instruments

NEMA ICS 1,2,3, and 4 shall include the components listed below. Instruments shall comply with ANSI C39.1.

(a) Voltmeter and Ammeter:

Semi-flush mounted direct indicating type, not less than 110 mm inch nominal round or square, 180° arc, with accuracy of 2% of full scale.

(b) Frequency Controls and Instruments

(c) Control Switches:

Voltage and ampere ratings suitable for the intended use. Contacts shall be rated in accordance with NEMA Standards ICS 2-125.

(d) Generator Output Circuit Breaker:

Molded case type, trip-free, and shall be mounted to allow operation from outside the control panel. Frame size shall be adequate for generator amperage when operating at standby rating, and an adjustable trip shall be provided. Lugs shall be provided for electrical connections.

(e) Voltage adjustment rheostat

(f) Panel lights and control switch

(g) Alarm indicating panel

7.2.2.6 Base Assembly and Enclosure: NEMA ICS 6

a) Engine Generator

Engine Generator shall be mounted on a fabricated steel skid base suitable for supporting, transportation, and skidding engine and generator without damage to equipment or alignment.

b) Vibration Isolators

Vibration isolators shall be provided to isolate the engine-generator set from the building floor, at least four isolators, as recommended by the isolator

manufacturer, are required. The isolators shall be manufactured by a firm specializing in this product, and the unit shall be specifically listed for this application and have a maximum deflection of 25 mm.

7.2.2.7 Treatment and Painting

All parts, including engine subject to high temperature, shall be treated and painted in accordance with manufacturer's standards. The generator and all associated electrical equipment shall be thoroughly cleaned and treated prior to painting. Color shall be manufacturer's standard.

7.2.3 EXECUTION

7.2.3.1 Installation

Installation shall conform to the requirements of NFPA 70.

7.2.3.2 Diesel Engine Generator

Diesel generating unit shall be installed on a concrete foundation as indicated. Vibration isolators shall be provided to isolated vibrations from the diesel generating unit to the foundations.

7.2.3.3 Testing

The following tests shall be performed on the generator set system provided. The Engineer shall be given seven (7) working days notice prior to each test. The Contractor shall provide all test equipment and personnel and submit three (3) copies of all test results.

a) Factory Tests

The engine-generator shall be subject to the manufacturer's standard run-in and conditioning tests.

Following the run-in tests, the engine-generator set shall be tested at rated speed and voltage for 8 hours of continuous operations with 2 hours each at 50, 74, 100 and 110 percent of rated load, consecutively, 0.8 power factor. The Contractor shall determine generator frequency, phase current, and voltage and record at 15 minute intervals. The Contractor shall tests run on the voltage regulator to determine the variation in terminal voltage under conditions of constant load, and under conditions of abrupt load changes to determine the maximum voltage change during the surging period and the time required.

b) Speed Governing Test

Engine speed governing system shall be tested in accordance with ASME PTC26.

c) Field Tests and Inspections

The Contractor shall perform all field tests and trial operations, and conduct all field inspections (except final field inspection). The Contractor shall provide all

labor, equipment, and incidentals requirements, including water, fuel, and lubricants required for tests. The Contractor shall give ample notice of the dates and times scheduled for tests, trial operations, and inspections which require the presence of the Engineer. All deficiencies found shall be rectified and work affected by such deficiencies shall be completely retested at the Contractor's expense. Field tests shall include the following:

- 1) Demonstrate proper operation of all system
- 2) Conduct three (3) hour run utilizing Contractor-furnished portable load bank or dummy load as follows:

1/2 load - one hour
Full load - two hours

7.3 UNDERGROUND ELECTRICAL WORKS

7.3.1 GENERAL

7.3.1.1 General Requirements

Section 7.1, "Electrical General Requirements" applies to this section with additions and modifications specified herein.

7.3.1.2 Submittals

Submit the following information for approval:

a) Manufacturer's Data and Shop Drawings:

- 1) Conduit
- 2) Handholes
- 3) Electrical Cables

b) Certificates:

1) Materials and Equipment:

- (a) Cables
- (b) Conduit

7.3.2 MATERIAL REQUIREMENTS

7.3.2.1 Materials and Equipment

Materials and equipment shall conform to the respective specifications and standards and to the specifications herein. Electrical ratings shall be as indicated.

a) Conduit:

- | | | |
|------------------------------|---|--------------------------|
| 1) Rigid Plastic Conduit | : | UL 651, Schedule 40 PVC. |
| 2) Rigid Steel Conduit (RSC) | : | Hot dip galvanized. |

3) Intermediate Metal Conduit : UL 1242.

b) Fittings and Outlet Boxes:

- 1) PVC Fittings : UL 651.
- 2) Fittings for Metal Conduit : UL 514B. Ferrous fittings shall be hot dip galvanized in accordance with UL 514.

Fittings for RSC : shall be threaded type.

Split couplings are not acceptable.

c) Tape:

UL 510. Plastic insulating tape shall be capable of performing in a continuous temperature environment of 80°C.

d) Power Wire and Cable:

1) Wire and Cable Conductor Sizes:

Wire and cable conductor sizes are designated by square millimeters. Conductors shall be copper. Insulated conductors shall bear the date of manufacture imprinted on the wire insulation with other identification. Wire and cable manufactured more than 6 months before delivery to the job site shall not be used. Provide conductor identification within each enclosure where a tap, a splice or a termination is made.

e) Wire Conformation:

Provide wires conforming to UL 83. Only wires with "W" in the type designation shall be used in wet or damp locations.

1) 600 Volt Wires and Cables:

Conductor sizes are indicated by square millimeters (mm²) for copper conductors. Insulated wires and cables manufactured more than six months prior to delivery shall not be used.

f) Connector and Terminals:

- 1) Wire Connectors and Terminals for use with Copper Conductors: UL-486A.

g) Pull Wire:

Pull wire shall be 2.0 mm hot-dip galvanized steel or plastic having a minimum tensile strength of 90 kg in each empty duct. A minimum of 300 mm of slack shall be left at each extremity of pull wires.

h) Grounding and Bonding Equipment:

Shall conform to UL 467.

i) Underground Structures:

Handholes shall have a smooth trowel finish for floors and horizontal surfaces. Top and bottom shall consist of reinforced concrete. Walls shall consist of concrete hollow blocks. Bottom shall be monolithic concrete construction. Duct entrances and windows shall be located near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide all necessary brackets. Set pulling-in irons and other built-in items in place before depositing concrete. A pulling-in iron shall be installed in the wall opposite each duct line entrance. The words "Electric" shall be cast in the top face of all handhole covers.

j) Drainage Pipe and Fittings:

Cast-iron, extra strength. Drains shall be cast-iron, coated or uncoated, plain pattern, bottom outlet with perforated or slotted hinged cover.

7.3.3 EXECUTION

7.3.3.1 Installation

Underground cable installation shall conform to PEC, NFPA 70 and ANSI C2.

a) Concrete

Concrete for electrical requirements shall be at least 20.7 MPa (3000 psi) concrete with 19 mm maximum aggregate.

b) Earthworks

Excavation, backfilling, and pavement repairs for electrical requirements shall conform to the requirements of Section 4.2, "Excavation and Backfilling for Buildings."

c) Concrete Hollow Block Handholes

Provide concrete hollow block handholes as indicated. Masonry works shall conform to the requirements of Section 4.6, "Masonry."

1) Ground Rods

In each electrical handhole, at a convenient point close to the wall, a 20 mm by 3.0 meter copper-clad steel ground rod shall be driven into the earth before the floor is cast so that approximately 100 mm of the ground rod will extend above the handhole floor.

2) Handhole Grounding

Ground rods installed in electrical distribution system handholes shall be properly connected to the cable shielding, metallic sheaths, and armor at each cable joint or splice by means of 8.0 mm² or equivalent braided tinned copper wire. Connections to metallic cable sheaths shall be by means of tinned terminals soldered to ground wires and to cable sheaths. Care shall be taken in soldering not to damage metallic cable sheaths or shields. Ground rods shall be protected with a double wrapping of pressure-sensitive plastic tape for a distance of 50 mm above and 150 mm below concrete penetrations. Ground wires shall be neatly and firmly attached to handhole walls and the amount of exposed bare wire shall be held to a minimum.

d) Underground Ducts with Concrete Encasement

Construct underground duct lines of individual conduits encased in concrete. Except where rigid galvanized steel conduit is indicated or specified, the conduit shall be of Schedule 40 PVC. Do not mix the kinds of conduit used in any one duct bank. Ducts shall be as indicated on the drawings. The concrete encasement surrounding the bank shall be rectangular in cross section and shall provide at least 76 mm of concrete cover for ducts.

- 1) The top of the concrete envelope shall not be less than 600 mm below grade.
- 2) Duct lines shall have a continuous slope downward toward handholes and away from buildings with a pitch of not less than 76 mm in 30 meters. Except at conduit risers, accomplish changes in direction of runs exceeding a total of 10 degrees, either vertical or horizontal, by long sweep bends having a minimum radius of curvature of 7.6 meters. Sweep bends may be made up of one or more curved or Straight sections or combinations thereof. Manufactured bends shall have a minimum radius of 457 mm for use with conduits of less than 80 mm in diameter and a minimum radius of 900 mm for ducts of 80 mm in diameter and larger.
- 3) Terminate conduits in end-bells where duct lines enter handholes. Separators shall be of precast concrete, high impact polystyrene, steel, or any combination of these. Stagger the joints of the conduits by rows and layers so as to provide a duct line having a maximum strength. During construction, protect partially completed duct lines from the entrance of debris such as mud, sand and dirt by means of suitable conduit plugs. As each section of a duct line is completed from handhole, draw a brush through having the diameter of the duct and having stiff bristles until the conduit is clear of all particles of earth, sand, and gravel then immediately install conduit plugs.

e) Cable Pulling

Test duct lines with a handhole and thoroughly swab out to remove foreign materials before the pulling of cables.

Pull cables down grade with feed-in points at the handholes or buildings at the highest elevation. Use flexible cable feeds to convey cables through the handhole openings and into the duct runs. Cable slack shall be accumulated at each handhole where space permits by training the cable around the interior to form one complete loop. Minimum allowable bending radii shall be maintained in forming such loops.

- 1) Lubricants for assisting in the pulling of jacketed cables shall be those specifically recommended by the cable manufacturer. Cable lubricants shall be soapstone, graphite, or talc for rubber or plastic jacketed cables. The lubricant shall not be deleterious to the cable sheath, jacket, or outer coverings.
- 2) Cable pulling tensions shall not exceed the maximum pulling tension recommended by the cable manufacturer.
- 3) Secondary cable runs, 600 volts and less, in non-metallic duct conduit shall, although not indicated, include and insulated copper equipment grounding conductor sized as required by the rating of the overcurrent device supplying the phase conductors.
- 4) Installation of Cables in Handholes:

Do not install cables utilizing the shortest route, but route along those walls providing the longest route and the maximum spare cable lengths. All cables shall form to closely parallel walls, not to interfere with duct entrances, and support on brackets and cable insulators at a maximum of 457 mm. Support cable splices in underground structures by racks on each side of the splice. Locate splices to prevent cyclic bending in the spliced sheath.

f) Grounding

Non-current carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid "earth" ground not exceeding the following values:

Grounds in handholes	10 ohms
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Grounded secondary distribution system neutral and non-current carrying metal parts associated with distribution systems and grounds not otherwise covered.	25 ohms
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- 1) Grounding electrodes shall be cone pointed driven ground rods driven full depth plus 150 mm, installed when indicated to provide an earth ground of the value stated for the particular equipment being grounded.
- 2) Make grounding connections which are buried or otherwise normally inaccessible, and excepting specifically those connections for which access for periodic testing is required by exothermite type process. Make thermit welds strictly in accordance with the weld manufacturer's written recommendations. Welds which have "puffed up" of which show

convex surfaces indicating improper cleaning are not acceptable. No mechanical connector is required at thermit weldments.

- 3) In lieu of an exothermic type process, a compression ground grid connector of a type which uses hydraulic compression tool to provide the correct circumferential pressure may be used. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.
- 4) Grounding conductors shall be bare soft-drawn copper wire minimum unless otherwise indicated or specified.
- 5) Connect copper-clad steel ground rods only to insulated TW copper ground conductor and weld the connection. Insulate the entire area of the rod in the vicinity of the weld and the connecting wire and seal against moisture penetration.

7.3.3.2 Field Tests

As an exception to requirements that may be stated elsewhere in the contract, the Engineer shall be given a five (5) working day notice prior to each tests.

- a) Distribution Conductors 600 Volt Class:

Test all 600 volt class conductors to verify that no short circuits or accidental grounds exist. Make tests using an instrument which applies a voltage of approximately 500 volts to provide a direct reading in resistance.

- b) Test Report

Grounding electrodes and systems (identify electrodes and systems, each test)

7.4 INTERIOR WIRING SYSTEMS

7.4.1 GENERAL

Section 7.1, "Electrical General Requirements," applies to this section with additions and modifications specified herein.

7.4.1.1 SUBMITTALS

- a) Shop Drawings: Submit for the following:

- 1) Panelboards

- b) Manufacturer's data:

Submit for the following:

- 1) Circuit breakers
- 2) Switches

- 3) Conduit and fittings (each type)
 - 4) Ground rods
 - 5) Device plates
 - 6) Insulated conductors
 - 7) Outlet and junction boxes
- c) Test Reports: Submit test results for approval in report form.
- 1) 600Volt - wiring test
 - 2) grounding system test
- d) Quality Assurance

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word “shall” has been substituted for “should” wherever it appears. Interpret reference in these standards to “authority having jurisdiction,” or words of similar meaning, to mean Engineer.

7.4.2 MATERIALS AND EQUIPMENT REQUIREMENTS

Materials, equipment, and devices shall, as minimum, meet requirements of UL, where UL standards are established for those items, and requirements of NFPA 70. All items shall be new.

7.4.2.1 Conduit and Fittings

- a) Rigid Steel Conduit (RSC):
- Hot dip galvanized: ANSI C80.1.
- b) Flexible Metal Conduit: UL 1.
- 1) Liquid Tight Flexible Metal Conduit (Steel): UL 360.
- c) Rigid Plastic Conduit: PVC schedule 40 in accordance with UL 651.
- d) Intermediate Metal Conduit (IMC): UL 1242, zinc coated steel only
- e) Fittings for Metal Conduit, and Flexible Metal Conduit: UL 514B.

Ferrous fittings shall be hot dip galvanized in accordance with UL 514.

- 1) Fittings for RSC: Shall be threaded-type. Split couplings are not acceptable.
- 2) Fittings for Rigid Nonmetallic Conduit: NEMA TC3.

7.4.2.2 Outlet Boxes and Covers

UL 514, hot dip galvanized for ferrous metal.

7.4.2.3 Cabinets, Junction Boxes, and Pull Boxes (With Volume Greater than 100 Cubic Inches)

UL 50, hot dip.

7.4.2.4 Wires and Cables

Wires and cables shall meet applicable requirements of PEC, NFPA 70 and UL for types of insulation, jackets, and conductors specified or indicated. Wires and cables manufactured more than 6 months prior to date of delivery to site shall not be used.

- a) Conductors: Conductor 3.5mm² and smaller shall be solid, 5.5 mm² and larger shall be stranded. All conductors indicated shall be copper.

1) Equipment Manufacturer Requirements:

If manufacturer's equipment requires copper conductors at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2) Minimum Conductor Sizes:

Minimum size for branch circuits shall be 3.5 mm².

b) Color Coding

For 240volt, 60Hz, 1 phase, 2-wire

Phase A	-	Black
Phase B	-	Red
Grounding	-	Green

For 400/230 volt, 3 phase, 4-wire

Phase A	-	brown
Phase B	-	orange
Phase C	-	yellow
Grounding	-	Green

c) Insulation:

Unless specified for indicated otherwise or required by PEC and NFPA 70, power and lighting wires shall be 600volt, Type THHN or THW.

d) Bonding Conductors:

ASTM B1, solid bare copper wire for sizes 8.0 mm² and smaller diameter; ASTM B8, Class B, stranded bare copper wire for sizes 14 mm² and larger diameter.

7.4.2.5 Splices And Termination Components

UL 486A as applicable, for wire connectors and UL 510 for insulating tapes. Connectors for 5.5 mm² and smaller diameter wires shall be insulated, pressure-type

in accordance with UL 486A or UL 486C (twist-on splicing connector).

Provide solderless terminal lugs on stranded conductors.

7.4.2.6 Device Plates

Provide UL listed, one-piece device plates for outlets and fittings to suit the devices installed. For metal outlets and fittings, plates on unfinished walls and on fittings shall be of zinc-coated sheet steel or cast metal having round or bevelled edges. Plates on finished walls shall be urea or phenolic, minimum 2.5mm wall thickness. Plates shall be same color as receptacle or toggle switch with which they are mounted. Screws shall be machine-type with countersunk heads in color to match finish of plate. Use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and UL listed for "wet locations."

7.4.2.7 Switches

a) Toggle Switches:

Totally enclosed with bodies of thermosetting plastic and mounting strap. Wiring terminal shall be screw-type, side-wired. Switches shall be rated quiet-type AC only, 250 volts, with current rating and number of poles indicated.

b) Receptacles

UL 498 and NEMA WD 1, heavy duty, grounding type. Ratings and configurations shall be as indicated. Wiring terminals shall be screw-type, side-wired. Connect grounding pole to mounting strap.

7.4.2.8 Special Purpose Receptacles:

Receptacles serving as indicated are special purpose. Provide ratings as indicated. Furnish one matching plug with each receptacle.

7.4.2.9 Panelboards

UL 67 and UL 50. Panelboards for use as service disconnecting means shall additionally conform to UL 869. Panelboards shall be circuit breaker-equipped. Design shall be such that individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL. Where "space only" is indicated, make provisions for future installation of breaker sized as indicated. Panelboard locks shall be keyed same. Directories shall be typed to indicate load served by each circuit and mounted in holder behind transparent protective covering.

a) Panelboard Buses:

All buses shall be copper support bus bars on bases independent of circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or lapping. Provide separate ground bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

b) Circuit Breakers:

Ambient-compensated thermal magnetic-type solid state-type with interrupting

capacity of 10,000 amperes symmetrical minimum. Breaker terminal shall be UL listed as suitable for type of conductor provided. Plug-in circuit breakers are unacceptable.

1) Multi-pole Breakers

Provide common trip-type multi-pole breakers with single operating handle. Breaker design shall be such that an overload in one pole automatically causes all poles to open.

7.4.2.10 Enclosed Circuit Breakers

UL 489. Individual moulded case circuit breakers with voltage and continuous current ratings, number of poles, overload trip setting, and short circuit interrupting rating as indicated. Enclosure type as indicated.

7.4.2.11 Reefer Van Outlet

- a) The refrigerated van power center shall be to service various container van of different origin or countries including Japan, USA, Australia and other European countries.
- b) Socket outlet for 250 volts shall be capable of handling current up to 60 amperes, 3 phase. Socket outlet shall be R-24604B-60 or R6-W0602B-60 series I or approved equal.
- c) Connectors shall be capable of servicing van socket and plug with ease and simple operation. If, required, socket adaptor shall be type P-24604 P-4 and C-W4332B-3h and C-W4501B-A or approved equal.
- d) Plug shall be capable of insertion with the socket outlet in smooth operation. Mechanical interlock, switch and circuit breaker shall be provided for safety operation of reefer van outlets. Plug shall be type P-W4604 P-A or approved equal.
- e) The socket outlet for 250 volts, 3 phase shall be Series 1 and shall meet the requirements of ISO for the container industry for both 250V and 460 volts, 3 phase.
- f) For 460 volts, socket outlet shall be Series II, 32 amperes, 3 phase (C.E.E., ISO). This device shall be in accordance with C.E.E. standards, IEC as well as ISO. Voltage configuration shall be capable for 380 to 440 VAC.
- g) The socket outlet shall have circuit breaker or switch and C.E.E. 3h contact position. This device shall be non-interchangeable type and keyway shall have 3 o'clock position. The socket outlet type shall be R-W4332B-3h and R7-W0302B-3h and P-W4333p-3h or approved equal.
- h) Connector shall be of smooth operation with type no. C-24332B-3h, C-W4315B-A and P-208295 or approved equal.
- i) Plug shall be of type, P-W4333p-3h, P-W4392P-A and P-207627-P.

- j) All the above devices shall be mechanical interlocked that could not be closed unless the plug is fully inserted.

7.4.2.12 Grounding and Bonding Equipment

UL 467. Ground rods shall be copper-clad steel, with minimum diameter of 20mm and minimum length of 3 meters.

7.4.2.13 Nameplates

Provide as specified in Section 7.1 "Electrical General Requirements."

7.4.3 EXECUTION

7.4.3.1 Installation

Electrical installation shall conform to requirements of PEC, NFPA 70 and to requirements specified herein.

- a) Underground Service:

Underground service conductors and associated conduit shall be continuous from service entrance equipment to outdoor power system connection.

- b) Wiring Methods:

Provide insulated conductors installed in conduits, except where specifically indicated or specified otherwise or required by PEC and NFPA 70 to be installed otherwise. Provide insulated, green equipment grounding conductor in feeder and branch circuits, including lighting circuits. Provide insulated, green colored conductor for grounding conductors installed in conduits or raceways.

- 1) Service Entrance Conduit: Rigid Steel Conduit (RSC), conduit underground: PVC schedule 40. The underground portion shall be encased as indicated.

Underground Conduit (other than service entrance) PVC where non-metallic conduit is used, shall be converted to plastic – coated rigid steel conduit before rising through floor slab; plastic coating shall extended at least 152mm above floor.

Conduit in Floor Slabs: RSC

- c) Conduit Installation:

Unless indicated otherwise, conceal conduit within finished walls, ceilings, and floors. Keep conduit a minimum of 150mm away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits in crawl space under slab as if exposed.

- 1) Where conduits rise through floor slabs, curved portion of bends shall not be visible above finish slab.

- 2) Conduit Support:

Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded studs, or spring tension clamps on steelwork. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load. Fasteners attached to concrete ceilings shall be vibration resistant and shock resistant. Holes cut to depth of more than 40mm in reinforced concrete beams or to depth of more than 20mm in concrete joints shall not cut main reinforcing bars. Fill unused holes. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations.

- 3) Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

- 4) Install pull wires in empty conduits in which wire is to be installed by others. Pull wire shall be plastic having minimum 91 kgs. tensile strength. Leave minimum 300mm of slack at each end of pull wire.

- 5) Conduit Installed in Concrete Floor Slabs:

Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits. Space conduits horizontally at a minimum of three diameters, except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Increase slab thickness as necessary to provide minimum 25 mm cover over conduits. Where embedded conduits cross expansion joints, provide suitable watertight expansion fittings and bonding jumpers. Conduit larger than 25mm trade size shall be parallel with or at right angles to main reinforcement; when at right angles to the reinforcements, the conduit shall be closed to one of the supports of the slab.

- 6) Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by PEC and NFPA 70, where insulated bushings are used, and where bushing cannot be brought into firm contact with the box; otherwise, use minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by PEC and NFPA 70.

7) Flexible Connection:

Provide flexible connection of short length, 1.8 meters maximum for recessed and semi-recessed lighting fixtures.

d) Boxes, Outlets, and Supports:

Provide boxes in wiring or raceway systems wherever required for pulling of wires, making connections, and mounting of devices or fixtures. Boxes for metallic raceways shall be cast-metal, hub-type when located in wet locations, when surface mounted on outside of exterior surfaces, when installed exposed up to 2.1meters above interior floors and walkways, or when installed in hazardous areas. Boxes in other locations shall be sheet steel, except that aluminum boxes may be used with aluminum conduit. Each box shall have the volume required by PEC and NFPA 70 for the number of conductors enclosed in the box. Boxes for mounting lighting fixtures shall not be less than 100 mm² or octagonal, except that smaller boxes may be installed as required for fixture configurations as approved. Boxes for use in masonry-block or tile walls shall be square-cornered, tile-type, or standard boxes having square-cornered, tile-type covers. Provide gaskets for cast-metal boxes installed flush with outside of exterior surfaces. Provide separate boxes for flush or recessed fixtures when required by fixture terminal operating temperature. Fixtures shall be readily removable for access to boxes unless ceiling access panels are provided. Support boxes and pendants for surface-mounted fixtures on suspended ceilings independently of ceiling supports, or make adequate provisions for distributing load over ceiling support members. Fasten boxes and supports with wood screws on wood, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel. In open overhead spaces, cast boxes threaded to raceways need not separately supported except where used for fixture support; support sheet metal boxes directly from building structure or by bar hangers. Where bar hangers are used, attach bar to raceways on opposite sides of box, and support raceway with approved type fastener maximum 600mm from the box. When penetrating reinforced concrete members, avoid cutting reinforcing steel.

- 1) Boxes for use with raceway systems shall be minimum 40mm deep, except where shallower boxes required by structural conditions are approved. Boxes for other than lighting fixture outlets shall be minimum 100mm², except that 100 by 50mm boxes may be used where only one raceway enters outlet.

- 2) Pull Boxes:

Construct of at least minimum size required by PEC and NFPA 70 of code-gauge aluminum sheet steel except where cast-metal boxes are required in locations specified herein. Furnish boxes with screw-fastened covers. Where several feeders pass through common pull box, tag feeders to indicate clearly electrical characteristics, circuit number, and panel designation.

e) Mounting Heights:

Mount panelboards, and circuit breakers, so height of operating handle at its

highest position is maximum 1.8 meters above floor. Mount lighting switches 1.4 meters above finished floor, receptacles 300mm above finished floor and other devices. Measure mounting heights of wiring devices and outlets to center of device or outlet.

f) Conductor Identification;

Provide conductor identification within each enclosure where tap, splice, or termination is made.

g) Splices:

Make splices in accessible locations. Make splices in conductors 5.5 mm² and smaller diameter with insulated, pressure-type connector. Make splices in conductors 8.0 mm² and larger diameter with solderless connector, and cover with insulation material equivalent to conductor insulation.

h) Covers and Device Plates:

Install with edges in continuous contact with finished wall surfaces without use of mats or similar devices. Plaster fillings are not permitted. Plates shall be installed with alignment tolerance of 3mm. Use of sectional-type device plates are not permitted. Plates installed in wet locations shall be gasketed.

i) Electrical Penetrations:

Openings around electrical penetrations through fire resistance-rated walls, partitions, floors, or ceilings shall be sealed to maintain fire resistive integrity as tested per ASTM E 814.

j) Reefer Van Outlets

Installation of the reefer van outlets and other related accessories shall be in accordance with the approved Drawings accepted by the Engineer.

k) Grounding and Bonding:

In accordance with PEC and NFPA 70. Ground all exposed, non-current-carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductor in metallic and non-metallic raceways, and conductor of wiring systems. Make ground connection to driven ground rods on exterior of building. Where ground fault protection is employed, ensure that connection of ground does not interfere with correct operation of fault protection.

1) Grounding Conductor:

Provide insulated, green equipment grounding conductor in feeder and branch circuits, including lighting circuits. Grounding conductor shall be separate from electrical system neutral conductor. Provide insulated, green conductor for grounding conductors installed in conduit or raceways.

2) Resistance:

Maximum resistance-to-ground of grounding system shall not exceed 25 ohms, contact the Engineer for further instructions.

7.4.3.2 Field Quality Control:

Furnish test equipment and personnel and submit written copies of test results. Give the Engineer five (5) working days notice prior to each test.

a) Devices Subject to Manual Operation:

Each device subject to manual operation shall be operated at least five times, demonstrating satisfactory operation each time.

b) Test on 600Volt Wiring:

Test 600Volt wiring to verify that no short circuits or accidental grounds exist. Perform insulation resistance tests on wiring No. 6 AWG and larger diameter using instrument which applies voltage of approximately 500 volts to provide direct reading of resistance. Minimum resistance shall be 25,000 ohms.

c) Grounding System Test:

The Grounding system shall be tested to ensure continuity and resistance to ground is not excessive. Test each ground rod for resistance to ground before making connections to rod; tie grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Submit written results of each test to the Engineer and indicate location of rods as well as resistance and soil conditions at the time measurements were made.

7.5 INTERIOR LIGHTING

7.5.1 GENERAL

7.5.1.1. General Requirements

Section 7.1, "Electrical General Requirements," applies to this section, with the additions and modifications specified herein.

7.5.1.2 Description of Work

The work includes providing lighting fixtures for interior use, including accessories mounted on the exterior surfaces of buildings. Materials not normally furnished by manufacturers of these devices are specified in Section 7.4, "Interior Wiring Systems."

7.5.1.3 Submittals

Data, shop drawings showing mounting heights, and reports shall employ the terminology, classifications, and methods prescribed by the IES Lighting Handbook,

as applicable, for the lighting system specified.

a) Manufacturer's Data:

1) Lighting fixtures, including lamps and ballasts

7.5.2 MATERIAL REQUIREMENTS

7.5.2.1 Luminaires

7.5.2.1.1 LED Luminaires

Provide luminaires complete with power supplies (drivers) and light sources. Provide design information including lumen output and design life in luminaire schedule on project plans for LED luminaires.

LED luminaires must also meet the following minimum requirements:

- a) Luminaires must have a minimum 5 year manufacturer's warranty.
- b) Luminaires must have a minimum L70 lumen maintenance value of 50,000 hours as calculated by IES TM-21, with data obtained per IES LM-80 requirements.
- c) Luminaire drive current value must be identical to that provided by test data for luminaire in question.
- d) Luminaires must be tested to IES LM-79 and IES LM-80 standards, with the results provided as required in the Submittals paragraph of this specification.

7.5.2.1.2 Fluorescent Luminaires

UL 1598. Provide linear and compact fluorescent luminaires complete with housing, ballast and light source. All fluorescent luminaires must be equipped with electronic ballasts.

7.5.2.1.3 High Intensity Discharge (HID) Luminaires

UL 1598. Provide HID luminaires complete with housing, ballast and light source.

7.5.2.2 DRIVERS and BALLASTS

a) LED Drivers

NEMA SSL 1, UL 8750. LED drivers must be electronic, UL Class 1, constant-current type

b) Fluorescent Electronic Ballasts

NEMA ANSLG C82.11, UL 935. Fluorescent ballasts must not contain any magnetic core and coil components. T8 Programmed Instant-Start Fluorescent Ballasts. Provide programmed instant-start T8 electronic fluorescent ballasts. Shall be labeled Certified Ballast Manufacturers (CBM) certified by Electrical Testing Laboratories (ETL). Ballasts shall be high power factor type and shall be designed to operate on the voltage system to which

they are connected. Ballasts shall be Class P and shall have sound rating "A". Fixtures and ballasts shall be designed and constructed to limit the ballast case temperature to 90 degrees Celsius (C) when installed in an ambient temperature of 40 degrees C.

c) Compact Fluorescent Ballasts

Provide programmed-start ballasts for compact fluorescent luminaires.

d) HID Ballasts

UL 1029, NEMA ANSLG C82.9, and ANSI C82.2. Provide ballast to serve one single light source.

7.5.2.3 LIGHT SOURCES

NEMA ANSLG C78.377, NEMA SSL 3. Provide type and wattage as indicated in luminaire schedule on project plans.

7.5.2.3.1 LED Light Sources

- a) Correlated Color Temperature (CCT) of 3500 degrees K.
- b) Minimum Color Rendering Index (CRI) R9 value of 80.
- c) High power, white light output utilizing phosphor conversion (PC) process or mixed system of colored LEDs, typically red, green and blue (RGB).
- d) RoHS compliant.

7.5.2.3.2 Fluorescent Light Sources

NEMA C78.376. Fluorescent light sources must be low-mercury, energy-savings type and be compliant with the most current TCLP test procedure per ANSI/NEMA C78.LL 1256 at the time of manufacture.

7.5.2.3.3 Compact Fluorescent (CFL) Light Sources

ANSI C78.901. Provide compact fluorescent (CFL) light sources with minimum CRI of 82 and CCT of 3500 degrees K.

7.5.2.3.4 HID Light Sources

ANSI C78.389. Light sources must be compliant with the most current TCLP test procedure per NEMA C78.LL 3 at the time of manufacture.

7.5.2.4 Exit and Emergency Lighting Equipment

UL 924, NFPA 101, NFPA 70 and PEC compliant.

a) LED Self-Powered Exit Signs

Provide in painted, die-cast aluminum housing with UL damp label configured for ceiling wall mounting. Provide single and double face. Equip with

automatic power failure device, test switch, and pilot light, and fully automatic high/low trickle charger in a self-contained power pack.

7.5.2.5 Recess and Flush-Mounted Fixtures

Provide types that can be relamped from the bottom. Trim for the exposed surface of flush-mounted fixtures shall be as indicated.

7.5.2.6 Suspended Fixtures

Provide hangers capable of supporting twice the combined weight of the adjoining fixtures. Provide with swivel hangers to ensure a plumb installation. Hangers shall be cadmium-plated steel with swivel-ball tapped for the conduit size indicated. Hangers shall allow fixtures to swing within an angle of 20 degrees. Brace pendants 1.2 meters or longer to limit swinging. Single-unit suspended fluorescent fixtures shall have twin-stem hangers. Multiple-unit or continuous row fluorescent fixtures shall have a tubing or stem for wiring at one point and a tubing or rod suspension provided for each unit length of chassis, including one at each end. Rods shall be a minimum 5mm diameter.

7.5.2.7 Power Hook Fixture Hangers

Provide UL listed assembly including through-wired power hook housing, interlocking plug and receptacle, power cord, and fixture support loop. Power hook housing shall be cast aluminum having two 20mm threaded hubs. Fixture support loop shall be cast aluminum with provisions for accepting 20mm threaded fixture stems. Power cord shall include 400mm of 3-conductor No. 16 Type SO cord.

7.5.3 EXECUTION

7.5.3.3 Installation

Set lighting fixtures plumb, square, and level with ceiling and walls, in alignment with adjacent lighting fixtures, and secure in accordance with manufacturer's directions and approved shop drawings. The installation shall meet with the requirements of PEC and NFPA 70. Mounting heights specified or indicated shall be to bottom of fixture for ceiling-mounted fixtures and to center of fixture for wall-mounted fixtures. Obtain approval of the exact mounting for lighting fixtures on the job before installation commence and, where applicable, after coordinating with the type, style, and pattern of the ceiling being installed. Recessed and semi-recessed fixtures may be supported from suspended ceiling support system ceiling tees if the ceiling system support rods or wires are provided at a minimum of four rods or wires per fixture and located not more than 150 mm from each corner of each fixture. Do not support fixtures by ceiling acoustical panels. Where fixtures of size less than the ceiling grid are indicated to be centered in the acoustical panel, support such fixtures independently or with at least two 20mm metal channels spanning, and secured to, the ceiling tees. Provide rods or wires for lighting fixture supports under this section of the specifications. Additionally, for recessed fixtures, provide support clips securely fastened to ceiling grid members, a minimum of one at or near each corner of each fixture.

7.5.3.4 Grounding

Ground non-current-carrying parts of equipment as specified in Section 7.4, "Interior Wiring Systems." Where the copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

7.5.3.5 Field Tests

The Contractor will provide electric power required for field tests.

a) Operating Test:

Upon completion of the installation, conduct an operating test to show that the equipment operate in accordance with the requirements of this section.

b) Insulation Resistance Test:

Perform as specified in Section 7.4, "Interior Wiring Systems", both before and after connection of fixtures and equipment.

c) Ground Resistance Tests:

Perform as specified in Section 7.4, "Interior Wiring System."

7.6 EXTERIOR LIGHTING

7.6.1 GENERAL

Section 7.1, "Electrical General Requirements," applies to this section, with the additions and modifications specified herein.

7.6.1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

a) American Association of State Highway and Transportation Officials (AASHTO)

AASHTO LTS-3	(2006) Structural Supports for Highway Signs, Luminaires and Traffic Signals
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b) American National Standards Institute (ANSI)

ANSI C82.4	(1992) Ballasts for High-Intensity-Discharge and Low-Pressure Sodium Lamps (Multiple-Supply Type)
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ANSI C136.14	(2004) Roadway Lighting Equipment - Enclosed Side-Mounted Luminaires for Horizontal-Burning High-Intensity-Discharge Lamps
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- c) American Society for Testing and Materials (ASTM)
 - ASTM A123/A123M (2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
 - ASTM A153/A153M (2005) Zinc Coating (Hot-Dip) on Iron and Steel Hardware - AASHTO No.: M232
- d) Illuminating Engineering Society of North America (IES)
 - IES LHBK (1993) Lighting Handbook, Reference and Application
- e) Institute of Electrical and Electronics Engineers, Inc. (IEEE)
 - IEEE C2 (2007) National Electrical Safety Code (ANSI/IEEE)
 - IEEE C136.3 (2005) Roadway Lighting Equipment - Luminaire Attachments
 - IEEE C136.10 (1996) Roadway Lighting Equipment - Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing
- f) National Electrical Manufacturers Association (NEMA)
 - NEMA C78.41 (2001) Guidelines for Low-Pressure Sodium Lamps
 - NEMA C78.42 (2007) Electric Lamps - Guidelines for High-Pressure Sodium Lamps
 - NEMA ICS 2 (2000; Errata 2002; R2005; Errata 2006) Industrial Control and Systems Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC
 - NEMA ICS 6 (1993; R2006) Industrial Control and Systems Enclosures
- g) National Fire Protection Association (NFPA)
 - NFPA 70 (2014) National Electrical Code
- h) Underwriters Laboratories Inc. (UL)
 - UL 773 (2002) Plug-In, Locking Type Photocontrols for Use with Area Lighting
 - UL 773A (2003) Non-industrial Photoelectric Switches for

Lighting Control

UL 1029 (2001) High-Intensity-Discharge Lamp Ballasts

i) Institute of Integrated Electrical Engineer (IIEE)

PEC (2009) Philippine Electrical Code

j) Philippine National Standard (PNS)

BS (2002) Bureau of Standard

7.6.1.2 Definitions

a) Average Life

Time after which 50 percent will have failed and 50 percent will have survived under normal conditions.

b) Groundline Section

That portion between 300 mm above and 600 mm below the groundline.

7.6.1.3 Submittals

Submit the following.

a) Shop Drawings

1) Luminaire drawings

2) Poles

b) Product Data

1) Luminaires

2) Lamps

3) Ballasts

4) Lighting contactor

5) Photocell switch

6) Steel poles

7) Brackets

c) Samples

1) Luminaires

Submit one sample of each luminaire type, complete with lamp and ballast.

d) Test Reports

1) Test Data for luminaires

7.6.1.4 Quality Assurance

a) Drawing Requirements

1) Luminaire Drawings

Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and computerized candlepower distribution data shall accompany shop drawings.

2) Poles

Include dimensions, wind load determined in accordance with AASHTO LTS-3, pole deflection, pole class, and other applicable information.

b) Test Data for Luminaires

1) Distribution data according to IES classification type as defined in IES LHBK.

2) Computerized horizontal illumination levels in lux at ground level, taken every 3000 mm. Include average maintained lux level and maximum and minimum ratio.

7.6.1.5 Delivery, Storage, and Handling

a) Steel Poles

Do not store poles on ground. Support poles so they are at least 305 mm above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

b) High Mast Tower

The high mast tower shall be transported by the contractor to the erection sites at his expenses and responsibility and shall be handled with care to avoid bending or damaged to the galvanizing. Materials on which galvanizing have been damage shall be re-dipped unless in the opinion of the Engineer the damage is local and can be repaired by painting with at least two (2) coats of zinc paint. The repair shall be made by and at the expense of the contractor.

7.6.2 MATERIAL REQUIREMENTS

7.6.2.1 Product Coordination

Products and materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 7.3, "Underground Electrical Works".

7.6.2.2 Luminaires

ANSI C136.14 or UL 1572. Provide luminaires as indicated. Provide luminaires complete with lamps of number, type, and wattage indicated. Details, shapes, and dimensions are indicative of the general type desired, but are not intended to restrict selection to luminaires of a particular manufacturer. Luminaires of similar designs, light distribution and brightness characteristics, and of equal finish and quality will be acceptable as approved.

a) High Pressure Sodium (HPS) Light Sources

ANSI ANSLG C78.42 and NEMA ANSLG C78.380. HPS light sources shall have a minimum average rated life of 24,000 hours, minimum color rendering index (CRI) of 21, and a minimum correlated color temperature (CCT) of 1900 degrees K. Provide type and wattage as indicated in luminaire schedule on project plans. Light sources shall be compliant with the most current TCLP test procedure per NEMA C78.LL 3 at the time of manufacture.

b) Metal Halide (MH) Light Sources

ANSI/ANSLG C78.43, NEMA ANSLG C78.44, ANSI C78.1381, and NEMA ANSLG C78.380. Provide type and wattage as indicated in luminaire schedule on project plans. Open fixtures are prohibited unless provided with a mechanism to utilize only Type O light sources and prohibit the use of Type E or S light sources. Light sources shall be specifically suited to operate in the burning position which they are installed, and shall be compliant with the most current TCLP test procedure per NEMA C78.LL 3 at the time of manufacture.

c) LED Light Sources

- 1) Correlated Color Temperature (CCT) shall be in accordance with NEMA ANSLG C78.377
- 2) Color Rendering Index (CRI) shall be: Greater than or equal to 70 for 4000 degrees K light sources.

d) Floodlight Fixtures

Floodlight fixture is in heavy duty weather resistant, a die cast aluminum housing with hinged, removable and gasketed front housing and captive screws for relamping access, integral ballast, optical assembly with provisions for vertically or horizontally mounted lamp, an adjustable aiming stops and built -in rifle sight for daytime aiming, ballast shall be mounted on the back housing and shall be prewired to the lamp socket, terminal board and ignitor or equivalent.

7.6.2.3 Luminaires Ballasts and Drivers

a) Electronic HID Ballasts

NEMA ANSLG C82.14, IEEE C62.41, 47 CFR 18 and shall meet the following requirements:

- 1) Minimum power factor shall be greater than 90 percent.
- 2) Input voltage shall be 120-277 volts plus or minus 10 percent.
- 3) Shall have end of life circuitry to prevent ballast from operating if light source is inoperable.
- 4) Shall have a sound rating of A and a lamp current crest factor less than 1.5.
- 5) Input current total harmonic distortion shall be less than 15 percent.
- 6) Minimum starting temperature shall be minus 30 degrees C minus 22 degrees F.
- 7) Shall be thermally protected to prevent overheating.
- 8) Shall be UL listed and RoHS compliant.

b) LED Drivers

UL 1310

- 1) Minimum efficiency shall be 85 percent.
- 2) Drive current to each individual LED shall not exceed 600 mA, plus or minus 10 percent.
- 3) Shall be rated to operate between ambient temperatures of minus 30 degrees C and 50 degrees C.
- 4) Shall be designed to operate on the voltage system to which they are connected, typically ranging from 120 V to 480 V nominal.
- 5) Operating frequency shall be: 60 Hz.
- 6) Power Factor (PF) shall be greater than or equal to 0.90.
- 7) Total Harmonic Distortion (THD) current shall be less than or equal to 20 percent.
- 8) Shall meet requirements of 47 CFR 15, Class B.
- 9) Shall be RoHS-compliant.
- 10) Shall be mounted integral to luminaire. Remote mounting of power supply is not allowed.

7.6.2.4 Lighting Contactor

NEMA ICS 2, electrically held contactor. Contacts shall be rated 240 volts, 20 amperes, and 2 poles. Coils shall be rated 240 volts. Provide in NEMA 3R enclosure conforming to NEMA ICS 6. Contactor shall have silver alloy double-break contacts and shall require no arcing contacts. Provide contactor with hand-off-automatic selector switch. Contactor shall be hermetically sealed.

7.6.2.5 Photocell Switch

UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated 240 volts ac, 60 Hz with single pole double-throw (spdt) contacts for mechanically held contactors rated 1000 watts. Switch shall turn on at or below 30 lux and off at 30 to 100 lux. A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

7.6.2.6 Poles

Provide poles designed for wind loading of 175 km/hr determined in accordance with AASHTO LTS-3 while supporting luminaires having effective projected areas indicated. Poles shall be anchor-base type designed for use with underground supply conductors. Poles, shall have oval-shaped handhole having a minimum clear opening of 65 by 130 mm. Handhole cover shall be secured by stainless steel captive screws.

a) Steel Poles

AASHTO LTS-3. Provide steel poles having minimum 11-gage steel with minimum yield/strength of 331 MPa and hot-dipped galvanized in accordance with ASTM A123/A123M factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 248 MPa.

7.6.2.7 Pole Foundations

Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa; the top 305 mm of the rod shall be galvanized in accordance with ASTM A153/A153M.

7.6.2.8 High Mast Tower

The number of floodlight fixtures pre-required and detail connection of high mast tower, as shown in the plan. Anchor bolts to be stainless steel or galvanized steel and designed and provided by the high mast tower manufacturer to ensure that the high mast tower and anchor bolts assembly capacity meets all the stresses composed of wind, luminaires weight and live load of maintenance personnel.

Protective coating for the high mast tower as be as follows:

a) Galvanizing Preparation

All mild steel parts exposed to weather shall be hot-dipped galvanized after fabrication as shown in the approved plan or directed by the Engineer in accordance with the requirements of JIS H88641. Prior to galvanizing, the surface shall be cleaned of dirt, weld splatter, grease, slag, oil, paint or other deleterious matters. The steel surfaces shall be chemically descaled and cleaned with abrasive blast or other suitable method as approved by the Engineer.

b) Coating

The zinc coating shall consist of uniform layer of commercially pure zinc free from abrasions, cracks, blisters, chemical spots or other imperfections, and shall adhere firmly to the surface of the steel. The weight of the zinc coating per square meter of actual surface shall not be less than 550 grams. Any surface damaged subsequent to galvanizing shall be given two coats of approved zinc paint.

c) Painting of Galvanize Steel Work

Hot-dipped galvanized high mast tower are to be treated at the works with an appropriate zinc chromate two packs etch primer followed by one coat of non-etch zinc chromate primer and one coat of micaceous iron oxide paint before shipment. On site damage to the coating is to be repaired and a final coat of micaceous iron oxide is to be applied after erection, generally in accordance with the specifications for shot blasted steel.

Manufacturer must submit a warranty for the corrosion resistant cladding material against manufacturing defects for a period of one (1) year from the date of original purchase.

7.6.3 EXECUTION

7.6.3.1 Installation of Poles

IEEE C2, NFPA 70, PEC and to the requirements specified herein.

a) Steel

Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad at the bottom end. Provide galvanized nuts, washers, and ornamental covers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 7.3, "Underground Electrical Works." Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location.

b) Pole Setting

Depth shall be as indicated.

c) Photocell Switch Aiming

Aim switch according to manufacturer's recommendations.

7.6.3.2 Installation of High Mast Tower (Method of Erection)

The Contractor shall use standard and accepted practice and methods of erecting the high mast tower depending upon their location. The high mast tower shall be erected by the Contractor in accordance with the structure list and the erection diagrams prepared by the high mast tower manufacturer.

The high mast tower may be erected by assembling in sections on the ground and hoisting successive sections in place, or they may be build-up in place individual members at the option of the Contractor. If erected by assembling in sections, not less than fifty percent (50%) of all bolting in place shall be done on each section before starting another section. All bolts shall be drawn up tight but not to such a degree as to endanger the strength of the bolt. All nuts shall be locked in place. All bolts ends below three (3) meters above ground should be flattened to prevent the nut from being taken out from the bolt. Only wrenches approved by the Engineer shall be used on the work, and the use of any wrench that may deform the nut or cut or flake the galvanizing shall not be permitted.

A reasonable amount of drifting shall be allowed in assembling but reaming for correction of mismatched holes due to shop errors shall be permitted. If any shop error in the steel is discovered, the Contractor shall notify the Engineer, who will decide whether the errors may be corrected in the field or the members returned to the manufacturer for correction or replacement. Galvanized damaged during the corrections of shop errors shall be repaired in accordance with the plans/specifications.

Final inspection of the high mast tower shall be made by the Engineer who shall make and report all loose bolts and other errors in erection, and shall make sure all bolts are in place and are tightened properly and that all nuts are locked properly.

The high mast tower shall be erected so that any portion of the high mast tower shall be in correct position relative to the high mast tower vertical center line, which shall not deviate from any plumb by more than 0.2% of height in either the transverse or longitudinal direction.

Construction of reinforced concrete high mast tower foundation and handhole shall be in accordance with all the details in the plan.

Excavations / backfilling required before /after installation of high mast tower and concrete pedestal post shall conform to the provisions of Earthwork and Concrete Construction.

Concrete Pedestal Post shall be reinforced concrete with appropriate weatherproof fittings as constructed as shown in the approved plan. Reinforced concrete materials shall conform to the requirements of concrete. Concrete shall be of 210kg/cm² compressive strength.

Metering: the local utility company shall be responsible for the supply and installation of metering equipment, and its accessories, but it is part of the contractor responsibility and expense to coordinate with them on this regard.

7.6.3.3 Grounding

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 7.3, "Underground Electrical Works." Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

7.6.3.4 Field Quality Control

Upon completion of installation, conduct an operating test to show that the equipment operates in accordance with the requirements

7.7 GROUNDING SYSTEM AND LIGHTNING PROTECTION

7.7.1 GENERAL

7.7.1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

- a) American National Standards Institute (ANSI)
 - ANSI C135.30 (1988) Zinc-Coated Ferrous Ground Rods for Overhead or Underground Line Construction
- b) Institute of Electrical and Electronics Engineers (IEEE)
 - IEEE Std 81 (1983) Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Potentials of a Ground System
- c) National Fire Protection Association (NFPA)
 - NFPA 70 (2014) National Electrical Code
 - NFPA 780 (2007) Lightning Protection Code
- d) Underwriters Laboratories (UL)
 - UL Elec Const Dir (2007) Electrical Construction Materials Directory
 - UL 96 (2005) Lightning Protection Components
 - UL 96A (2007) Installation Requirements for Lightning Protection Systems
 - UL 467 (2007) Grounding and Bonding Equipment

- e) Institute of Integrated Electrical Engineer (IIEE)
PEC (2009) Philippine Electrical Code
- f) Philippine National Standard (PNS)
BS (2002) Bureau of Standard

7.7.1.2 Related Requirements

Section 7.1, "Electrical General Requirements," applies to this section with additions and modifications specified herein.

a) System Requirements

Materials shall consist of standard products of a manufacturer regularly engaged in production of lightning protection systems and shall be manufacturer's latest UL approved design. Lightning protection system shall conform to PEC, NFPA 70, NFPA 780, UL 96 and UL 96A.

7.7.1.3 Submittals

a) Shop Drawings

Overall lightning protection system

Each major component

b) Test Reports

Grounding system test

Lightning protection system inspection

c) Certificates

UL listing or label

7.7.1.4 Quality Assurance

In each standard referred to herein, consider the advisory provisions to be mandatory, as though the word "shall" has been substituted for "should" wherever it appears.

a) Installation Drawings

- 1) Submit installation shop drawing for the overall lightning protection system. Drawings shall include physical layout of the equipment, mounting details, relationship to other parts of the work, and wiring diagram.

- 2) Submit detail drawings for each major component to include manufacturer's descriptive and technical literature, catalog cuts, and installation instructions.

b) UL Listing or Label

Submit proof of compliance. Label of or listing in UL Elec Const Dir is acceptable evidence. In lieu of label or listing, submit written certificate from an approved, nationally recognized testing organization equipped to perform such services, stating that items have been tested and conform to requirements and testing methods of Underwriters Laboratories.

7.7.1.5 Site Conditions

Contractor will become familiar with details of the work, verify dimensions in the field, and advise the Engineer of discrepancies before performing work. Deviations from contract drawings will not be made without prior approval of the Engineer.

7.7.2 Material Requirements

7.7.2.1 Materials

Do not use a combination of materials that forms an electrolytic couple of such nature that corrosion is accelerated in presence of moisture unless moisture is permanently excluded from the junction of such metals. Where unusual conditions exist which would cause corrosion of conductors, provide conductors with protective coatings or oversize conductors. Where mechanical hazard is involved, increase conductor size to compensate for hazard or protect conductors by covering them with or tubing made of nonmagnetic material.

a) Main and Bonding Conductors

NFPA 780 and UL 96

b) Copper

Provide copper conductors on nonmetallic stacks that do not weigh less than 144.83 kg per 300 meters, and provide cable such that the size of any strand in the cable is not less than 2 mm².

7.7.2.2 Components

a) Air Terminals

Provide terminals in accordance with UL 96. Support air terminals by suitable brace, with guides, not less than one-half the height of the terminal.

b) Ground Rods

Provide ground rods made of copper-clad steel conforming UL 467. Provide ground rods that are not less than 20 mm in diameter and 3000 mm in length. Do not mix ground rods of copper-clad steel, stainless steel, galvanized ferrous, or solid copper on the job.

c) Connections and Terminations

Provide connectors for splicing conductors that conform to UL 96, class as applicable. Conductor connections can be made by clamps or welds (including exothermic). Provide style and size connectors required for the installation.

d) Connector Fittings

Provide connector fittings for "end-to-end", "Tee", or "Y" splices that conform to NFPA 780.

e) Lightning Protection Components

Provide bonding plates, air terminal supports, clips, and fasteners that conform to UL 96 classes as applicable.

7.7.3 EXECUTION

7.7.3.1 Integral System

Lightning protection system consists of air terminals, down conductors, ground connections, grounding electrodes and ground loop conductor. Electrically interconnect lightning protection system to form the shortest distance to ground. Do not use non-conducting parts of the structure as part of the building's lightning protection system. Conductors are required to be in protective sleeves.

a) Air Terminals

Air terminal design and support conforming to NFPA 780. Rigidly connect terminals to, and make electrically continuous with, down conductors by means of pressure connectors or crimped joints of T-shaped malleable metal. Provide pressure connector or crimped joint with a dowel or threaded fitting to connect ground rod conductor with air terminal. Set air terminals at ends of structures not more than 610 mm from ends of ridges. Where nonmetallic spires, is present, mount air terminals to the side. In addition, where spires project more than 3050 mm above the building, continue conductor from air terminal to nearest down conductor securely connect thereto.

b) Down Conductors

Make down conductors electrically continuous from air terminals to grounding electrodes. Equally and symmetrically spaced down conductors about the perimeter of the structure. Protect conductors where necessary, to prevent physical damage or displacement to the conductor.

1) Ground Connections

Securely connect conductor forming continuations of down conductors from structure to grounding electrode in a manner to ensure electrical continuity between the two. Provide clamp type connections or welds (including exothermic) for continuation. Attach down conductor to ground rods by welding including exothermic, brazing, or clamping. Provide clamps

suitable for direct burial. Protect ground connection from mechanical injury. In making ground connections, take advantage of all permanently moist places where practicable, although avoid such places when area is wet with waste water that contains chemical substances, especially those corrosive to metal.

2) Grounding Electrodes

Provide grounding electrode for down conductor. Extend driven ground rods into the existing undisturbed earth for a distance of not less 3050 mm. Set ground rods less than 610 mm nor more than 3050 mm, from the structure. After the completed installation, measure the total resistance to ground using the fall-of-potential method described in IEEE Std 81. Maximum resistance of a driven ground rod shall be 10 ohms, under normally dry conditions. Make connections between ground conductors and grounds or electrically continuous.

7.7.3.2 Field Quality Control

a) Grounding System Test

Test the grounding system to ensure continuity and that resistance to ground is not in excess of 10 ohms. Test the ground rod for resistance to ground before making connections to the rod. Tie the grounding system together and test for resistance to ground. Make resistance measurements in dry weather, not earlier than 48 hours after rainfall. Include in the written report: locations of ground rods, resistance, and soil conditions at the time that measurements were made. Submit results of each test to the Engineer.

b) Lightning Protection System Inspection

Make visual inspections to verify that there are no loose connections which may result in high resistance joints, and that conductors and system components are securely fastened to their mounting surfaces and are protected against accidental mechanical displacement.

7.8 SOLAR PHOTOVOLTAIC (PV) COMPONENTS

7.8.1 GENERAL

7.8.1.1 References

a) American Society of Civil Engineers (ASCE)

ASCE 7 (2010) Minimum Design Loads for Buildings and Other Structures

b) ASTM International (ASTM)

ASTM D149 (2013) Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies

- | | |
|------------|--|
| ASTM D1876 | (2008) Test Method for Peel Resistance of Adhesives (T-Peel Test) |
| ASTM D2244 | (2015) Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates |
| ASTM D257 | (2014) Test Methods for D-C Resistance or Conductance of Insulating Materials |
| ASTM D2765 | (2011) Determination of Gel Content and Swell Ratio of Crosslinked Ethylene Plastics |
| ASTM D5870 | (2011) Calculating Property Retention Index of Plastics |
| ASTM D709 | (2013) Laminated Thermosetting Materials |
| ASTM D7567 | (2009) Test Method for Determining Gel Content in Crosslinked Ethylene Plastics Using Pressurized Liquid Extraction |
| ASTM D882 | 2012) Tensile Properties of Thin Plastic Sheeting |
| ASTM D903 | (2010) Peel or Stripping Strength of Adhesive Bonds |
| ASTM E1171 | (2015) Test Methods for Photovoltaic Modules in Cyclic Temperature and Humidity Environments |
| ASTM E308 | (2013) Computing the Colors of Objects by Using the CIE System |
| ASTM E424 | (2007) Test Methods for Solar Energy Transmittance and Reflectance Terrestrial) of Sheet Materials |
| ASTM E772 | (2015) Terminology of Solar Energy Conversion |
| ASTM F1249 | (2013) Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor |
| ASTM G155 | (2013) Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials |
- c) Non-Metallic Materials Institute of Electrical and Electronics Engineers (IEEE)
- | | |
|-----------|--|
| IEEE 1547 | (2008) Interconnecting Distributed Resources with Electric Power Systems |
| IEEE C2 | (2012) National Electrical Safety Code |

- IEEE Std
Dictionary (2009) IEEE Standards Dictionary: Glossary of Terms & Definitions
- d) International Code Council (ICC)
- ICC IBC (2012) International Building Code
- e) International Electrical Testing Association (NETA)
- NETA ATS (2013) Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems
- f) International Electrotechnical Commission (IEC)
- IEC 61215 (2005) Crystalline Silicon Terrestrial Photovoltaic (PV) Modules - Design Qualification and Type Approval
- IEC 61853-1 (2011) Photovoltaic (PV) Module Performance Testing and Energy Rating - Part 1: Irradiance and Temperature Performance Measurements and Power Rating
- g) International Organization for Standardization (ISO)
- ISO 9001 (2009) Quality Management Systems- Requirements
- h) National Electrical Manufacturers Association (NEMA)
- ANSI C12.1 (2008) Electric Meters Code for Electricity Metering
- NEMA 250 (2014) Enclosures for Electrical Equipment (1000 Volts Maximum)
- NEMA IEC 60529 (2004) Degrees of Protection Provided by Enclosures (IP Code)
- i) National Fire Protection Association (NFPA)
- NFPA 1 (2015) Fire Code
- NFPA 70 (2014) National Electrical Code
- NFPA 70E (2015) Electrical Safety in the Workplace
- NFPA 780 (2014) Installation of Lightning Protection Systems

- j) Institute of Integrated Electrical Engineers of the Philippines (IIEE)
PEC (2009) Philippine Electrical Code
- k) Bureau of Product Standards (BS)
PNS (2002) Philippine National Standard
- l) Underwriters Laboratories (UL)
UL 1449 (2014) Surge Protective Devices
UL 1703 (2014) Safety Flat-Plate Photovoltaic Modules and Panels
UL 1741 (2015) Safety Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 2703 (2015) Safety Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs For Use With Flat-Plate Photovoltaic Modules And Panels
UL 969 (2014) Marking and Labeling Systems
UL Electrical Construction (2012) Electrical Construction Equipment Directory

7.8.1.2 Related Requirements

Section 7.4 - Interior Wiring Systems apply to this section with additions and modifications specified herein.

7.8.1.3 Definitions

- a) Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, are as defined in the IEEE Stds Dictionary.
- b) Unless otherwise specified or indicated, solar energy conversion terms used in these specifications, and on the drawings, are as defined in ASTM E772.

7.8.1.4 Submittals

- a) Shop Drawings
 - 1) Schematic Diagrams
 - 2) Interconnection Diagrams
 - 3) Installation Drawings

- b) Product Data
 - 1) Combiner Boxes
 - 2) Disconnects
 - 3) Inverters
 - 4) Mounting Structure for Modules
 - 5) Photovoltaic Module Backsheet
 - 6) Photovoltaic Module Encapsulant
 - 7) Photovoltaic Modules
 - 8) Photovoltaic Wire
 - 9) System Monitoring
- c) Design Data
 - 1) System Operation
 - 2) Calculations
- d) Test Reports
 - 1) NETA Acceptance Checks and Tests
- e) Certificates
 - 1) Installer
 - 2) Materials
 - 3) Warranty
- f) Manufacturer's Instructions
 - 1) Installation Instructions
- g) Operation and Maintenance Data
 - 1) Electrical Systems, Data Package 5
 - 2) Training Course

7.8.1.5 Quality Assurance

- a) Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Engineer. Provide equipment, materials, installation, and workmanship in accordance with the mandatory and advisory provisions of NFPA 70 and PEC unless more stringent requirements are specified or indicated.

- b) Installation Drawings
 - 1) Submit drawings for Owner approval prior to equipment construction or integration.

- 2) Submit shop drawings at a minimum of 11 by 17 inches in size A3 paper.
- 3) All details legible and all text no smaller than 2.50 mm in height on any drawing. As needed, provide enlargements to ensure clarity of intent.
- 4) Shop drawings must include one-wire diagrams and installation details of photovoltaic (PV) system equipment indicating location as proposed in design drawings, layout and arrangement of PV modules, support and mounting mechanism, inverters, combiner boxes, AC and DC disconnects, equipment enclosures, conduits, monitors, meters, security systems, and all other accessories associated with the installation of the PV system. Wiring diagrams must identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each equipment item.
- 5) Shop drawings may include legible copies of manufacturer's product literature, with selected items and specifications highlighted thereon.
- 6) Modifications to original drawings made during installation must be immediately recorded for inclusion into the as-built drawings. When items have changed relative to the approved design, the designer must provide certification indicating that the changes will not negatively affect the system's operation or the structure supporting the system.

c) System Operation

Provide a complete description of the function of each component including PV modules, DC wiring, combiner boxes, inverters, AC wiring, AC and DC disconnect switches, and monitoring system. Provide a discussion of the overall system operation.

d) Installer

Submit PV Installation certification, and a resume with references that details least four successful projects that, in aggregate, equal or exceed the size of the proposed project.

e) Materials

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Submit proof of compliance with requirements of UL, where material or equipment is specified to comply. The label of or listing in UL Electrical Construction Directory will be acceptable evidence. In lieu of the label or listing, a written certificate from an approved nationally recognized testing laboratory (NRTL) equipped to perform such services, stating that the items have been tested and conform to the requirements and testing methods of Underwriters Laboratories may be submitted.

f) Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if the manufacturer has been regularly engaged in the design and production of

solar photovoltaic products for a minimum of 5-years. Similar photovoltaic products must have been in satisfactory commercial or industrial use for 5-years prior to bid opening and must have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 5-year period.

g) Material and Equipment Manufacturing Date

Products manufactured more than 1-year prior to date of delivery to site must not be used, unless specified otherwise.

7.8.1.6 Operation and Maintenance Data

Submit Solar Photovoltaic Systems data package for the following items.

- a) Troubleshooting guide.
- b) Warranty.
- c) Operation instructions.
- d) Preventive maintenance and inspection data, including a schedule for system operators.
- e) As-built plans displaying modules identified according groups or zones, coordinated with activity to organize as required.

7.8.1.7 Electrical Systems

Submit operation and maintenance data in accordance with this specification:

- a) Service and maintenance information including preventive maintenance, assembly, and disassembly procedures.
- b) Complete operation, repair, and maintenance information, detailed to the smallest replaceable unit.
- c) Adjustment, trouble-shooting, configuration, tuning, and system calibration instructions.
- d) Programming information for the communications and monitoring interface.
- e) An instruction manual with pertinent items and information highlighted.
- f) A layout drawing showing locations as well as views of equipment; front, top, and side views.
- g) A one-line drawing showing all components and interfaces to the electrical system.
- h) Prices for spare parts and supply list.
- i) Inverter efficiency report and field acceptance test reports.

- j) Actual nameplate diagram.
- k) Date of purchase.

7.8.1.8 Training Course

The proposed Training Course Curriculum (including topics and dates of discussion) indicating that all of the items contained in the operating and maintenance instructions, as well as demonstrations of safety and routine maintenance operations, including testing procedures included in the maintenance instructions, are to be covered. The proposed Training Course must be video-recorded and provided with any PowerPoint slides as part of the final documentation for those that cannot attend. Safety training must be extended to fire department representatives.

7.8.1.9 Bill of Materials

Submit a Bill of Materials listing each product being incorporated into the system. Bill of Materials includes a general description of the product, quantity, and exact manufacturer's model number. Where the manufacturer's model number does not fully identify the product, list options, accessories, or custom features by additional descriptions.

7.8.1.10 Qualified Testing Organization

Engage the services of a qualified testing organization, or licensed electrician to provide inspection, testing, calibration, and adjustment of the solar photovoltaic electrical distribution system and equipment listed herein. Organization must be independent of the supplier, and manufacturer of the equipment.

Organization calibration program requirements:

- a) Provide a calibration program which assures that all applicable test instruments are maintained within rated accuracy.
- b) Accuracy: Traceable to the National Institute of Standards and Technology.
- c) Instrument calibration frequency schedule: Less than or equal to 12 months for both test floor instruments and leased specialty equipment.
- d) Dated calibration tables: Visible on all test equipment.
- e) Calibrating standard: Higher accuracy than that of the instrument tested.
- f) Keep up-to-date records that indicate dates and test results of instruments calibrated or tested. For instruments calibrated by the manufacturer on a routine basis, in lieu of third party calibration, include the following:
 - 1) Maintain up-to-date instrument calibration instructions and procedures for each test instrument.
 - 2) Identify the third party laboratory calibrated instrument to verify that calibrating standard is met.

7.8.1.11 System Performance Calculations

Submit system performance calculations to show that the components provided will produce the minimum required production of power in accordance with PERFORMANCE REQUIREMENTS paragraph.

7.8.2 DELIVERY, STORAGE, AND HANDLING

- a) Store solar PV modules in their original packaging according to the manufacturer's guidance, and do not remove from packaging until day of installation.
- b) If a solar PV module is removed from its packaging, store it according to the manufacturer's guidance.
- c) Do not store solar PV modules on-site for more than 12 months.

7.8.3 WARRANTY

The equipment items must be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

7.8.3.1 Solar Photovoltaic Modules

Furnish the solar photovoltaic module manufacturer's warranty. The warranty must be a 25-year linear 80 percent (minimum) power warranty (at the end of the 25th year after purchase an actual minimum power output of 80 percent based on the nameplate rating must be achieved) and not less than 10-years for workmanship material and manufacturing defects from the date of manufacture.

The warranty must state that the malfunctioning solar photovoltaic module must be exchanged by the manufacturer and promptly shipped to the Owner facility. The replacement solar module must be identical to, or an improvement upon, the original design of the malfunctioning solar module. Provide an extra spare modules in the event of necessary replacement of malfunctioning installed module.

7.8.3.2 Inverters

Furnish the inverter manufacturer's warranty. The warranty period must be 15 years (minimum) from the date of manufacture. Inverter device installation, transportation, and on-site storage must not exceed 12 months, thereby permitting 14 years of the 15 year warranty to be in service and energized.

The warranty must state that the malfunctioning inverter must be exchanged by the manufacturer and promptly shipped to the Owner facility, and arrive in no more than ten days. The replacement inverter must be identical to, or an improvement upon, the original design of the malfunctioning inverter. Provide an extra spare inverters in the event of necessary replacement of malfunctioning installed inverter.

7.8.4 CALCULATIONS

If construction deviates from design, provide relevant calculations to demonstrate that new design is satisfactory and approved by a licensed professional engineer.

7.8.5 PRODUCTS

7.8.5.1 System Description

- a) The PV system described in this document is of the grid-connected type and does not include battery/backup storage or secondary electrical generation devices. PV system feeds AC power into the local services when solar energy is available and immediately disconnects from the grid upon loss of grid power to the service in accordance with IEEE 1547 and local utility regulations.
- b) PV system must comply with these specifications, all applicable construction document drawings, all applicable codes, and all local authorities having jurisdiction. System must comply with all policies and standards required by the electrical utility having jurisdiction and all applicable incentive program guidelines. PV system equipment includes, but is not limited to, PV modules and electrical insulating components such as encapsulants and backsheets, raceways, inverters, combiner boxes, disconnect switches, wire, conduit, junction boxes, mounting hardware, monitoring and communication equipment.
- c) Provide lightning arrestor listed to UL 1449.

7.8.5.2 System Requirements

Conform electrical installations to IEEE C2, NFPA 70, PEC and requirements specified in the design drawing.

- a) All equipment must be listed and labeled in accordance with nationally recognized testing laboratories (NRTL) and installed in accordance with the listing requirements and the manufacturer's instructions.
- b) Provide all accessories needed for a complete, secure, operational grid-tied PV system.
- c) Wiring and connections of inverters, PV source circuits, AC branch circuits, and all interconnections must be rated at a minimum for IP65 in accordance with NEMA IEC 60529.

7.8.5.3 Photovoltaic Modules

- a) PV modules must be IEC 61215 compliant and listed to UL 1703, and manufactured in an ISO 9001 certified facility.
- b) PV modules must be of polycrystalline technology and for rack-mounting.
- c) PV module efficiency must be greater than 15 percent for crystalline technology.
- d) PV modules must be of the same manufacturer and model number and consistent sub-components.

- e) Submit on cutsheets PV module performance data from the manufacturer that must include a flash test data in accordance with IEC 61853-1, and temperature coefficients at: STC, nominal operating cell temperature (NOCT), low irradiance conditions (LIC), high temperature conditions (HTC), and low temperature conditions (LTC).
- f) Photovoltaic wire, wiring methods, and utilization of locking-type connectors must comply with the requirements of NFPA 70 and PEC. Provide USE-2 or RHH or RHW-2 wire, and sunlight-resistant wire when exposed to sunlight.

7.8.5.4 Crystalline Photovoltaic Module Backsheet

- a) Backsheet component must consist of a tri-layer construction (minimum thickness of 250 microns 9.8 mils) with outer layers of polyvinyl fluoride (PVF) and an inner layer of polyester for crystalline-silicon modules with a maximum system voltage of 1000 VDC.
- b) Alternate polymeric backsheets consisting of different chemical composition, thickness, or construction must fulfill the safety and performance specifications and acceptance criteria in Table 7.1. The required component properties in Table 7.2 must be verified by a test report provided by a nationally recognized testing laboratory (NRTL) and a cutsheet submitted.

TABLE 7.1 - PV MODULE BACKSHEET COMPONENT SAFETY AND PERFORMANCE		
Items	Test Methods	Specification
Tensile Strength (MPa)	ASTM D882	≥ 100 (TD) ≥ 100 (MD)
Elongation at Break (percent)	ASTM D882	≥ 80 (TD) ≥ 100 (MD)
Dimensional Stability (percent, 150 degrees C, 0.5 h)	ASTM D882	≤ 1.0 (TD) ≤ 1.0 (MD)
Breakdown Voltage (kV)	ASTM D149	≥ 18
WVTR (g/m ² day, 37.8 degrees C, 100 percent RH)	ASTM F1249	≤ 2.5
Interlayer Peeling Strength (N/cm)	ASTM D1876	≥ 4
Peeling Strength with EVA (N/cm)	ASTM D903	≥ 40
Damp Heat (85 degrees C, 85 percent RH, 1000 hrs) -Color Change delta b - Elongation Retention (percent) -Appearance	ASTM E1171 ASTM E308/ ASTM D2244 ASTM D882/ASTM D5870	≤ 2.5 ≥ 70 No cracking or delamination.

TABLE 7.2 - PV MODULE BACKSHEET COMPONENT SAFETY AND PERFORMANCE

UV Exposure Irradiance of 0.55 W/m ² at 340 nm (61 W/m ²) using a xenon lamp with a daylight filter (outer layer). Exposure is 4200 hours (260 kWh/m ² total UV (300-400 nm)) -Color Change delta b -Elongation Retention (percent) -Tensile Retention (percent) -Appearance	ASTM G155 ASTM E308/ASTM D2244 ASTM D882/ASTM D5870	≤2.0 ≥70 ≥70 No cracking or delamination.
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7.8.5.5 Crystalline Photovoltaic Module Encapsulant

- a) Encapsulant component must consist of ethyl vinyl acetate (EVA) with a total nominal (prelamination) thickness of 900 microns 35 mils or greater in the completed module. The EVA must have a minimum of 28 percent VA content. Through statistical process control, the module manufacturer must ensure that the cured EVA has a minimum of 70 percent gel content per ASTM D7567 or ASTM D2765. The EVA must have a UV cutoff wavelength of 360 nm as measured according to ASTM E424. The EVA must have a minimum volume resistivity of 1X10¹⁵ ohm-cm per ASTM D257.
- b) Thermoplastic encapsulants consisting of different chemical composition, thickness, or construction must fulfill the safety and performance specifications and acceptance criteria described in Table 7.3. The required component properties described in Table 2 must be verified by a test report provided by a nationally recognized testing laboratory (NRTL) and a cutsheet submitted.

TABLE 7.3 - PV MODULE ENCAPSULANT COMPONENT PROPERTIES

Items	Test Methods	Specification
Appearance	Visual Examination	No bubble, crack, or delamination.
Gel Content (percent)	ASTM D7567/ASTM D2765	≥70
UV Cutoff Wavelength (nm)	ASTM E424	≥360
Volume Resistivity (ohm-cm)	ASTM D257	≥1X10 ¹⁵

7.8.5.6 Inverters

- a) Array-to-inverter kW ratio must not exceed manufacturer recommendations. Inverter must be IEEE 1547 compliant, listed to UL 1741, comply with the latest applicable ANSI standards and addenda, and inspected before commissioning,

- testing, and operation of the system. Submit documentation validating system performance requirements.
- b) All same-sized inverters supplied must be of the same manufacturer and model number.
 - c) Provide inverter utilizing a support structure mount system.
 - d) Provide inverter utilizing a NEMA 3R outdoor enclosure in accordance with NEMA 250.
 - e) Provide inverter with anti-islanding protection to prevent back-feeding inverter generated power to the grid in the event of a utility outage. Anti-islanding protection must be listed to UL 1741 and IEEE 1547.
 - f) Overcurrent protection, ground fault protection, arc fault circuit interrupter (AFCI), and rapid shutdown must comply with the requirements of NFPA 70 and PEC.
 - g) Provide inverter with self-diagnostics routines, and remote and local display of operating status and remote monitoring capabilities. Provide inverter compatible with monitoring system and metering system. If capability for remote monitoring and control does not exist, then it must be added.
 - h) Provide inverter with integrated monitoring system.
 - i) Rate inverter output as 30 AC kW at unity (1), 3 phase, 400 volts, 480 to 800 MPPT voltage range.
 - j) Match inverter DC input to the design of the PV module array outputs and account for the following:
 - 1) The inverter low voltage is 50 percent of the maximum system voltage, to account for 25 year degradation.
 - 2) Voltage decrease due to high temperatures at project site.
 - 3) Provide isolation transformer via system central transformer for multiple inverters to provide safe galvanic separation between the AC side of the inverter and the grid.
 - 4) Inverter must include AC and DC disconnecting means. DC and AC disconnecting means must be listed with ratings suitable for the intended use and purpose. System disconnecting means must meet the requirements of NFPA 70 and PEC.

7.8.5.7 String Inverters

- a) Submit String Inverter having a weighted average inverter power conversion efficiency of 96 percent or greater.
- b) Inverter must feature maximum power point tracking (MPPT).

7.8.5.8 Combiner Boxes

- a) All combiner boxes must be listed to UL 1741, and inspected before commissioning, testing, and operation of the system.
- b) Provide combiner boxes support structure mount, NEMA 3R outdoor enclosures in accordance with NEMA 250.
- c) Supply combiner boxes designed for use with the inverter provided, and coordinated to the specific PV source circuit design.
- d) Provide combiner boxes of compact design with simplified input and output wiring.
- e) Provide overcurrent protection and output disconnecting means that comply with the requirements of NFPA 70 and PEC.

7.8.5.9 Roof Mounting Structure for Modules (Racking)

- a) Provide racking for array as indicated on the drawings, including the module azimuth and tilt for each inverter's separate array. Provide racking compliant with UL 2703.
- b) Racking and PV array, including modules, hardware, and attachments, must withstand wind loads as required by ASCE 7 and ICC IBC.
- c) Racking must be suitable for Seismic Design Category 1 as defined by ASCE 7 and ICC IBC.
- d) Submit seismic and wind load design calculations for the array mounting system and its attachment to the structure showing compliance with seismic and wind requirements while supporting the PV modules.
- e) Provide the mechanical hardware for mounting the PV arrays and all other hardware required for assembling the PV modules, and the attachments to the building structure.
- f) Use array mounting hardware compatible with the site considerations and environment. Select mechanical hardware for corrosion resistance and durability. Use a stainless steel, galvanized steel, or aluminum support structure. Do not use wood or plastic components for support.
- g) Use cathodic protection compatible with the site considerations and environment. Utilize galvanized anchor driven into ground.

7.8.5.10 Mounting System Base Supports

Fabricate with fastening points integral to the mounting structure. Mounting system supports must be permanently affixed stanchions that are anchored to the building structure. Coordinate height with thickness of roof insulation.

7.8.5.11 Flashing Boot

Fabricate for precision fit over base support. Coordinate height with base supports.

7.8.5.12 Base Cap

Fabricate to overlap base support and flashing boot a minimum of 51 mm ².

7.8.5.13 Base Cap Gasket

EPDM with self-adhesive closed cell foam or other gasketing material compatible with the roofing material.

7.8.5.14 Framing

Provide with wall thickness as determined by structural calculations.

7.8.5.15 Hardware

Bolts, nuts, washers, and screws must be 18-8 stainless steel.

7.8.5.16 PV SYSTEM MONITORING

- a) Provide a PV system monitoring panel mounted as indicated.
- b) The following quantities must be viewable from a remote screen display mounted at location as indicated:
 - 1) DC Input Voltage from PV array
 - 2) DC Input Power from PV system
 - 3) DC Input Current from PV system
 - 4) AC Phase Current from inverter (average)
 - 5) AC Voltage from inverter (average)
 - 6) AC Real Power from inverter
 - 7) Daily, Weekly, Monthly, Yearly, and Cumulative Energy Production
 - 8) Fault Status Report
 - 9) DC Ground Current Report
 - 10) AC Neutral Current from inverter
 - 11) AC Reactive Power from inverter
 - 12) AC Apparent Power from inverter
 - 13) AC Power Factor
 - 14) AC Phase Current from inverter (A, B, C)
 - 15) AC Voltage from inverter (A, B, C)
 - 16) AC Voltage and Current Balance.
- c) Provide additional data acquisition sensors to measure irradiance, wind speed, ambient temperature and PV module temperature. Any additional data acquisition sensors require a conduit separate from the current conductor conduit.

7.8.5.17 PV System Metering

- a) Provide a non-revenue-grade Interval Data Recording (IDR) meter complete with industry standard telemetry for communications with Ethernet, cellular, or other common output capabilities.

- b) Connect to a monitoring/data collection recording solar production through time increments applicable to installation and utility standards, with a minimum of 15-minute intervals and 30-day memory.
- c) UL listed and conform to ANSI C12.1.
- d) Measure kWh, demand, instantaneous power, volts, amps, and watts.
- e) Provide UL listed communication and annunciator panel.

7.8.5.18 Posted Operating Instructions

Provide for each system and principal item of equipment as specified in the technical sections for use by the operation and maintenance personnel. The operating instructions include the following:

- a) Wiring diagrams, schematic diagrams, interconnection diagrams, control diagrams, and control sequence for each principal system and item of equipment.
- b) Array layout showing the locations of all DC and AC disconnects.
- c) Start up, proper adjustment, operating, and shutdown procedures.
- d) Safety precautions.
- e) The procedure in the event of equipment failure.
- f) Other items of instruction as recommended by the manufacturer of each system or item of equipment.

Print operating instructions and frame under glass or in approved laminated plastic. Post instructions where directed. For operating instructions exposed to the weather, provide weather-resistant materials or weatherproof enclosures. Operating instructions do not fade when exposed to sunlight and secure to prevent easy removal or peeling.

7.8.5.19 Manufacturer's Nameplate

Each item of equipment must have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. For PV modules, a label on the back of the module is acceptable.

7.8.5.20 Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified. Each nameplate inscription identifies the function and, when applicable, the position. Nameplates are of melamine plastic, 3.0 mm thick, white with black center core. Surface is of matte finish. Square corners. Accurately align lettering and engrave into the core. Minimum size of nameplates is 25.0 mm by 65.0 mm. Lettering is a minimum of 6.0 mm high normal block style.

7.8.5.21 PV Equipment Marking and Warning Labels

Provide warning signs for the enclosures of electrical equipment having a nominal rating exceeding 600 volts.

- a) Provide PV equipment with UL 969 weather-resistant marking and warning labels in compliance with NFPA 1, NFPA 70 and PEC.

7.8.5.22 Grounding and Bonding

- a) Provide properly sized equipment grounding conductors.
- b) Provide bonding fittings on concentric/eccentric knockouts with metal conduits for circuits over 250 volts in accordance with NFPA 70 and PEC.
- c) Provide bonding fittings for ferrous metal conduits enclosing grounding electrode conductors in accordance with NFPA 70 and PEC.
- d) Provide grounding lugs for aluminum PV solar module frames of either stainless steel or tin-coated copper.

7.8.5.23 Execution

- a) Installation Instructions and Installation Drawings
 - 1) Complete all electrical work in accordance with NFPA 70 and PEC.
 - 2) Provide all permanent and temporary shoring, anchoring, and bracing required by the nature of this work in order to make all parts absolutely stable and rigid, even when such shoring, anchoring, and bracing are not explicitly called for.
 - 3) Install the solar PV system in accordance with this section, installation drawings, and the printed installation instructions of the manufacturer.
 - 4) Follow the manufacturer's installation recommendations to ensure no electricity is being fed to the grid and that all available disconnects are in the open position and fuses are not installed during wiring operations. Utilize on-site measurements in conjunction with engineering designs to accurately cut wires and layout before making permanent connections. Locate wires out of the way of windows, doors, openings, and other hazards. Ensure wires are free of snags and sharp edges that have the potential to compromise the wire insulation. If the system is roof-mounted, it must have direct current ground fault protection in accordance with NFPA 70 and PEC. Ensure breakers in combiner box are in the off position (or fuses removed) during combiner box wiring.
 - 5) Attach solar PV modules to the mounting structure according to the manufacturer's instructions and approved plans.
 - 6) Install instrumentation according to the manufacturer's instructions, with control panels located as indicated.

b) Wiring Methods

Install wiring in accordance with NFPA 70, PEC, Section 7.4 - Interior Wiring System and Section 7.3 - Underground Electrical Works.

c) Electrical Connections

- 1) Use twist on wire connectors listed for the environment (i.e. wet, damp, direct burial) and installed per manufacturer's instructions.
- 2) Use listed power distribution blocks.
- 3) Use terminals containing more than one conductor listed for multiple conductors.
- 4) Use connectors and terminals used for fine strand conductors that are listed for use with such conductors.
- 5) Utilize appropriate tools for connector type as recommended by the manufacturer.
- 6) Tighten and secure module connectors.
- 7) Provide corrosion protection in accordance with Section 7.4 - Interior Wiring System, and by adding a stainless steel isolating washer between components of incompatible metals on the racking structure.

d) Disconnects

- 1) Install disconnects for all current carrying conductors of the PV source.
- 2) Install disconnects for the PV equipment. For inverters and other equipment that are energized from more than one source, group and identify the disconnecting means.
- 3) Install disconnects and overcurrent protection for all ungrounded conductors in ungrounded (transformerless) PV power systems.

e) Overcurrent Protection

- 1) Install the PV interconnect overcurrent protective device as indicated in accordance with NFPA 70 and PEC.
- 2) Install lightning arrestor as indicated and in accordance with NFPA 780.

f) Fire Safety

Firestop conduit that penetrates fire-rated walls, fire-rated partitions, or fire-rated floors.

g) Grounding

1) PV System Grounding

NFPA 70, PEC and IEEE C2, except provide grounding systems with a resistance to solid earth ground not exceeding 25 ohms. Ground according to racking manufacturer's recommendations.

Install grounding lugs in locations on the solar PV module as designated by the module manufacturer, using stainless steel machine screws of the thread size provided in the pre-tapped holes, along with a stainless steel star washer placed between the grounding lug and the solar module frame.

2) Grounding Electrodes

Provide driven ground rods as specified in Section 7.3 - Underground Electrical Works. Connect ground conductors to the upper end of ground rods by exothermic weld or compression connector. Provide compression connectors at equipment end of ground conductors.

3) Installation of Equipment and Assemblies

(a) Ground Mounted Structures

(1) For driven pile, install in accordance with approved drawing.

(2) For helical pile, install in accordance with ICC IBC.

h) Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

i) Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

j) Warning Sign Mounting

1) Display calculated maximum and minimum voltages and their respective amperages on engraved warning labels.

2) Provide the number of signs required to be readable from each accessible side. Space the signs in accordance with NFPA 70E.

k) Foundation for Equipment and Assemblies

Provide cast-in-place concrete work in accordance with the requirements.

l) Field Quality Control

Perform in accordance with Section 4 - Interior Wiring System.

m) Performance of Acceptance Checks and Tests

Perform all inspections in accordance with inspection procedures, and in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests.

n) PV Modules

1) Visual and Mechanical Inspection

(a) Solar PV module manufacturer, model, and number of modules must match the approved plans.

(b) Solar PV modules must be in good conditions (including but not limited to no broken glass or cells, no discoloration, frames not damaged).

2) Electrical Tests

(a) Verify output of PV modules according to manufacturer's recommendations.

o) Inverters

1) Visual and Mechanical Inspection

(a) Inverter manufacturer, model, and number of inverters must match the approved plans.

(b) Inverters must be in good condition.

2) Electrical Tests

(a) Verify output of inverters according to manufacturer's recommendations.

(b) Performance of NETA Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations, and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

p) Grounding System

1) Visual and Mechanical Inspection

(a) Inspect ground system for compliance with contract plans and specifications.

2) Electrical Tests

- (a) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod, perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground resistance tester in accordance with manufacturer's instructions to test each ground or group of grounds. Use an instrument equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.
- (1) Submit the measured ground resistance of each ground rod and grounding system, indicating the location of the rod and grounding system. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

3) Functional Acceptance Tests

- (a) Provide final and complete commissioning of the solar PV system in accordance with IEEE 1547.
- (b) Verify that all electrical components are installed and connected according to the requirements of the PV electrical drawings, specifications, and manufacturer's written instructions.
- (c) Before starting or operating the system, check continuity of all conductors and grounding conductors to verify that there are no faults and that all equipment has been properly installed according to the manufacturer's recommendations. Check factory instructions to see that installations have been made accordingly. Check equipment for any damage that may have occurred during shipment, after delivery, or during installation. Replace damaged equipment.
- (d) Before starting or operating the system, obtain a final inspection approval and final inspection from the Engineer. Be present on site for both of these inspections.
- (e) Make final adjustments to all inverters and monitoring equipment so that they will be placed in an acceptable operating condition. Adjustable parameters must be set so that the PV system will produce the maximum possible amount of energy on an annual basis.

q) Closeout Activities

1) Demonstration

Upon completion of the work and at a time approved by the Engineer, provide instructions by a qualified instructor to the Owner personnel in the proper adjustment, system operation, and maintenance of the specified systems and equipment, including pertinent safety

requirements as required. Owner personnel must receive training comparable to the equipment manufacturer's factory training. Instructor must provide a separate training course for the monitoring system.

2) Instructor's Qualification Resume

Instructors must be thoroughly familiar with all parts of the installation and trained in operating theory as well as practical operation and maintenance work. Submit the name(s) and qualification resume(s) of instructor(s) to the engineer for approval.

3) Training Plan

The training period must consist of a total of 2 hours of normal working time and begin after the system is functionally completed but prior to final acceptance tests. Submit the training course curriculum for approval, along with the proposed training date, at least 14 days prior to the date of proposed conduction of the training course. Instruction must be given during the first regular work week after the equipment or system has been accepted and turned over to the Owner for regular operation. Provide any PowerPoint slides as part of the final documentation for those that cannot attend. Extend safety training to fire department representatives. Coordinate with Engineer for Fire Department first responder training.

7.9 OVERHEAD DISTRIBUTION SYSTEM

7.9.1 GENERAL

7.9.1.1 References

a) ASME International (ASME)

ASME B16.11 (2011) Forged Fittings, Socket-Welding and Threaded

b) ASTM International (ASTM)

ASTM A123/A123M (2013) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M (2009) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A36/A36M (2014) Carbon Structural Steel

ASTM A475 (2014) Zinc-Coated Steel Wire Strand

ASTM A53/A53M (2012) Pipe, Steel, Black and Hot-Dip, Zinc-Coated, Welded and Seamless

- | | |
|-----------------|---|
| ASTM B232/B232M | (2011) Concentric-Lay-Stranded Aluminum
Conductors, Coated-Steel Reinforced (ACSR) |
| ASTM B3 | (2013) Soft or Annealed Copper Wire |
| ASTM D1654 | (2008) Evaluation of Painted or Coated Specimens
Subjected to Corrosive Environments |
| ASTM D709 | (2013) Laminated Thermosetting Materials |
- c) Institute of Electrical and Electronics Engineers (IEEE)
- | | |
|--------------|--|
| IEEE 100 | (2000) The Authoritative Dictionary of IEEE Standards
Terms |
| IEEE C135.22 | (1988) Zinc-Coated Ferrous Pole-Top Insulator Pins
with Lead Threads for Overhead Line Construction |
| IEEE C2 | (2014) National Electrical Safety Code |
- d) International Electrical Testing Association (NETA)
- | | |
|----------|--|
| NETA ATS | (2013) Acceptance Testing Specifications for Electrical
Power Equipment and Systems |
|----------|--|
- e) National Electrical Manufacturers Association (NEMA)
- | | |
|--------------------------|--|
| ANSI C29.2 | (2012) Insulators - Wet-Process Porcelain and
Toughened Glass - Suspension Type |
| ANSI C29.5 | (2002) Wet-Process Porcelain Insulators (Low and
Medium Voltage Pin Type) |
| NEMA WC 74/ICEA S-93-639 | (2012) 5-46 kV Shielded Power Cable for Use in
the Transmission and Distribution of Electric Energy |
| NEMA/ANSI C29.7 | (2002) Wet Process Porcelain Insulators - High-Voltage
Line Post Type |
- f) National Fire Protection Association (NFPA)
- | | |
|---------|---------------------------------|
| NFPA 70 | (2014) National Electrical Code |
|---------|---------------------------------|
- g) Institute of Integrated Electrical Engineers of the Philippines (IIEE)
- | | |
|-----|-----------------------------------|
| PEC | (2009) Philippine Electrical Code |
|-----|-----------------------------------|
- h) Bureau of Product Standards (BS)
- | | |
|-----|-------------------------------------|
| PNS | (2002) Philippine National Standard |
|-----|-------------------------------------|

- i) U.S. Department Of Agriculture (USDA)
 - RUS 202-1 (2004) List of Materials Acceptable for Use on Systems of RUS Electrification Borrowers
- j) Underwriters Laboratories (UL)
 - UL 467 (2007) Grounding and Bonding Equipment
 - UL 486A-486B (2014) Wire Connectors
 - UL 510 (2013) Polyvinyl Chloride, Polyethylene and Rubber Insulating Tape
 - UL 6 (2014) Electrical Rigid Metal Conduit-Steel

7.9.1.2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100.

7.9.1.3 SUBMITTALS

- a) Product Data
 - Conductors
 - Insulators
 - Concrete poles
 - Steel poles
 - Surge arresters
 - Guy strand
 - Anchors
- b) Design Data
 - Concrete poles
 - Steel poles
 - Power-Installed Screw Foundations
- c) Test Reports
 - Field Test Plan
 - Field Quality Control

Ground resistance test reports

Submit report of the acceptance test results as specified by paragraph entitled "Field Quality Control"

d) Certificates

Concrete poles

Steel poles

e) Operation and Maintenance Data

Operation and Maintenance Manuals, Data Package 5

Submit operation and maintenance data as specified herein.

7.9.1.4 Quality Assurance

a) Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Engineer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70, PEC and IEEE C2 unless more stringent requirements are specified or indicated.

b) Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

c) Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

d) Material and Equipment Manufacturing Date

Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

e) Ground Resistance Test Reports

Submit the measured ground resistance of grounding system. When testing grounding electrodes and grounding systems, identify each grounding electrode and each grounding system for testing. Include the test method and test setup (i.e. pin location) used to determine ground resistance and soil conditions at the time the measurements were made.

1) Field Test Plan

Provide a proposed field test plan 15 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits.

7.9.1.5 Maintenance

a) Additions to Operations and Maintenance Data

In addition to requirements of Data Package 5, include the following in the operation and maintenance manuals provided:

- 1) Assembly and installation drawings
- 2) Prices for spare parts and supply list
- 3) Date of purchase

7.9.1.6 Delivery, Storage, And Handling

Devices and equipment shall be visually inspected by the Contractor when received and prior to acceptance from conveyance. Stored items shall be protected from the environment in accordance with the manufacturer's published instructions. Damaged items shall be replaced. Metal poles shall be handled and stored in accordance with the manufacturer's instructions.

7.9.1.7 Warranty

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

7.9.2 PRODUCTS

7.9.2.1 Materials And Equipment

Consider materials specified herein or shown on contract drawings which are identical to materials listed in RUS 202-1 as conforming to requirements. Equipment and component items, not hot-dip galvanized or porcelain enamel finished, shall be provided with corrosion-resistant finishes which shall withstand 120 hours of exposure to the salt spray test specified in ASTM B117 without loss of paint or release of adhesion of the paint primer coat to the metal surface in excess of 1.6 mm (1/16 inch) from the test mark. The described test mark and test evaluation shall be in accordance with ASTM D1654 with a rating of not less than 7 in accordance with

TABLE 1, (procedure A). Cut edges or otherwise damaged surfaces of hot-dip galvanized sheet steel or mill galvanized sheet steel shall be coated with a zinc rich paint conforming to the manufacturer's standard.

7.9.2.2 POLES

Poles shall be of lengths and strengths indicated.

a) Steel Poles

Steel poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors, shall be hot-dip galvanized in accordance with ASTM A123/A123M and shall not be painted. Poles shall have tapered tubular members, either round in cross-section or polygonal, and comply with strength calculations performed by a registered professional engineer. Calculations shall be submitted in accordance with the design data portion of paragraph entitled "SUBMITTALS." Provide certification, from the manufacturer, that the technical requirements of this specification shall be met. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1200 mm above grade and shall include manufacturer, year of manufacture, top and bottom diameters, length, and a loading tree. Attachment requirements shall be provided as indicated, including grounding provisions. Climbing facilities are not required. Bases shall be of the anchor-bolt-mounted type.

b) Concrete Poles

Concrete poles shall be designed to withstand the loads specified in IEEE C2 multiplied by the appropriate overload capacity factors. Poles shall be reinforced or prestressed, either cast or spun. Spun poles shall be manufactured by a centrifugal spinning process with concrete pumped into a polished round tapered metal mold. Concrete for spun poles shall have a compressive strength of at least 34.5 MPa at 28 days; steel wire shall have an ultimate tensile strength of at least 827 MPa; and reinforcing bars shall have an ultimate tensile strength of at least 276 MPa. After the high speed spinning action is completed, a spun pole shall be cured by a suitable wet steam process. Spun poles shall have a water absorption of not greater than three percent to eliminate cracking and to prevent erosion. Concrete poles shall have hollow shafts. Poles shall have a hard, smooth, nonporous surface that is resistant to soil acids, road salts, and attacks of water. Poles shall not be installed for at least 15 days after manufacture. Fittings and brackets that conform to the concrete pole design shall be provided. Poles shall conform to strength calculations performed by a registered professional engineer and submitted in accordance with design data portion of paragraph entitled "SUBMITTALS." Provide certification, from the manufacturer, that the technical requirements of this specification shall be met.

7.9.2.3 Brackets

a) Armless Construction

Pole mounting brackets for line-post or pin insulators and eye bolts for suspension insulators shall be as shown. Brackets shall be attached to poles

with a minimum of two bolts. Brackets may be either provided integrally as part of an insulator or attached to an insulator with a suitable stud. Bracket mounting surface shall be suitable for the shape of the pole. Horizontal offset brackets shall have a 5-degree uplift angle. Pole top brackets shall conform to IEEE C135.22, except for modifications necessary to provide support for a line-post insulator. Brackets shall provide a strength exceeding that of the required insulator strength, but in no case less than a 12.5 kN cantilever strength.

7.9.2.4 Hardware

Hardware shall be hot-dip galvanized in accordance with ASTM A153/A153M and ASTM A123/A123M.

7.9.2.5 Insulators

Provide wet-process porcelain insulators which are radio interference free.

- a) Line post type insulators: NEMA/ANSI C29.7,
13.2 kV - Class 57-1
- b) Suspension insulators: ANSI C29.2
13.2kV-Class 52-1; Quantity per phase, 2
Pin insulators: ANSI C29.5, 13.2kV-Class 55-3.

7.9.2.6 Overhead Conductors, Connectors and Splices

Conductors of bare aluminum conductor steel reinforced (ACSR) of sizes and types indicated. Where aluminum conductors are connected to dissimilar metal, fittings conforming to UL 486A-486B shall be used.

- a) Aluminum Conductor Steel Reinforced (ACSR) ASTM B232/B232M, aluminum
- b) Connectors and Splices

Connectors and splices shall be of aluminum alloys for aluminum-composition conductors, and a type designed to minimize galvanic corrosion for copper to aluminum-composition conductors. Aluminum-composition, and aluminum-composition to copper shall comply with UL 486A-486B.

7.9.2.7 Guy Strand

ASTM A475, extra high-strength, Class A or B, galvanized strand steel cable. Guy strand shall be 9.5 mm in diameter with a minimum breaking strength of 68,500 Newton. Provide guy terminations designed for use with the particular strand and developing at least the ultimate breaking strength of the strand.

7.9.2.8 Round Guy Markers

Vinyl or PVC material, yellow colored, 2400 mm long and shatter resistant at sub-zero temperatures.

- a) Guy Attachment
Thimble eye guy attachment.

7.9.2.9 Anchors And Anchor Rods

Anchors shall present holding area indicated on drawings as a minimum. Anchor rods shall be triple thimble-eye, 20 mm diameter by 2400 mm long. Anchors and anchor rods shall be hot dip galvanized.

a) Screw Anchors

Screw type anchors having a manufacturer's rating of not less than 100,000 Newton in loose to medium sand/clay soil, Class 6 and extra heavy pipe rods conforming to ASTM A53/A53M, Schedule 80, and couplings conforming to ASME B16.11.

b) Plate Anchors

Minimum area of 90,000 square mm and rated by manufacturer for 100,000 Newton or more in soils classified as medium dense coarse sand and sandy gravels; firm to stiff clays and silts.

c) Rock Anchors

Rock anchors having a manufacturer's rating of 100,000 Newton.

7.9.2.10 Grounding and Bonding

a) Driven Ground Rods

Provide copper-clad steel ground rods conforming to UL 467 not less than 20 mm in diameter by 3 m in length.

b) Grounding Conductors

ASTM B3. Provide soft drawn copper wire ground conductors a minimum 22 mm². Ground wire protectors shall be PVC.

c) Grounding Connections

UL 467. Exothermic weld or compression connector.

7.9.2.11 Surge Arresters

IEEE C62.11, metal oxide, surge arresters arranged for indicated mounting. Arresters shall be Distribution class.

7.9.2.12 Conduit Risers And Conductors

The riser shield shall be PVC containing a PVC back plate and PVC extension shield or a rigid galvanized steel conduit, as indicated, and conforming to UL 6. Provide conductors and terminations as specified in Section - 7.3 Underground Electrical Works.

7.9.2.13 Electrical Tapes

Tapes shall be UL listed for electrical insulation and other purposes in wire and cable splices. Terminations, repairs and miscellaneous purposes, electrical tapes shall comply with UL 510.

7.9.2.14 Caulking Compound

Compound for sealing of conduit risers shall be of a puttylike consistency workable with hands at temperatures as low as 2 degrees C, shall not slump at a temperature of 150 degrees C, and shall not harden materially when exposed to air. Compound shall readily caulking or adhere to clean surfaces of the materials with which it is designed to be used. Compound shall have no injurious effects upon the workmen or upon the materials.

7.9.2.15 Nameplates

a) Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable. Equipment containing liquid-dielectrics shall have the type of dielectric on the nameplate.

b) Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be a minimum of 6 mm high normal block style.

7.9.3 INSTALLATION

Provide overhead pole line installation conforming to requirements of IEEE C2 for Grade B construction of overhead lines in light loading districts, NFPA 70 and PEC for overhead services. Provide material required to make connections into existing system and perform excavating, backfilling, and other incidental labor. Consider street, alleys, roads and drives "public." Pole configuration shall be as indicated.

7.9.3.1 Tree Trimming

Where lines pass through trees, trees shall be trimmed at least 4.5 meters clear on both sides horizontally and below for medium-voltage lines. No branch shall overhang horizontal clearances. Where trees are indicated to be removed to provide a clear right-of-way, clearing is specified in Section 5.4 - Clearing and Grubbing.

7.9.3.2 Steel and Concrete Pole Setting

Poles shall be mounted on cast-in-place or power-installed screw foundations. Concrete poles shall be embedded in accordance with the details shown. Conduit elbows shall be provided for cable entrances into pole interiors.

a) Cast-In-Place Foundations

Concrete foundations, sized as indicated, shall have anchor bolts accurately set in foundations using templates supplied by the pole manufacturer. Concrete work and grouting is specified in Section 4.4 – Concrete Works for Building. After the concrete has cured, pole anchor bases shall be set on foundations and leveled by shimming between anchor bases and foundations or by setting anchor bases on leveling nuts and grouting. Poles shall be set plumb. Anchor bolts shall be the manufacturer's standard, and not less than necessary to meet the pole wind loading specified herein and other design requirements.

b) Power-Installed Screw Foundations

Power-installed screw foundations may be used if they have the required strength, mounting-bolt, and top plate dimensions. Screw foundations shall be of at least 6 mm thick structural steel conforming to ASTM A36/A36M and hot-dip galvanized in accordance with ASTM A123/A123M. Conduit slots in screw foundation shafts and top plates shall be marked to indicate orientation. Design calculations indicating adequate strength shall be approved before installation of screw foundation is permitted. Calculations shall be submitted in accordance with the design data portion of paragraph entitled "SUBMITTALS."

7.9.3.3 Anchors and Guys

Place anchors in line with strain. The length of the guy lead (distance from base of pole to the top of the anchor rod) shall be as indicated.

a) Setting Anchors

Set anchors in place with anchor rod aligned with, and pointing directly at, guy attachment on the pole with the anchor rod projecting 150 to 230 mm out of ground to prevent burial of rod eye.

b) Backfilling Near Anchors

Backfill plate, expanding, concrete, or cone type anchors with tightly tamped coarse rock 600 mm immediately above anchor and then with tightly tamped earth filling remainder of hole.

c) Screw Anchors

Install screw anchors by torquing with boring machine.

d) Swamp Anchors

Install swamp anchors by torquing with boring machine or wrenches, adding sections of pipe as required until anchor helix is fully engaged in firm soil.

e) Rock Anchors

Install rock anchors minimum depth 300 mm in solid rock.

f) Guy Installation

Provide guys where indicated, with loads and strengths as indicated, and wherever conductor tensions are not balanced, such as at angles, corners and dead-ends. Where single guy will not provide the required strength, two or more guys shall be provided. Where guys are wrapped around poles, at least two guy hooks shall be provided. Provide pole shims where guy tension exceeds 27,000 Newton. Guy clamps 150 mm in length with three 16 mm (5/8 inch) bolts, or offset-type guy clamps, or approved guy grips shall be provided at each guy terminal. Securely clamp plastic guy marker to the guy or anchor at the bottom and top of marker. Complete anchor and guy installation, dead end to dead end, and tighten guy before wire stringing and sagging is begun on that line section. Provide strain insulators at a point on guy strand 2400 mm minimum from the ground and 1800 mm minimum from the surface of pole.

7.9.3.4 Hardware

Provide hardware with washer against wood and with nuts and lock nuts applied wrench tight. Provide locknuts on threaded hardware connections. Locknuts shall be M-F style and not palnut style.

7.9.3.5 Grounding

Unless otherwise indicated, grounding shall conform to IEEE C2, NFPA 70 and PEC. Pole grounding electrodes shall have a resistance to ground not exceeding 25 ohms. When work in addition to that indicated or specified is directed in order to obtain specified ground resistance, provisions of the contract covering changes shall apply.

a) Grounding Electrode Installation

Grounding electrodes shall be installed as follows:

- 1) Driven rod electrodes - Unless otherwise indicated, ground rods shall be located approximately 900 mm out from base of the pole and shall be driven into the earth until the tops of the rods are approximately 300 mm below finished grade. Multiple rods shall be evenly spaced at least 3 m apart and connected together 600 mm below grade with a minimum 14 mm² bare copper conductor.
- 2) Plate electrodes - Plate electrodes shall be installed in accordance with the manufacturer's instructions and IEEE C2, NFPA 70 and PEC.

b) Grounding Electrode Conductors

On multi-grounded circuits, as defined in IEEE C2, provide a single continuous vertical grounding electrode conductor. Surge arresters, and equipment grounding conductors shall be bonded to this conductor. Grounding electrode conductors on metal poles, a preformed galvanized steel strap, 16 mm wide by

22 gauge minimum by length, secured by a preformed locking method standard with the manufacturer, shall be used to support a grounding electrode conductor installation on the pole and spaced at intervals not exceeding 1.5 m with one band not more than 75 mm from each end of the vertical grounding electrode conductor. Grounding electrode conductors shall be sized as indicated.

c) Grounding Electrode Connections

Make above grade grounding connections on pole lines by exothermic weld or by using a compression connector. Make below grade grounding connections by exothermic weld. Make exothermic welds strictly in accordance with manufacturer's written recommendations. Welds which have puffed up or which show convex surfaces indicating improper cleaning, are not acceptable. No mechanical connectors are required at exothermic weldments. Compression connectors shall be type that uses a hydraulic compression tool to provide correct pressure. Provide tools and dies recommended by compression connector manufacturer. An embossing die code or similar method shall provide visible indication that a connector has been fully compressed on ground wire. Bends greater than 45 degrees in grounding electrode conductor are not permitted.

d) Grounding and Grounded Connections

Where no primary or common neutral exists, surge arresters and frames of equipment operating at over 750 volts shall be bonded together and connected to a dedicated primary grounding electrode.

7.9.3.6 Conductor Installation

a) Line Conductors

Unless otherwise indicated, conductors shall be installed in accordance with manufacturer's approved tables of sags and tensions. Conductors shall be handled with care necessary to prevent nicking, kinking, gouging, abrasions, sharp bends, cuts, flattening, or otherwise deforming or weakening conductor or any damage to insulation or impairing its conductivity. Remove damaged sections of conductor and splice conductor. Conductors shall be paid out with the free end of conductors fixed and cable reels portable, except where terrain or obstructions make this method unfeasible. Bend radius for any insulated conductor shall not be less than the applicable NEMA specification recommendation. Conductors shall not be drawn over rough or rocky ground, nor around sharp bends. When installed by machine power, conductors shall be drawn from a mounted reel through stringing sheaves in straight lines clear of obstructions. Initial sag and tension shall be checked by the Contractor, in accordance with the manufacturer's approved sag and tension charts, within an elapsed time after installation as recommended by the manufacturer.

b) Connectors and Splices

Conductor splices, as installed, shall exceed ultimate rated strength of conductor and shall be of type recommended by conductor manufacturer. No splice shall be permitted within 3000 mm of a support. Connectors and splices shall be mechanically and electrically secure under tension and shall be of the

non-bolted compression type. The tensile strength of any splice shall be not less than the rated breaking strength of the conductor. Splice materials, sleeves, fittings, and connectors shall be noncorrosive and shall not adversely affect conductors. Aluminum-composition conductors shall be wire brushed and an oxide inhibitor applied before making a compression connection. Connectors which are factory-filled with an inhibitor are acceptable. Inhibitors and compression tools shall be of types recommended by the connector manufacturer. Primary line apparatus taps shall be by means of hot line clamps attached to compression type bail clamps (stirrups). Non-insulated connectors shall be smoothly taped to provide a waterproof insulation equivalent to the original insulation, when installed on insulated conductors. On overhead connections of aluminum and copper, the aluminum shall be installed above the copper.

c) Conductor-To-Insulator Attachments

Conductors shall be attached to insulators by means of clamps, shoes or tie wires, in accordance with the type of insulator. For insulators requiring conductor tie-wire attachments, tie-wire sizes shall be as specified in TABLE 7.4.

TABLE 7.4 - TIE-WIRE REQUIREMENTS	
CONDUCTOR	TIE WIRE
AAC, AAAC, or ACSR	AAAC OR AAC (AWG)
Any size	6 or 4

d) Armor Rods

A armor rods shall be provided for AAC, AAAC, and ACSR conductors. Armor rods shall be installed at supports, except armor rods will not be required at primary dead-end assemblies if aluminum or aluminum-lined zinc-coated steel clamps are used. Lengths and methods of fastening armor rods shall be in accordance with the manufacturer's recommendations. For span lengths of less than 60 m, flat aluminum armor rods may be used. Flat armor rods, not less than 762.0 micrometers by 6.4 mm (0.03 by 0.25 inch) shall be used on No. 1 AWG AAC and AAAC and smaller conductors and on No. 5 AWG ACSR and smaller conductors. On larger sizes, flat armor rods shall be not less than 1.3 by 7.6 mm (0.05 by 0.30 inches). For span lengths of 60 m or more, preformed round armor rods shall be used.

7.9.3.7 Ties

Provide ties on pin insulators tight against conductor and insulator and ends turned down flat against conductor so that no wire ends project.

7.9.3.8 New Conductor Installation

String new conductors to "initial" sag table values recommended by the manufacturer for conductor type and size of conductor and ruling span indicated.

7.9.3.9 Fittings

Dead end fittings, clamp or compression type, shall conform to written recommendations of conductor manufacturer and shall develop full ultimate strength of conductor.

7.9.3.10 Aluminum Connections

Make aluminum connections to copper or other material using only splices, connectors, lugs, or fittings designed for that specific purpose. Keep a copy of manufacturer's instructions for applying these fittings at job site for use of the inspector.

7.9.3.11 Risers

Secure PVC riser shields on poles as indicated.

7.9.4 FIELD APPLIED PAINTING

7.9.4.1 Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

7.9.5 FIELD FABRICATED NAMEPLATE MOUNTING

7.9.5.1 Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

7.9.6 FIELD QUALITY CONTROL

7.9.6.1 General

Field testing shall be performed in the presence of the Engineer. The Contractor shall notify the Engineer 5 days prior to conducting tests. The Contractor shall furnish materials, labor, and equipment necessary to conduct field tests. The Contractor shall perform tests and inspections recommended by the manufacturer unless specifically waived by the Engineer. The Contractor shall maintain a written record of tests which includes date, test performed, personnel involved, devices tested, serial number and name of test equipment, and test results. Field reports will be signed and dated by the Contractor.

7.9.6.2 Safety

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

7.9.6.3 Medium-Voltage Preassembled Cable Test

After installation, prior to connection to an existing system, and before the operating test, the medium-voltage preassembled cable system shall be given a high potential test. Direct-current voltage shall be applied on each phase conductor of the system by

connecting conductors at one terminal and connecting grounds or metallic shieldings or sheaths of the cable at the other terminal for each test. Prior to the test, the cables shall be isolated by opening applicable protective devices and disconnecting equipment. The method, voltage, length of time, and other characteristics of the test for initial installation shall be in accordance with NEMA WC 74/ICEA S-93-639 for the particular type of cable installed, and shall not exceed the recommendations of IEEE 404 for cable joints unless the cable and accessory manufacturers indicate higher voltages are acceptable for testing. Should any cable fail due to a weakness of conductor insulation or due to defects or injuries incidental to the installation or because of improper installation of cable, cable joints, terminations, or other connections, the Contractor shall make necessary repairs or replace cables as directed. Repaired or replaced cables shall be retested.

7.9.6.4 Sag and Tension Test

The Engineer shall be given prior notice of the time schedule for stringing conductors or cables serving overhead medium-voltage circuits and reserves the right to witness the procedures used for ascertaining that initial stringing sags and tensions are in compliance with requirements for the applicable loading district and cable weight.

7.9.6.5 Pre-Energization Services

The following services shall be performed on the equipment listed below. These services shall be performed subsequent to testing but prior to the initial energization. The equipment shall be inspected to insure that installation is in compliance with the recommendations of the manufacturer and as shown on the detail drawings. Terminations of conductors at major equipment shall be inspected to ensure the adequacy of connections. Bare and insulated conductors between such terminations shall be inspected to detect possible damage during installation. If factory tests were not performed on completed assemblies, tests shall be performed after the installation of completed assemblies. Components shall be inspected for damage caused during installation or shipment and to ensure that packaging materials have been removed. Components capable of being both manually and electrically operated shall be operated manually prior to the first electrical operation. Components capable of being calibrated, adjusted, and tested shall be calibrated, adjusted, and tested in accordance with the instructions of the equipment manufacturer.

7.9.6.6 Performance of Acceptance Checks and Tests

Perform in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

7.9.6.7 Grounding System

- a) Visual and mechanical inspection Inspect ground system for compliance with contract plans and specifications.
- b) Electrical tests
- c) Perform ground-impedance measurements utilizing the fall-of-potential method. On systems consisting of interconnected ground rods, perform tests after interconnections are complete. On systems consisting of a single ground rod

perform tests before any wire is connected. Take measurements in normally dry weather, not less than 48 hours after rainfall. Use a portable ground testing megger in accordance with manufacturer's instructions to test each ground or group of grounds. The instrument shall be equipped with a meter reading directly in ohms or fractions thereof to indicate the ground value of the ground rod or grounding systems under test.

7.9.6.8 Devices Subject to Manual Operation

Each device subject to manual operation shall be operated at least three times, demonstrating satisfactory operation each time.

7.9.6.9 Follow-Up Verification

Upon completion of acceptance checks and tests, the Contractor shall show by demonstration in service that circuits and devices are in good operating condition and properly performing the intended function. As an exception to requirements stated elsewhere in the contract, the Engineer shall be given 5 working days advance notice of the dates and times of checking and testing.

7.10 AUTOMATIC TRANSFER SWITCH

7.10.1 GENERAL

7.10.1.1 References

- a) International Electrical Testing Association (NETA)
NETA ATS (2013) Acceptance Testing Specifications for Electrical Power Equipment and Systems
- b) National Fire Protection Association (NFPA)
NFPA 70 (2014) National Electrical Code
- c) Underwriters Laboratories (UL)
UL 1008 (2013) Transfer Switch Equipment
UL 508 (2013) Industrial Control Equipment
- d) Institute of Integrated Electrical Engineers of the Philippines (IIEE)
PEC (2009) Philippine Electrical Code
- e) Bureau of Product Standards (BS)
PNS (2002) Philippine National Standard

7.10.1.2 Submittals

- a) Shop Drawings
 - Automatic Transfer Switch Drawings
- b) Product Data
- c) Automatic Transfer Switch
- d) Test Reports
- e) Acceptance Checks and Tests
- f) Functional Acceptance Tests
- g) Certificates
- h) Proof of Listing
- i) Operation and Maintenance Data
- j) Automatic Transfer Switch

7.10.1.3 Quality Assurance

- a) Proof of Listing
 - Submit proof of listing by UL 1008.
- b) Automatic Transfer Switch Drawings

Drawings shall include outline, arrangement, and detail drawings. Detail drawings shall include manufacturer's name and catalog number, electrical ratings, total system transfer statement, reduced normal supply voltage at which transfer to the alternate supply is initiated, transfer delay times, short-circuit current rating, wiring diagram, description of interconnections, testing instructions, acceptable conductor type for terminals, tightening torque for each wire connector, and other required UL 1008 markings.

7.10.2 PRODUCTS

7.10.2.1 Automatic Transfer Switch

Provide number of pole as indicated in the drawing, automatic transfer switch for use in emergency system in accordance with UL 1008. Automatic transfer switch shall be rated for total system transfer and have the current and voltage ratings as indicated. The rating of the switch shall be adequate for withstanding the effects of the indicated RMS symmetrical fault current when protected by the indicated overcurrent device without contact welding. The switch operating mechanism shall be electrically operated from the source to which it is transferring, shall have quick-make, quick-break, load break contacts, and shall be mechanically held in both positions. Switches utilizing circuit breakers are not acceptable. The manual operating means

shall affect the opening and closing of the switch contacts at the same rate of speed as that caused by the automatic operation of the switch. The switch enclosure shall comply with UL 508, NEMA Type 12 and shall be equipped with an equipment ground lug.

7.10.2.2 Automatic Transfer Switch Controls

a) Controls for Utility-Generator Automatic Transfer Switch

Provide all necessary controls to start the generator set upon loss of the normal (utility) source, transfer the load to the generator set upon reaching rated voltage and frequency, re-transfer the load when the normal (utility) source returns, and stop the generator set.

The switch shall include the following control features.

- 1) Three-phase normal source voltage sensing circuit with adjustable dropout, 75-93 percent of nominal, and pickup, 85-100 percent of nominal.
- 2) Engine starting control contacts with adjustable commit-to-start delay circuit, 0.5-6.0 seconds.
- 3) Voltage/frequency sensing circuit, set for 80 percent of nominal, for enabling load transfer to emergency source.
- 4) Transfer to emergency source time delay for transfer switch, adjustable 0-5 minutes.
- 5) Re-transfer to normal source time delay, adjustable 1-30 minutes.
- 6) Programmable exerciser to allow automatic starting of the generator set and subsequent load transfer. Exercise periods shall be selectable for 1 to 24 hours per day for 0 to 7 days a week.

b) Front Panel Devices

Provide devices mounted on cabinet front consisting of:

- 1) Mode selector switch with the following positions and associated functions;
 - (a) TEST - Simulates loss of normal/preferred source system operation.
 - (b) NORMAL - Transfers system to normal/preferred source bypassing re-transfer time delay.
- 2) Lamps for indicating connected source and normal/preferred source is available.
- 3) Auxiliary contacts for indicating connected source and normal/preferred source available.

7.10.3 EXECUTION

7.10.3.1 Installation

Installation shall conform to the requirements of NFPA 70, PEC and manufacturer's recommendation.

7.10.3.2 Prerequisites For Functional Acceptance Testing

Completion of the following requirements is mandatory prior to scheduling functional acceptance tests for the automatic transfer switch.

a) Performance of Acceptance Checks and tests

Complete as specified in paragraph entitled "Acceptance Checks and Tests". The Acceptance Checks and Tests shall be accomplished by the Testing organization.

b) Manufacturers O&M Information

The manufacturers O&M information required by the paragraph entitled Operation and Maintenance Data, shall have been submitted to and approved by the Engineer.

c) Test Equipment

All test equipment and instruments shall be on hand prior to scheduling field tests, or subject to Engineer's approval, evidence shall be provided to show that arrangements have been made to have the necessary equipment and instruments on site prior to field testing.

7.10.3.3 Field Quality Control

Give Engineer 7 days notice of dates and times scheduled for tests which require the presence of the Engineer. The Engineer will coordinate with the using activity and schedule a time that will eliminate or minimize interruptions and interference with the activity operations. The contractor shall be responsible for costs associated with conducting tests outside of normal working hours and with incorporating special arrangements and procedures, including temporary power conditions. The contractor shall provide labor, equipment, apparatus, including test load, and consumables required for the specified tests. Calibration of all measuring devices and indicating devices shall be certified. The test load shall be a cataloged product in accordance with Section 7.1 – Electrical General Requirements. Perform the following field tests in accordance with the manufacturer's recommendations and include the following visual and mechanical inspections and electrical tests, performed in accordance with NETA ATS.

a) Automatic Transfer Switch Acceptance Checks and Tests

1) Visual and Mechanical Inspection

- (a) Compare equipment nameplate data with specifications and approved shop drawings.

- (b) Inspect physical and mechanical condition.
- (c) Confirm correct application of manufacturer's recommended lubricants.
- (d) Verify that manual transfer warnings are attached and visible.
- (e) Verify tightness of all control connections.
- (f) Verify tightness of accessible bolted connections by calibrated torque-wrench method. Thermographic survey is not required.
- (g) Perform manual transfer operation.
- (h) Verify positive mechanical interlocking between normal and alternate Sources.

2) Electrical Tests

- (a) Measure contact-resistance.
- (b) Perform insulation-resistance on each pole, phase-to-phase and phase-to-ground with switch closed, and across each open pole for one minute. Perform tests in both source positions.
- (c) Verify settings and operations of control devices.
- (d) Calibrate and set all relays and timers.

b) Functional Acceptance Tests

Functional Acceptance Tests shall include simulating power failure and demonstrating the following operations for automatic transfer switch. Contractor shall show by demonstration in service that the automatic transfer switch is in good operating condition, and function not less than five times.

- 1) Perform automatic transfer tests:
 - (a) Simulate loss of normal/preferred power.
 - (b) Return to normal/preferred power.
 - (c) Simulate loss of emergency power.
 - (d) Simulate all forms of single-phase conditions.
- 2) Verify correct operation and timing of the following functions:
 - (a) Normal source voltage-sensing relays.
 - (b) Engine start sequence.
 - (c) Time delay upon transfer.

- (d) Alternate source voltage-sensing relays.
- (e) Automatic transfer operation.
- (f) Interlocks and limit switch function.
- (g) Time delay and retransfer upon normal power restoration.

7.11 TRANSFORMER TURN RATIO TESTER

7.11.1 REFERENCES

The following standards contain provision which, through reference in this text, constitute provisions of this specification. For dated editions the cited edition will apply; for undated editions the latest edition of the referenced document shall apply.

- a) International Electrical Testing Association (NETA)

ANSI/IEEE C57.12.90 (2006) Test Code for Liquid-Immersed Distribution,
Power and Regulating Transformers

- b) International Electrotechnical Commission (IEC)

IEC 61557 (2019) Electrical Safety in Low Voltage Distribution System up
to 1000 V AC and 15000 V DC

- c) National Fire Protection Association (NFPA)

NFPA 70 (2014) National Electrical Code

- d) Institute of Integrated Electrical Engineers of the Philippines (IIEE)

PEC (2009) Philippine Electrical Code

- e) Bureau of Product Standards (BS)

PNS (2002) Philippine National Standard

- f) European Standard (EN)

EN 61010-1 (2019) Safety Requirements for Electrical Equipment for
Measurement, Control and Laboratory use, General
Requirements

7.11.2 REQUIREMENTS

a) Service Conditions

The Portable Transformer Turns Ratio Tester shall be suitable for use outdoors in tropical areas and harsh climatic conditions including areas exposed to:

- 1) Altitudes of up to 2200m above sea level
- 2) Relative Humidity (RH) of up to 70%
- 3) Average ambient temperature of +30°C with a minimum of -1°C and a maximum of +40°C
- 4) Pollution: Design pollution level to be taken as "Heavy" (Pollution level III) for inland and "Very Heavy"

b) Design and Construction

- 1) The portable Transformer Turns Ratio Tester shall be designed, manufactured and tested according to ANSI/IEEE C57.12.90
- 2) The portable Transformer Turns Ratio Test Set shall be capable of taking different measurements, including:
 - (a) Transformer
 - (b) current transformer (CT)
 - (c) voltage transformer (PT)
- 3) It shall be portable, weight, compact and rugged.
- 4) It shall have direct digital readings (no conversion scales required).
- 5) suitable for site testing
- 6) NiMH batteries (Installed), 115V power cord, set of two 15 ft. leads, 10 fr USB cable, external battery charger (90-264VAC 50/60Hz) and soft carrying case.
- 7) Portable turn ratio tester be equipped with the function of monitoring and protecting the Battery.
- 8) Mechanical key for "run/stop".
- 9) Portable turn ratio tester has the functions of high and low voltage reverse connection.
- 10) Protection, short circuit protection of transformer and inter-turn short circuit protection.

- 11) With function of automatic shutdown: shutdown without operation exceeding 5 minutes.
- 12) USB port facilitates configuring the instrument and downloading test results.
- 13) It shall have the technical particulars as shown in Table 7.5 below:

Table 7.5: Technical particulars of Portable Transformer Turns Ratio Tester

Parameter	Requirement
VT/PT Ratio Range	Auto- Ranging 0.8000:1-8000:1
CT Ratio Range	Auto-Ranging 0.8000 to 1000.0
Accuracy	Ratio<10 to 1 : $\pm 0.2\%$ of Reading Ratio 0 to 1000 to 1: $\pm 0.1\%$ of Reading Ratio >1000 to 1: $\pm 0.2\%$ of Reading Ratio 5000 to 8000.0: $\pm 0.25\%$ of Reading
Excitation Signal	VT/PT Mode: 32Vrms maximum CT Mode: 0 to 1A, 0.1 to 4.5Vrms
Excitation Current Display	Range:0 to 1000mA; Accuracy: $\pm 2\%$ of Reading ± 2 mA
Excitation Frequency	70Hz
Measurement Method	In accordance with ANSI/IEEE C57.12.90
Display	LCD 16 character, 2 line, large format, LED backlight, day/night visible
Communication	Optically isolated USB: 2.0
Data Storage	Stores up to 10,000 complete measurements
Power Source	Two rechargeable 12V NiMH batteries (included)
External Charger	Universal voltage (90-240V supply, 50-60Hz) via external smart/fast battery charger; complete charge in less than 4 hours
Battery Life	Up to 10 hours continuous operation; May not be used while recharging; Low battery LED/LCD indication.
Charging Time	4 hours

7.11.3 TESTS REQUIREMENTS

The Portable Transformer Turns Ratio Tester shall be inspected and tested in accordance with the requirements of relevant standards and provision of this

specification.

7.11.4 MARKING AND PACKING

a) Marking

The following information shall be marked legibly and in a permanent manner on the Portable Transformer Turns Ratio Tester:

- 1) The manufacturer's name or trade mark;
The type reference number / model number;
- 2) Units of the measured quantity;
- 3) Ranges of measurement;
- 4) Type of battery and polarity of connection in the battery compartment
- 5) Standard of manufacture;
- 6) The serial number;
- 7) The instructions for handling and use (in the English Language).

b) Packing

The Portable Transformer Turns Ratio Tester shall be packed in a carrying case so as to protect it from damage and entry of moisture during transportation, handling and storage.

The carrying case shall shock proof and impact resistant and shall be able to withstand a fall of one meter without damage to the Portable Transformer Turns Ratio Tester.

7.12 OIL DIELECTRIC TESTER SET

Digital liquid dielectric tester set accurately and reliably test the dielectric strength of insulating liquids used in a wide variety of electric apparatus.

7.12.1 REFERENCES

a) ASTM International (ASTM)

ASTM D1816 (2018) Test Method for Dielectric Breakdown Voltage of Insulating Liquids using VDE Electrodes

ASTM D877 Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

b) International Electrotechnical Commission (IEC)

IEC 156 (1995) Insulating Liquids – Determination of breakdown voltage at power frequency – Test Method

c) National Fire Protection Association (NFPA)

NFPA 70 (2014) National Electrical Code

- d) Institute of Integrated Electrical Engineers of the Philippines (IIEE)

PEC (2009) Philippine Electrical Code

- e) Bureau of Product Standards (BS)

PNS (2002) Philippine National Standard

7.12.2 PRODUCT

Provide 60 kV Automatic Liquid Oil Dielectric Tester designed to meet testing specifications for ASTM D877, ASTM D1816 and IEC 156 testing standards and will meet the following features:

- a) Breakdown voltage accuracy of $\pm 2\%$ of full scale
- b) Automatic breakdown detection with $4\mu s$ of breakdown poin
- c) Internal digital kilovoltmeter automatically records the breakdown voltage for each test sample.
- d) Pre-programme test standards in basic mode or create their own tests using custom mode
- e) Battery operated
- f) Each test can be saved into the unit's internal memory and transfer via USB drive.
- g) Record and transfer each test result and data analysis via USB2.0
- h) 7" color, touch screen display with adjustable brightness
- i) Adjustable test parameters such as target voltage, ramp rate, dwell and wait time
- j) Lightweight and portable design
- k) Rugged and reliable construction
- l) Multi-purpose for field and factory use

DIVISION 8

WIRE COMMUNICATION AND SIGNAL SYSTEM

DIVISION 8 WIRE COMMUNICATION AND SIGNAL SYSTEM

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8.1 CLOSED CIRCUIT TELEVISION (CCTV)

8.1.1 GENERAL

Section 7.1 "Electrical General Requirements" of Division 7 applies to this section with the addition and modifications specified herein.

8.1.1.1 Scope of Work

This section covers requirements for the supply, delivery and installation of Closed Circuit Television (CCTV).

8.1.1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

- a) National Fire Protection Association (NFPA) Publication

NFPA 70
(2017) National Electrical Code
- b) Institute of Integrated Electrical Engineer (IIEE)

PEC
(2009) Philippine Electrical Code
- c) Philippine National Standard (PNS)

BS
(2002) Bureau of Standard

8.1.1.3 Submittals

- a) System schematic wiring diagram clearly indicating equipment and termination of devices.
- b) Mounting/installation details and fabrication drawing equipment certified with dimensions.

- c) Control and design logic.
- d) Schedule of materials and equipment to be supplied and its delivery.
- e) Comprehensive technical data and catalogues.

8.1.2 MATERIAL REQUIREMENTS

8.1.2.1 Closed Circuit Television System (CCTV)

a) System Components

Select system components that conform to the Open Network Video Interface Forum (ONVIF) specification. Display alphanumeric camera location ID on all monitors. Provide the number of alarm monitors as required. The scene from each camera must appear clear, crisp, and stable on the respective monitor during both daytime and night time operation. Provide component equipment that minimizes both preventive and corrective maintenance. Provide components from a single manufacturer or justify mixing manufacturer components and demonstrate compatibility in submittal information.

1) Cameras

(a) CCTV Camera

Provide cameras of digital fixed, pan-tilt-zoom (PTZ), or panoramic type as identified on the drawings.

- (1) Day-Night, Color-B&W, fixed, PTZ or panoramic cameras are to be used in all outdoor environments. Standard fixed, PTZ, or panoramic cameras are to be used for all indoor applications except when backlighting issues are observed. Use Day-Night cameras or standard cameras with backlighting compensation for backlighting or high contrast applications.
- (2) Provide PTZ cameras with a direct drive motor assembly. Belt driven PTZ camera units are not acceptable. Equip PTZ cameras with a slip ring assembly having an optical interface and be rated for continuous duty. PTZ cameras have to be fully integrated units. The pan-tilt mechanism must be an integral part of the camera.
- (3) Provide cameras that operate Power over Ethernet (PoE) IEEE 802.3.
- (4) All cameras must be constructed to provide rigid support for electrical and optical systems so that unintentional changes in alignment or microphonic effects do not occur during operation, movement, or lens adjustments.

(5) Video Frame Rate: 30 frames per second (fps)

Minimum essential requirements for cameras include the following:

i) Sensitivity

Minimum Illumination: 0.8 lux at F1.4 color mode; 0.1 lux at F1.4 in the B&W mode.

ii) Signal-To-Noise Ratio

Show a signal-to-noise ratio of not less than 50 decibels (dB) at Automatic Gain Control (AGC) "Off", weight "On".

iii) Resolution

Provide a minimum of 2.1 megapixel resolution. The imager must have a minimum of 1920 horizontal x 1080 picture in progressive scan format. Resolution is to be maintained over the specified input voltage and frequency range, and not vary from minimum specification over the specified operating temperature range.

iv) Synchronization

Provide cameras that have internal and line lock.

v) Low Light Level

Provide Day-Night cameras that have a B-W mode that may be automatically engaged on low light level and permit the use of an external infrared illuminator. Electronic removal of the color signal is not acceptable. The camera must have an infrared cut filter capable of being removed automatically upon low light threshold or manually.

(b) Camera Lenses

Camera lenses are to be all glass with coated optics. Provide lens with the camera that have a maximum f-stop opening of f/1.2 or the maximum available for the focal length specified. The lens is to have an auto-iris mechanism unless otherwise specified. Lenses having auto iris, manual iris, or zoom and focus functions are to be supplied with connectors, wiring, receiver and driver units, and controls as needed to operate the lens functions. Provide lenses with sufficient circle of illumination to cover the image sensor evenly. Lenses are not to be used on a camera with an image format larger than the lens is configured to cover. Provide lens with focal lengths as indicated or specified in the manufacturer's lens selection tables.

(c) Camera Housing and Mounts

The camera and lens are to be enclosed in a tamper resistant housing installed on a camera support. Any ancillary housing mounting hardware needed to install the housing at the camera location is to be provided as part of the housing. The camera support must be capable of supporting the mounted equipment and withstanding wind and ice loads normally encountered at the site.

(1) Environmentally Sealed Camera Housing

The housing is to provide an environment needed for camera operation and be condensation free; dust and water tight; keep the viewing window free of fog, snow, and ice, and be fully operational in 100 percent condensing humidity. Provide housing equipped with a sunshield. Both the housing and sunshield are to be white. Purge the housing of atmospheric air and pressurized with dry nitrogen, equipped with a fill valve, overpressure valve, and include a humidity indicator visible from the exterior. Housing must not have a leak rate greater than 13.8 kPa at sea level within a 90 day period.

Provide housing equipped with supplementary camera mounting blocks or supports needed to position the camera and lens to maintain the proper optical centerline. All electrical and signal connections required for camera and lens operation are to be supplied. Provide a mounting bracket as part of the housing which allows weight adjustment to center the weight of the assembly.

(2) Indoor Camera Housing

Provide housing with a tamper resistant enclosure for indoor camera operation and with the proper mounting brackets for the specified camera and lens. The housing and appurtenances color are not to conflict with the building interior color scheme.

(3) Interior Mount

Provide camera mount suitable for either wall or ceiling mounting and have an adjustable head for mounting the camera. The wall mount and head must be constructed of aluminum or steel with a corrosion-resistant finish. Provide adjustable head with 360 degrees of pan and plus or minus 90 degrees of tilt.

(4) Low Profile Ceiling Mount

Provide tamperproof ceiling housing which is low profile and suitable for use in 600 by 600 mm ceiling tiles. The housing must be equipped with a camera mounting bracket and allows a 360 degree viewing setup.

(5) Interior Dome Housing

The dome housing is to be capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings. The lower dome is to be black opaque acrylic and have a light attenuation factor of not more than 1 f-stop. Provide housing with:

- i) Integral pan-tilt complete with wiring
- ii) Wiring harnesses
- iii) Connectors
- iv) Permanent lubrication
- v) Motors that are thermally or impedance protected against overload damage.
- vi) Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

(6) Exterior Dome Housing

Provide dome housing capable of being mounted by pendant, pole, ceiling, surface, or corner as shown on the drawings and constructed to be dust and water tight, and fully operational in 100 percent condensing humidity. Purge the housing of atmospheric air and pressurize with dry nitrogen. Provide a fill valve and overpressure valve with a pressure indicator visible from the exterior. The housing is to be equipped with supplementary camera mounting blocks or supports as needed to position the specified camera and lens to maintain the proper optical centerline.

Provide all electrical and signal connections required for camera and lens operation. The housing is to provide the environment needed for camera operation. The lower dome is to be black opaque acrylic with a light attenuation factor of not more than 1 f-stop. Provide housing with:

- i) Integral pan-tilt complete with wiring
- ii) Wiring harnesses
- iii) Connectors
- iv) Permanent lubrication
- v) Motors that are thermally or impedance protected against overload damage.
- vi) Any other hardware and equipment as needed to provide a fully functional pan-tilt dome. Provide pan movement of 360 degrees and tilt movement of at least plus or minus 90 degrees. Pan speed must be at least 20 degrees per second and tilt speed be at least 10 degrees per second.

(7) Exterior Wall Mount

The wall mount and head must be constructed of aluminum, stainless steel, or steel with a corrosion-resistant finish. Provide

adjustable head for at least plus and minus 90 degrees of pan, and at least plus and minus 45 degrees of tilt. If to be used in conjunction with a pan-tilt, provide bracket without the adjustable mounting head, and a bolt hole pattern to match the pan-tilt base.

(8) Pan-Tilt Mount

Provide pan-tilt mount capable of supporting the camera, lens, and housing specified that is weatherproof and sized to accommodate the camera, lens and housing weight plus maximum wind loading encountered at the installation site if the pan-tilt is to be mounted outdoors. Provide pan-tilt with:

- i) Heavy duty bearings
- ii) Hardened steel gears
- iii) Externally adjustable limit stops for pan and tilt
- iv) Mechanical, dynamic, or friction brakes
- v) Permanent lubrication
- vi) Motors that are thermally or impedance protected against overload damage.

Provide pan movement of 360 degrees pan rotation, a minimum tilt movement of plus and minus 90 degrees.

The pan-tilt is to be supplied complete with wiring, wiring harnesses, connectors, receiver-driver, pan-tilt control system, pre-position cards, or any other hardware and equipment as needed to provide a fully functional pan-tilt mount to fulfill the site design requirements.

2) Video Analytics (VA)

(a) Software

Provide capability range from basic activity detection to the search through databases to pre-empt serious incidents. The VA is to provide graphic identified movement identification, user-selectable monitored areas, compensation for environmental movement, and other features specified when provided as a capability of the NVR. Provide the following features:

(1) Basic Motion Detection

- i) Adaptive Motion
- ii) Abandoned Object
- iii) Object Removal
- iv) Camera Sabotage
- v) Directional Motion
- vi) Object Counting
- vii) Loitering Detection
- viii) Stopped Vehicle

3) Color Video Monitors

(a) Except as specified, provide video monitors that:

- (1) Are rated for continuous operation and incorporate printed circuit board modular construction.
- (2) Have printed circuit modules that are easily replaceable.
- (3) Use solid-state devices for electronic circuits.
- (4) Are constructed to provide rigid support for electrical systems so that unintentional changes in alignment or microphonic effects will not occur during operation or movement.
- (5) Incorporate circuit safety margins of not less than 25 percent where possible, with respect to power dissipation ratings, voltage ratings, and current carrying capacity.
- (6) Have a diagonal viewing angle that nominally measures inches for monitors LED displays.
- (7) Provide adequate safeguards to protect personnel from exposure to line voltage during operation or adjustment.

(b) Mounting and Identification

- (1) Mount monitors and other devices to facilitate easy replacement.
- (2) The printed circuit board functions and component numbers or markings are to be easily read.
- (3) Mount monitors in a desk top console.
- (4) Protect monitors from circuit overloads by fuse or fuses in the power source line. Mount power source line fuses in finger-operated extractor fuse posts. Fuse holders are to be located in a readily accessible position.

(c) Video and Signal Input

Monitors are to operate with video input requiring a one nominal composite video signal switchable to either loop-through or internal 75-ohm terminating impedance.

Signal input connectors must be HMDI type.

4) Ancillary Equipment

Equipment is to consist of the items specified below:

(a) Video Date and Time Generator

The video time and date is to originate from either the camera, video, video recorder, or time server.

(b) Camera Identifiers

Label video signal from each camera using alphanumeric identifiers. Camera alphanumeric identifiers may originate from either the camera or the video recorder.

(c) Video Recording

(1) Network Video Recorder (NVR)

- i) Provide NVR with an integral software server function. Dedicated CCTV monitors and authorized computers networked to the NVR are to be capable of viewing recorded and live video from the network. The NVR is to be able to record and transmit video with up to 30 fps at maximum camera resolution. The NVR is to network with and utilize smaller, non-server computers at off-site camera locations as local recorders.
- ii) Provide NVR with the capability to de-warp live and recorded images.
- iii) The storage memory capacity of the NVR (including local recorders) is to be sufficient to store a minimum of 30 days of video.
- iv) The NVR must record all cameras onto a hard drive and allow remote network viewing via internet browser. Hard drive capability must be sized to store all cameras recording 24 hours a day 7 days a week.

(2) Video Recording Performance

The video recording performance is to be as follows:

- i) The NVR is to use modular hard disk media.
- ii) Provide video multiplexer capable of performing encoding, recording and multiscreen viewing modes simultaneously.
- iii) Provide a 10-100Base-T connection for record review and camera view and control that is compatible for a PC workstation.
- iv) Each camera is to support individual Recording Rate and Image Quality settings for each mode (Emergency, Event, Schedule and Manual Recording). This array of Camera Recording Rate and Image Quality settings by the Recording Modes is to form one of four Program Actions. The Program Action is to be assignable to a Time Table to form one of 16

Independent Recording Profiles. Allow each Recording Profile to be manually activated, activated via RS-232C interface, automatically activated by Time Table, or activated by separate alarm or emergency inputs.

- v) Digital display on the monitor and also recording of the following information to included:
 - (i) Year
 - (ii) Month
 - (iii) Day
 - (iv) Hour
 - (v) Minute
 - (vi) Second
 - (vii) Alphanumeric camera location ID up to 8 characters. The NVR is to feature video loss detection on all channels.
- vi) Pre-event recording: Buffer at least 20 seconds of pre-event pictures simultaneously for all individual camera channels.
- vii) Playback: Permit direct camera selection for recording playback of any of video sources at the same time as multiscreen viewing and multiplexed camera encoding (triplex multiplexer capability).
- viii) Multiplexer Functions: Include an integral, programmable switcher with programmable dwell time and camera order that automatically switches multiple camera images to enable sequential spot monitoring and simultaneous field recording. Provide switcher with separate spot, multiscreen, multiscreen-RGB, and cascaded video monitor outputs. The unit must have full screen and multiscreen monitoring modes.
- ix) Networking: All recording, review, playback, camera control and setup are to be available via the internally mounted Network Interface. A 10-100Base-T connection for record review and camera view and control will be required on a personal computer equipped with Internet Browser Software and an Ethernet 100Base-T connection.
- x) Power: The video recording equipment must have a power source of 230 VAC at 60 Hz.

(3) Camera Control

Provide access to camera functions and control for all cameras via the multiplexer for all camera control, set-up and alarm functions, including preset sequence, digital motion detector mask set, and back light compensation set-up. Controllable camera functions are to be accessible via front panel controls or the optional system controller. These functions are to include:

- i) Direct access of preset position
- ii) Zoom (near/far)
- iii) Focus (near/far)
- iv) Iris (open/close)
- v) Pan (left/right)

(4) Camera Mounting Structures

Provide camera mounting structures designed specifically for CCTV cameras. The structure is to accommodate appropriate wiring pathways for power and communication as well as proper grounding and surge protection. Design loads for the camera mounting structure must conform to TIA-222 and all applicable addendums of the TIA standard. Allowable pole deflection is determined from the point of the camera mount and must not exceed 0.5 percent of the pole height under adjusted maximum wind load conditions. Adjusted maximum wind load conditions for deflection calculations must be 48 km per hour or 35 percent of the basic wind speed as determined by TIA-222, whichever is greater. Confirm compliance to TIA standards by structure manufacturer data or by analysis. Provide additional measures as required to stabilize the camera if placed in an environment that is subject to induced vibrations such as heavy winds or excessive traffic.

8.1.3 EXECUTION;

8.1.3.1 Installation

Install the system in accordance with safety and technical standards NFPA 70 and PEC.

Configure components within the system with appropriate service points to pinpoint system trouble in less than 20 minutes.

Install all system components and appurtenances in accordance with the manufacturer's instructions, IEEE C2 and as shown on the drawings, and furnish all necessary connectors, terminators, interconnections, services, and adjustments required for a complete and operable system.

a) Existing Equipment

Connect to and utilize existing video equipment, video and control signal transmission lines, and devices as shown. Video equipment and signal lines that are usable in their original configuration without modification may be reused with Owner approval. Perform a field survey, including testing and inspection of all existing video equipment and signal lines intended to be incorporated into the CCTV system, and submit a report to the Owner. For those items considered nonfunctioning, provide (with the report) specification sheets, or written functional requirements to support the findings and the estimated cost to correct the deficiency. As part of the report, include the scheduled need date for connection to all existing equipment. Make written requests and obtain approval prior to disconnecting any signal lines and equipment, and creating equipment downtime. Such work shall proceed only

after receiving Owner approval of these requests. If any device fails after the Contractor has commenced work on that device, signal or control line, diagnose the failure and perform any necessary corrections to the equipment. The Owner is responsible for maintenance and repair of Owner equipment. The Contractor will be held responsible for repair costs due to Contractor negligence or abuse of Owner equipment.

b) Software Installation

Load software as specified and required for an operational system, including databases and specified programs. Provide original and backup copies of all accepted software, including diagnostics, upon successful endurance test completion.

c) Enclosure Penetrations

Enclosures are to be penetrated from the bottom unless shown otherwise. Penetrations of interior enclosures having transitions of conduit from interior to exterior, and penetrations of exterior enclosures are to be sealed with rubber silicone sealant to preclude the entry of water. Terminate conduit risers in a hot-dipped galvanized metal cable terminator that is filled with a sealant as recommended by the cable manufacturer, and in a manner that does not damage the cable.

d) Galvanizing

Ferrous metal is to be hot-dip galvanized in accordance with ASTM A123/A123M. Provide screws, bolts, nuts, and other fastenings and supports that are corrosion resistant.

Field welds or brazing on factory galvanized boxes, enclosures, conduits, and so on, are to be coated with a cold galvanized paint containing at least 95 percent zinc by weight.

e) Cable and Wire Runs

Perform required cable and wire routings per NFPA 70, PEC and as specified. Terminate conduits including flexible metal and armored cable in the device enclosure. Fit ends of conduit with insulated bushings. Exposed conductors at ends of conduits external to devices are not acceptable.

f) Conduits

Install interior conduits in accordance with NFPA 70, PEC and Interior Wiring System.

g) Camera Housings, Mounts, and Poles

Install the camera housings and mounts as specified by the manufacturer and as shown, provide mounting hardware sized appropriately to secure each camera, housing and mount with maximum wind loading encountered at the site; provide electrical and signal transmission cabling to the mount location as specified connect signal lines and AC power to mount interfaces; and connect

pole wiring harness to camera.

8.1.3.2 Adjustment, Alignment, Synchronization, and Cleaning

- a) Clean each system component of dust, dirt, grease, or oil incurred during and after installation or accrued subsequent to installation from other project activities subsequent to installation.
- b) Prepare for system activation by manufacturer's recommended procedures for adjustment, alignment, or synchronization.
- c) Prepare each component in accordance with appropriate provisions of component installation, operations, and maintenance manuals.
- d) Remove large vegetation that may sway in the wind and touch fencing.

8.1.3.3 System Start-up

Do not apply power to the system until after:

- a) Set up system equipment items and communications in accordance with manufacturer's instructions.
- b) Conduct a system visual inspection to ensure that defective equipment items have not been installed and that there are no loose connections.
- c) Test and verify system wiring as correctly connected.
- d) Verify system grounding and transient protection systems as properly installed.
- e) Verify the correct voltage, phasing, and frequency of the system power supplies.

Satisfaction of the requirements above does not relieve the contractor of responsibility for incorrect installations, defective equipment items, or collateral damage as result of Contractor work or equipment.

8.1.3.4 Supplemental Contractor Quality Control

Provide the services of technical representatives who are familiar with all components and installation procedures of the installed system; and are approved by the Engineer. These representatives are to be present on the job site during the preparatory and initial phases of quality control to provide technical assistance. These representatives are also to be available on an as needed basis to provide assistance with follow-up phases of quality control. These technical representatives are to participate in the system testing and validation and provide certification that their respective system portions meet the contractual requirements.

The above requirements supplement the quality control requirements specified elsewhere in the contract.

8.1.3.5 Training

The training is to be oriented to the specific system being installed. Training content is to include training manuals and audio-visual materials. Deliver training manuals for each trainee with 2 additional copies delivered for archiving at the project site. The manuals are to include an agenda, defined objectives for each lesson, and a detailed subject matter description for each lesson.

Furnish audio-visual equipment and other training materials and supplies.

8.1.3.6 Nameplate Mounting

Provide nameplate number, location, and letter designation as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or rivets.

8.2 STRUCTURED CABLING SYSTEM

8.2.1 General

Section 7.1 "Electrical General Requirements" and Section 7.5, "Interior Wiring Systems" of Division 7 apply to this section with the addition and modifications specified herein.

8.2.1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

a) ASTM International (ASTM)

ASTM D709 (2017) Laminated Thermosetting Materials

b) Electronic Components Industry Association (ECIA)

ECIA EIA/ECA 310-E (2005) Cabinets, Racks, Panels, and Associated Equipment

c) Institute Of Electrical And Electronics Engineers (IEEE)

IEEE 100 (2000) The Authoritative Dictionary of IEEE Standards Terms

d) Insulated Cable Engineers Association (ICEA)

ICEA S-83-596 (2016) Indoor Optical Fiber Cables

ICEA S-90-661 (2012) Category 3, 5, & 5e Individually Unshielded Twisted Pair Indoor Cables for Use in General Purpose and LAN Communications Wiring Systems Technical Requirements

e) National Electrical Contractors Association (NECA)

NECA/BICSI 568 (2006) Standard for Installing Building Telecommunications Cabling

f) National Fire Protection Association (NFPA)

NFPA 70 (2014) National Electrical Code

g) Institute Of Integrated Electrical Engineers Of The Philippines (IIEE)

PEC (2009) Philippine Electrical Code

h) Bureau of Product Standards (BS)

PNS (2002) Philippine National Standard

i) Telecommunications Industry Association (TIA)

TIA-1152 (2009) Requirements for Field Test Instruments and Measurement for Balanced Twisted-Pair Cabling

TIA-455-21 (2012) FOTP-21 - Mating Durability of Fiber Optic Interconnecting Devices

TIA-526-14 (2015) OFSTP-14A Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant

TIA-568-C.0 (2012) Generic Telecommunications Cabling for Customer Premises

TIA-568-C.1 (2012) Commercial Building Telecommunications Cabling Standard

TIA-568-C.2 (2016) Balanced Twisted-Pair Telecommunications Cabling and Components Standards

TIA-568-C.3 (2011) Optical Fiber Cabling Components Standard

TIA-569 (2015) Commercial Building Standard for Telecommunications Pathways and Spaces

TIA-606 (2017) Administration Standard for the Telecommunications Infrastructure

TIA-607 (2017) Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises

TIA/EIA-598 (2018) Optical Fiber Cable Color Coding

TIA/EIA-604-10 (2002) FOCIS 10 Fiber Optic Connector Intermateability
Standard - Type LC

j) Underwriters Laboratories (UL)

UL 1286	(2018) Safety Office Furnishings
UL 1666	(2012) Test for Flame Propagation Height of Electrical and Optical-Fiber Cables Installed Vertically in Shafts
UL 1863	(2016) Safety Communication Circuit Accessories
UL 444	(2015) Communications Cables
UL 467	(2017) Safety Grounding and Bonding Equipment
UL 50	(2015) Safety Enclosures for Electrical Equipment, Non-Environmental Considerations
UL 514C	(2018) Safety Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL 969	(2018) Safety Marking and Labeling Systems

8.2.1.2 Definitions

Unless otherwise specified or indicated, electrical and electronics terms used in this specification shall be as defined in TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, TIA-606 and IEEE 100 and herein.

a) System Description

The building telecommunications cabling and pathway system shall include permanently installed backbone and horizontal cabling, horizontal and backbone pathways, service entrance facilities, work area pathways, telecommunications outlet assemblies, conduit, raceway, and hardware for splicing, terminating, and interconnecting cabling necessary to transport telephone and data (including LAN) between equipment items in a building. The horizontal system shall be wired in a star topology from the telecommunications work area to the floor distributor or campus distributor at the center or hub of the star. The backbone cabling and pathway system includes intrabuilding interconnecting cabling, pathway, and terminal hardware. The intrabuilding backbone provides connectivity from the floor distributors to the building distributor and from the building distributors to the campus distributor as required. The backbone system shall be wired in a star topology with the campus distributor at the center or hub of the star.

b) Submittals

1) Shop Drawings

Telecommunications drawings

2) Product Data

Telecommunications cabling (backbone and horizontal)

Patch panels

Telecommunications outlet/connector assemblies

Equipment support frame

(a) Test Reports

(b) Telecommunications cabling testing

(c) Certificates

Telecommunications Contractor Qualifications

Manufacturer Qualifications

(d) Manufacturer's Field Reports

Factory reel tests

(e) Operation and Maintenance Data

Telecommunications cabling and pathway system

8.2.1.3 Quality Assurance

a) Shop Drawings

Include wiring diagrams and installation details of equipment indicating proposed location, layout and arrangement, control panels, accessories, piping, ductwork, and other items that must be shown to ensure a coordinated installation. Wiring diagrams shall identify circuit terminals and indicate the internal wiring for each item of equipment and the interconnection between each item of equipment. Drawings shall indicate adequate clearance for operation, maintenance, and replacement of operating equipment devices. Submittals shall include the nameplate data, size, and capacity. Submittals shall also include applicable federal, military, industry, and technical society publication references.

b) Telecommunications Qualifications

Work under this section shall be performed by and the equipment shall be provided by the approved telecommunications contractor and key personnel. Qualifications shall be provided for: the telecommunications system contractor, the telecommunications system installer, and the supervisor (if different from the installer). A minimum of 30 days prior to installation, submit documentation of the experience of the telecommunications contractor and of the key personnel.

c) Telecommunications Contractor

The telecommunications contractor shall be a firm which is regularly and professionally engaged in the business of the applications, installation, and testing of the specified telecommunications systems and equipment. The telecommunications contractor shall demonstrate experience in providing successful telecommunications systems of similar scope and size. Submit documentation for a minimum of three and a maximum of five successful telecommunication system installations for the telecommunications contractor.

d) Minimum Manufacturer Qualifications

Cabling, equipment and hardware manufacturers shall have years experience in the manufacturing, assembly, and factory testing of components which comply with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3.

e) Regulatory Requirements

In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Engineer. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of NFPA 70 and PEC unless more stringent requirements are specified or indicated.

f) Standard Products

Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

g) Alternative Qualifications

Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

h) Material and Equipment Manufacturing Date

Products manufactured more than 1 year prior to date of delivery to site shall not be used, unless specified otherwise.

8.2.1.4 Delivery and Storage

Provide protection from weather, moisture, extreme heat and cold, dirt, dust, and other contaminants for telecommunications cabling and equipment placed in storage.

8.2.1.5 Environmental Requirements

Connecting hardware shall be rated for operation under ambient conditions of 0 to 60 degrees C and in the range of 0 to 95 percent relative humidity, noncondensing.

8.2.1.6 Warranty

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

8.2.1.7 Maintenance

a) Operation and Maintenance Manuals

Commercial off the shelf manuals shall be furnished for operation, installation, configuration, and maintenance of products provided as a part of the telecommunications cabling and pathway system. Ensure that these drawings and documents depict the as-built configuration.

8.2.2 PRODUCTS

8.2.2.1 Components

Components shall be UL or third party certified. Where equipment or materials are specified to conform to industry and technical society reference standards of the organizations, submit proof of such compliance. The label or listing by the specified organization will be acceptable evidence of compliance. In lieu of the label or listing, submit a certificate from an independent testing organization, competent to perform testing, and approved by the Engineer. The certificate shall state that the item has been tested in accordance with the specified organization's test methods and that the item complies with the specified organization's reference standard. Provide a complete system of telecommunications cabling and pathway components using star

topology. Provide support structures and pathways, complete with outlets, cables, connecting hardware and telecommunications cabinets/racks. Cabling and interconnecting hardware and components for telecommunications systems shall be UL listed or third party independent testing laboratory certified, and shall comply with NFPA 70, PEC and conform to the requirements specified herein.

8.2.2.2 Telecommunications Pathway

Provide telecommunications pathways in accordance with Interior Distribution System. Provide system furniture pathways in accordance with UL 1286.

8.2.2.3 Telecommunications Cabling

Cabling shall be UL listed for the application and shall comply with TIA-568-C.0, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, NFPA 70 and PEC. Provide a labelling system for cabling as required by TIA-606 and UL 969. Ship cable on reels or in boxes bearing manufacture date for unshielded twisted pair (UTP) in accordance with ICEA S-90-661 and optical fiber cables in accordance with ICEA S-83-596 for all cable used on this project. Cabling manufactured more than 12 months prior to date of installation shall not be used.

- a) Backbone Cabling
- b) Backbone Optical Fiber

Provide in accordance with ICEA S-83-596, TIA-568-C.3, UL 1666, NFPA and PEC. Cable shall be imprinted with fiber count, fiber type and aggregate length at regular intervals not to exceed 1 meter.

Provide tight buffered fiber optic multimode, 62.5/125-um diameter (OM1) cable.

Provide plenum (OFNP), riser (OFNR), or general purpose (OFN or OFNG) rated non-conductive, fiber optic cable in accordance with NFPA 70 and PEC. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70 and PEC. The cable cordage jacket, fiber, unit, and group color shall be in accordance with TIA/EIA-598.

- c) Horizontal Cabling

Provide horizontal cable in compliance with NFPA 70, PEC and performance characteristics in accordance with TIA-568-C.1.

- 1) Horizontal Copper

Provide horizontal copper cable, UTP, 100 ohm in accordance with TIA-568-C.2, UL 444, ICEA S-90-661. Provide four each individually twisted pair, minimum size 24 AWG conductors, Category 5E, with a blue thermoplastic jacket. Cable shall be imprinted with manufacturers name or identifier flammability rating, gauge of conductor, transmission performance

rating (category designation) and length marking at regular intervals in accordance with ICEA S-90-661. Provide plenum (CMP), riser (CMR), or general purpose (CM or CMG) communications rated cabling in accordance with NFPA 70 and PEC. Substitution of a higher rated cable shall be permitted in accordance with NFPA 70 and PEC. Cables installed in conduit within and under slabs shall be UL listed and labelled for wet locations in accordance with NFPA 70 and PEC.

d) Work Area Cabling

1) Work Area Copper

Provide work area copper cable in accordance with TIA-568-C.2, with a blue thermoplastic jacket.

8.2.2.4 Telecommunications Spaces

Provide connecting hardware and termination equipment in the telecommunications entrance facility and telecommunication equipment room to facilitate installation as shown on design drawings for terminating and cross-connecting permanent cabling. Provide telecommunications interconnecting hardware color coding in accordance with TIA-606.

a) Backboards

Provide void-free, interior grade A-C plywood 20mm thick. Backboards shall be fire rated by manufacturing process. Fire stamp shall be clearly visible. Backboards shall be provided on a minimum of two adjacent walls in the telecommunication spaces.

b) Equipment Support Frame

Provide in accordance with ECIA EIA/ECA 310-E and UL 50.

- 1) Cabinets, freestanding modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Cabinet shall have removable and lockable side panels, front and rear doors, and have adjustable feet for leveling. Cabinet shall be vented in the roof and rear door. Cabinet shall have cable access in the roof and base and be compatible with panel mounting. Provide cabinet with grounding bar 15 cu. m 550 CFM fan with filter. All cabinets shall be keyed alike.
- 2) Cabinets, wall-mounted modular type, 16 gauge steel construction, minimum, treated to resist corrosion. Cabinet shall have have lockable front door, louvered side panels, 7 cu.m. 250 CFM fan, ground lug, and top and bottom cable access. Cabinet shall be compatible with panel mounting. All cabinets shall be keyed alike.

c) Cable Guides

Provide cable guides specifically manufactured for the purpose of routing cables, wires and patch cords horizontally and vertically on equipment cabinets and telecommunications backboards. Cable guides of ring or bracket type devices for horizontal cable management and individually mounted for vertical cable management. Mount cable guides with screws, and or nuts and lockwashers.

d) Patch Panels

Provide ports for the number of horizontal and backbone cables terminated on the panel plus 25 percent spare. Provide pre-connectorized optical fiber and copper patch cords for patch panels. Provide patch cords, as complete assemblies, with matching connectors as specified. Provide fiber optic patch cables with crossover orientation in accordance with TIA-568- C.3. Patch cords shall meet minimum performance requirements specified in TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3 for cables, cable length and hardware specified.

1) Modular to 110 Block Patch Panel

Provide in accordance with TIA-568-C.1 and TIA-568-C.2. Panels shall be third party verified. Panel shall be constructed of 2.2 mm minimum aluminum and shall be cabinet mounted and compatible with an ECIA EIA/ECA 310-E equipment cabinet. Panel shall provide 48 non-keyed, 8-pin modular ports, wired to T568A. Patch panels shall terminate the building cabling on Type 110 IDCs and shall utilize a printed circuit board interface. The rear of each panel shall have incoming cable strain-relief and routing guides. Panels shall have each port factory numbered and be equipped with laminated plastic nameplates above each port.

2) Fiber Optic Patch Panel

Provide panel for maintenance and cross-connecting of optical fiber cables. Panel shall be constructed of 16 gauge steel minimum and shall be cabinet mounted and compatible with a ECIA EIA/ECA 310-E equipment rack. Each panel shall provide 12 multimode adapters as duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves. Provide dust cover for unused adapters. The rear of each panel shall have a cable management tray a minimum of 200 mm deep with removable cover, incoming cable strain-relief and routing guides. Panels shall have each adapter factory numbered and be equipped with laminated plastic nameplates above each adapter.

8.2.2.5 Telecommunications Outlet/Connector Assemblies

a) Outlet/Connector Copper

Outlet/connectors shall comply with TIA-568-C.1, and TIA-568-C.2. UTP outlet/connectors shall be UL 1863 listed, non-keyed, 8-pin modular, constructed of high impact rated thermoplastic housing and shall be third party verified and shall comply with TIA-568-C.2 Category 5E requirements. Outlet/connectors provided for UTP cabling shall meet or exceed the requirements for the cable provided. Outlet/connectors shall be terminated using a Type 110 IDC PC board connector, color-coded for T568A wiring. Each outlet/connector shall be wired T568A. UTP outlet/connectors shall comply with TIA-568-C.2 for 200 mating cycles.

b) Optical Fiber Adapters(Couplers)

Provide optical fiber adapters suitable for duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves. Provide dust cover for adapters. Optical fiber adapters shall comply with TIA-455-21 for 500 mating cycles.

c) Optical Fiber Connectors

Provide in accordance with TIA-455-21. Optical fiber connectors shall be duplex LC in accordance with TIA/EIA-604-10 with zirconia ceramic alignment sleeves, epoxyless crimp style compatible with 62.5/125 multimode fiber. The connectors shall provide a maximum attenuation of 0.3 dB at 1300 nm with less than a 0.2 dB change after 500 mating cycles.

d) Cover Plates

Telecommunications cover plates shall comply with UL 514C, and TIA-568-C.1, design constructed of high impact thermoplastic material white in color to match color of receptacle/switch cover plates specified In Interior Wiring System. Provide labelling in accordance with the paragraph LABELLING in this section.

8.2.2.6 Grounding and Bonding Products

Provide in accordance with UL 467, TIA-607, NFPA 70 and PEC. Components shall be identified as required by TIA-606. Provide ground rods, bonding conductors, and grounding busbars as specified in Interior Distribution System.

a) Manufacturer's Nameplate

Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

b) Field Fabricated Nameplates

ASTM D709. Provide laminated plastic nameplates for each equipment enclosure, relay, switch, and device; as specified or as indicated on the drawings. Each nameplate inscription shall identify the function and, when applicable, the position. Nameplates shall be melamine plastic, 3 mm thick, white with black center core. Surface shall be matte finish. Corners shall be square. Accurately align lettering and engrave into the core. Minimum size of nameplates shall be 25 by 65 mm. Lettering shall be a minimum of 6 mm high normal block style.

c) Tests, Inspections, And Verifications

1) Factory Reel Tests

Provide documentation of the testing and verification actions taken by manufacturer to confirm compliance with TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, and TIA-526-14 for multimode optical fiber cables.

8.2.3 EXECUTION

8.2.3.1 INSTALLATION

Install telecommunications cabling and pathway systems, including the horizontal and backbone cable, pathway systems, telecommunications outlet/connector assemblies, and associated hardware in accordance with NECA/BICSI 568, TIA-568-C.1, TIA-568-C.2, TIA-568-C.3, TIA-569, NFPA 70, PEC and UL standards as applicable. Provide cabling in a star topology network. Pathways and outlet boxes shall be installed as specified in INTERIOR DISTRIBUTION SYSTEM. Install telecommunications cabling with copper media in accordance with the following criteria to avoid potential electromagnetic interference between power and telecommunications equipment. The interference ceiling shall not exceed 3.0 volts per meter measured over the usable bandwidth of the telecommunications cabling.

a) Cabling

Install UTP, and optical fiber telecommunications cabling system as detailed in TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. Screw terminals shall not be used except where specifically indicated on plans. Use an approved insulation displacement connection (IDC) tool kit for copper cable terminations. Do not exceed manufacturers' cable pull tensions for copper and optical fiber cables. Provide a device to monitor cable pull tensions. Do not exceed 110 N pull tension for four pair copper cables. Do not chafe or damage outer jacket materials. Use only lubricants approved by cable manufacturer. Do not over cinch cables, or crush cables with staples. For UTP cable, bend radii shall not be less than four times the cable diameter. Cables shall be terminated; no cable shall contain unterminated elements. Cables shall not be spliced. Label cabling in accordance with paragraph LABELLING in this section.

b) Open Cable

Use only where specifically indicated on plans for use in cable trays. Install in accordance with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3. Do not exceed cable pull tensions recommended by the manufacturer. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items. Placement of cable parallel to power conductors shall be avoided, if possible; a minimum separation of 300 mm shall be maintained when such placement cannot be avoided.

Plenum cable shall be used where open cables are routed through plenum areas. Plenum cables shall comply with flammability plenum requirements of NFPA 70 and PEC.

c) Backbone Cable

Optical fiber Backbone Cable. Install intrabuilding backbone optical fiber in indicated pathways. Do not exceed manufacturer's recommended bending radii and pull tension. Prepare cable for pulling by cutting outer jacket 250 mm leaving strength members exposed for approximately 250 mm. Twist strength members together and attach to pulling eye. Vertical cable support intervals shall be in accordance with manufacturer's recommendations.

d) Horizontal Cabling

Install horizontal cabling as indicated on drawings. Do not untwist Category 5E UTP cables more than 12 mm from the point of termination to maintain cable geometry. Provide slack cable in the form of a figure eight (not a service loop) on each end of the cable, 3 m in the telecommunications room, and 300 mm in the work area outlet.

1) Pathway Installations

Provide in accordance with TIA-569, NFPA 70 and PEC. Provide building pathway as specified In Interior Distribution System.

2) Cable Tray Installation

Install cable tray as specified in INTERIOR DISTRIBUTION SYSTEM. Only CMP-and OFNP type cable shall be installed in a plenum.

3) Work Area Outlets

4) Terminations

Terminate UTP cable in accordance with TIA-568-C.1, TIA-568-C.2 and wiring configuration as specified. Terminate fiber optic cables in accordance with TIA-568- C.3.

5) Cover Plates

As a minimum, each outlet/connector shall be labelled as to its function and a unique number to identify cable link in accordance with the paragraph LABELING in this section.

6) Cables

Unshielded twisted pair and fiber optic cables shall have a minimum of 300 mm of slack cable loosely coiled into the telecommunications outlet boxes. Minimum manufacturer's bend radius for each type of cable shall not be exceeded.

7) Pull Cords

Pull cords shall be installed in conduit serving telecommunications outlets that do not have cable installed.

e) Telecommunications Space Termination

Install termination hardware required for Category 5E and optical fiber system. An insulation displacement tool shall be used for terminating copper cable to insulation displacement connectors.

1) Connector Blocks

Connector blocks shall be cabinet mounted in orderly rows and columns. Adequate vertical and horizontal wire routing areas shall be provided between groups of blocks. Install in accordance with industry standard wire routing guides in accordance with TIA-569.

2) Patch Panels

Patch panels shall be mounted in equipment cabinets with sufficient ports to accommodate the installed cable plant plus 25 percent spares.

(a) Copper Patch Panel. Copper cable entering a patch panel shall be secured to the panel with cable ties as recommended by the manufacturer to prevent movement of the cable.

(b) Fiber Optic Patch Panel. Fiber optic cable loop shall be provided as recommended by the manufacturer. The outer jacket of each cable entering a patch panel shall be secured to the panel to prevent movement of the fibers within the panel, using clamps or brackets specifically manufactured for that purpose.

f) Equipment Support Frames

Install in accordance with TIA-569:

- 1) Cabinets, freestanding modular type. When cabinets are connected together, remove adjoining side panels for cable routing between cabinets. Mount rack mounted fan in cabinet.
- 2) Cabinets, wall-mounted modular type. Mount cabinet to plywood backboard in accordance with manufacturer's recommendations. Mount cabinet so height of highest panel does not exceed 1800 mm above floor.

g) Electrical Penetrations

Seal openings around electrical penetrations through fire resistance-rated wall, partitions, floors, or ceilings.

h) Grounding and Bonding

Provide in accordance with TIA-607, NFPA 70, PEC as specified In Interior Distribution System.

8.2.3.2 Labeling

a) Labels

Provide labelling in accordance with TIA-606. Handwritten labelling is unacceptable. Stenciled lettering for voice and data circuits shall be provided using laser printer.

b) Cable

Cables shall be labelled using color labels on both ends with identifiers in accordance with TIA-606.

c) Termination Hardware

Workstation outlets and patch panel connections shall be labelled using color coded labels with identifiers in accordance with TIA-606.

8.2.3.3 Field Applied Painting

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

8.2.3.4 Painting Backboards

If backboards are required to be painted, then the manufactured fire retardant backboard must be painted with fire retardant paint, so as not to increase flame spread and smoke density and must be appropriately labelled. Label and fire rating stamp must be unpainted.

8.2.3.5 Field Fabricated Nameplate Mounting

Provide number, location, and letter designation of nameplates as indicated. Fasten nameplates to the device with a minimum of two sheet-metal screws or two rivets.

8.2.3.6 Testing

a) Telecommunications Cabling Testing

Perform telecommunications cabling inspection, verification, and performance tests in accordance with TIA-568-C.1, TIA-568-C.2, and TIA-568-C.3. Test equipment shall conform to TIA-1152. Perform optical fiber field inspection tests via attenuation measurements on factory reels and provide results along with manufacturer certification for factory reel tests. Remove failed cable reels from project site upon attenuation test failure.

b) Inspection

Visually inspect UTP and optical fiber jacket materials for UL or third party certification markings. Inspect cabling terminations in telecommunications rooms and at workstations to confirm color code for T568A pin assignments, and inspect cabling connections to confirm compliance with TIA-568-C.1, TIA-568-C.2 and TIA-568-C.3. Visually confirm Category 5E marking of outlets, cover plates, outlet/connectors, and patch panels.

c) Verification Tests

UTP backbone copper cabling shall be tested for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors, and between conductors and shield, if cable has overall shield. Test operation of shorting bars in connection blocks. Test cables after termination but prior to being cross-connected.

For multimode optical fiber, perform optical fiber end-to-end attenuation tests in accordance with TIA-568-C.3 and TIA-526-14 using Method A, Optical Power Meter and Light Source for multimode optical fiber. Perform verification acceptance tests.

d) Performance Tests

Perform testing for each outlet as follows:

- 1) Perform Category 5E link tests in accordance with TIA-568-C.1 and TIA-568-C.2. Tests shall include wire map, length, insertion loss, NEXT, PSNEXT, ELFEXT, PSELFEXT, return loss, propagation delay, and delay skew.
- 2) Optical fiber Links. Perform optical fiber end-to-end link tests in accordance with TIA-568-C.3.

e) Final Verification Test

Perform verification tests for UTP and optical fiber systems after the complete telecommunications cabling and workstation outlet/connectors are installed.

- 1) Voice Tests. These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and DSN telephone call.
- 2) Data Tests. These tests assume the Information Technology Staff has a network installed and are available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

8.3 FIRE DETECTION AND ALARM SYSTEM

8.3.1 GENERAL

Section 7.1, "Electrical General Requirements" applies to this section with additions and modifications specified herein.

8.3.1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

- a) Factory Mutual Engineering and Research Corporation (FM)
FM P7825 (2005) Approval Guide Fire Protection
- b) National Fire Protection Association (NFPA)
NFPA 70 (2014) National Electrical Code
NFPA 72 (2002) National Fire Alarm Code
NFPA 90A (2002) Installation of Air Conditioning and Ventilating Systems
NFPA 101 (2002) Life Safety Code
- c) Institute of Integrated Electrical Engineer (IIEE)
PEC (2009) Philippine Electrical Code
- d) Philippine National Standard (PNS)
BS (2002) Bureau of Standard
- e) Underwriters Laboratories Inc. (UL)
UL 268 (1996; Rev Thru Oct 2003) Smoke Detectors for Fire Alarm Signaling Systems

UL 514A	(2004) Metallic Outlet Boxes
UL 514B	(2004) Fittings for Conduit and Outlet Boxes
UL 864	(2003; Rev Thru Oct 2003) Control Units and Accessories for Fire alarm Systems
UL 464	(2003; Rev Thru Oct 2003) Audible Signal Appliances
UL 1242	(2000; Rev Thru May 2003) Intermediate Metal Conduit
UL 1971	(2000; Rev Thru May 2004) Safety Signaling Devices for the Hearing Impaired
UL 521	(1999; Rev Thru Oct 2002) Heat Detectors for Fire Protective Signaling Systems

8.3.1.2 Description of Work

The work includes providing new interior fire alarm system including material, tools, equipment, installation, and testing necessary for and incidental to the provision of a complete and usable standard system conforming to the applicable requirements of PEC, NFPA 70, NFPA 72, NFPA 90A, and NFPA 101, and this specification. Materials and equipment to be furnished under this contract shall be essentially the current design products of manufacturers regularly engaged in production of such equipment and shall be listed by the Underwriters' Laboratories, Inc. in the UL FPED, or approved by Factory Mutual System and listed in FM P7825.

8.3.1.3 Submittals

Submit the following.

- a) Shop Drawings
 - 1) System layout
 - 2) System wiring diagrams
 - 3) Conductor wire marker schedule
- b) Product Data
 - 1) Control panel and modules
 - 2) batteries
 - 3) Battery charger
 - 4) Manual pull stations
 - 5) Heat detectors
 - 6) smoke detectors
 - 7) Audio/Visual/Alarm horns
 - 8) Graphic annunciator panel
 - 9) Wiring
 - 10) Conduit
 - 11) Outlet boxes
 - 12) Fittings for conduit and outlet boxes

Data which describe more than one type of item shall be clearly marked to indicate which type the Contractor intends to provide. Submit one original for each item and clear, legible, first-generation photocopies for the remainder of the specified copies. Incomplete or illegible photocopies will not be accepted. Partial submittals will not be accepted.

- c) Test Reports
- d) Preliminary testing
- e) Final acceptance testing

Submit for all inspections and tests specified under paragraph entitled "Field Quality Control."

- f) Certificates
 - 1) Qualifications of installer
 - 2) Qualifications of system technician
- g) Operation and Maintenance Data
 - 1) Fire alarm system
- h) Closeout Submittals
 - 1) System as-built drawings

8.3.1.4 Quality Assurance

- a) Qualifications of Installer

The Contractor or installer shall have satisfactorily installed fire alarm systems of the same type and design as specified herein.

Prior to commencing fire alarm system work, submit data showing that the Contractor or installer has satisfactorily installed three fire alarm systems of the same type and design as specified herein within the past three years.

For each system installed, submit the following:

- 1) A detailed summary of the type and design of the system;
- 2) The contract name or number, completion date of the project and total cost of the system;
- 3) The name and telephone number of the facility or installation for whom the work was performed;

b) Manufacturer's Representative

Provide the services of a representative or technician from the manufacturer of the system, experienced in the installation and operation of the type of system being provided, to supervise installation, adjustment, preliminary testing, and final testing of the system and to provide instruction to Owner representative.

c) Qualifications of System Technician

Installation drawings, shop drawings and as-built drawings shall be prepared by, or under the supervision of, a qualified technician. Qualified technician shall be an individual who is experienced with the types of work specified herein. Contractor shall submit data showing the name and certification of the technician at or prior to submittal of drawings.

d) Drawing Requirements

1) System Layout

Submit shop drawings of the system layout showing locations of initiating devices and alarm horns. Show wire color coding, wire counts, and device wiring order.

2) System Wiring Diagrams

Submit complete wiring diagrams of the system showing points of connection and terminals used for all electrical connections in the system. Show all modules and lamps in the control panel.

3) System As-Built Drawings

Upon completion, and before final acceptance of the work, furnish to the Engineer 4 complete sets of as-built drawings, including complete as-built circuit diagrams, of each the system. The as-built drawings shall be as the contract drawings and with title block similar to contract drawings.

8.3.1.5 Maintenance

a) Spare Parts

Furnish the following spare parts:

- 1) Five (5) complete sets of system keys
- 2) One (1) of each type of audible and visual alarm device installed
- 3) Two (2) of each type of fuse required by the system
- 4) One (1) spare zone modules for modular type control panels in addition to those installed in the panel
- 5) Two (2) of each type of heat detector installed

6) Two (2) of each type of smoke detector base and head installed

b) Manuals

Submit operation and maintenance data manuals. The manual shall include: circuit drawings; wiring and control diagrams; installation instructions; maintenance instructions; safety precautions, diagrams, and illustrations; test procedures; performance data; and parts list.

8.3.2 MATERIAL REQUIREMENTS

8.3.2.1 System Design

a) Operation

Provide a complete, electrically supervised, zoned, annunciated, fire alarm system as described herein, and as shown on the drawings. Provide separate circuits from the control panel to each zone of initiating devices as specified herein.

1) Fire Alarm Signal Initiation

Operation shall be such that actuation of any:

- a) Manual station
- b) Heat detector
- c) Smoke detector

Shall cause all of the following actions:

- All building evacuation alarm devices Audio/visual alarm horns to operate continuously;
- The annunciators to properly register;
- All operations shall remain in the alarm mode until the system is manually restored to normal.

2) Monitoring Integrity of Installation Conductors

All system circuits shall be electrically monitored for integrity including the following:

- a) Initiating circuits.
- b) Evacuation alarm circuits
- c) Battery power supply low and no voltage across the standby battery terminals and open battery circuit.

Provide Class A initiating device circuits, and Class A notification device circuits as defined by NFPA 72. For Class A circuits, provide separate conduits for outgoing and return (redundant) conductors as required by NFPA 72. A ground fault condition or single break in any other circuit shall cause operation of the system trouble signals. Loss of AC power, abnormal AC voltage, a break in the standby battery power circuit, or low battery voltage shall also cause operation of system trouble signals. The abnormal position of any switch in the control panel shall also cause operation of the system trouble signals. Audible and visual equipment for supervision of the AC power supply shall be energized from the auxiliary DC power supply and vice versa. Trouble signals shall sound continuously until manually silenced or the system has been restored to normal.

3) Walk-Test Mode

Provide system with walk-test mode to allow one person to test alarm and supervisory features of initiating devices. Walk-test mode shall be enabled from the control panel by authorized service personnel. Control panel shall display a unique visual indication when system is in walk-test mode. If testing ceases while in walk-test mode, after a preset delay system shall automatically return to normal standby mode.

4) Alarm Verification Feature

System shall have a smoke detector alarm verification feature. Upon activation of any area smoke detector, system shall institute an alarm verification process prior to enabling of the alarm functions as specified herein. Activation of any initiating device other than an area smoke detector shall cause immediate enabling of system into alarm mode. If an alarm input from a smoke detector on the initial zone in alarm is present at the end of an initial delay period not exceeding 20 seconds, all alarm functions as specified herein shall be immediately enabled. If a smoke detector alarm input is not present at the end of the initial delay period, a second-stage confirmation period of one minute shall be initiated. If a smoke detector alarm input is received during the second-stage confirmation period, all alarm functions shall be immediately enabled. During the verification process, activation of any area smoke detector on any zone other than the initial zone in alarm shall also cause system to go into alarm mode immediately. If no smoke detector alarm input occurs within the second-stage confirmation period, system shall reset to normal. Any alarm input received from an area smoke detector after the second-stage confirmation period has elapsed shall cause system to institute a new verification process.

b) Primary Power

Primary power source shall be 240 volts AC service, transformed through a two winding isolation type transformer and rectified to 24 volts DC for operation of all initiating device, notification device signaling line and trouble signal. The alarm current draw of the entire fire alarm system shall not exceed 80 percent of the rated output of the system power supply modules. Obtain AC operating power as shown on contract drawings. Provide an independent enclosed

circuit breaker with provisions for locking the cover and operating handle in the "POWER ON" position. Paint the enclosure red and identify it by the lettered designation "FIRE ALARM SYSTEM POWER".

c) Auxiliary Power

Provide secondary DC power supply for operation of system in the event of failure of the AC source. Transfer from normal to emergency power or restoration from emergency to normal power shall be fully automatic and shall not cause transmission of a false alarm.

1) Storage Batteries

Provide sealed lead calcium or sealed lead acid or batteries and charger. Drycell batteries are not acceptable. House batteries in the control panel. Provide batteries of adequate ampere-hour rating to operate the system, including audible trouble signal devices, and under supervisory conditions for 60 hours, at the end of which time batteries shall be capable of operating the entire system in a full alarm condition for not less than 15 minutes. Provide calculations substantiating the battery capacity. Provide reliable separation between cells to prevent contact between terminals of adjacent cells and between battery terminals and other metal parts.

2) Battery Charger

Provide completely automatic high/low charging rate type capable of recovery of the batteries from full discharge to full charge in 24 hours or less. Provide a trouble light to indicate when batteries are manually placed on a high rate of charge as part of the unit assembly if a high rate switch is provided. House charger in the control panel.

8.3.2.2 Component Design

a) Control Panel

Control Panel shall comply with the applicable requirements of UL 864. Provide modular type panel installed in a surface mounted steel cabinet with hinged door and cylinder lock. Mount with panel centerline 1.5 m above finished floor elevation. Switches and other controls shall not be accessible without the use of a key. The control panel shall be a neat, compact assembly containing all parts and equipment required to provide specified operating and supervisory functions of the system. Each control panel component shall be UL listed or FM approved and approved by the control panel manufacturer for use in the control panel. Panel cabinet shall be finished on the inside and outside with factory-applied enamel finish. Provide main annunciator located on the exterior of the cabinet door or visible through the cabinet door. Provide audible trouble signal. Provide permanent engraved rigid plastic or metal identification plates, or silk screened labels attached to the rear face of the panel viewing window, for all lamps and switches. Provide panel with the following switches:

- 1) Trouble silencing switch which silences audible trouble signals without extinguishing trouble indicating lamps. For non-self-resetting type switch,

upon correction of the trouble condition, audible signals will again sound until the switch is returned to its normal position. For silencing switch of the momentary action, self resetting type, the trouble signal circuit shall be automatically restored to normal upon correction of the trouble condition.

- 2) Evacuation alarm silencing switch which when activated will silence all alarm notification devices without resetting the panel, and cause operation of system trouble signals. Subsequent alarms from additional zones not originally in alarm shall cause activation of the notification devices even with the alarm silencing switch in the "silenced" position.
- 3) Individual zone disconnect switches which when operated will disable only their respective initiating circuit and cause operation of the system and zone trouble signals.
- 4) Reset switch which when activated will restore the system to normal standby status after the cause of the alarm has been corrected, and all activated initiating devices reset. Operation of reset switch shall restore activated smoke detectors to normal standby status.
- 5) Lamp test switch.
- 6) Drill switch which will enable test of notification devices and restoration to normal.

b) Graphic Annunciator Panel

Provide panel located as shown. Mount with panel centerline 1.5 m above finished floor elevation. Panel shall be of the interior type, surface-mounted. Panel shall be provided with the building floor plan, drawn to scale, with alarm lamps mounted to represent the location of each initiating device. Panel graphic shall also show the locations of the control panel, and shall have a "you are here" arrow showing its location. Orient building floor plan on graphic to location of person viewing the graphic, i.e. the direction the viewer is facing shall be toward the top of the graphic display. Provide a North arrow. Lamps shall illuminate upon activation of corresponding device and shall remain illuminated until the system is reset. Panel shall have a lamp test switch.

c) Manual Pull Stations

Provide non-coded single action type with mechanical reset features. Stations shall be surface semi-flush mounted and interior type as indicated. For surface mounting provide station manufacturer's approved back box. Back box finish shall match station finish. Equip each station with a terminal strip with contacts of proper number and type to perform functions required. Stations shall be a type not subject to operation by jarring or vibration. Break-glass-front stations are not permitted; however, a pull-lever break-rod type is acceptable provided presence of rod is not required to reset station. Station color shall be red. Station shall provide visible indication of operation. Restoration shall require use of a key. Keys shall be identical throughout the system for all stations and control panel. Mount stations with operating lever not more than 1.2 m above finished floor.

d) Heat Detectors

Provide detectors designed for detection of fire by combination fixed temperature rate-of-rise principle. Locate detectors in accordance with their listing by UL or FM and the requirements of NFPA 72, except provide at least two detectors in all rooms of 54 square meters or larger in area. For mounting heights greater than 3 m above floor level, reduce actual detector linear spacing from listed spacing as required by NFPA 72; heat detector spacing shall be rated in accordance with UL 521. Temperature rating of detectors shall be in accordance with NFPA 72. No detector shall be located closer than 300 mm to any part of any lighting fixture nor closer than 600 mm to any part of an air supply or return diffuser. Provide with terminal screw type connections. Removal of detector head from its base shall cause activation of system trouble signals if detectors are provided with separable heads and bases.

1) Combination Fixed Temperature Rate of Rise Detectors

Designed for surface outlet box mounting and supported independently of conduit, tubing or wiring connections. Contacts shall be self resetting after response to rate of rise actuation. Operation under fixed temperature actuation shall result in an external indication.

e) Smoke Detectors

Provide smoke detector in accordance with NFPA 101, Life Safety Code. Provide detectors designed for detection of abnormal smoke densities by the photoelectric principle. Detectors shall be 4-wire type. Provide necessary control and power modules required for operation integral with the control panel. Detectors and associated modules shall be compatible with the control panel and shall be suitable for use in a supervised circuit. Malfunction of the electrical circuits to the detector or its control or power units shall result in the operation of the system trouble signals. Each detector shall contain a visible indicator lamp that shall flash when the detector is in the normal standby mode and shall glow continuously when the detector is activated. Each detector shall be the plug-in type with tab-lock or twist-lock, quick disconnect head and separate base in which the detector base contains screw terminals for making all wiring connections. Detector head shall be removable from its base without disconnecting any wires. Removal of detector head from its base shall cause activation of system trouble signals. Each detector shall be screened to prevent the entrance of insects into the detection chambers.

1) 4-Wire Smoke Detectors

Detector circuits shall be of the 4-wire type whereby the detector operating power is transmitted over conductors separate from the initiating circuit. Provide a separate, fused, power circuit for each smoke detection initiating circuit (zone). Failure of the power circuit shall be indicated as a trouble condition on the corresponding initiating circuit.

2) Photoelectric Detectors

Operate on the light scattering principle using a LED light source. Detector shall respond to both flaming and smoldering fires. Detectors shall be factory set for sensitivity and shall require no field adjustments of any kind. Detectors shall have an obscuration rating in accordance with UL 268.

3) Detector Spacing and Location

Detector spacing and location shall be in accordance with the manufacturer's recommendations and the requirements of NFPA 72, except provide at least two detectors in all rooms of 54 square meters or larger in area. In no case shall spacing exceed 9 by 9 m per detector, and 9 linear m per detector along corridors. Detectors shall not be placed closer than 0.9 m from any air discharge or return grille, nor closer than 300 mm to any part of any lighting fixture.

f) Notification Devices

Provide in accordance with NFPA 72 and as indicated. Do not exceed 80 percent of the listed rating in amperes of any notification device circuit. Additional circuits above those shown shall be provided if required to meet this requirement. Effective sound levels shall comply with NFPA 72. Provide devices in addition to those shown if required in order to meet NFPA 72 sound level requirements.

1) Alarm Horns

Surface-mounted vibrating type suitable for use in an electrically supervised circuit and shall have a sound output rating of at least 90 decibels at 3 m, when tested in accordance with UL 464 while emitting a slow whoop tone.

2) Visible Devices

Surface-mounted assembly of the stroboscopic type suitable for use in an electrically supervised circuit and powered from the notification device circuits. Devices shall provide a minimum of 75 candela measured in accordance with UL 1971, but in no case less than the effective intensity required by NFPA 72 for the device spacing and location shown. Lamps shall be protected by a thermoplastic lens and labeled "FIRE" in letters at least 12 mm high. Provide visible devices within 300 mm of each audible appliance and as indicated. Visible devices may be part of an audio-visual assembly. Where more than two devices are located in the same room or corridor, provide synchronized operation.

g) Conduit

1) Intermediate Metal Conduit (IMC)

UL 1242, zinc-coated steel only.

a) Outlet Boxes

UL 514A, zinc-coated steel.

b) Fittings for Conduit and Outlet Boxes

UL 514B, zinc-coated steel.

c) Wiring

NFPA 70, PEC and NFPA 72. Wire for 240V circuits shall be 3.5 mm² minimum copper conductor. Wire for low voltage DC circuits shall be 2.0 mm² minimum copper conductor. Insulation shall be 75 degree C minimum with nylon jacket. Color code all wiring.

8.3.3 EXECUTION

8.3.3.1 Installation

Installation shall be in accordance with the requirements of NFPA 70, PEC NFPA 72 and NFPA 90A. Each conductor used for the same specific function shall be distinctively color coded. Each function color code shall remain consistent throughout the system. Use colors as directed by the Engineer. All wiring shall be in steel conduit. All circuit conductors shall be identified within each enclosure where a tap, splice or termination is made. Conductor identification shall be by plastic coated self sticking printed markers. The markers shall be attached in a manner that will not permit accidental detachment. Control circuit terminations shall be properly identified. Wire devices so that their removal will activate system trouble signals. Pigtail or "T" tap connections are prohibited. Wiring for DC circuits shall not be permitted in the same conduit or tubing as wiring for AC circuits. Paint all junction box covers red or provide them with permanent labels reading "FIRE ALARM CIRCUIT." Provide a written schedule of conductor markings identifying each wire marker, the purpose, the origin, and termination point of each conductor. The conductor wire marker schedule shall be turned over to the Engineer at the time of preliminary testing with as built drawings.

a) Additional Installation Requirements

Pull all conductors splice free. Make all conductor connections under screw terminals. Provide insulated barrier type terminal strips at junction points. Use of wire nuts, crimped connectors, or twisting of conductors is prohibited. All control panels shall be dressed out in a professional manner with all wires running in the vertical or horizontal plane, cut to exact length, making all turns at 90 degree angles, and tightly bundled and wire wrapped. Conduit may not enter the top of control panel cabinet.

8.3.3.2 Field Quality Control

a) Preliminary Testing

Notify Engineer prior to performing preliminary testing. Contractor shall conduct the following tests during installation of wiring and system components. Any deficiency pertaining to these requirements shall be

corrected by the Contractor prior to final acceptance testing of the system. Record results of testing. Submit all test results to the Engineer.

- 1) Operation of Entire System. Operate all initiating and indicating devices.
- 2) Operation of Supervisory Systems: Operate all portions to demonstrate correctness of installation.
- 3) Smoke Detector Test: Clean the smoke detectors in accordance with the manufacturer's recommended procedures. Test smoke detectors using magnet-activated test switch, manufacturer-provided test card, or smoke. Use of aerosol sprays to test smoke detectors is prohibited.
- 4) Duct Detector Differential Pressure Test: Measure and record the observed differential pressure between sampling tubes with completed HVAC system operating normally to verify airflow requirements through detector housing. Perform test on smoke detector heads as specified above for smoke detectors.

b) Final Acceptance Testing

The Contractor shall notify the Engineer when the system is ready for final acceptance testing. Request scheduling for final acceptance testing only after all necessary preliminary tests have been made and all deficiencies found have been corrected to the satisfaction of the equipment manufacturer's technical representative and the Engineer and written certification to this effect has been received by the Fire Protection Engineer. The system shall be in service at least 15 calendar days prior to final acceptance testing. The Contractor shall allow at least 15 calendar days between the date final testing is requested and the date the final acceptance testing takes place. The Contractor shall furnish all equipment, instruments, devices and personnel for this test. The system shall be tested for approval in the presence of representatives of the manufacturer, the Engineer, and the Fire Protection Engineer. All necessary tests shall be made including the following, and any deficiency found shall be corrected and the system retested.

1) Entire System

Test the entire system by operating all fire alarm initiating, notification, and signaling devices. Perform tests with the system operating on primary power and repeat the test with the system operating on battery power only. Provide necessary equipment to test smoke detectors and heat detectors.

2) Supervisory Systems

All aspects of the supervisory functions of the systems shall be operated. Introduce faults in each circuit at random locations as directed by the Fire Protection Engineer. Verify proper trouble annunciation at the control panel.

3) Additional Tests

When deficiencies, defects or malfunctions develop during the tests required, all further testing of the system shall be suspended until proper adjustments, corrections or revisions have been made to assure proper performance of the system. If these revisions require more than a nominal delay, the Engineer shall be notified when the additional work has been completed, to arrange a new inspection and test of the fire alarm system. All tests required shall be repeated prior to final acceptance, unless directed otherwise.

8.4 PUBLIC ADDRESS SYSTEM

8.4.1 GENERAL

Section 7.1 Electrical General Requirements, applies to this section, with the additions and modifications specified herein.

8.4.1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only. The edition or the revised version of such codes and standards current at the date twenty eight (28) days prior to date of bid submission shall apply. During Contract execution, any changes in such codes and standards shall be applied after approval by the Owner.

a) Electronic Industries Alliance (EIA)

EIA ANSI/EIA-310-D (1992) Racks, Panels, and Associated Equipment

a) Institute Of Electrical And Electronics Engineers (IEEE)

IEEE C62.41 (1991; R 1995) Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits

b) National Fire Protection Association (NFPA)

NFPA 70 (2007) National Electrical Code

NFPA 72 (2002) National Fire Alarm Code

c) Underwriters Laboratories (UL)

UL 1449 (2006) Transient Voltage Surge Suppressors

8.4.1.2 Submittals

The following shall be submitted.

a) Shop Drawings

1) Detail Drawings

Detail drawings as specified.

b) Product Data

1) Spare Parts

Spare parts data for each different item of material and equipment specified.

c) Test Reports

1) Approved Test Procedures

Test plan and test procedures for the acceptance tests. The test plan and test procedures shall explain in detail, step by step actions and expected results to demonstrate compliance with the requirements specified. The procedure shall also explain methods for simulating the necessary conditions of operation to demonstrate system performance.

2) Acceptance Tests

Test reports in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports shall include the manufacturer, model number, and serial number of test equipment used in each test. Each report shall indicate the final position of controls and operating mode of the system.

d) Certificates

1) Components

Copies of current approvals or listings issued by UL, or other nationally recognized testing laboratory for all components.

e) Operation and Maintenance Data

1) Public Address System

8.4.1.3 System Description

The public address system shall consist of an audio distribution network to include amplifiers, mixers, microphones, speakers, cabling, and ancillary components required to meet the required system configuration and operation.

a) Multi-Channel System with Paging

The system shall include microphones, microphone outlet receptacles, microphone inputs with preamplifiers, inputs for sound sources, channel paging, control for each input, power amplifying equipment, and accessories required to output the public address and paging audio signals through selected portions of the audio distribution network as indicated. The paging signal shall replace by zones channel of the radio system output, when the paging function is activated.

b) System Performance

The system shall provide even sound distribution throughout the designated area, plus or minus 3 dB for the 1/1 octave band centered at 4000 Hz. The system shall provide uniform frequency response throughout the designated area, plus or minus 3 dB as measured with 1/3-octave bands of pink noise at locations across the designated area selected by the Engineer. The system shall be capable of delivering 75 dB average program level with additional 10 dB peaking margin sound pressure level (SPL) in the area at an acoustic distortion level below 5 percent total harmonic distortion (THD). Unless otherwise specified the sound pressure reference level is 20 micro Pascal (0.00002 Newtons per square meter).

c) Detail Drawings

The Contractor shall submit detail drawings consisting of a complete list of equipment and material, including manufacturer's descriptive and technical literature, performance charts and curves, catalog cuts, and installation instructions. Note that the contract drawings show layouts based on typical speakers. The Contractor shall check the layout based on the actual speakers to be installed and make necessary revisions in the detail drawings. Detail drawings shall also contain complete point to point wiring, schematic diagrams and other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout of equipment and appurtenances, and equipment relationship to other parts of the work including clearances for maintenance and operation.

d) Spare Parts

The Contractor shall submit spare parts data for each different item of material and equipment specified. The data shall include a complete list of parts and supplies, with current unit prices and source of supply.

8.4.1.4 Delivery and Storage

Equipment placed in storage until installation shall be stored with protection from the weather, humidity and temperature variations, dirt and dust, and other contaminants.

8.4.1.5 Verification of Dimensions

The Contractor shall become familiar with the details of the work and working conditions, shall verify dimensions in the field, and shall advise the Engineers of any discrepancies before performing the work.

8.4.2 MATERIAL REQUIREMENTS

8.4.2.1 Standard Products

Material and equipment to be provided shall be the standard products of a manufacturer regularly engaged in the manufacture of such products, and shall essentially duplicate material and equipment that have been in satisfactory use at least 2 years. All components used in the system shall be commercial designs that comply with the requirements specified.

a) Identical Items

Items of the same classification shall be identical. This requirement includes equipment, modules, assemblies, parts, and components.

b) Nameplates

Each major component of equipment shall have the manufacturer's name, address, model and catalog number, and serial number on a plate secured to the equipment.

8.4.2.2 Mixer-Preamplifier

Mixer-preamplifier shall as a minimum conform to the following specifications:

Rated Output: 18 dB

Frequency Response: Plus or Minus 1 dB, 20 - 20,000 Hz

Distortion: Less than 0.5 percent, 20 - 20,000 Hz

Signal to noise:	Microphone	-	60 dB
	Aux	-	70 dB

Inputs: 5-independent balanced low-impedance transformer-isolated

Input Sensitivity	Microphone	-	0.003 volts
	Aux	-	0.125 volts
	Magnetic Cartridge	-	0.0005 volts

Input Channel Isolation: 80 dB minimum

Tone Controls: Plus or Minus 10 dB range at 50 and 15,000 Hz

Power Requirement: 220-240 Vac 60 Hz

8.4.2.3 Power Amplifiers

The power amplifier shall be provide with a nameplate indicating power rating to satisfy design, coverage, SPL requirements and reserve capacity requirements. Listed for Protective Signal Service and supervised in accordance with NFPA 72.

Power amplifiers as a minimum conform to the following specifications:

Rated power output:	250 watts RMS
Frequency Response:	Plus or Minus 3 dB, 20-20,000 Hz
Distortion:	Less than 2 percent at RPO, 600-13,000 Hz
Input Impedance:	50 k ohm unbalanced
Output Impedance:	Balanced 4 and 8 ohms
Output voltage:	25 and 70.7 volts
Power Requirement:	220-240 Vac 60 Hz

8.4.2.4 Mixer Amplifier

Mixer amplifier shall as a minimum conform to the following specifications:

Rated Power Output (RPO):	125 watts RMS
Frequency Response:	Plus or Minus 3 dB, 20-20,000 Hz
Distortion:	Less than 1% at RPO, 60 - 13,000 Hz
Inputs:	2 microphones (high impedance or Low -impedance unbalanced 2 Aux. (high-impedance)
Output Impedance:	Balanced 4 and 8 ohms
Output Voltage:	25 and 70.7 volts
Power Requirement:	110-125 Vac 60 Hz

8.4.2.5 Microphone Input Modules

Microphone input modules shall as a minimum conform to the following specifications:

Rated Outputs:	0.25 volts into 10,000 ohms 1.0 volts into 10,000 ohms
Frequency Response:	Plus or Minus 2 dB, 20 - 20,000 Hz
Distortion:	Less than 0.5 percent 20 - 20,000 Hz
Inputs:	4 transformer - coupled balanced 150 ohm
Input Sensitivity:	0.003 volts
Input Channel Isolation:	70 dB minimum

8.4.2.6 Microphones

a) Desk Microphone

Microphones shall as a minimum conform to the following specifications:

Element:	Dynamic
Pattern:	Cardioid (Unidirectional)
Frequency Response:	50 - 12,000 Hz
Impedance:	Low impedance mic (150-400 ohms)
Front to back Ratio:	20 dB

b) Gooseneck Microphone

Gooseneck microphone shall meet the minimum requirements of the desk microphone. Microphone shall have push to talk button. Gooseneck tube length shall be 300 mm.

c) Microphone Jack

Each outlet for microphones shall consist of a standard outlet box, flush-mounted, and fitted with a three-pole, polarized, locking-type, female microphone jack and a corrosion resistant-steel device plate.

8.4.2.7 Loudspeakers

a) Cone Speaker

The cone speaker shall as a minimum conform to the following specifications:

Application:	Ceiling
Frequency range:	60 to 12,000 Hz
Power Rating:	Normal- 7 watts Peak - 10 watts
Voice Coil Impedance:	8 ohms
Line Matching Transformer Type:	25/ 70.7 volt line
Capacity:	4 watts
Magnet:	10 ounces or greater
Primary Taps:	0.5, 1, 2 and 4 watts

Primary Impedance:	25 volts - 1250, 625, and 312 ohms 70.7 volts - 10k, 5k, and 2.5k ohms
Frequency Response:	30 - 20,000 Hz
Insertion Loss:	Less than 1 dB

b) Ceiling Speaker Enclosures

Ceiling speaker enclosure shall be constructed of heavy gauge cold steel with interior undercoating and 40 mm thick high density fiberglass 24 kg/cu. m. The unit shall be round and designed for recessed installations which will be accomplished via standard screw mounting. Enclosure shall include four triple compound conduit knockouts.

8.4.2.8 Speaker Switching Panel

a) Selector Switches

Zone control shall be provided for the paging function. The speaker switching panel shall contain at least double-pole push button selector switches and shall be desk mounted to activate priority relays. Selector switches labeling shall be provided to identify the zones.

b) System Power supply

Power supply shall be provided for priority relays and controls, rack-mounted and sized for a capacity equal to 200 percent of the as-built control system, and shall operate at 24 Vdc. Input and output shall be protected to permit Class 2 wiring in accordance with NFPA 70.

8.4.2.9 Priority Relays and Controls

Priority relays and controls required to accomplish operations specified shall be provided. Relays shall be completely enclosed with a plastic dust cover for maximum protection against foreign matter, and shall be plug-in type. Relays shall be provided with a diode wired across the relay coil for transient suppression and shall be installed utilizing factory prewired, rack mounted receptacle strips. Coil shall be maximum 24 volts dc.

8.4.2.10 Equipment Racks

Equipment shall be mounted on 500 mm racks in accordance with ECIA EIA/ECA 310-E and located as shown on drawings. Ventilated rear panels, solid side panels, and solid top panels shall be provided. Equipment racks shall be provided with lockable front panels that limit access to equipment. The lockable front shall not cover items that require operator access such as am/fm tuner or CD player. Rack cooling shall be through perforations or louvers in front panels to ensure adequate ventilation of equipment. The racks and panels shall be factory finished with a uniform baked enamel over rust inhibiting primer.

8.4.2.11 Cables

a) Speaker Cable

Cables shall be of the gauge required depending upon the cable run length. In no case shall cable be used which is smaller than 18 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.2 mm. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.5 mm minimum.

b) Microphone Cable

Cable conductor shall be stranded copper 20 AWG. Insulation on the conductors shall be polyvinyl chloride (PVC) or an equivalent synthetic thermoplastic not less than 0.2 mm. Cable shall be shielded 100 percent of aluminum polyester foil with a bare 22 gauge stranded soft copper drain conductor. Cables shall be jacketed with a PVC compound. The jacket thickness shall be 0.5 mm minimum.

c) Antenna Cable

Antenna coaxial cable shall have 75 ohm plus or minus 2 ohm. Attenuation of the coaxial cable span between the antenna and amplifier shall not exceed 2.5 dB at 108 MHz.

8.4.2.12 Terminals

Terminals shall be solderless, tool-crimped pressure type.

8.4.3 EXECUTION

8.4.3.1 Installation

Equipment shall be installed as indicated and specified, and in accordance with the manufacturer's recommendations except where otherwise indicated. Equipment mounted out of doors or subject to inclement conditions shall be weatherproofed. The antenna shall be supported at least 1.5 m clear above the roof by means of self supported or guyed mast.

a) Equipment Racks

Mount racks side-by-side and bolt together. Group items of the same function together, either vertically or side-by-side. Arrange controls symmetrically at a height as indicated. Make audio input and interconnections with approved shielded cable and plug connectors; output connections may be screw terminal type. All connections to power supplies shall utilize standard male plug and female receptacle connectors with the female receptacle being the source side of the connection. Inputs, outputs, interconnections, test points, and relays shall be accessible at the rear of the equipment rack for maintenance and testing. Each item shall be removable from the rack without disturbing other items or connections. Empty space in equipment racks shall be covered by blank panels so that the entire front of the rack is occupied by panels.

b) Wiring

Wiring shall be installed in rigid steel conduit, intermediate metal conduit, cable trays, or electric metallic tubing as specified in Section 7.5 INTERIOR WIRING SYSTEM. Wiring for microphone, grounding, line level, speaker and power cables shall be isolated from each other by physical isolation and metallic shielding. Shielding shall be terminated at only one end.

8.4.3.2 Grounding

All grounding practices shall comply with NFPA 70. Equipment shall be grounded to the serving panelboard ground bus through a green grounding conductor. Metallic conduits serving the equipment shall be isolated on the equipment end with an insulating bushing to prevent noise from being transferred to the circuit. Equipment racks shall be grounded to the panelboard ground bus utilizing a #8 conductor. Grounding conductor shall be terminated to the rack using connector suitable for that purpose.

8.4.3.3 Acceptance Tests

Submit test reports in booklet form showing all field tests performed to adjust each component and to prove compliance with the specified performance criteria, upon completion and testing of the installed system. The reports shall include the manufacturer, model number, and serial number of test equipment used in each test. Each report shall indicate the final position of controls and operating mode of the system. After installation has been completed, conduct acceptance tests, utilizing the approved test procedures, to demonstrate that equipment operates in accordance with specification requirements. The acceptance tests shall include originating and receiving messages at specified stations, at proper volume levels, without cross talk or noise from other links or non-designated units.

8.4.3.4 Training

The Contractor shall conduct a training course for 2 members of the operating and maintenance staff as designated by the Engineer. The training course will be given at the installation during normal working hours for a total of 2 hours and shall start after the system is functionally complete but prior to final acceptance tests. The field instructions shall cover all of the items contained in the approved operating and maintenance manuals, as well as demonstrations of routine maintenance operations. The Engineer shall be notified at least 14 days prior to the start of the training course.

DIVISION 9 MECHANICAL WORKS

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9.1 MECHANICAL GENERAL REQUIREMENT

9.1.1 GENERAL

This section applies to all sections of Division 9, "MECHANICAL WORKS" except where specified in each individual section.

9.1.1.1 Work Description

The work shall include the furnishing of equipment, materials, tools, scaffoldings, transportation, labor, supervision, and other services required to install, complete, test and make operational the whole system as described on the Drawings and the Technical Specifications.

Specifically the work shall involve the following:

- a) To supply, haul, install, wire and make operational the split type packaged/window type air conditioning units including exhaust fans for toilets and kitchen areas as shown on the Drawings.
- b) To supply and install the refrigerant piping system and condensate drain lines including necessary insulation and hangers.
- c) To supply and install the electrical wiring connections from the supply outlet provided by the Electrical Contractor which is located close to the point of installation. This shall include power and control wirings and interlocks with the thermostat control.

9.1.1.2 Submittals

Submit shop drawings, manufacturer's data and certificates for equipment, materials, and finish, and pertinent details for each system where specified in each individual section, and obtain approval before procurement, fabrication, or delivery of the items to the job site. Partial submittals are not acceptable and will be returned without review. Submittals shall include the manufacturer's name, trade name, catalog model, or number, nameplate data, size, layout dimensions, capacity, project specification and paragraph reference, applicable industry, and technical society publication references, years of satisfactory service, and other information necessary