PROJECT SPECIFICATIONS

I. GENERAL CONDITIONS

The work to be undertaken shall include the furnishing of labor, materials, tools and equipment for the following:

Project : **PROVISION OF FLOOD CONTROL SYSTEM AND REHABILITAITON OF DRIVING RANGE AND NETTING (PERIMETER DRAINAGE AT FAIRWAY)**
Location : CIGC, Intramuros Manila

A. Scope of Work

The construction work must be executed strictly in accordance with the plans and specifications. The following principal items of work shall include but not limited to the following:

1.	Item A.1.1(8)	:	Provision of Field Office for the Engineers (Rental Basis)
2.	Item B.3	:	Permits and Clearances
3.	Item B.5(1)	:	TIEZA Project Billboard
4.	Item B.5(2)	:	COA Billboard Construction of Bridge
5.	Item B.7(2)	:	Occupational Safety and Health
6.	Item B.9	:	Mobilization / Demobilization
7.	Item B.20	:	Temporary Fence
8.	Item 101(3)b3	:	Removal of Sidewalk (100mm thk)
9.	Item 103(1)a	:	Structure Excavation (Common Soil)
10.	Item 201(1)	:	Aggregate Sub Base Course
11.	Item 404(1)a	:	Reinforcing Steel, Grade 40
12.	Item 405(1)a3	:	Structural Concrete, Class "A", 28 Days
13.	Item 407(8)	:	Lean Concrete, Class B, 16.5 Mpa
14.	Item 500(1)b3	:	Pipe Culvert 910mm Ø (Class IV)
15.	Item 500(3)a	:	Lined Canal, Rectangular CHB
16.	Item 502(1)a3	:	Manholes, 910mm Ø (Concrete)
17.	Item 601(1)	:	Sidewalk (100 mm thk.)
18.	Item 807	:	Site Development
19.	Item 800(1)	:	Clearing and Grubbing
20.	Item 803(1)a	:	Structure Excavation (Common Soil)
21.	Item 804(1)b	:	Embankment from Common Borrow
22.	Item 804(4)	:	Gravel Fill
23.	Item 900(1)b1	:	Structural Concrete (Class A, 4000 Psi @ 14 Days)
24.	Item 901(1)	:	Lean Concrete (Ready Mix 28 Days)
25.	Item 902(1)a	:	Reinforcing Steel (Deformed), Grade 40
26.	Item 903(2)	:	Formworks and Falseworks
27.	Item 1000(1)	:	Soil Poisoning
28.	Item 1052(6)	:	Structural Steel Sheet Piles, Furnised (New)
29.	Item 1052(12)	:	Structural Steel Sheet Piles, Driven

30.	Item 1100(10)	:	Conduits, Boxes & Fittings (Conduit Works/Conduit Rough-in
31.	Item 1101(33)	:	Wires and Wiring Devices
32.	Item 1201(4)	:	Submersible Sump Pump with Controls
33.	Item 1600(3)	:	Dewatering
34.	Item 1726(1)	:	Motor Control Center (For Main pumps and Facilities)
35.	Item 1727(4)b	:	Trash Screen Rake Complete with Accessories Ready for Service
36.	Item 1727(5)	:	Flood Gate Complete with Accessories Ready for Service

The construction procedures shall be done in accordance with the DPWH Standard Specifications, and in full compliance with the approved plans and specifications.

All items not specifically mentioned in the specifications or noted on the plans but which are obviously necessary for the completion of the work shall be included.

II. ITEM A.1.1 FIELD OFFICE, LABORATORIES AND LIVING QUARTERS

The Contractor shall construct field offices, laboratories and living quarters, including all the necessary air conditioning, electricity, water, drainage and security services for the use of the Engineer and his staff for 24 h a day or provide the same on a rental basis until end of Contract. All offices, laboratories and living quarters shall be ready for occupancy and use by the Engineer immediately for rental basis; or if to be constructed within 3 months upon the commencement of the Works. Their location and final plan shall require the approval of the Engineer prior to the start of construction.

It is the intent of this Specification to locate the field offices, laboratories and living quarters in Government owned lots so that the use by the Government of these facilities can be maximized even after the completion of the project. In the selection of construction site of the Engineer's Building/s and Recreational Facilities, first priority shall be on DPWH property lots, second is public school lots, third is public health lots, fourth is Local Government Unit (LGU) lots, and then other government property lots. The proximity, access road and cost of development of the proposed site shall be properly evaluated. The construction of building/s and recreational facilities on property other than DPWH-owned shall be covered by an approved Memorandum of Agreement (MOA) between the concerned parties. The Implementing Office shall be allowed to use the other government lots for the construction of the field offices, laboratories and living quarters free of charge until the completion of the project and shall be turned over without cost, effective after completion or acceptance of the project from the Contractor. The transfer/turnover shall be supported by applicable document and shall be a requirement to support the issuance of project Completion Certificate of the Contractor.

If no Government lot is available, and these structures are to be erected on private property, it is the responsibility of the Contractor to make the necessary arrangements for the negotiation with the property owner for the lease/rental of the lot. The field office shall display an appropriate sign that identifies the DPWH facility to the public in locating it. The field offices, laboratories, and living quarters, the improvements thereon, including appurtenances shall be removed or transferred if so required in the Contract upon completion of the project.

All facilities provided by the Contractor shall be within the 5 km radius or preferably near the job site, where necessary and shall conform to the best standard for the required types. On completion of the Contract, the facilities provided by the Contractor including utilities shall

revert to the Government including office equipment, apparatus, pieces of furniture, laboratory equipment, etc. unless otherwise specified in the Contract documents.

The Contractor shall be responsible for raising the ground (if necessary), grading and drainage in the vicinity of each facility with suitable access walkways, seeding and sodding of the ground around as directed and approved by the Engineer. Also, the Contractor shall construct a parking area for the compound near the buildings and a satisfactory access road to the parking areas. The whole area of the Engineer's compound shall be fenced with barbed wire (or equivalent) with necessary gates as directed by the Engineer.

III. ITEM B.3 PERMITS AND CLEARANCES

B.3.1 General Requirements

The concerned DPWH Implementing Office (central, regional, district, project management office) shall be responsible for securing all necessary permits and clearances related to the project, which shall include but not limited to building permits, occupancy permit, excavation permit, locational clearances and environmental compliance certificate, etc. Contractors All Risk Insurance & Third Party Liability and Workman's Compensation Insurance (CARI), and other insurances required by the Local Government Unit (LGU) among others, including payment of assessed fees as may be required by the LGU and/or Regulating Agencies before the implementation of the project. However, for projects implemented by DPWH but owned by other agencies, the owner shall secure all the necessary permits and clearances.

All heads of Regional/District/Project Management Offices of the DPWH are enjoined to review, and fully familiarize themselves with, the requirements of and procedures for application for Building Permits pursuant to Rules I and II of the Implementing Rules and Regulations of the National Building Code, such as conformity to local land use plan and zoning and ownership of the building site. Public buildings and traditional indigenous family dwelling shall be exempt from payment of building permit fees.

B.3.2 Method of Measurement

Permits and Clearances shall be measured by lump sum.

B.3.3 Basis of Payment

The accepted quantities, measured as provided in Section B.3.2, Method of Measurement shall be paid for at the Contract Unit Price of the Pay Item listed below that is included in the Bill of Quantities. The unit price shall cover full compensation for all related services necessary to complete the Item.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
B.3	Permits and Clearances	Lump Sum

IV. ITEM B.5 PROJECT BILLBOARD / SIGNBOARD

B.5.1 General Requirements

The Contractor shall install two (2) Project Information Signs at/or near the beginning and the end of the project or upon the discretion of the Engineer.

The signs are prescribed separately by the department of Public Works and Highways (DPWH) for government Infrastructure projects to inform the public of the implementation of the project and to advise the road users of the on going construction.

The new billboard design layout, dimension and letter sizes on white background, shall be depicted on a standard billboard measuring 1,220 mm x 2,440 mm using 12.50 mm thick marine plywood or tarpaulin of the same size posted on 5 mm marine plywood. For each building project, the billboard shall be installed in front of the project site. For each road/bridge/flood control project, two billboards shall be installed, one (1) at the beginning and one (1) at the end of the project.

For road projects with a length of 10 km or more, additional billboard shall also be installed at every five (5) km interval. Name(s) and/or picture(s) of any personages should not appear in the billboard.

No other billboards shall be allowed to be installed 100 m before and 100 m after all DPWH projects and in-between the project limits or within the road right-of-way. DPWH contractors shall not be allowed to place names of politicians or carry political billboard on their equipment.

The Contractor shall also install one (1) Billboard as per COA Circular No. 2013-004, Information and Publicity on Programs/Projects/Activities of Government Agencies.

Upon completion of the work, all signs installed shall be removed from the site.

B.5.2 Method of Measurement

All expenses incurred in the furnishing/installation/illumination of the signs shall be paid for each billboard installed.

B.5.3 Basis of Payment

The accepted quantities, measured as provided in Section B.5.2, Method of Measurement shall be paid for at the Contract Unit Price of the Pay Item listed below that is included in the Bill of Quantities. The unit price shall cover full compensation for all related services necessary to complete the Item.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
B.5	Project Billboard/Signboard	Each

V. ITEM B.7 OCCUPATIONAL SAFETY AND HEALTH

B.7.1 Description

This Item covers the implementation of construction safety in all stages of project procurement (design, estimate, construction and maintenance), requirements, provisions, and instructions for the guidance of the Engineer.

B.7.2 Construction Safety and Health Program (CSHP)

Every construction project shall have a suitable and approved Construction Safety and Health Program (CSHP) as required in all projects regardless of amount, funding source and mode of implementation which shall comply with the minimum safety and health requirements as specified in the Occupational Safety and Health Standards.

The required CSHP shall include but not limited to the following:

1. Composition of the Safety and Health personnel responsible for the proper implementation of CSHP.

2. Specific safety policies which shall be undertaken in the construction site, including frequency of and persons responsible for conducting toolbox and gang meetings.

3. Penalties and sanctions for violations of the CSHP.

4. Frequency, content and persons responsible for orienting, instructing and training all workers at the site with regard to the CSHP which they operate.

5. The manner of disposing waste arising from the construction.

B.7.3. Construction Safety and Health Personnel

At the start of the project, the Contractor shall establish construction safety and health committee composed of the following personnel:

1. Project Manager/Project Engineer

The Contractor must provide for a full time Project Manager/Project Engineer, who is tasked to observe, monitor and supervise if the enforcement of CSHP was being followed strictly and correctly.

2. General Safety Engineer/Officer

The General Contractor (under which are a number of subcontractors) must provide for a full time Officer, who shall be assigned as the CSHP to oversee and enforce full time the overall management of the CSHP. Furthermore, deployment of part-time or full-time safety man depending on the number of workers shall be complied in accordance with Rule 1033 of the Occupational Safety and Health Standards (OSHS) and applicable provisions under 26 Section 7.0, Safety Personnel of Department of Labor and Employment (DOLE) Department Order D.O.) 13 Series of 1998.

3. Health Personnel

The Contractor’s health personnel may be full time or part time certified first aider, registered nurse, physician and dentist depending on the total number of workers conforms to Section 8.0, Emergency Occupational Health Personnel and Facilities or DOLE D.O. 13, Series of 1998.

4. Safety Practitioner

The Contractor must provide a full time or part time Safety Practitioner, who shall initiate and supervise safety and health training for employees.

B.7.4 Supervision, Control and Monitoring

Overall supervision, control and monitoring of the implementation of CSHP for projects undertaken by administration/contracts shall be under the Implementing Office.

B.7.5 Construction Safety and Health Training

The Construction Safety and Health Seminar (COSH) shall be a 40 h training course as prescribed by the DOLE-Bureau of Working Conditions (BWC). All safety personnel involved in a construction project shall be required to complete such basic training course.

The Contractor shall provide continuing construction safety and health training to all technical personnel under his organization. Continuing training shall be a minimum of 16 h per year for every full-time safety personnel.

B.7.6 Construction Safety and Health Reports

The Contractor shall be required to submit a monthly construction safety and health report to the DOLE Regional Office concerned. The report shall include a monthly summary of all safety and health committee meeting agreements, a summary of all accident investigations/reports and periodic hazards assessment with the corresponding remedial measures/action for each hazard.

In case of any dangerous occurrence or major accident resulting in death or permanent total disability, the concerned employer shall initially notify the DOLE Regional Office within 24 h from occurrence. After the conduct of investigation by the concerned construction safety and health officer, the employer shall report all permanent total disabilities to DOLE Regional Office on or before the 20th of the month following the date of occurrence of accident using the DOLE Employer's Work Accident Illness Report.

B.7.7 Personal Protective Equipment (PPE) and Devices

The Contractor shall furnish his workers with protective equipment for eyes, face, hands and feet, lifeline, safety belt/harness, protective shields and 27 barriers whenever necessary by reason of the hazardous work process or environment, chemical or radiological or other mechanical irritants of hazards capable of causing injury or impairment in the function of any part of the body through absorption, inhalation or physical agent.

All PPE and Devices shall be in accordance with the requirements of the OSHS and should pass the test conducted and/or standards set by the Occupational Safety and Health Center (OSHC).

For General Construction Work, the required basic PPEs for all workers shall be safety helmet, safety gloves and safety shoes. Specialty PPEs shall be provided to workers in addition to or in lieu of the corresponding basic PPE as the work or activity requires. Workers within the construction project site shall be required to wear the necessary PPE at all times. Moreover, all other persons who are either authorized or allowed to be at a construction site shall also wear appropriate PPEs.

Construction workers who are working from unguarded surfaces 6 m or more above water or ground, temporary or permanent floor platform, scaffold or where they are exposed to the possibility of falls hazardous to life or limb, must be provided with safety harnesses and life lines.

B.7.8 Signages and Barricades

Construction Safety Signages and Barricades shall be provided as a precaution and to advice the workers and the general public of the hazards existing in the worksite. Signages shall be posted in prominent positions at strategic location and as far as practicable, be in the language understandable to most of the workers employed. For road projects, it shall be in accordance with the DPWH Road Works Safety Manual.

B.7.9 Facilities

The Contractor shall provide the following welfare facilities in order to ensure humane working conditions:

1. Adequate supply of safe drinking water.

2. Adequate sanitary and washing facilities.

3. Suitable living accommodation for workers and as may be applicable for their families.

4. Separate sanitary, washing and sleeping facilities for men and women workers.
The services of a full time registered nurse, a full time physician, a dentist and an infirmary or emergency hospital with one (1) bed capacity when the number of employees exceed 300. In addition, there should be one (1) bed capacity for every 100 employees in excess of three hundred (300).

B.7.10 Costing

The cost for the implementation of construction safety and health shall be integrated to the overall project cost under the prescribed pay item. In consideration of the cost involved of providing the necessary safety equipment and manpower for an effective implementation of safety in the workplace, the following shall be used as a guide:
1. Personal Protective Equipment (PPE)

The PPEs shall be provided by the Contractor, and its cost shall be duly quantified and made part of the overall cost of Item B.7, Occupational Safety and Health. The use of PPEs shall conform to Section B.7.7 Personal Protective Equipment and Devices.

2. Clinical Materials and Equipment

Clinical materials and equipment such as medicines, beds and linens, other related accessories shall be to the account of the Contractor implementing the project and shall be in accordance with the Occupational Health Services of OSHS.

3. Signages and Barricades

The quantities and cost of signages and barricades necessary for a specific item of work shall be quantified and made part of that particular pay item of work. For general signages and

barricades not included in specific pay item of work but necessary for promoting safety in and around the construction site, the quantities and cost shall be a separate pay item and included in the overall cost of Item B.7, Occupational Safety and Health.

4. Facilities

Facilities such as portable toilets, waste disposal, sanitary and washing facilities, convenient dwellings and office, adequate lighting, and other facilities related to construction safety and health shall be in accordance with OSHS and previously approved guidelines of the Department and shall be quantified and the cost thereof be made a separate pay item under "Facilities for the Engineers" and "Other General Requirements" as required in the DPWH Standard Specifications.

5. Salaries

Labor cost for the medical and safety personnel actually assigned in the field shall be included in the overall cost of Item B.7, Occupational Safety and Health. Manpower cost shall be established based on the cost of labor in the area. Duration of employment shall be based on project duration of the particular project.

6. Safety and Health Training

Cost associated for the provision of basic and continuing construction safety and health training to all safety and technical personnel shall be made part of the indirect/overhead cost of the project.

B.7.11 Safety on Construction during Heavy Equipment Operation

In relation to heavy equipment operation in all construction sites, the following are required in the different phases of the project.

1. Pre-Construction

The Contractor must ensure that appropriate certification is obtained from DOLE duly accredited organizations for the following:

a. All heavy equipment operators assigned at the project site must be tested and certified in accordance with a standard trade test prescribed by Technical Education and Skills Development Authority (TESDA) in coordination with its accredited organization.

b. All heavy equipment must be tested and certified in accordance with the standards prepared by DOLE or its recognized organization prior to commissioning of said equipment.

2. During Construction

The Contractor must ensure that the following conditions are met or complied with:

a. For mobilization or transport of heavy equipment, load restrictions, height and width clearances as imposed by Department for all roads and bridges to be utilized during transport. Moreover, only duly certified operators are allowed to load and unload heavy equipment to low-bed trailer.

b. During erection and set-up of heavy equipment, existing hazards must be avoided. Standard checklist of steps and procedures must be observed. List of necessary equipment, tools and materials must be available and properly utilized.

c. In the interest of accident prevention, duly certified mechanics and operators shall conduct daily routine inspection of all heavy equipment deployed at the site in accordance with standards set by TESDA in coordination with the Association of Construction Equipment Lessors (ASCEL, Inc.). During routine inspection all equipment which do not comply with the minimum safety standards for equipment certification shall be immediately removed from the work site for restoration or repair until they meet said standards or requirements. The Contractor and the equipment owner shall maintain a separate logbook for data on maintenance, repair, tests and inspections for each heavy equipment. Such logbook shall be used as a necessary reference during the conduct of equipment inspection.

3. Post Operation and Post Construction

The procedures for dismantling and demobilization of heavy equipment shall follow the same requirements as listed under provisions of mobilization or transport of heavy equipment and erection and set-up of heavy equipment.

B.7.12 Violations and Penalties

The Contractor if found violating safety rules and regulations shall be meted sanctions depending on the gravity of offense. The amount corresponding to non-compliance shall be deducted from the Contractor's billing.

B.7.13 Method of Measurement

Occupational safety and health program shall be measured by lump sum.

B.7.14 Basis of Payment

The accepted quantities, measured as prescribed in Section B.7.13, Method of Measurement shall be paid for at the Contract Unit Price or for the pay item listed below that is included in the Bill of Quantities. Such payment shall be full compensation for furnishing, maintaining and ensuring against loss of the equipment/tools.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
B.7	Occupational Safety and Health	Lump Sum

VI. ITEM B.9 MOBILIZATION / DEMOBILIZATION

B.9.1 General Requirements

Mobilization shall mean the transport to the project site of the Contractor's personnel, construction plant and equipment as stipulated in the proposal and Contract of the project while demobilization shall be their subsequent removal from the site after the completion of the project. The Contractor shall secure approval of the Engineer should he opted to demobilize any of the major plant and/or equipment before the completion of the project.

B.9.2 Method of Measurement

Mobilization/demobilization shall be paid by lump sum.

B.9.3 Basis of Payment

The accepted quantities, measured as prescribed in Section B.9.2, Method of Measurement shall be paid for at the Contract Unit Price or for the pay item listed below that is included in the Bill of Quantities. Such payment shall be full compensation for furnishing, maintaining and ensuring against loss of the equipment/tools.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
B.9	Mobilization/Demobilization	Lump Sum

VII. ITEM B.20 – TEMPORARY FENCE

B.20.1 Description

This work shall consist of furnishing, erecting, moving and removing chain link fencing and metal gates of the size and type shown on top of the temporary concrete barriers, and in sidewalk and roadway areas at the locations, as shown on the Plans or as directed by the Engineer.

B.20.2 Material Requirements

B.20.2.1 Barbed Wire

Barbed wire shall conform to the requirements of ASTM A121, Class I, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire. The barbed wire shall consist of two (2) strands of 12.5 gauge wire, twisted with two (2) points, 14 gauge barbs spaced 100 mm apart.

B.20.2.2 Chain Link Fence Fabric

Chain link fence fabric shall be fabricated from ten (10) gauge-galvanized wire conforming to AASHTO M 181, Chain Link Fence, and shall be of the type shown on the Plans. Before ordering the chain link fence fabric, the Contractor shall submit a sample of the material to the Engineer for testing and for approval.

B.20.2.3 Concrete Post

Concrete posts shall be made of Class A concrete in accordance with Item 900, Structural Concrete. The posts shall be cast to a tapered section as shown on the Plans and shall have a smooth surface finish.

B.20.2.4 Steel Post

Steel posts shall be of the sections and length as specified or as shown on the Plans. The posts shall be copper bearing steel and shall conform to the requirements of ASTM A702, Standard Specification for Steel Fence Post, Hot Wrought, for the grade specified.

B.20.2.5 Steel Reinforcement

Steel reinforcement for concrete posts shall be deformed steel bars conforming to the provisions of Item 902, Reinforcing Steel.

B.20.2.6 Hardware

Nuts, bolts, washers and other associated hardware shall be galvanized after fabrication as specified in ASTM A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

B.20.3 Construction Requirements

The Contractor shall perform such clearing and grubbing as may be necessary to construct the fence to the required grade and alignment.

The Contractor shall install fence posts on the concrete barrier in 38 mm diameter, 300 mm deep drilled or formed holes near each end of each section of the barrier. In addition, if the concrete barrier is furnished in lengths exceeding 3 m, it will be necessary for the Contractor to provide an additional hole at the center of the section to permit the installation of an intermediate post.

Line posts, corner and end posts on grade, and gate posts shall be installed in accordance with the Plans. Heights of the posts and fencing shall conform to the dimensions shown on the Plans.

At locations where breaks in a run of fencing are required, or at interactions with existing fences, appropriate adjustments in post spacing shall be made to conform to the requirement for the type of closure indicated.

When the Plans require that the posts, braces, or anchors be embedded in concrete, the Contractor shall install temporary guys or braces, as may be required to hold the posts in proper position until such time as the concrete has set sufficiently to hold the posts. Unless otherwise permitted, no materials shall be installed on posts or strain placed on guys or bracing set in concrete until seven days elapsed from the time of placing the concrete.

All posts shall be set vertically and to the required grade and alignment. Cutting off the tops of the posts will be allowed only with the approval of the Engineer and under conditions specified by the Engineer.

The fence fabric of the size and type required shall be firmly attached to the posts and braces in the manner indicated. All fence fabric shall be stretched taut and installed to the required elevations.

The fence shall generally follow the contour of the ground, with the bottom of fence fabric not less than 50 mm nor more than 150 mm from the ground surface. Grading shall be performed where necessary to provide a neat appearance. Line posts shall be spaced equidistantly in the fence line at the spacing shown on the Plans or as directed by the Engineer. The end, corner, and intermediate posts shall be placed at the locations indicated on the Plans or where directed by the Engineer, and shall be braced as shown on the Plans. When chain-link fence is on a long curve, intermediate posts shall be evenly spaced so that the strain of the fence will not bend the line posts.

All end, corner, and intermediate posts shall be set plumb in concrete bases of the depth and diameter shown on the Plans. The Contractor shall have the option of setting the line posts in concrete bases or using methods of driving and anchoring specified by the fence manufacturer and approved by the Engineer.

1. Chain Link Fencing With Top Rail

Posts shall be set so they are equidistant with a maximum of three (3) meters on center.

All top rails shall pass through the base of the post caps and shall form a continuous brace from end to end of each stretch of fence. Top rail lengths shall be joined with sleeve couplings with expansion sleeves provided at 30 m intervals. Top rails shall be securely fastened to end posts by means of approved rail end connectors. Horizontal braces shall be provided at all intermediate posts, midway between the top rail and ground as shown on the Plans.

Diagonal truss rods shall be installed with the horizontal braces as indicated in the Plans.

Fence fabric shall be installed approximately 50 mm above the ground level and securely fastened along the bottom and to all braces, top rails, line and pull posts, at the intervals indicated on the Plans. The fabric shall be secured to all end, corner, and gate posts with stretcher bars fastened to the posts, with stretcher bands spaced at a maximum of 355 mm and in a manner permitting adjustment of the fabric tension.

If the Contractor selects the option of using pieces, roll-formed sections, the fence fabric shall be integrally woven into the fabric loops on the end, corner, pull and gate posts. The fabric shall be attached to the end, corner and line posts as shown on the Plans.

2. Chain Link Fencing With Top Tension Wire

The construction details specified in Chain-Link Fencing with top Rail shall apply with the following modifications:

a. Top tension wire shall be installed as shown on the Plans or as directed by the Engineer.

b. All posts shall be spaced equidistant in the fence line on a maximum of
2.44 m on center, except that a 3 m spacing will be permitted on concrete barriers.

c. Additional pull posts shall be placed at locations indicated on the Plans. Brace assemblies shall be installed at each intermediate post as indicated on the Plans or Standard Sheets.

3. Vinyl Coated Chain-link Fencing on Plastic Coated Frame

The construction details specified on Chain-Link Fencing with Top Rail or Chain- Link Fencing with Top Tension Wire shall apply with the following addition:

If any of the resin-clad material specified under Item that has the protective resin coating is damaged that impairs its effectiveness to prevent corrosion of

the base material, the Contractor shall repair such parts by applying one coat of an approved compound of color to match the original material.

4. Fence Gates

The Contractor shall construct metal fence gates of the type and size as indicated on the Plans, and in the location shown or ordered by the Engineer. Upon removal, fence gates shall become the property of the Contractor and shall be removed from the project site.

B.20.4 Method of Measurement

This work under this Item shall be measured by lump sum of temporary fence installed as measured along the top of the fencing, including gates, center to center of end posts erected in place and accepted.

B.20.5 Basis of Payment

The quantity, as determined in Section B.20.4, Method of Measurement shall be paid for at the Contract Unit Price bid per Lump Sum for temporary chain- link fencing, which shall include the cost of all materials, labor tools and equipment necessary to satisfactorily install the fencing, and gates and to subsequently remove them. It shall include all necessary clearing, grubbing, excavation and disposal, fill, concrete, anchoring, posts, hardware, fencing, gates, gate posts, locks, bracing, drilling or forming holes in concrete barriers as necessary, repair of material damaged by the Contractor's operations and all other materials.

Payment shall be made under:

Pay Item Number	Description	Unit of Measurement
B.20 (1)	Temporary Fence	Lump Sum
B.20 (2)	Temporary Fence (Rental Basis)	Monthly

VIII. ITEM 101 – REMOVAL OF STRUCTURES AND OBSTRUCTIONS

101.1 Description

This Item shall consist of the removal wholly or in part, and satisfactory disposal of all buildings, fences, structures, old pavements, abandoned pipe lines, and any other obstructions which are not designated or permitted to remain, except for the obstructions to be removed and disposed off under other items in the Contract. It shall also include the salvaging of designated materials, and backfilling the resulting trenches, holes and pits.

101.2 Construction Requirements

101.2.1 General

The Contractor shall perform the work described above, within and adjacent to the roadway, on Government land or easement, as shown on the Plans or as directed by the Engineer. All designated salvable material shall be removed, without unnecessary damage, in sections or pieces which may be readily transported, and shall be stored by the Contractor at specified places on the project or as otherwise shown in the Special Provisions. Perishable material shall be handled as designated in Subsection 100.2.2 Nonperishable material may be disposed off outside the limits of view from the project with written permission of the property owner on whose property the material is placed. Copies of all agreements with property owners are to be furnished to the Engineer. Basements or cavities left by the structure removal shall be filled with acceptable material to the level of

the surrounding ground and, if within the prism of construction, shall be compacted to the required density.

101.2.2 Removal of Existing Bridges, Culverts, and other Drainage Structures

All existing bridges, culverts and other drainage structures in use by traffic shall not be removed until satisfactory arrangements have been made to accommodate traffic. The removal of existing culverts within embankment areas will be required only as necessary for the installation of new structures. Abandoned culverts shall be broken down, crushed and sealed or plugged. All retrieved culvert for future use as determined by the Engineer shall be carefully removed and all precautions shall be employed to avoid breakage or structural damage to any of its part. All sections of structures removed which are not designated for stockpiling or re-laying shall become the property of the Government and be removed from the project or disposed off in a manner approved by the Engineer.

Unless otherwise directed, the substructures of existing structures shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed down to at least 300 mm below natural ground surface. Where such portions of existing structures lie wholly or in part within the limits for a new structure, they shall be removed as necessary to accommodate the construction of the proposed structure.

Steel bridges and wood bridges when specified to be salvaged shall be carefully dismantled without damaged. Steel members shall be match marked unless such match marking is waived by the Engineer. All salvaged material shall be stored as specified in Subsection 101.2.1.

Structures designated to become the property of the Contractor shall be removed from the right-of-way.

Blasting or other operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work, unless otherwise provided in the Special Provisions.

101.2.3 Removal of Pipes Other than Pipe Culverts

Unless otherwise provided, all pipes shall be carefully removed and every precaution taken to avoid breakage or damaged. Pipes to be relaid shall be removed and stored when necessary so that there will be no loss of damage before re-laying. The Contractor shall replace sections lost from storage or damage by negligence, at his own expense.

101.2.4 Removal of Existing Pavement, Sidewalks, Curbs, etc.

All concrete pavement, base course, sidewalks, curbs, gutters, etc., designated for removal, shall be:

(1) Broken into pieces and used for riprap on the project, or

(2) Broken into pieces, the size of which shall not exceed 300 mm in any dimension and stockpiled at designated locations on the project for use by the Government, or

(3) Otherwise demolished and disposed off as directed by the Engineer. When specified, ballast, gravel, bituminous materials or other surfacing or pavement materials shall be

removed and stockpiled as required in Subsection 101.2.1, otherwise such materials shall be disposed off as directed.

There will be no separate payment for excavating for the removal of structures and obstructions, or for backfilling and compacting the remaining cavity.

101.3 Method of Measurement

When the Contract stipulates that payment will be made for removal of obstructions on lump-sum basis, the pay item will include all structures and obstructions encountered within the roadway. Where the contract stipulates that payment will be made for the removal of specific items on a unit basis, measurement will be made by the unit stipulated in the Contract.

Whenever the Bill of Quantities does not contain an item for any aforementioned removals, the work will not be paid for directly, but will be considered as a subsidiary obligation of the Contractor under other Contract Items.

101.4 Basis of Payment

The accepted quantities, measured as prescribed in Section 101.3, shall be paid for at the Contract unit price or lump sum price bid for each of the Pay Items listed below that is included in the Bill of Quantities which price and payment shall be full compensation for removing and disposing of obstructions, including materials, labor, equipments, tools and incidentals necessary to complete the work prescribed in this Item. The price shall also include backfilling, salvaging of materials removed, their custody, preservation, storage on the right-of-way and disposal as provided herein.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
101 (1)	101 (1) Removal of Structures and Obstruction	Lump Sum
101 (2)	101 (2) Removal of actual structures/obstruction	Each
101 (3)	101 (3) Removal of actual structures/obstruction	Square Meter
101 (4)	101 (4) Removal of actual structures/obstruction	Linear Meter

IX. ITEM 103 – STRUCTURE EXCAVATION

103.1 Description

This Item shall consist of the necessary excavation for foundation of bridges, culverts, underdrains, and other structures not otherwise provided for in the Specifications. Except as otherwise provided for pipe culverts, the backfilling of completed structures and the disposal of all excavated surplus materials, shall be in accordance with these Specifications and in reasonably close conformity with the Plans or as established by the Engineer.

This Item shall include necessary diverting of live streams, bailing, pumping, draining, sheeting, bracing, and the necessary construction of cribs and cofferdams, and furnishing

the materials therefore, and the subsequent removal of cribs and cofferdams and the placing of all necessary backfill.

It shall also include the furnishing and placing of approved foundation fill material to replace unsuitable material encountered below the foundation elevation of structures.

No allowance will be made for classification of different types of material encountered.

103.2 Construction Requirements

103.2.1 Clearing and Grubbing

Prior to starting excavation operations in any area, all necessary clearing and grubbing in that area shall have been performed in accordance with Item 100, Clearing and Grubbing.

103.2.2 Excavation

(1) General, all structures. The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-sectional elevations and measurements may be taken on the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the Engineer.

Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the Plans or as staked by the Engineer. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The elevations of the bottoms of footings, as shown on the Plans, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary, to secure a satisfactory foundation.

Boulders, logs, and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed, the Contractor shall notify the Engineer to that effect and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

(2) Structures other than pipe culverts. All rock or other hard foundation materials shall be cleaned of all loose materials, and cut to a firm surface, either level, stepped, or serrated as directed by the Engineer. All seams or crevices shall be cleaned and grouted. All loose and disintegrated rocks and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed. When the foundation material is soft or mucky or otherwise unsuitable, as determined by the Engineer, the Contractor shall remove the unsuitable material and backfill with approved granular material. This foundation fill shall be placed and compacted in 150 mm layers up to the foundation elevation.

When foundation piles are used, the excavation of each pit shall be completed before the piles are driven and any placing of foundation fill shall be done after the piles are driven. After the driving is completed, all loose and displaced materials shall be removed, leaving a smooth, solid bed to receive the footing.

(3) Pipe Culverts. The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 300 mm or 4 mm for each 100 mm of fill over the top of pipe, whichever is greater, but not to exceed three-quarters of the vertical inside diameter of the pipe. The width of the excavation shall be at least 300 mm greater than the horizontal outside diameter of the pipe. The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 150 mm in uncompacted depth to form a uniform but yielding foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed to the depth directed by the Engineer and replaced with approved granular foundation fill material properly compacted to provide adequate support for the pipe, unless other special construction methods are called for on the Plans.

The foundation surface shall provide a firm foundation of uniform density throughout the length of the culvert and, if directed by the Engineer, shall be cambered in the direction parallel to the pipe centerline.

Where pipe culverts are to be placed in trenches excavated in embankments, the excavation of each trench shall be performed after the embankment has been constructed to a plane parallel to the proposed profile grade and to such height above the bottom of the pipe as shown on the Plans or directed by the Engineer.

103.2.3 Utilization of Excavated Materials

All excavated materials, so far as suitable, shall be utilized as backfill or embankment. The surplus materials shall be disposed off in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated materials shall be deposited at any time so as to endanger the partly finished structure.

103.2.4 Cofferdams

Suitable and practically watertight cofferdams shall be used wherever water-bearing strata are encountered above the elevation of the bottom of the excavation. If requested, the Contractor shall submit drawings showing his proposed method of cofferdam construction, as directed by the Engineer.

Cofferdams or cribs for foundation construction shall in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may

require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as shown on the Plans or directed by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are employed and the mass is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire mass of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdams shall be vented or ported at low water level as directed.

Cofferdams shall be constructed so as to protect green concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into substructure masonry, without written permission from the Engineer.

Any pumping that may be permitted from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete material being carried away. Any pumping required during the placing of concrete, or for a period of at least 24 hours thereafter, shall be done from a suitable sump located outside the concrete forms. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Unless otherwise provided, cofferdams or cribs, with all sheeting and bracing involved therewith, shall be removed by the Contractor after the completion of the substructure. Removal shall be effected in such manner as not to disturb or mar finished masonry.

103.2.5 Preservation of Channel

Unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the side of the structure before caissons, cribs, or cofferdams are sunk in place, the Contractor shall, after the foundation base is in place, backfill all such excavations to the original ground surface or stream bed with material satisfactory to the Engineer.

103.2.6 Backfill and Embankment for Structures Other Than Pipe Culverts

Excavated areas around structures shall be backfilled with free draining granular material approved by the Engineer and placed in horizontal layers not over 150 mm in thickness, to the level of the original ground surface. Each layer shall be moistened or dried as required and thoroughly compacted with mechanical tampers.

In placing backfills or embankment, the material shall be placed simultaneously in so far as possible to approximately the same elevation on both sides of an abutment, pier, or wall. If conditions require placing backfill or embankment appreciably higher on one side than on the opposite side, the additional material on the higher side shall not be placed until the masonry has been in place for 14 days, or until tests made by the laboratory under the supervision of the Engineer establishes that the masonry has attained sufficient strength to withstand any pressure created by the methods used and materials placed without damage or strain beyond a safe factor.

Backfill or embankment shall not be placed behind the walls of concrete culverts or abutments or rigid frame structures until the top slab is placed and cured. Backfill and embankment behind abutments held at the top by the superstructure, and behind the

sidewalls of culverts, shall be carried up simultaneously behind opposite abutments or sidewalls.

All embankments adjacent to structures shall be constructed in horizontal layers and compacted as prescribed in Subsection 104.3.3 except that mechanical tampers may be used for the required compaction. Special care shall be taken to prevent any wedging action against the structure, and slopes bounding or within the areas to be filled shall be benched or serrated to prevent wedge action. The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled against except insofar as undisturbed material obtrudes upon the area.

Broken rock or coarse sand and gravel shall be provided for a drainage filter at weepholes as shown on the Plans.

103.2.7 Bedding, Backfill, and Embankment for Pipe Culverts

Bedding, Backfill and Embankment for pipe culverts shall be done in accordance with Item 500, Pipe Culverts and Storm Drains.

103.3 Method of Measurement

103.3.1 Structure Excavation

The volume of excavation to be paid for will be the number of cubic metres measured in original position of material acceptably excavated in conformity with the Plans or as directed by the Engineer, but in no case, except as noted, will any of the following volumes be included in the measurement for payment:

(1) The volume outside of vertical planes 450 mm outside of and parallel to the neat lines of footings and the inside walls of pipe and pipe-arch culverts at their widest horizontal dimensions.

(2) The volume of excavation for culvert and sections outside the vertical plane for culverts stipulated in (1) above.

(3) The volume outside of neat lines of underdrains as shown on the Plans, and outside the limits of foundation fill as ordered by the Engineer.

(4) The volume included within the staked limits of the roadway excavation, contiguous channel changes, ditches, etc., for which payment is otherwise provided in the Specification.

(5) Volume of water or other liquid resulting from construction operations and which can be pumped or drained away.

(6) The volume of any excavation performed prior to the taking of elevations and measurements of the undisturbed ground.

(7) the volume of any material rehandled, except that where the Plans indicate or the Engineer directs the excavation after embankment has been placed and except that when installation of pipe culverts by the imperfect trench method specified in Item 500 is required, the volume of material re-excavated as directed will be included.

(8) The volume of excavation for footings ordered at a depth more than 1.5 m below the lowest elevation for such footings shown on the original Contract Plans, unless the Bill of Quantities contains a pay item for excavation ordered below the elevations shown on the Plans for individual footings.

103.3.2 Bridge Excavation

The volume of excavation, designated on the Plans or in the Special Provisions as "Bridge Excavation" will be measured as described below and will be kept separate for pay purposes from the excavation for all structures.

The volume of bridge excavation to be paid shall be the vertical 450 mmoutside of and parallel to the neat lines of the footing. The vertical planes shall constitute the vertical faces of the volume for pay quantities regardless of excavation inside or outside of these planes.

103.3.3 Foundation Fill

The volume of foundation fill to be paid for will be the number of cubic metres measured in final position of the special granular material actually provided and placed below the foundation elevation of structures as specified, completed in place and accepted.

103.3.4 Shoring, Cribbing, and Related Work

Shoring, cribbing and related work whenever included as a pay item in Bill of Quantities will be paid for at the lump sum bid price. This work shall include furnishing, constructing, maintaining, and removing any and all shoring, cribbing, cofferdams, caissons, bracing, sheeting, water control, and other operations necessary for the acceptable completion of excavation included in the work of this Section, to a depth of 1.5 m below the lowest elevation shown on the Plans for each separable foundation structure.

103.3.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 103.3, shall be paid for at the contract unit price for each of the particular pay items listed below that is included in the Bill of Quantities. The payment shall constitute full compensation for the removal and disposal of excavated materials including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item, except as follows:

(1) Any excavation for footings ordered at a depth more than 1.5 m below the lowest elevation shown on the original Contract Plans will be paid for as provided in Part K, Measurement and Payment, unless a pay item for excavation ordered below Plan elevation appears in the Bill of Quantities.

(2) Concrete will be measured and paid for as provided under Item 405, Structural Concrete.

(3) Any roadway or borrow excavation required in excess of the quantity excavated for structures will be measured and paid for as provided under Item 102.

(4) Shoring, cribbing, and related work required for excavation ordered more than 1.5 m below Plan elevation will be paid for in accordance with Part K.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
103 (1)	Structure Excavation	Cubic Meter
103 (2)	Bridge Excavation	Cubic Meter
103 (3)	Foundation Fill	Cubic Meter
103 (4)	Excavation ordered below Plan elevation	Cubic Meter
103 (5)	Shoring, cribbing, and related work	Lump Sum
103 (6)	Pipe culverts and drain excavation	Cubic Meter

X. ITEM 201 – AGGREGATE BASE COURSE

201.1 Description

This Item shall consist of furnishing, placing and compacting an aggregate base course on a prepared subgrade/subbase in accordance with this Specification, and the lines, grades, thickness and typical cross-sections shown on the Plans, or as established by the Engineer.

201.2 Material Requirements

Aggregate for base course shall consist of hard, durable particles or fragments of crushed stone, crushed slag, crushed or natural gravel, and filler of natural or crushed sand, 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.

In some areas where the conventional base course materials are scarce or non-available, the use of 40% weathered limestone blended with 60% crushed stones or gravel shall be allowed, provided that the blended materials meet the requirements of this Item.

The base course material shall conform to Table 201.1, whichever is called for in the Bill of Quantities.

Table 201.1 – Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard, mm	Alternate US Standard	Grading A	Grading B
50	2”	100	
37.5	1-1/2”	-	100
25.0	1”	60-85	-
19.0	¾”	-	60-85
12.5	½”	36-65	-
4.75	No. 4	20-50	30-55
0.425	No. 40	5-20	8-25
0.075	No. 400	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.

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 test determined by AASHTO T 96.

The material passing the 19 mm (3/4 inch) sieve shall have a soaked CBR value of not less than 80% as determined by AASHTO T 193. The CBR value shall be obtained at the maximum dry density (MDD) as determined by 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 base course material on the road or in a pugmill unless otherwise specified or approved. Filler shall be taken from sources approved by the Engineer, free from hard lumps and shall not contain more than 15 percent of material retained on the 4.75 mm (No. 4) sieve.

201.3 Construction Requirements

201.3.1 Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Item 105, Subgrade Preparation, before placing the base material.

201.3.2 Placing

It shall be in accordance with all the requirements of Subsection 200.3.2, Placing.

201.3.3 Spreading and Compacting

It shall be in accordance with all the requirements of Subsection 200.3.3, Spreading and Compacting.

201.3.4 Trial Sections

Trial sections shall conform in all respects to the requirements specified in Subsection 200.3.4.

201.3.5 Tolerances

The aggregate base course shall be laid to the designed level and transverse slopes shown on the Plans. The allowable tolerances shall be in accordance with following:

Permitted variation from design THICKNESS OF LAYER	± 10 mm
Permitted variation from design LEVEL OF SURFACE	+ 5 mm -10 mm
Permitted SURFACE IRREGULARITY Measured by 3-m straight-edge	5 mm
Permitted variation from design CROSSFALL OR CAMBER	± 0.2%

Permitted variation from design LONGITUDINAL GRADE over 25 m in length	± 0.1%

201.4 Method of Measurement

Aggregate Base Course will be measured by the cubic meter (m3). The quantity to be paid for shall be the design volume compacted in-place as shown on the Plans, and accepted in the completed base course. No allowance shall be given for materials placed outside the design limits shown on the cross-sections. Trial sections shall not be measured separately but shall be included in the quantity of aggregate base course.

201.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 201.4, shall be paid for at the contract unit price for Aggregate Base Course which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
201	Aggregate Base Course	Cubic Meter

XI. ITEM 404 – REINFORCING STEEL

404.1 Description

This Item shall consist of furnishing, bending, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with this Specification and in conformity with the requirements shown on the Plans or as directed by the Engineer.

404.2 Material Requirements

Reinforcing steel shall meet the requirements of Item 710, Reinforcing Steel and Wire Rope.

404.3 Construction Requirements

404.3.1 Order Lists

Before materials are ordered, all order lists and bending diagrams shall be furnished by the Contractor, for approval of the Engineer. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams. Any expense incident to the revisions of materials furnished in accordance with such lists and diagrams to make them comply with the Plans shall be borne by the Contractor.

404.3.2 Protection of Material

Steel reinforcement shall be stored above the surface of the ground upon platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, detrimental rust, loose scale, paint, grease, oil, or other foreign materials. Reinforcement shall be free from injurious defects such as cracks and laminations. Rust, surface seams, surface irregularities or mill scale will not be cause for

rejection, provided the minimum dimensions, cross sectional area and tensile properties of a hand wire brushed specimen meets the physical requirements for the size and grade of steel specified.

404.3.3 Bending

All reinforcing bars requiring bending shall be cold-bent to the shapes shown on the Plans or as required by the Engineer. Bars shall be bent around a circular pin having the following diameters (D) in relation to the nominal diameter of the bar (d):

Nominal Diameter, d, mm	Pin Diameter (D)
10 to 20	6d
25 to 28	8d
32 and Greater	10d

Bends and hooks in stirrups or ties may be bent to the diameter of the principal bar enclosed therein.

404.3.4 Placing and Fastening

All steel reinforcement shall be accurately placed in the position shown on the Plans or as required by the Engineer and firmly held there during the placing and setting of the concrete. Bars shall be tied at all intersections except where spacing is less than 300 mm in each directions, in which case, alternate intersections shall be tied. Ties shall be fastened on the inside.

Distance from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports, so that it does not vary from the position indicated on the Plans by more than 6mm. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shapes and dimensions. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks shall not be permitted. Unless otherwise shown on the Plans or as required by the Engineer, the minimum distance between bars shall be 40 mm. Reinforcement in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and removal may be required. If fabric reinforcement is shipped in rolls, it shall be straightened before being placed. Bundled bars shall be tied together at not more than 1.8 m intervals.

404.3.5 Splicing

All reinforcement shall be furnished in the full lengths indicated on the Plans. Splicing of bars, except where shown on the Plans, will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible and with a minimum separation of not less than 40 bar diameters. Not more than one-third of the bars may be spliced in the same cross-section, except where shown on the Plans.

Unless otherwise shown on the Plans, bars shall be lapped a minimum distance of:

Splice Type	Grade 280(40)	Grade 420(60)	But not less than
Tension	24 bar dia.	36 bar dia.	300mm
Compression	20 bar dia.	24 bar dia.	300mm

In lapped splices, the bars shall be placed in contact and wired together. Lapped splices will not be permitted at locations where the concrete section is insufficient to provide minimum clear distance of one and one-third the maximum size of coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the Plans or if authorized by the Engineer in writing. Spiral reinforcement shall be spliced by lapping at least one and a half turns or by butt welding unless otherwise shown on the Plans.

404.3.6 Lapping of Bar Mat

Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The overlap shall not be less than one mesh in width.

404.4 Method of Measurement

The quantity of reinforcing steel to be paid for will be the final quantity placed and accepted in the completed structure.

No allowance will be made for tie-wires, separators, wire chairs and other material used in fastening the reinforcing steel in place. If bars are substituted upon the Contractor's request and approved by the Engineer and as a result thereof more steel is used than specified, only the mass specified shall be measured for payment.
No measurement or payment will be made for splices added by the Contractor unless directed or approved by the Engineer.

When there is no item for reinforcing steel in the Bill of Quantities, costs will be considered as incidental to the other items in the Bill of Quantities.

404.5 Basis of Payment

The accepted quantity, measured as prescribed in Section 404.4, shall be paid for at the contract unit price for Reinforcing Steel which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
404	Reinforcing Steel	Kilogram

XII. ITEM 405 – STRUCTURAL CONCRETE

405.1 Description

405.1.1 Scope

This Item shall consist of furnishing, placing and finishing concrete in all structures except pavements in accordance with this Specification and conforming to the lines, grades, and dimensions shown on the Plans. Concrete shall consist of a mixture of Portland Cement, fine aggregate, coarse aggregate, admixture when specified, and water mixed in the proportions specified or approved by the Engineer.

405.1.2 Classes and Uses of Concrete

Five classes of concrete are provided for in this Item, namely: A, B, C, P and Seal. Each class shall be used in that part of the structure as called for on the Plans.

The classes of concrete will generally be used as follows:

Class A – All superstructures and heavily reinforced substructures. The important parts of the structure included are slabs, beams, girders, columns, arch ribs, box culverts, reinforced abutments, retaining walls, and reinforced footings.

Class B – Footings, pedestals, massive pier shafts, pipe bedding, and gravity walls, unreinforced or with only a small amount of reinforcement.

Class C – Thin reinforced sections, railings, precast R.C. piles and cribbing and for filler in steel grid floors.

Class P – Prestressed concrete structures and members.

Seal – Concrete deposited in water.

405.2 Material Requirements

405.2.1 Portland Cement

It shall conform to all the requirements of Subsection 311.2.1.

405.2.2 Fine Aggregate

It shall conform to all the requirements of Subsection 311.2.2.

405.2.3 Coarse Aggregate

It shall conform all the requirements of Subsection 311.2.3 except that gradation shall conform to Table 405.1.

Table 405.1 – Grading Requirements for Coarse Aggregate

Sieve Designation		Mass Percent Passing				
Standard Mm	Alternate US Standard	Class A	Class B	Class C	Class P	Class Seal
63	2-1/2”					
50	2”	100	100			
37.5	1-1/2”	95-100	-			100
25	1”	-	35-70		100	95-100
19.0	¾”	35-70	-	100	-	-
12.5	½”	-	10-30	90-100	-	25-60
9.5	3/8”	10-30	-	40-70	20-55	-
4.75	No. 4	0-5	0-5	0-15	0-10	0-10

*The measured cement content shall be within plus (+) or minus (-) 2 mass percent of the design cement content.

405.2.4 Water

It shall conform to the requirements of Subsection 311.2.4.

405.2.5 Reinforcing Steel

It shall conform to the requirements of Item 710, Reinforcing Steel and Wire Rope.

405.2.6 Admixtures

Admixtures shall conform to the requirements of Subsection 311.2.7.

405.2.7 Curing Materials

Curing materials shall conform to the requirements of Subsection 311.2.8.

405.2.8 Expansion Joint Materials

Expansion joint materials shall be:

1. Preformed Sponge Rubber and Cork, conforming to AASHTO M 153.

2. Hot-Poured Elastic Type, conforming to AASHTO M 173.

3. Preformed Fillers, conforming to AASHTO M 213.

405.2.9 Elastomeric Compression Joint Seals

These shall conform to AASHTO M 220.

405.2.10 Elastomeric Bearing Pads

These shall conform to AASHTO M 251 or Item 412 – Elastomeric Bearing Pads.

405.2.11 Storage of Cement and Aggregates

Storage of cement and aggregates shall conform to all the requirements of Subsection 311.2.10.

405.3 Sampling and Testing of Structural Concrete

As work progresses, at least one (1) sample consisting of three (3) concrete cylinder test specimens, 150 x 300 mm, shall be taken from each seventy five (75) cubic meters of each class of concrete or fraction thereof placed each day.

Compliance with the requirements of this Section shall be determined in accordance with the following standard methods of AASHTO:

Sampling of fresh concrete	T141
Weight per cubic metre and air content (gravi-metric) of concrete	T121
Sieve analysis of fine and coarse aggregates	T27

Slump of Portland Cement Concrete	T119
Specific gravity and absorption of fine aggregate	T84

Tests for strength shall be made in accordance with the following:

Making and curing concrete compressive and flexural tests specimens in the field	T23
Compressive strength of molded concrete Cylinders	T22

405.4 Production Requirements

405.4.1 Proportioning and Strength of Structural Concrete

The concrete materials shall be proportioned in accordance with the requirements for each class of concrete as specified in Table 405.2, using the absolute volume method as outlined in the American Concrete Institute (ACI) Standard 211.1. "Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete". Other methods of proportioning may be employed in the mix design with prior approval of the Engineer. The mix shall either be designed or approved by the Engineer. A change in the source of materials during the progress of work may necessitate a new mix design.

The strength requirements for each class of concrete shall be as specified in Table 405.2.

Table 405.2 - Composition and Strength of Concrete for Use in Structures

Class of Concrete	Minimum Cement Content per m^3 40kg/(bag**)	Maimum Water/ Cement Ratio Kg/kg	Consistency Range in Slump Mm	Designated Size of Coarse Aggregates Square Opening Std. mm	Minumum Compressive Strength of 150x300 mm Concrete Cylinder Speciment at 28 Days MN/m^2
A	364 (9.1 bags)	0.53	50-100	37.5-4.75 (1-1/2" – No. 4)	20.7
B	320 (8 bags)	0.58	50-100	50-4.75 (2" – No. 4)	16.5
C	380 (9.5 bags)	0.55	50-100	12.5-4.75 (1/2" – No. 4)	20.7
P	440 (11 bags)	0.49	100 max.	19.0-4.75 (3/4" – No. 4)	37.7
Seal	380 (9.5 bags)	0.58	100-200	25 – 4.75 (1" – No. 4)	20.7

* The measured cement content shall be within plus or minus 2 mass percent of the design cement content.
** Based on 40 kg/bag

405.4.2 Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcing steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be gauged by the ability of the equipment to properly place it and not by the difficulty in mixing and transporting. The quantity of mixing water shall be determined by the Engineer and shall not be varied without his consent. Concrete as dry as it is practical to place with the equipment specified shall be used.

405.4.3 Batching

Measuring and batching of materials shall be done at a batching plant.

1. Portland Cement

Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed. All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be properly sealed and vented to preclude dusting operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will neither be lodged in it nor leak from it.

Accuracy of batching shall be within plus (+) or minus (-) 1 mass percent.

2. Water

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not more than 1 percent.

3. Aggregates

Stockpiling of aggregates shall be in accordance with Subsection 311.2.10. All aggregates whether produced or handled by hydraulic methods or washed, shall be stockpiled or binned for draining for at least 12 hours prior to batching. Rail shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. If the aggregates contain high or non-uniform moisture content, storage or stockpile period in excess of 12 hours may be required by the Engineer.

Batching shall be conducted as to result in a two (2) mass percent maximum tolerance for the required materials.

4. Bins and Scales

The batching plant shall include separate bins for bulk cement, fine aggregate and for each size of coarse aggregate, a weighing hopper, and scales capable of determining accurately the mass of each component of the batch.

Scales shall be accurate to one-half (0.5) percent throughout the range used.

5. Batching

When batches are hauled to the mixer, bulk cement shall be transported either in waterproof compartments or between the fine and coarse aggregate. When cement is placed in contact with moist aggregates, batches will be rejected unless mixed within 1-1/2 hours of such contact. Sacked cement may be transported on top of the aggregates.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss, and, when more than one batch is carried on the truck, without spilling of material from one batch compartment into another.

6. Admixtures

The Contractor shall follow an approved procedure for adding the specified amount of admixture to each batch and will be responsible for its uniform operation during the progress of the work. He shall provide separate scales for the admixtures which are to be proportioned by weight, and accurate measures for those to be proportioned by volume. Admixtures shall be measured into the mixer with an accuracy of plus or minus three (3) percent.

The use of Calcium Chloride as an admixture will not be permitted.

405.4.4 Mixing and Delivery

Concrete may be mixed at the site of construction, at a central point or by a combination of central point and truck mixing or by a combination of central point mixing and truck agitating. Mixing and delivery of concrete shall be in accordance with the appropriate requirements of AASHTO M 157 except as modified in the following paragraphs of this section, for truck mixing or a combination of central point and truck mixing or truck agitating. Delivery of concrete shall be regulated so that placing is at a continuous rate unless delayed by the placing operations. The intervals between delivery of batches shall not be so great as to allow the concrete inplace to harden partially, and in no case shall such an interval exceed 30 minutes.

In exceptional cases and when volumetric measurements are authorized, for small project requiring less than 75 cu.m. per day of pouring, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate. Batching and mixing shall be in accordance with ASTM C 685, Section 6 through 9.

Concrete mixing, by chute is allowed provided that a weighing scales for determining the batch weight will be used.

For batch mixing at the site of construction or at a central point, a batch mixer of an approved type shall be used. Mixer having a rated capacity of less than a one-bag batch shall not be used. The volume of concrete mixed per batch shall not exceed the mixer’s nominal

capacity as shown on the manufacturer's standard rating plate on the mixer except that an overload up to 10 percent above the mixer's nominal capacity may be permitted, provided concrete test data for strength, segregation, and uniform consistency are satisfactory and provided no spillage of concrete takes place. The batch shall be so charge into the drum that a portion of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall not be less than 60 seconds for mixers having a capacity of 1.5 m or less. For mixers having a capacity greater than 1.5m^3, the mixing time shall not be less than 90 seconds. If timing starts, the instant the skip reaches its maximum raised position, 4 seconds shall be added to the specified mixing time. Mixing time ends when the discharge chute opens.

The mixer shall be operated at the drum speed as shown on the manufacturer's name plate on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed off by the Contractor at his own expenses.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

Retempering concrete will not be permitted. Admixtures for increasing the workability, for retarding the set, or for accelerating the set or improving the pumping characteristics of the concrete will be permitted only when specifically provided for in the Contract, or authorized in writing by the Engineer.

1. Mixing Concrete: General

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.

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.

Equipment having components made of aluminum or magnesium alloys, which would have contact with plastic concrete during mixing, transporting or pumping of Portland Cement concrete, shall not be used. Concrete mixers shall be equipped with adequate water storage and a device of accurately measuring and automatically controlling the amount of water used.

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 (1) percent of the desired amounts. The water measuring device shall be accurate to plus or minus 0.5 mass 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.

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 more than one (1) mass percent for cement, one and a half (1-1/2) mass percent for any size of aggregate, or one (1) mass percent for the total aggregate in any batch.

2. Mixing Concrete at Site

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.

When bulk cement is used and volume of the batch is 0.5 m^3 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 also be interlocked against opening when the amount of cement in the hopper is underweight by more than one (1) mass percent or overweight by more than three (3)mass percent of the amount specified.

When the aggregate contains 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.
The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregate. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer so that it will not result in loss of cement due to the effect of wind, or in accumulation of cement on surface of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire content of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than 1-1/2 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.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanics shall be so interlocked that during normal operation no part of the batch will be charged until the specified mixing time has elapsed.

The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat 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. Mixing Concrete at Central Plant

Mixing at central plant shall conform to the requirements for mixing at the site.

4. Mixing Concrete in Truck

Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, water-tight, 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 of which the mixing time can be readily verified by the Engineer.

The maximum size of batch in truck mixers shall not exceed the minimum rated capacity of the mixer as stated by the manufacturer 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.

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 32oC, 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 judgement of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

When a truck mixer is used for transportation, the mixing time specified in Subsection 405.4.4 (3) at a stationary mixer may be reduced to 30 seconds and the mixing completed in a truck mixer. The mixing time in the truck mixer shall be as specified for truck mixing.

5. Transporting Mixed Concrete

Mixed concrete may only be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturers of the equipment as agitating speed, or in non-agitating hauling equipment, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable point for adequate placement and consolidation in place.

Truck agitators shall be loaded not to exceed the manufacturer’s guaranteed capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.

No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point.

The rate of discharge of mixed concrete from truck mixers or agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before 250 revolutions of the drum or blades, whichever comes first, after the introduction of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete or when the temperature of the concrete is 30oC, or above, a time less than one hour will be required.

6. Delivery of Mixed Concrete

The Contractor shall have sufficient plant capacity and transportation apparatus to insure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing of the minimum handling.

405.5 Method of Measurement

The quantity of structural concrete to be paid for will be the final quantity placed and accepted in the completed structure. No deduction will be made for the volume occupied by pipe less than 100 mm in diameter or by reinforcing steel, anchors, conduits, weep holes or expansion joint materials.

405.6 Basis of Payment

The accepted quantities, measured as prescribed in Section 405.5, shall be paid for at the contract unit price for each of the Pay Item listed below that is included in the Bill of Quantities.

Payment shall constitute full compensation for furnishing, placing and finishing concrete including all labor, equipment, tools and incidentals necessary to complete the work prescribed in the Item.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
405 (1)	Structural Concrete, Class A	Cubic Meter
405 (2)	Structural Concrete, Class B	Cubic Meter
405 (3)	Structural Concrete, Class C	Cubic Meter
405 (4)	Structural Concrete, Class D	Cubic Meter
405 (5)	Seal Concrete	Cubic Meter

XIII. ITEM 407 – CONCRETE STRUCTURES

407.1 Description

This Item shall consist of the general description of the materials, equipment, workmanship and construction requirements of concrete structures and the concrete portions of composite structures conforming to the alignment, grades, design, dimensions and details shown on the Plans and in accordance with the Specifications for piles, reinforcing steel, structural steel, structural concrete and other items which constitute the completed structure. The class of concrete to be used in the structure or part of the structure shall be as specified in Item 405, Structural Concrete.

407.2 Material Requirements

1. Concrete and Concrete Ingredients

Concrete and concrete materials shall conform to the requirements in Item 405, Structural Concrete. Unless otherwise shown on the Plans or specified in Special Provisions, concrete shall be of Class A.

2. Reinforcing Steel

Reinforcing steel shall conform to the requirements in Item 404, Reinforcing Steel.

3. Structural Steel

Structural steel shall conform to the requirements of correspondingmaterials in Item 403, Metal Structures.

4. Bridge Bearing (Elastomeric Bearing Pad)

Elastomeric bearing pads shall conform to Item 412, Elastomeric Bearing Pads.

5. Paints

Paints shall conform to the requirements in Item 411, Paint.

6. Waterproofing and Dampproofing

Unless otherwise shown on the Plans or indicated in Special Provisions, materials for waterproofing and dampproofing shall conform to the requirements of the following specifications:

a. AASHTO M 115 Asphalt for dampproofing and waterproofing.

b. AASHTO M 116 Primer for the use with Asphalt in dampproofing and waterproofing.

c. AASHTO M 117 Woven cotton fabrics saturated with bituminoussubstances for use in waterproofing.

d. AASHTO M 118 Coal-Tar pitch for roofing, dampproofing and water-proofing.

e. AASHTO M 121 Creosote for priming coat with coal-tar pitch damp-proofing and waterproofing.

f. AASHTO M 159 Woven burlap fabric saturated with bituminoussubstances for use in waterproofing.

g. AASHTO M 166 Numbered cotton duck and array duck.

h. AASHTO M 239 Asphalt for use in waterproofing membrane construction.

7. Concrete Curing Compound

Curing compound shall conform to the requirements of AASHTO M 148 Liquid membrane-forming compounds for curing concrete.

8. Joint Filler

Unless otherwise shown on the Plans or in Special Provisions, materials forexpansion joint filler shall conform to the requirements of the followingspecifications:

a. AASHTO M 33 Preformed expansion joint filler for concrete.

b. AASHTO M 153 Preformed sponge rubber and cork expansion jointfillers for concrete paving and structural construction.

c. AASHTO M 173 Concrete joint sealer hot poured elastic type.

d. AASHTO M 213 Preformed expansion joint filler for concrete paving andstructural construction-non-extruding and resilient bituminous types.

e. AASHTO M 220 Preformed elastomeric compression joint seals forconcrete.

407.2.1 Proportioning and Strength of Structural Concrete

This shall be in accordance with Item 405, Structural Concrete.

407.2.2 Sampling and Testing

This shall be in accordance with Item 405, Structural Concrete.

407.3 Construction and Requirements

407.3.1 Handling and Placing Concrete: General

Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer.

If lean concrete is required in the Plan or as directed by the Engineer prior to placing of reinforcing steel bar, the lean concrete should have a minimum compressive strength of 13.8 MPa.

In preparation for the placing of concrete all sawdust, chips and other construction debris and extraneous matter shall be removed from inside the formwork. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used which does not reach its final position in the forms within the time stipulated under “Time of Hauling and Placing Mixed Concrete”.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes, and pipes for conveying concrete to the

forms shall be permitted only on written authorization of the Engineer. The Engineer shall reject the use of the equipment for concrete transportation that will allow segregation, loss of fine materials, or in any other way will have a deteriorating effect on the concrete quality.

Open troughs and chutes shall be of metal lined; where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement to avoid segregation.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure.

When placing operations would involve dropping the concrete more than 1.5 m, concrete shall be conveyed through sheet metal or approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower end shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement bars.
The concrete shall be placed as nearly as possible to its final position and the use of vibrators for moving of the mass of fresh concrete shall not be permitted.

407.3.1.1 Placing Concrete by Pneumatic Means

Pneumatic placing of concrete will be permitted only if specified in the Special Provisions or authorized by the Engineer. The equipment shall be so arranged that vibration will not damage freshly placed concrete.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine. The discharge end of the line shall not be more than 3 m from the point of deposit.

At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

407.3.1.2 Placing of Concrete by Pumping

The placing of concrete by pumping will be permitted only if specified or if authorized by the Engineer. The equipment shall be so arranged that vibration will not damage freshly placed concrete.

Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

407.3.1.3 Placing Concrete in Water

Concrete shall not be placed in water except with approval of the Engineer and under his immediate supervision. In this case the method of placing shall be hereinafter specified.

Concrete deposited in water shall be Class A concrete with a minimum cement content of 400 kg/m3 of concrete. The slump of the concrete shall be maintained between 10 and 20 cm. To prevent segregation, concrete shall be carefully placed in a compact mass, in its final position, by means of a tremie, a bottom-dump bucket, or other approved means, and shall not be disturbed after being placed.

A tremie shall consist of a tube having a diameter of not less than 250 mm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge and over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times. The tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by lightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the work is completed.

When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The buckets shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

407.3.2 Compaction of Concrete

Concrete during and immediately after placing shall be thoroughly compacted. The concrete in walls, beams, columns and the like shall be placed in horizontal layers not more than 30 cm thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding layer has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the layers. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer.

The compaction shall be done by mechanical vibration. The concrete shall be vibrated internally unless special authorization of other methods is given by the Engineer or is provided herein. Vibrators shall be of a type, design, and frequency approved by the Engineer. The intensity of vibration shall be such as to visibly affect a mass of concrete with a 3 cm slump over a radius of at least 50 cm. A sufficient number of vibrator shall be provided to properly compact each batch immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms and shall be applied at the point of placing and in the area of freably placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The vibration shall be of sufficient duration and intensity to compact the concrete thoroughly but shall not be continued so as to cause segregation and at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced, and not farther apart than twice the radius over which the vibration is visibly effective. Vibration shall not be applied directly or thru the reinforcement to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms of troughs or chutes.

407.3.3 Casting Sections and Construction Joints

The concrete in each form shall be placed continuously. Placing of concrete in any such form shall not be allowed to commence unless sufficiently inspected and approved materials for the concrete is at hand, and labor and equipment are sufficient to complete the pour without interruption.

Joints in the concrete due to stopping work shall be avoided as much as possible. Such joints, when necessary, shall be constructed to meet the approval of the Engineer.

When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its shape, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. Where a “faster edge” might be produced at a construction joint, as in the sloped top surface of a wingwall, an inset formwork shall be used to produce an edge thickness of not less than 15 cm in the succeeding layer. Work shall not be
discontinued within 50 cm of the top of any face, unless provision has been made for a coping less than 50 cm thick, in which case if permitted by the Engineer, the construction joint may e made at the underside of coping.

Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. Care shall be exercised, during the cleaning of the reinforcing steel, not to injure or break the concrete-steel bond at and near the surface of the concrete.

407.3.4 Casting Box Culverts

In general, the base slab of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. In the construction of box culverts the side walls and top slab may be constructed as a monolith.

If the concrete in the walls and top slab is placed in two separate operations, special care shall be exercised in order to secure bonding in the construction joint and appropriate keys shall be left in the sidewalls for anchoring the top slab. Each wingwall shall be constructed, if possible, as a monolith. Construction joints where unavoidable, shall be horizontal and so located that no joints will be visible in the exposed face of the wingwall above the ground line.

Vertical construction joints shall be at right angles to the axis of the culverts.

407.3.5 Casting Columns, Slabs and Girders

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set for at least 20 hours before the caps are placed.

Unless otherwise permitted by the Engineer, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the condition of the concrete in the column. The load of the super structure shall not be allowed to come upon the bents until they have been in place at least 14 days, unless otherwise permitted by the Engineer.

Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise provided.

Concrete in T-Beam or deck girder spans shall be placed in one continuous operation unless otherwise directed. If it is permitted to place the concrete in two separate operations, each of the operations, shall be continuous: first, to the top of the girder stems, and second, to completion. In the latter case, the bond between stem and slab shall be secured by means of suitable shear keys which may be formed by the use of timber blocks approximately 50 mm x 100 mm in cross section having a length of 100 mm less than the width of the girder stem. These key blocks shall be placed along the girder stems as required, but the spacing shall not be greater than 300 mm center to center. The blocks shall be beveled and oiled in such a manner as to insure their ready removal, and they shall be removed as soon as the concrete has set sufficiently to retain its shape. If the contractor wishes to place the concrete in two separate operations, he shall, with his request for permission to do so, submit plans and proposals of the required changes to the reinforcement, which plans and proposals shall be subject to the approval of the Engineer.
In box girders, the concrete in the bottom slab shall be poured first, as a separate operation.

The concrete in the webs and the top slab shall be placed in one continuous operation unless otherwise specified. If it is permitted to place the concrete in more than one operation, the requirements for T-beam shall apply.

407.3.6 Construction Joints

Construction joints shall be made only where shown on the Plans or called for in the pouring schedule, unless otherwise approved by the Engineer. Shear keys or reinforcement shall be used, unless otherwise specified, to transmit shear or to bond the two sections together.

Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not leave loose particles of aggregate or damage concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance. When directed by the Engineer, the surface of the hardened concrete which will be in contact with new concrete shall be washed with water to this satisfaction. To insure an excess of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and saturated surfaces, including vertical and inclined surfaces shall first be thoroughly covered with a coating of mortar of the same proportion of sand and cement as the class of concrete used against which the new concrete shall be placed before the grout or mortar has attained its initial set.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation.

407.3.7 Concrete Surface Finishing

Surface finishing shall be classified as follows:

Class 1, Ordinary Finish
Class 2, Rubbed Finish
Class 3, Floated Finish

All concrete shall be given Class 1, Ordinary Finish and additionally any further finish as specified.

Unless otherwise specified, the following surfaces shall be given a Class 2, Rubbed Finish.

1. The exposed faces of piers, abutments, wingwalls, and retaining walls.
2. The outside faces of girders, T-beams, slabs, columns, brackets, curbs, headwalls, railings, arch rings, spandrel walls and parapets.

Excluded, however, are the tops and bottoms of floor slabs and sidewalks, bottoms of beams and girders, sides of interior beams and girders, backwalls above bridge seats or the underside of copings. The surface finish on piers and abutments shall include all exposed surfaces below the bridge seats to 20 cm below low water elevation or 50 cm below finished ground level when such ground level is above the water surface. Wingwalls shall be finished from the top to 50 cm below the finished slope lines on the outside face and shall be finished on top and for a depth of 20 cm below the top on the back sides.

Unless otherwise specified, the surface of the traveled way shall be Class 3, Floated Finish.

Class 1, Concrete Ordinary Finish

Immediately following the removal of forms, all fins and irregular protection shall be removed from all surface except from those which are not to be exposed or are not to be waterproofed. On all surfaces the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned, and after having been kept saturated with water for a period of not less than three hours shall be carefully pointed and made true with a mortar of cement and fine aggregate mixed in the proportions used in the grade of the concrete being finished. Mortar used in pointing shall not be more than one hour old. The mortar patches shall be cured as specified under Subsection 407.3.8. All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with a clean and true edges.

The resulting surface shall be true and uniform. All repaired surfaces, the appearance of which is not satisfactory to the Engineer, shall be “rubbed” as specified below.

Class 2, Concrete Rubbed 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 road holes and defects to thoroughly set. Surfaces to be finished shall be rubbed with a minimum coarse carborundum stone using 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, protections 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.

Class 3, Concrete Floated Finish

After the concrete is compacted as specified in Subsection 407.3.2, Compaction of Concrete, the surface shall be carefully struck off with a strike board to conform to the cross-section and grade shown on the Plans. Proper allowance shall be made for camber if required. The strike board may be operated longitudinally or transversely and shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither is raised from the side forms during the process. A slight excess of concrete shall be kept in front of the cutting edge at all times.

After striking off and consolidating as specified above, the surface shall be made uniform by longitudinal or transverse floating or both. Longitudinal floating will be required except in places where this method is not feasible.

The longitudinal float, operated from foot bridges, shall be worked with a sawing motion while held in a floating position parallel to the road centerline and passing gradually from one side of the pavement to the other. The float shall then be moved forward one-half of each length and the above operation repeated. Machine floating which produces an equivalent result may be substituted for the above manual method.

The transverse float shall be operated across the pavement by starting at the edge and slowly moving to the center and back again to the edge. The float shall then be moved forward one-half of each length and the above operation repeated. Care shall be taken to preserve the crown and cross-section of the pavement.

After the longitudinal floating has been completed and the excess water removed, but while the concrete is still plastic, the slab surface shall be tested for trueness with a straight-edge. For the purpose, the Contractor shall furnish and use an accurate 3 m straight-edge swing handless 1 m longer than one half the width of the slab.

The straight-edge shall be held in successive positions parallel to the road centerline and in contact with the surface and the whole area gone over from one side of the slab to the other as necessary. Advancement along the deck shall be in successive stages of not more than one-half the length of the straight-edge. Any depression found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. The straight-edge testing and refloating shall continue until the entire surface is found to be free from observable departure from the straight-edge and the slabs has the required grade and contour, until there are no deviations of more than 3 mm under the 3 m straight-edge.

When the concrete has hardened sufficiently, the surface shall be given a broom finish. The broom shall be an approved type. The strokes shall be square across the slabs from edge to edge, with adjacent strokes slightly overlapped, and shall be made by drawing the broom without tearing the concrete, but so as to produce regular corrugations not over 3 mm in depth. The surface as thus finished shall be free from porous spots, irregularities, depressions and small pockets or rough spots such as may be caused by accidental disturbing, during the final brooming of particles of coarse aggregate embedded near the surface.

Concrete Surface Finish for Sidewalk.

After the concrete has been deposited in place, it shall be compacted. The surface shall be struck off by means of strike board and floated with a wooden or cork float. An edging tool shall be used on all edges and at all expansion joints. The surface shall not vary more than 3 mm under a 3 m straight-edge. The surface shall have a granular or matted texture which will not slick when wet.

407.3.8 Curing Concrete

All newly placed concrete shall be cured in accordance with this Specification, unless otherwise directed by the Engineer. The curing method shall be one or more of the following:

1. Water Method

The concrete shall be kept continuously wet by the application of water for a minimum period of 7 days after the concrete has been placed.

The entire surface of the concrete shall be kept damp by applying water with an atomizing nozzle. Cotton mats, rugs, carpets, or earth or sand blankets may be used to retain the moisture. At the expiration of the curing period the concrete surface shall be cleared of the curing medium.

2. Curing Compound

Surfaces exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer.

The membrane forming compound used shall be practically colorless liquid. The use of any membrane-forming compound that will alter the natural color of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film and shall be of such character that it will harden within 30 minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power-operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay, in the application of the curing compound, which results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under “Water Method”, shall be started immediately and shall be continued until the application of the compound is resumed or started, however, the compound shall not be applied over any resulting freestanding water. Should the film of compound be damaged from any cause before the expiration of 7 days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compound shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within 120 days after the date of manufacture, the Engineer may require additional testing before the use to determine compliance to requirements.

An anti-setting agent or a combination of anti-setting agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located on the Site. Storage tank shall have a permanent system designed to completely redisperse any settled material without introducing air or any
other foreign substance. Containers shall be well-sealed with ring seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be labeled with a manufacturer's name, specification number, batch number, capacity and date of manufacture, and shall have label warning concerning flammability. The label shall also warn that the curing compound shall be well-stirred before use. When the curing compound is shipped in tanks or tank trunks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required herein for container labels.

Curing compound may be sampled by the Engineer at the source of supply and on the Site.

3. Waterproof Membrane Method

The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed until the concrete has set, after which a curing membrane of waterproof paper or plastic sheeting shall be placed. The curing membrane shall remain in place for a period of not less than 72 hours.

Waterproof paper and plastic sheeting shall conform to the specification of AASHTO M 171.

The waterproof paper or plastic sheeting shall be formed into sheets of such width as to cover completely the entire concrete surface.

All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have a minimum lap of 100 mm.

The sheets shall be securely weighed down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within 72 hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.

Sections of membrane which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing, the concrete shall not be used.

4. Forms-in-Place Method

Formed surfaces of concrete may be cured by retaining the form-in place. The forms shall remain in place for a minimum period of 7 days after the concrete has been placed, except that for members over 50 cm in least dimensions, the forms shall remain in place for a minimum
period of 5 days. Wooden forms shall be kept wet by watering during the curing period.

5. Curing Cast-In-Situ Concrete

All newly placed concrete for cast-in-situ structures, other than highway bridge deck, shall be cured by the water method, the forms-in place method, or as permitted herein, by the curing compound method, all in accordance with the requirements of Subsection, 407.3.8 Curing Concrete.

The curing compound method may be used on concrete surfaces which are to be buried under ground and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform color is not required and which will not be visible from public view.

The top surface of highway bridge decks shall be cured by either the curing compound method or the water method. The curing compound shall be applied progressively during the deck finishing operations. The water cure shall be applied not later than 4 hours after completion of the deck finishing.

When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surface being cured by the curing compound method or by the forms-in-place method until the Engineer determine that a cooling effect is no longer required.

6. Curing Pre-Cast Concrete (except piles)

Pre-cast concrete members shall be cured for not less than 7 days by the water method or by steam curing. Steam curing for pre-cast members shall conform to the following provisions:

a. After placement of the concrete, members shall be held for a minimum 4-hour pre-steaming period.

b. To prevent moisture loss on exposed surfaces during the pre steaming period, members hall be covered immediately after casting or the exposed surface shall be kept wet by fog spray or wet blankets.

c. Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good condition and secured in such a manner to prevent the loss of steam and moisture.

d. Steam at jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed 20oC per hour. The curing temperature throughout the enclosure shall not exceed 65oC and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature of the enclosure will be the same as that of the concrete.

e. Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per 50 m of continuous bed length will be required for checking temperature.

f. Curing of pre-cast concrete will be considered completed after the termination of the steam curing cycle.

7. Curing Pre-cast Concrete Piles

All newly placed concrete for pre-cast concrete piles, conventionally reinforced or prestressed shall be cured by the "Water Method" as described in Subsection 407.3.8, Curing Concrete, except that the concrete shall be kept under moisture for at least 14 days. At the option of the Contractor, steam curing may be used in which case the steam curing provisions of Subsection 407.3.8 (6), Curing Pre-Cast Concrete (except piles) shall apply except that the concrete shall be kept wet for at least 7 days including the holding and steaming period.

407.3.9 Falsework Design and Drawings

Detailed working drawings and supporting calculations of the false work shall be furnished by the Contractor to the Engineer. No falsework construction shall start until the Engineer has reviewed and approved the design. The Contractor shall provide sufficient time for the Engineer to complete this review. Such time shall be proportionate to the complexity of the falsework design and in no case be less than two weeks.

The Contractor may review the falsework drawings at any time provided sufficient time is allowed for the Engineer's review before construction is started on the revised portion.

Assumptions used in design of the falsework shall include but not be limited to the following:

1. The entire superstructure cross-section, except for the railing, shall be considered to be placed at one time, except when in the opinion of the Engineer, a portion of the load is carried by members previously cast and having attained a specified strength.

2. The loading used on timber piles shall not exceed the bearing value for the pile and shall in no case exceed 20 tonne per pile.

3. Soil bearing values and soil condition (wet and dry) shall be designated by the Contractor on the falsework drawings. Falsework footings shall be designed to carry the loads imposed upon them without exceeding estimated soil bearing values or allowable settlements.

4. The maximum loadings and deflections used on jacks, brackets, columns and other manufactured devices shall not exceed the manufacturer's recommendations. If requested by the Engineer, the Contractor shall furnish catalogue or other data verifying these recommendations.

5. If the concrete is to be prestressed, the falsework shall be designed to support any increased or readjusted loads caused by the prestressing forces.

6. Joints supporting slabs and overhangs shall be considered as falsework and designed as such.

For the construction of falsework over and adjacent to roadways where falsework openings are required for maintaining traffic, the Contractor shall provide any additional features for the work needed to ensure that the falsework will be stable if subjected to impact by vehicles.

The falsework design at the locations where said openings are required shall include but not be limited to the following minimum provisions:

a. Each exterior stringer in a span shall be securely anchored to the following cap or framing.

b. Adequate bracing shall be used during all stages of falsework construction and removal over or adjacent to public traffic.

c. Falsework members shall be at least 300 mm clear of temporary protective railing members.

The falsework drawings shall include a superstructure placing diagram showing proposed concrete placing sequence and construction joint locations, except that where a schedule for placing concrete is shown on the Contract Plans, no deviation will be permitted there from unless approved in writing by the Engineer.

The falsework drawings shall show pedestrian openings which are required through the falsework.

Anticipated total settlements of falsework and forms shall be indicated by the Contractor on the falsework drawings. These should include falsework footing settlements over 20 mm which will not be allowed unless otherwise permitted by the Engineer. Deck slab forms between girders shall be constructed with no allowance for settlement relative to the girders.

Detailed calculations by the Contractor showing the stresses deflections, and camber necessary to compensate for said deflections in all load supporting members shall be supplied.

After approving the Contractor's falsework deflection camber, the Engineer will furnish to the Contractor the amounts of camber necessary to compensate for vertical alignment or anticipated structure deflection, if these are not shown on the drawings. The total camber used in constructing falsework shall be the sum of the aforementioned cambers.

407.3.10 Falsework Construction

The falsework shall be constructed to conform to the falsework drawings. The materials used in the falsework construction shall be of the quantity and quality necessary to withstand the stresses imposed. The workmanship used in falsework shall be of such quality that the falsework will support the loads imposed on it without excessive settlement or take-up beyond that shown on the falsework drawings.

When falsework is supported on piles, the piles shall be driven to a bearing value equal to the total calculated pile loading as shown on the falsework drawings.

Suitable jacks or wedges shall be used in connection with falsework to set the forms to their required grade and to take up any excessive settlement in the falsework either before or during the placing of concrete.

The Contractor shall provide tell-tales attached to the soffit forms easily readable and in enough systematically-placed locations to determine the total settlement of the entire portion of the structure where concrete is being placed.

Should unanticipated events occur, including settlements that deviate more than ±20 mm from those indicated on the falsework drawings, which in the opinion of the Engineer would prevent obtaining a structure conforming to the requirement of the Specification, the placing of concrete shall be discontinued until corrective measures satisfactory to the Engineer are provided. In the event satisfactory measures are not provided prior to initial set of the concrete in the affected area, the placing of concrete shall be discontinued at a location determined by the Engineer. All unacceptable concrete shall be removed.

407.3.11 Removing Falsework

Unless otherwise shown on the drawings, or permitted by the Engineer, falsework supporting any span of a supported bridge shall not be released before 14 days after the last concrete, excluding concrete above the bridge deck, has been placed. Falsework supporting any span of a continuous or rigid frame bridge shall not be released before 14 days after the last concrete excluding concrete above the bridge deck, has been placed in that span and in the adjacent portions of each adjoining span for a length equal to at least half the length of the span
where falsework is to be released.

Falsework supporting deck overhangs and deck slabs between girders shall not be released until 7 days after the deck concrete has been placed.

In addition to the above requirements, no falsework for bridges shall be released until the supported concrete has attained a compressive strength of at least 80% of the required 28-day strength. Falsework for cast-in place prestressed portion of structure shall not be released until after the prestressing steel has been tensioned.

All falsework materials shall be completely removed. Falsework piling shall be removed at least 50 cm below the surface of the original ground or stream bed. When falsework piling is driven within the limits of ditch or channel excavation areas, the falsework piling within such areas shall be removed to at least 50 cm below the bottom and side slopes of said excavated areas.

All debris and refuse resulting from work shall be removed and the site left in a neat and presentable condition.

407.3.12 Formwork Design and Drawings

The Contractor shall prepare drawings and materials data for the formwork and shutters to be submitted to the Engineer for approval unless otherwise directed.

The requirements for design of formwork are the same as described under Section 407.3.9.

407.3.13 Formwork Construction

Concrete forms shall be mortar tight, true to the dimensions, lines and grades of the structure and with the sufficient strength, rigidity, shape and surface smoothness as to leave the finished works true to the dimensions shown on the Plans or as required by the Engineer and with the surface finish as specified.

Formwork and shutters are to be constructed in accordance with the approved Plans.

The inside surfaces of forms shall be cleaned of all dirt, mortar and foreign material. Forms which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be of commercial quality form oil or other approved coating which will permit the ready release of the forms and will not discolor the concrete.

Concrete shall not be deposited in the forms until all work in connection with constructing the forms has been completed, all materials required for the unit to be poured are present, and the Engineer has inspected and approved said forms and materials. Such work shall include the removal of all dirt, chips, sawdust and other foreign material from the forms.

The rate of depositing concrete in forms shall be such to prevent bulging of the forms or form panels in excess of the deflections permitted by the Specification.

Forms for all concrete surfaces which will not be completely enclosed or hidden below the permanent ground surface shall conform to the requirements herein for forms for exposed surfaces. Interior surfaces of underground drainage structures shall be completely enclosed surfaces.

Formwork for concrete place under water shall be watertight. When lumber is used, this shall be planed, tongued and grooved.

Forms for exposed concrete surface shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding either 2 mm or 1/270 of the center to center distance between studs, joists, form stiffeners, form fasteners, or wales will be considered to be excessive. Should any form of forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein specified may be rejected by the Engineer.

All exposed surfaces of similar portions of a concrete structure shall be formed with the same forming material or with materials which produce similar concrete surface textures, color and appearance.

Forms for exposed surfaces shall be made of form materials of even thickness and width and with uniform texture. The materials shall have sharp edges and be mortar-tight.

Forms for exposed surfaces shall be constructed with triangular fillets at least 20 mm wide attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp edges of the concrete.

Form fasteners consisting of form bolts, clamps or other devices shall be used as necessary to prevent spreading of the forms during concrete placement. The use of ties consisting of twisted wire loops to hold forms in position will not be permitted.

Anchor devices may be cast into the concrete for later use in supporting forms or for lifting precast members. The use of driven types of anchorage for fastening forms of form supports to concrete will not be permitted.

407.3.14 Removal of Forms and Falsework

Forms and falsework shall not be removed without the consent of the Engineer. The Engineer's consent shall not relieve the Contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the time the forms are removed and in no case shall any portion of the wood forms be left in the concrete.

Falsework removal for continuous or cantilevered structures shall be as directed by the Engineer or shall be such that the structure is gradually subjected to its working stress.

When concrete strength tests are used for removal of forms and supports, such removal should not begin until the concrete has attained the percentage of the specified design strength shown in the table below.

Part of Structure	Minimum Time	Minimum Percentage Design Strength
Centering under girders, beams frames or arches	14 days	80%
Floor slabs	14 days	70%
Walls	1 day	70%
Columns	2 days	70%
Sides of beams and all other vertical surfaces	1 day	70%

In continuous structures, falsework shall not be released in any span until the first and second adjoining spans on each side have reached the strengthspecified herein, or in the Special Specifications. When cast-in-place post tensioned bridges are constructed, falsework shall remain in place until all post tensioning has been accomplished.

Falsework under all spans of continuous structures shall be completely released before concrete is placed in railings and parapets. In order to determine the condition of column concrete, forms shall be removed from columns before releasing supports from beneath beams and girders.

Forms and falsework shall not be released from under concrete without first determining if the concrete has gained adequate strength without regard to the time element. In the absence of strength determination, the forms and falsework are to remain in place until removal is permitted by the Engineer.

The forms for footings constructed within cofferdams or cribs may be left in place when, in the opinion of the Engineer, their removal would endanger the safety of the cofferdam or crib, and when the forms so left intact will not be exposed to view in the finished structure. All other forms shall be removed whether above or below the ground line or water level.

All forms shall be removed from the cells of concrete box girders in which utilities are present and all formwork except that necessary to support the deck slab shall be removed from the remaining cells of the box girder.

To facilitate finishing, forms used on ornamental work, railing, parapets and exposed vertical surfaces shall be removed in not less than 12 nor more than 48 hours, depending upon weather conditions. In order to determine the condition of concrete in columns, forms shall

always be removed from them before the removal of shoring from beneath beams and girders.

Falsework and centering for spandrel-filled arches not be struck until filling at the back of abutments has been placed up to the spring line. Falsework supporting the deck of rigid frame structure shall not be removed until fills have been placed back to the vertical legs.

407.4 Method of Measurement

The quantity of structural steel, structural concrete, reinforcing steel or other Contract Pay Items shall constitute the completed and accepted structure which shall be measured for payment in the manner prescribed in the several items involved.

407.5 Basis of Payment

The quantities measured as provided in Section 407.4, Method of Measurement shall be paid for at the contract price for the several Pay Items which price and payment shall be full compensation for furnishing, preparing, fabricating, placing, curing and for all labor, equipment, tools and incidentals necessary to complete the Item. Such payment shall constitute full payment for the completed structure ready for use.

Payment will be made under:

Pay Item	Description	Unit of Measurement
405(1)	Concrete Class A, C & P	Cubic Meter
405(2)	Concrete Post/Baluster Railings	Each
405(3)	Parapet Walls	Cubic Meter
00	Piling	Linear Meter
103	Structure Excavation	Cubic Meter
601	Sidewalk Concrete	Square Meter or Cubic Meter
404	Reinforcing Steel Bars	Kilogram
407(1)	Lean Concrete	Cubic Meter

XIV. ITEM 500 – PIPE CULVERTS AND STORM DRAINS

500.1 Description

This item shall consist of the construction or reconstruction of pipe culverts and storm drains, hereinafter referred to as “conduit” in accordance with this Specification and in conformity with the lines and grades shown on the Plans or as established by the Engineer.

500.2 Material Requirements

Material shall meet the requirements specified in the following specifications:

Zinc coated (galvanized) corrugated iron or steel culverts and underdrains	AASHTO M 36
Cast iron culvert pipe	AASHTO M 64
Concrete sewer, storm drain and culvert pipe	AASHTO M 86

Reinforced concrete culvert, storm drain and sewer pipe	AASHTO M 170
Bituminous coated corrugated metal culvert pipe and pipe arches	AASHTO M 190
Reinforced concrete arch culvert, storm drain and sewer pipe	AASHTO M 206
Reinforced concrete elliptical culvert, storm drain and sewer pipe	AASHTO M 207
Asbestos cement pipe for culverts and storm drains	AASHTO M 217

Joint Mortar – Joint mortar for concrete pipes shall consist of 1 part, by volume of Portland Cement and two (2) parts of approved sand with water as necessary to obtain the required consistency.

Portland Cement and sand shall conform to the requirements of Item 405, Structural Concrete. Mortar shall be used within 30 minutes after its preparation.

Rubber gaskets	AASHTO M 198

Oakum – Oakum for joints in bell and spigot pipes shall be made from hemp (Cannavis Sativa) line or Benares Sunn fiber or from a combination of these fibers. The oakum shall be thoroughly corded and finished and practically free from lumps, dirt and extraneous matter.

Hot poured joint sealing compound	AASHTO M 173

Bedding material shall conform to the requirements of Subsection 500.3.2, Bedding.

Backfill material shall conform to the requirements of Subsection 500.3.6, Backfilling.

When the location of manufacturing plants allow, the plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with materials quality requirements. This shall be the basis for acceptance of manufacturing lots as to quality.

Prior to and during incorporation of materials in the work, these materials will be subjected to the latest inspection and approval of the Engineer.

500.3 Construction Requirements

500.3.1 Trenches Excavation

Trenches shall be excavated in accordance with the requirement of Item 103, Structure Excavation, to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill materials under and around the conduit. Where feasible, trench wall shall be vertical.

The completed trench bottom shall be firm for its full length and width. Where required, in the case of crop drains, the trench shall have a longitudinal camber of the magnitude specified.

When so specified on the Plans, the excavation for conduits placed in embankment fill, shall be made after the embankment has been completed to the specified or directed height above the designed grade of the conduit.

500.3.2 Bedding

The bedding shall conform to one of the classes specified. When no bedding class is specified, the requirements for Class C bedding shall apply.

Class A bedding shall consist of a continuous concrete cradle conforming to the plan details.

Class B bedding shall consist of bedding the conduit to a depth of not less than 30 percent of the vertical outside diameter of the conduit. The minimum thickness of bedding material beneath the pipe shall be 100 mm. The 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 0.075 mm sieve. The layer of the bedding material shall be shaped to fit the conduit for at least 15 percent of its total height. Recesses in the trench bottom shall be shaped to accommodate the bell when bell and spigot type conduit is used.

Class C bedding shall consist of bedding the conduit to a depth of not less than 10 percent of its total height. The foundation surface, completed in accordance with Item 103, Structure Excavation, shall be shaped to fit the conduit and shall have recesses shaped to receive the bells, if any.

For flexible pipe, the bed shall be roughly shaped and a bedding blanket of sand or fine granular material as specified above shall be provided as follows:

Pipe Corrugation Depth	Minimum Bedding Depth
10 mm	25 mm
25 mm	50 mm
50 mm	75 mm

For large diameter structural plate pipes the shaped bed need not exceed the width of bottom plate

500.3.3 Laying Conduit

The conduit laying shall begin at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream. Flexible conduit shall be placed with longitudinal laps or seams at the sides.

Paved or partially-lined conduit shall be laid such that the longitudinal center line of the paved segment coincides with the flow line. Elliptical and elliptically reinforced conduits shall be placed with the major axis within 5 degrees of a vertical plane through the longitudinal axis of the conduit.

500.3.4 Jointing Conduit

Rigid conduits may either be of bell and spigot or tongue and groove design unless another type is specified. The method of joining conduit sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

Joints shall be made with (a) Portland Cement mortar, (b) Portland Cement grout, (c) rubber gaskets, (d) oakum and mortar, (e) oakum and joint compound, (f) plastic sealing compound, or by a combination of these types, or any other type, as may be specified. Mortar joints shall be made with an excess of mortar to form a continuous bead around the outside of the conduit and finished smooth on the inside. For grouted joints, molds or runners shall be used to retain the poured grout. Rubber ring gaskets shall be installed so as to form a flexible water-tight seal. Where oakum is used, the joint shall be called with this material and then sealed with the specified material.

When Portland Cement mixtures are used, the completed joints shall be protected against rapid drying by any suitable covering material.

Flexible conduits shall be firmly joined by coupling bands.

Conduits shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be taken up and relaid or replaced.

500.3.5 Field Strutting

When required by the Plans, vertical diameter of round flexible conduit shall be increased 5 percent by shop elongation or by means of jacks applied after the entire line of conduit has been installed on the bedding but before backfilling. The vertical elongation shall be maintained by means of sills and struts or by horizontal ties shall be used on paved invert pipe.

Ties and struts shall be 300 mm in place until the embankment is completed and compacted, unless otherwise shown on the Plans.

These construction specifications shall also apply in the case of relaid conduits. In addition, all conduits salvaged for relaying shall be cleaned of all foreign materials prior to reinstallation.

500.3.6 Backfilling

Materials for backfilling on each side of the conduit for the full trench width and to an elevation of 300 mm above the top of the conduit shall be fine, readily compactible soil or granular material selected from excavation or from a source of the Contractor’s choice, and shall not contain stones that would be retained on a 50 mm sieve, chunks of highly plastic clay, or other objectionable material. Granular backfill material shall have not less than 95 percent passing a 12.5 mm sieve and not less than 95 percent retained on a 4.75 mm sieve. Oversized material, if present, shall be removed at the source of the material, except as directed by the Engineer.

When the top of the conduit is flushed with or below the top of the trench, backfill material shall be placed at or near optimum moisture content and compacted in layers not exceeding 150 mm (compacted) on both sides to an elevation 300 mm above the top of the conduit. are shall be exercised to thoroughly compact the backfill under the haunches of the conduit.

The backfill shall be brought up evenly on both sides of the conduit for the full required length. Except where negative projecting embankment-type installation is specified, the backfill material shall be placed and compacted for the full depth of the trench.

When the top of the conduit is above the top of the trench, backfill shall be placed at or near optimum moisture content and compacted in layers not exceeding 300 mm (compacted). It shall be brought up evenly on both sides of the conduit for its full length to an elevation 300 mm above the top of the conduit. The width of the backfill on each side of the conduit for the portion above the top of the trench shall be equal to twice the diameter of the conduit or 3.5 m, whichever is less. The backfill material used in the trench section and the portion above the top of the trench for a distance on each side of the conduit equal to the horizontal inside diameter and to 300 mm above the top of the conduit shall conform to the requirements for backfill materials in this Subsection. The remainder of the backfill shall consist of materials from excavation and borrow that is suitable for embankment construction.

Compaction to the density specified in Item 104, Embankment, shall be achieved by use of mechanical tampers or by rolling.

All conduits after being bedded and backfilled as specified in this Subsection shall be protected by one metre cover of fill before heavy equipment is permitted to cross during construction of the roadway.

500.3.7 Imperfect Trench

Under this method, for rigid conduit, the embankment shall be completed as described in Subsection 500.3.6, Backfilling, to a height above the conduit equal to the vertical outside diameter of the conduit plus 300 mm. A trench equal in width to the outside horizontal diameter of the conduit and to the length shown on the plans or as directed by the Engineer shall then be excavated to within 300 mm of the top of the conduit, trench walls being as nearly vertical as possible. The trench shall be loosely filled with highly compressible soil. Construction of embankment above shall then proceed in a normal manner.

500.4 Method of Measurement

Conduit of the different types and sizes, both new and relaid, will be measured by the linear metre in place. Conduit with sloped or skewed ends will be measured along the invert.

Each section will be measured by the number of units installed.

Branch connection and elbows will be included in the length measurement for conduit, or they may be measured by the number of units installed.

Class B bedding material placed and approved shall be measured by the cubic metre in place.

When the Bid Schedule contains an estimated quantity for “Furnishing and Placing Backfill Material, Pipe Culvert”, the quantity to be paid for will be the number of cubic metre completed in place and accepted, measured in final position between limits as follows:

1. Measurement shall include backfill material in the trench up to the top of the original ground line but will not include any material placed outside of vertical planes 450 mm up outside of and parallel to the inside wall of pipe at its widest horizontal dimension.

2. When the original ground line is less than 300 mm above the top of the pipe, the measurement will also include the placing of all backfill materials, above the original ground line adjacent to the pipe for a height of 300 mm above the top of pipe and for a distance on each side of the pipe not greater than the widest horizontal dimension of the pipe.

3. The measurement shall include the placing of backfill material in all trenches of the imperfect trench method. Materials re excavated for imperfect trench construction will be measured for payment under Item 103, Structure Excavation.

500.5 Basis of Payment

The accepted quantities of conduit, determined as provided in Section 500.4, Method of Measurement, shall be paid for at the contract unit price per linear meter for the conduit of the types and sizes specified complete in place. End sections and, when so specified, branch connections and elbows, shall be paid for at the contract unit price per piece for the kind and size specified complete in place.

Excavation for culverts and storm drains, including excavation below flow line grade and for imperfect trench, shall be measured and paid for as provided in Item 103, Structure Excavation.

Concrete for Class A bedding will be paid for under Item 405, Structural Concrete.

When the Bid Schedule does not contain as estimated quantity for "Furnishing and Placing Backfill Material, Pipe Culvert" payment for placing backfill material around pipe culverts will be considered as included in the payment for excavation of the backfill material.

Payment will be made under:

Pay Item	Description	Unit of Measurement
500 (1)	Pipe Culvers, -mm, Class -	Linear Meter
500 (2)	Storm Drain, -mm, Class -	Linear Meter

XV. ITEM 502 – MANHOLES, INLETS AND CATCH BASINS

502.1 Description

This item shall consist of the construction, reconstruction or adjustment of manholes, inlets and catch basins in accordance with this Specification and in reasonably close conformity with the lines and grades shown on the Plans or as established by the Engineer.

502.2 Material Requirements

Concrete for these structures shall meet the requirements of Item 405, Structural Concrete. Other materials shall meet the following specifications:

Corrugated Metal Units – The units shall conform to Plan dimensions and the metal to AASHTO M 36. Bituminous coating, when specified, shall conform to ASTM D 1187, Asphalt-base Emulsion for use as Protective Coating for Metal.

Sewer and manhole brick

(Made from clay or shale)	AASHTO M 91
Building brick (Solid masonry units made from clay or shale)	AASHTO M 114

Joint Mortar- Unless otherwise indicated on the Plans, joints mortar shall be composed of one part Portland Cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight. All materials for mortar shall meet the requirements of Item 405, Structural Concrete.

Frames, Gratings, Covers and Ladder Rungs – Metal units shall conform to the Plan dimensions and to the following specification requirements for the designated materials.

Metal gratings and covers which are to rest on frames shall bear on them evenly. They shall be assembled before shipment and so marked that the same pieces may be reassembled readily in the same position when installed. Inaccuracy of bearings shall be corrected by machining, if necessary. A frame and a grating or cover to be used with it shall constitute one pair.

All castings shall be uniformly coated with asphalt-based emulsion meeting the requirements of ASTM D 1187, Asphalt-base Emulsion for use as Protective Coating for Metal.

Samples of the material in casting shall be taken during the casting of the units and shall be separate casting poured from the same material as the casting they represent.

Gray iron casting	AASHTO M 105
Mild to medium-strength carbon steel castings for general application	AASHTO M 103
Structural steel	AASHTO M 183
Galvanizing, where specified for these units, shall conform to the requirements of	AASHTO M 111
Reinforcing Steel	AASHTO M 31

Pre-cast Concrete Units – These units shall be cast in substantial permanent steel forms. Structural concrete used shall attain a minimum 28-day compressive strength of 20.682 MPa. The pre-cast units shall be cured in accordance with AASHTO M 171. Water absorption of individual cores taken from such units shall not exceed 7 percent. Additional reinforcement shall be provided as necessary to provide for handling of the pre-cast units.
A sufficient number of cylinders shall be cast from the concrete of each unit for compression tests at 7, 14 and 28 days, and to allow for at least 3 cylinders for each test. If the strength requirement is met at 7 or 14 days, the units shall be certified for use 14 days from the date of casting. If the strength is not met at 28 days, all units made from that batch or load will be rejected.

Cracks in units, honeycombed or patched areas in excess of 2,000 square millimeters, excessive water absorption and failure to meet strength requirements shall be the causes for rejection. Pre-cast reinforced concrete manhole risers and tops shall conform to the requirements of AASHTO M 199.

The plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with material quality requirements. This may be the basis for acceptance of manufacturing lots as to quality.

All materials shall be subjected to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials into the work.

502.3 Construction Requirements

Concrete construction shall conform to the requirements for Item 405, Structural Concrete.

Metal frames shall be set in full mortar bed. Pipe sections shall be flushed on the inside of the structure wall and projected outside sufficiently for proper connection with next pipe section. Masonry shall fit neatly and tightly around the pipe.

When grade adjustment of existing structures is specified, the frames, covers and gratings shall be removed and the walls reconstructed as required. The cleaned frames shall be reset at the required elevation. Upon completion, each structure shall be cleaned of any accumulation of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

Excavation and backfill shall be done in accordance with Item 103, Structure Excavation.

502.4 Method of Measurement

Standard manholes, inlets and catch basins, both new and reconstructed as applicable, will be measured by the unit. Any additional concrete, reinforcing steel, or masonry required for authorized increases in heights of structures paid of under this Item and in excess of the standard height shown on the Plans will be measured and paid for under Item 405, Structural Concrete and Item 404, Reinforcing Steel, as applicable. Structures noted on the Plans as “junction boxes” will be measured for payment as manholes.

The number of concrete covers, pairs of metal frames and gratings, and pairs of metal frames and covers will be measured as acceptably completed.

The number of existing manholes, inlets and catch basins adjusted as directed will be measured as acceptably completed.

502.5 Basis of Payment

The accepted quantities, determined as provided in Section 502.4, Method of Measurement of the Pay Items in the Bill of Quantities will be paid for at the contract unit prices, which shall constitute full compensation for furnishing and placing all materials and for all labor, equipment, tools and incidentals necessary to complete the Item.

Excavation and backfill will be measured and paid for as provided in Item 103, Structure Excavation.

Payment will be made under:

Pay Item	Description	Unit of Measurement
502 (1)	Manholes	Each
502 (2)	Inlets, type	Each
502 (3)	Catch basins	Each
502 (4)	Concrete Covers	Each
502 (5)	Metal frames and gratings, type	Pair
502 (6)	Metal frames and covers	Pair
502 (7)	Adjusting manholes	Each
502 (9)	Adjusting catch basin	Each

XVI. ITEM 601 – SIDEWALK

601.1 Description

This Item shall consist of the construction of asphalt or portland cement concrete sidewalk in accordance with this Specification and to the lines, grades, levels and dimensions shown on the Plans, or as required by the Engineer.

601.2 Material Requirements

601.2.1 Portland Cement Concrete

The cement concrete shall be Class A as specified in Item 405, Structural Concrete.

601.2.2 Asphalt

Asphaltic material shall be as specified in Item 308, Bituminous Plant-Mix Surface Course, Cold-Laid, or Item 310, Bituminous Concrete Surface Course, Hot Laid.

601.2.3 Expansion Joint Filler

Unless otherwise ordered, the preformed joint filler shall have a thickness of 5 mm and shall conform to the requirements of Item 311, Portland Cement Concrete Pavement.

601.2.4 Forms

Forms shall be of wood or metal as 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.

601.2.5 Bed Course Material

Bed course material consists of cinders, sand, slag, gravel, crushed stone or other approved permeable granular material of such grading that all particles shall pass a 12.5 mm (1/2 inch) sieve.

601.2.6 Asphaltic Prime Coat

Prime coat shall be cut-back asphalt conforming to the requirements of Item 301, Bituminous Prime Coat.

601.3 Construction Requirements

601.3.1 Asphalt Sidewalk

Excavation shall be made to the depth and width required that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to a firm and even surface conforming to the section shown on the Plans. All materials from soft areas shall be removed and replaced with suitable materials.

The bed course shall be compacted in layers not exceeding 100 mm to the depths, lines and levels shown on the Plans.

The prepared bed course material shall receive an application of prime coat in accordance with the requirements of Item 301, Bituminous Prime Coat.

The asphalt mixture shall be placed on the previously primed and prepared bed only when, in the opinion of the Engineer, the bed is sufficiently dry and weather conditions are suitable. The mixture shall be placed in one or more layers of uniform thickness to the total depth shown on the Plans. Each layer shall be smoothed by raking or screeding and shall be thoroughly compacted by rolling with a hand operated roller of a type satisfactory to the Engineer. After compaction, the surfacing shall be of the thickness and section shown on the Plans and shall be smooth, even and of a dense uniform texture. Forms, if used, shall be removed and the shoulders shaped and compacted to the required section.

601.3.2 Cement Concrete Sidewalk

Excavation shall be as specified above. The bed course material shall be placed in accordance with the Item 200, Aggregate Subbase Course.

All forms shall be staked securely in position at the correct line and level. Preformed joint filler shall be set in position shown on the Plans before placing of the concrete is started. The top of the joint filler shall be placed 5 mm below the top surface of the finished sidewalk.

The mixing, placing, finishing and curing of concrete shall be as specified in Item 405, Structural Concrete. The portland cement concrete shall be placed to the total depth shown on the Plans.

The surface shall be cut through to a depth of 10 mm with a trowel at intervals of 1 m or, were required, in straight lines perpendicular to the edge of sidewalk. The surface shall then be brushed. The edges of the sidewalk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges to a radius of 15 mm.

601.4 Method of Measurement

The area to be paid for shall be the number of square meters of sidewalk measured, completed in-place and accepted.

601.5 Basis of Payment

The quantity as determined in Subsection 601.4, Method of Measurement, shall be paid for all the contract unit price per square meter for Sidewalk which price and payment shall constitute full compensation for furnishing and placing all materials for asphalt sidewalk, concrete sidewalk, expansion joint material, for excavating and compacting the foundation bed, for furnishing and placing cinders, gravel or other permeable bed course material, for prime coat material, for forms, and for all labor, equipment, tools and incidentals necessary to complete the Item.

Payment will be made under:

Pay Item	Description	Unit of Measurement
601	Sidewalk	Square Meter

XVII. ITEM 807 – SITE DEVELOPMENT

807.1 Description

This Item shall consist of furnishing and installation of the complete site development work consisting of earthworks, roadway, drainage and sewerage, driveway/parking, turfing, planting, mowing, sanitary works (waterline), electrical works (lighting works), delivery of materials and other labor necessary for the completion of the project in accordance with the Plans and this Specification.

807.2 Material and Construction Requirements

807.2.1 Softscape Specification

807.2.1.1 Turfing

Preparation

The areas to be turfed shall be completely cleared of all builders' debris, large stones and other obstructions.

The planting area shall be cultivated to an average depth of 150 mm. Where the ground is clay, hardpan, sun baked earth or other impervious materials, it shall be ploughed or scarified to a minimum depth of 150 mm to reduce to granular material of sizes not exceeding 75 mm.

The ground shall be later finished by lightly rolling with roller not exceeding 136 kgs in weight. Rolling shall only be done when the formation is dry.

Trimming and Levelling

Before spreading the top soil the ground of filled earth must be trimmed and levelled. In case of banks, the edge must be trimmed off to a curve to allow the grass to be cut with a motor mower.

Turfing Existing Ground

Where existing ground is to be turfed, mounds shall be levelled and depressions, holes, channels, etc., shall be filled-in to the general level of the area or to the levels shown on the Plans.

Garden Soil (Top Soil)
The top soil is to be selected vegetable garden soil, free from roots, weeds and any unnecessary hard granular material. Top soil shall be spread and levelled over the whole area to be turfed to form an even layer of 50 mm (consolidated thickness). The Contractor shall submit a sample of the top soil to the Engineer for approval before application.

Ground to be Forked

Before turfing, the ground or filled earth shall be forked to a depth of 100 mm to 150 mm to thoroughly loosen the soil.

Turf

The turf for use in the work shall be of the best quality and shall be obtained from sources approved by the Engineer. The turfs shall be very healthy, free from defects, decay, disfiguring of roots, sun or wind scaled injury, plant disease, insect or pest or any other form of infestation.

The Contractor shall furnish the Engineer of approved samples of the turf before planting. The Engineer shall visit and inspect the nursery from where the turfs are obtained.

The turfs for use in the Contract shall be of the following type:

1. Cow Grass

The turf shall be cut into approximately 225 mm square and lifted carefully with proper cutting tools and shall be flat, square or rectangular, with even thickness, but shall be as thick as possible. The minimum thickness of turf shall be 40 mm. The root formation shall be moist and the grass shall not exceed 20 mm long and shall be dense green with vigorous roots and healthy.

The grass shall be stacked on site, and the Engineer shall inspect the grass for weeds before laying. The grass shall always be kept moist by spraying with water and covering with wet sacks.
2. Grass Planting

Cow grass shall be planted within 24 h after being cut or stripped off. Dry turf shall be rejected.

a. Spot Turfing - Spot shall be at 450 mm at centers.

b. Close Turfing - The turf shall be laid on top of vegetable garden soil and shall be laid accurately to level and full with close butt joints. Immediately after laying, the turfs shall be lightly beaten with wooden beater until they are firmly bedded to the ground. Any depression produced by the beatings shall be leveled by packing the depression with additional top soil from underneath the turf. The turf shall be beaten again. Laying and beating shall continue until all the turfs are firmly bedded and a continuous turfing area is obtained.

The minimum total thickness of the turf and the top soil shall be 75 mm and shall be measured after the turf has been laid and beaten. For this purpose, small trial holes shall be dug as directed by the Engineer. If the thickness between the top of the grass and the

formation level is less than 75 mm, the Contractor shall, without additional cost, relay the turfs to the approval of the Engineer. Turfing to banks shall be firmly cured by 150 mm long wooden pegs driven each piece.

Top Dressing

The material used for the top dressing shall be between 80:20 and 90:10 sand:soil mixes. Organic matter shall be included in the mixture. Fertilizers, soil ameliorants such as lime, and pesticides shall also be included for special purposes. The Contractor shall apply top dressing to the turfed area immediately after they are laid and thereafter until the turfs survive independently.

The top dressing shall be deposited and spread evenly over the turfed area at the rate of 11.2 g/m2.

Commencement of Turfing

Turfing shall be carried out at least well in advance 3 months before the completion of the whole works.

Watering

The Contractor shall immediately after laying, water the turf adequately. The Contractor shall water the turf throughout the planting and maintenance periods until the turfs survive independently.

The Contractor shall water the turfs by spraying so that no turf or soil will be disturbed. The rate of application shall be not less than 0.47 mL/ m2.

807.2.1.2 Softscape Maintenance

Nursing and Watering

It is the Contractor's responsibility to ensure that the grass is properly nursed and tended until fully established, including watering as necessary during dry periods. Any grass which fails to flourish shall be replaced at the Contractor's expense until the grasses survive independently.

Cutting and Rolling

The Contractor shall cut the grass at least once a month throughout the planting and maintenance periods or at any time instructed by the Engineer. Grass cutting shall be carried out with hand or mechanical tools with sharp and well-adjusted blade, so that the turf shall be cleanly cut and no tearing will take place.

The Contractor shall take reasonable care not to cut or damage the stolons or rhizomes of the spreading grass when cutting spot turfing. No cutting shall be carried out when the grass is wet or when it is raining.

Where and when instructed by the Engineer, the Contractor shall roll the turf with a roller weighing not exceeding 360 kg to press the roots firmly into the soil and to produce a close well knitted turfing.

807.2.1.3 Lawn Maintenance

Watering

During drought periods, the only way to maintain a desirable greenness is to give the lawn a thorough soaking once or twice a week. Light daily sprinkling does more harm than good. It requires from 1,900 L to 2,840 L of water for every 93 m2 of lawn for each application to give an equivalent 20 mm to 38 mm of rain. This shall moisten the soil from 65 mm to 125 mm deep.

Continuous heavy watering favors diseases.

The surface layer of soil shall be kept damp by frequent light watering with a fine spray during the germination period after seeding or vegetative planting and until the young plants are rooted firmly. It is often necessary to water three (3) or four (4) times daily in hot windy periods. After the grass is established, water shall be used sparingly and with maximum intervals between applications.

Water shall be applied to new seeding and vegetative plantings in a fine spray that will not wash that soil away from the base of young plants. It shall be applied slowly so that the surface will not puddle and crust.

Weeding

Keep all planting areas free from weeds and undesirable grasses, by a method and by materials approved/ permitted by the Engineer.

Mowing

All grass area shall be mowed at regular intervals which will keep grass height from exceeding 80 mm. Mower blades shall be set at 40 mm unless otherwise directed by the Engineer. All for season beyond the Contractor's control, the height of the grass has exceeded 80 mm, the mower blades shall be raised so that at no time will more than ½ of the grass leaf surface be removed.

807.2.1.4 Planting

Plant holes shall be excavated at a minimum of twice the size of the volume of the pot size specified in the Plans.

Plants shall be provided with the following characteristics:

1. Large healthy root systems, with no evidence of root curl, restriction or damage;

2. Vigorous, well established, free from disease and pests, of good form consistent with the species or variety; and

3. Hardened off, not soft or forced, and suitable for planting in the natural climatic conditions prevailing at the site.

Trees which, unless required to be multi-stemmed, have a single leading shoot shall be provided.

At least one plant shall be labelled of each species or variety in a batch using a durable, readable tag.

Planting shall be carried out on the same day that plants are delivered to the site. Plants shall not be planted in unsuitable weather conditions such as extreme heat, cold, wind or rain. In other than sandy soils, excavation shall be suspended when the soil is wet.

Plants shall be watered thoroughly before planting and immediately after planting.

Mulching

Mulch shall be free from deleterious and extraneous matter such as stones, soil, weeds and sticks.

Mulch shall be placed clear of plant stems, and rake to an even surface flush with the surrounding finished levels.

Depth shall be at 75 mm maximum.

Mulch types hays shall be from seasonal grasses and free from noxious weeds etc.

Laterite gravel shall be uniform in color and size or graded from 5 mm to 25 mm.

Brush chippings shall be approved “Forest Blend” vegetative material processed to pieces not larger than 75 x 50 x 15 mm and aged from 6 to 12 weeks.

Washed river pebble shall be uniform in size or graded from 10 to 25 mm.

Stakes

Stakes material shall be hardwood, straight, free from knots or twists, pointed at one end.

1. Installation

Stakes shall be driven into the ground at least one third of their length, avoiding damage to the root system. Those no longer required at the end of the establishment period shall be removed.

Stake sizes shall conform to the following:

a. For plants 1 m to 2.5 m high: Two 50 mm x 50 mm x 1,800 mm stakes per plant.

b. For plants smaller than 1 m high: One 38 mm x 38 mm x 1,200 mm stake per plant.

2. Ties

Ties fixed securely to the stakes, one tie at half the height of the main stem, shall be provided whenever necessary to stabilize the plant. Ties shall be attached loosely and 50 mm hessian webbing stapled to the stake shall be likewise provided.

807.2.1.5 Irrigation

Installation

Pipework shall be installed in straight lines and uniform grades. Unions, flanges and isolating valves shall be provided for the satisfactory removal of piping and fittings for maintenance or replacement of plant. Pipework shall be arranged and supported so that it remains free from vibration while permitting necessary movements such as thermal expansion and contraction. Pipework shall conform to the applicable requirements of Item 1201, Water Pumping System.

Accessibility Location

Fittings requiring maintenance or servicing, including control valves, joints designed to enable removal of pipes, and the like, shall be located in accessible positions, with adequate clearance. The pipework shall be arranged so that it does not interfere with the removal or servicing of associated equipment or valves.

Fixed location type with automatically or manually operated sprinklers, sprays, microsprays and drippers shall be used.

Irrigation Controller

The controller shall be mounted in a weatherproof lockable cabinet. The following features shall be included:

a) Variable timer for each station with a range from 1 min to 30 min.
b) Manual cycle and individual station operation.
c) Manual on-off operation of irrigation without loss of program.
d) 240 V input and 24 V output capable of operating two (2) control valves simultaneously.
e) 24 h battery program backup (if possible).

Micro irrigation system polyethylene irrigation pipe shall conform to Item 1201, Water Pumping System with barbed fittings of similar pressure rating fastened with ratchet type clamps. Lay pipe on finished ground surface under planting

bed mulch and anchor at minimum 1.5 m intervals with U-shaped stakes. Connect micro-tube laterals with proprietary push-in or screw in-fittings.

Microsprays shall be mounted on stakes 300 mm above ground and connected to the pipework with microtubes.

Drippers

Use drippers which are turbulent flow types, easily dismantled for cleaning. Connect directly into the pipework or with microtubes. Micro irrigation valve box: Use micro irrigation valve boxes which are of high impact plastic with snap lock covers at finished ground level, each housing a stop cock, filter (200 mm for microsprays, 100 mm for drippers), pressure reducing valve (170 kPa outlet pressure) and automatic control valve. Use vandal resistant controls in public areas.

Completion of Planting

Maintenance manual shall be provided which includes notes and specifications of all landscape and irrigation work and recommendations for on-going maintenance work.

Plant Establishment

The planted areas shall be maintained for a minimum of 13 weeks from the time of practical completion. Damaged, stolen or vandalized stock shall be replaced as required and at the expense of the Contractor. For all other work including irrigation and hardworks, the contractual provisions for defects liability period shall apply.

807.2.1.6 Trees and Shrubs

Specifications for the trees and shrubs to be used in the project shall be specified in detail in the Plans. The Engineer shall inspect whether the delivered trees and shrubs are approved based on physical features and the capacity of the trees and shrubs to survive after planting.

Specifications and procedures for establishing trees and shrubs shall be submitted by the Contractor prior to planting. Fertilization, mulching, staking, establishment and irrigation shall be indicated on the procedures.

807.2.2 Hardscapes Specifications

807.2.2.1 Fountains

Work of this Section includes all labor, materials, equipment, tools, incidentals, and services necessary to design, engineer, manufacture, supply, and install the Fountain with related mechanical and electrical systems complete including all components, hardware, and accessories as indicated on the Plans and specified herein:

1. Discharge and suction piping systems
2. Electrical conduit and wiring systems
3. Subterranean vaults
4. Collector Tank
5. Mechanical and electrical equipment with components and accessories
6. Manufacture of primary fountain equipment and components is a “Basis of Design”
7. Include fountain system testing, adjustment, and operational training for Owner
8. Fountain Electrical Control Panel

Related fountain system work shall be as follows:

1. Paving systems
2. Cast-in-place Concrete
3. Earthwork including trench excavation and backfill
4. Waterproofing

The material to be used in the project shall be, as much as possible, cast aluminum with mounting pit to house plumbing, curvilinear blade. Dimensions, height, sizes, and thickness shall be indicated in the Plans.

Installation shall be based on manufacturer’s specification and relevant standards and codes.

The fountain to be installed shall be inspected by the Contractor prior to gathering. Defects in installation shall be replaced at the expense of the Contractor.

Quality Control Submittals

Test Reports: Fountain manufacturer's test report shall be included in the control panel information package. This report shall include results of the test on both motors and all lighting circuits.

Field Reports: The manufacturer shall provide a field test report in the controls package. This report, which includes information on the field voltage, current, and resistance at all components, shall be filled out by the installing electrical contractor and submitted to the manufacturer and the Engineer for approval.

Contract Closeout, Operations and Maintenance

Manuals shall be submitted pertaining to the operations and maintenance of the fountain system prior to final approval of system installation. The manuals shall include specification sheets, operations and maintenance data, copies of field and test reports, exploded diagrams, preventative maintenance schedule, water quality information, cleaning instructions, and warranty information.

Quality Assurance

Insofar as possible, all materials and equipment used in the installation of this work shall be of the same brand or manufacturer throughout for each class of material or equipment.

Piping materials shall bear Department of Trade and Industry (DTI) approved ICC sticker, and or other markings of specified testing agency.

Maintenance and Extra Materials

The Contractor shall supply chemical treatment materials of sufficient quantity, in addition to materials needed for system testing and adjustment, in maintenance of the system for a period of at least one month after Substantial Completion.

The Contractor shall supply any other special tools or parts that would be needed for maintenance of the fountain system.

Extra Material – Contractor shall be the one to provide one spare element for each cartridge filter, an extra solenoid valve for water make-up, and one replacement bulb for each U.V.

807.2.2.2 Benches

Raw materials for steel benches shall conform to the applicable requirements of Item 1047 – Metal Structures.

Wooden benches shall conform to the specie indicated in the Plans and shall conform to the applicable requirements of Item 1003, Carpentry and Joinery Works.

Other materials to be used on the projects shall submit certificates of conformance to ASTM and/or PNS.

807.2.2.3 Gazebos

Wooden gazebos shall conform to the specie indicated in the Plans and shall conform to the applicable requirements of Item 1003, Carpentry and Joinery Works.

Vinyl gazebos shall conform to the specifications indicated in the Plans.

Roofing tiles/ shingles shall be as indicated in the Plans and shall conform to the applicable requirements of Item 1015, Clay Roof Tile and Item 1056, Asphalt Roofing Shingles.

807.2.3 Aquatic Plants

807.2.3.1 Plant Materials

Provide select quality of root stocks, tubers, rhizomes or container grown plugs/ quarts of moisture-favoring plants, trees and shrubs. All referenced seeding rates are bulk. All seeds and container grown stock will be subject to standards for such material. All plant materials are subject to review and approval by the Engineer. Inferior or substandard material will be rejected and must be replaced with acceptable material at the Contractor's expense.

807.2.3.2 Installation

Woody and herbaceous plants associated with the wetland shall be installed in the arrangements shown on the Plans. The limits of each planting area indicated on the plan (whether for individual species or groups of species) shall be staked with survey lath by the contractor and checked by the designer prior to planting. Stakes shall be repositioned as directed by the designer.

Plant in masses of a single species, if so indicated on the Plans, shall be spaced at 600 mm on center for wetlands. Plants may be hand planted (push manually into soil with growing ends exposed) in soft substrates or planted using a planting bar, if necessary, in firmer substrates.

Planting of plugs in wetlands shall follow all specifications for other container grown, terrestrial, herbaceous material.

Sedges and other wetland species provided as seed, shall be hand seeded at the specified rates, and then lightly raked into the top 6.35 mm to 1.27 mm of soil and mulched lightly with straw.

807.2.3.3 Maintenance

Wetland Plantings: During the first growing season, restore eroded wetland soils with organic soil, fertilize and replace dead plants as directed by the Engineer.

Sedimentation Basin: Accumulated sediments shall be removed periodically. If dredging is required, the root stock of installed rhizomatous material shall be removed prior to dredging. Following removal of dredging spoil, reinstall root stock in same relative topographic and hydrologic positions from which it was removed. If root stock is not salvageable, replace emergent and wetland vegetation with original species and in original quantities. Following dredge spoil removal, re-seed basin as required with original mix at original rates and cover with coconut-straw erosion control blanket to stabilize immediately.

807.2.4 Aquatic Animals

It shall be salt water or fresh water fishes, molluscs, or crustaceans, depending on the request of the Engineer or if specified in the Plans.

The aquatic animals to be transported shall be free from any diseases (such as Epizootic haematopoietic necrosis, Oncorhynchus masou virus disease, Viral haemorrhagic septicaemia, and others). The animals shall be checked-up and approved by licensed veterinarian prior to delivery to the site.

807.2.4.1 Water Parameters for Salt Water Animals

The following table shall be the general guideline of acceptable water parameter ranges for different types of tropical marine aquariums.

Parameter	Suggested Level: Reef Aquarium	Suggested Level: FOWLR Aquarium	Average Level: Coral Reefs	Test Requirements
SpecificGravity	1.023 - 1.025	1.020 - 1.025	1.025	ASTM D1429 - Standard Test Methods for Specific Gravity of Water and Brine
Temperature	22 - 26°C	22 - 26°C	28°C	
pH	8.1 - 8.4	8.1 - 8.4	8.0 - 8.5	ASTM D1293 - Standard Test Methods for pH of Water
Alkalinity	8 - 12 dKH	8 - 12 dKH	6 - 8 dKH	ASTM D1067 - Standard Test Methods for Acidity or Alkalinity of Water
Ammonia (NH3)	Undetectable	Undetectable	Near Zero	ASTM D1426 - Standard Test Methods for Ammonia Nitrogen In Water
Nitrite (NO2)	Undetectable	Undetectable	Near Zero	ASTM D3867 - Standard Test Methods for Nitrite-Nitrate in Water
Nitrate – Nitrogen(NO3)	< 1.0 ppm	< 30 ppm	0.25 ppm	
Phosphate (PO4)	< 0.2 ppm	< 1.0 ppm	0.13 ppm	ASTM D4327 - Standard Test Method for Anions in Water by Suppressed Ion Chromatography
Calcium	350 - 450 ppm	350 - 450 ppm	380 - 420 ppm	ASTM D511 - Standard Test

Magnesium	1250 - 1350 ppm	1150 - 1350 ppm	1300 ppm	Methods for Calcium and Magnesium In Water
Iodine	0.06 - 0.10 ppm	0.04 - 0.10 ppm	0.06 ppm	
Strontium	8 - 14 ppm	4 - 10 ppm	8 - 10 ppm	ASTM D3920 - Standard Test Method for Strontium in Water

807.2.4.2 Water Parameters for Fresh Water Animals

The following table shall be the general guideline of acceptable water parameter ranges for different types of freshwater aquariums, brackish water aquariums, and ponds. The water parameters listed are a general guideline for maintaining each specific type of aquarium or pond.

Parameter	Freshwater Community	African Cichlid	Freshwater Plants & Discus	Brackish	Test Requirements
Temperature	22 - 28°C	22 - 28°C	22 - 28°C	22 - 28°C	
pH	6.5 - 7.5	7.8 - 8.5	6.0 - 7.5	7.5 - 8.4	ASTM D1293
Ammonia	0.0	0.0	0.0	0.0	ASTM D1426
Nitrite	0.0	0.0	0.0	0.0	ASTM D3867
Nitrate	< 50 ppm	< 50 ppm	< 30 ppm	< 50 ppm	
Alkalinity (Carbonate Hardness)	4 - 8 KH	10 - 18 KH	3 - 8 KH	10 - 18 KH	ASTM D1067
General Hardness	4 - 12 GH	12 - 20 GH	3 - 8 GH	12 - 20 GH	ASTM D1126 - Standard Test Method for Hardness in Water

807.2.5 Concrete Masonry Unit

Concrete masonry units (also called pavers, concrete pavers, paving stones, paving block, and brick pavers) included in the design for vehicles (such as driveways, access lanes and parking areas), floors (such as floors on grade and patios) and walking paths (including sideways) shall conform to the applicable requirements of Item 741, Interlocking Precast Concrete Blocks of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

807.2.6 Curbs

Curbs shall conform to the requirements of Item 600, Curb and/or Gutter of the DPWH Standard Specifications for Highways, Bridges and Airports, Volume II.

807.2.7 Column Guards

The cover for column guards shall be extruded high impact vinyl, with nominal thickness of 2.2 mm. For retainer, it shall be extruded recycled high impact vinyl, with nominal thickness of 1.8 mm. Injection molded thermoplastic shall be the material for closure caps.

807.2.7.1 Impact Resistance

Extruded profiles shall resist damage from impact at apex of 90 degree corner when tested in accordance with applicable sections of ASTM F476, Standard Test Methods for Security of Swinging Door Assemblies.

Izod impact strength shall conform to ASTM D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics method A notched, 130 kg-cm/cm average with no break.

Charpy impact strength shall conform to ASTM D6110, Standard Test Method for Determining the Charpy Impact Resistance of Notched Specimens of Plastics notched, 142 kg-cm/cm average with no break.

807.2.7.2 Installation

The substrate shall be cleaned to remove dust and debris prior to installation of the column guards.

The materials shall be acclimatized to building conditions for at least 24 h prior to installation.

Wall protection products shall be installed in accordance with manufacturer's installation instructions provided by the manufacturer.

807.2.8 Wheel Guard

Wheel guard shall conform to the applicable requirements of Item 900, Structural Concrete, or as shown in the Plans.

807.2.9 Fences

807.2.9.1 Concrete Fences

Concrete fences shall conform to the applicable requirements of Item 1046, Masonry Works and Item 1027, Cement Plaster Finish. The Bars and Grills at the top of fences shall conform to Item 1047, Metal Structures.

807.2.9.2 Steel Fences

Steel fence materials (such as angular, tubular and rod/ rectangular steel bars) shall conform to the applicable requirements of Item 1047, Metal Structures.

807.2.10 Gates

807.2.10.1 Wood Gates

Wooden gates shall conform to the specie indicated in the Plans and shall conform to the applicable requirements of Item 1003, Carpentry and Joinery Works.

807.2.10.2 Metal Gates

The aluminum to be used for the gate shall conform to the applicable requirements of ASTM B 209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.

The stainless steel plate to be used for the gate shall conform to the applicable requirements of ASTM A240, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.

The framing for the gate shall conform to the applicable requirements of Subsection 807.2.9.2, Steel Fences.

Gates shall be constructed to match the fencing and in the locations shown on the Plans or as directed by the Engineer.

807.3 Method of Measurements

All the units installed shall be measured and determined by the number of units approved by and ready for service as provided in the Bill of Materials and Quantities accepted to the satisfaction of the Engineer.

807.4 Basis of Payment

The items measured and determined as provided in Subsection 807.3, Method of Measurement shall be paid for at the unit bid price which payment constitute full compensation of materials, labor, and incidentals necessary to complete this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
807 (1)	Site Development	Lump Sum
807 (2)	Softscape	Lump Sum
807 (3)a	Softscape ,Trees	Each
807 (3)b	Softscape, Shrubs	Each
807 (4)	Softscape, Grass	Square Meter
807 (5)	Hardscape	Lump Sum
807 (6)a	Hardscape, fountains	Each
807 (6)b	Hardscape, benches	Each
807 (6)c	Hardscape, gazebos	Each
807 (7)	Garden Soil	Cubic Meter
807 (8)a	Aquatic, Plants	Each
807 (8)b	Aquatic, Animals	Each
807 (9)	Paver Blocks	Square Meter
807 (10)	Curbs	Linear Meter
807 (11)	Column Guards	Each

807 (12)	Wheel Guards	Each
807 (13)	Fence, CHB	Square Meter
807 (14)	Gate	Lump Sum

XVIII. ITEM 800 – CLEARING AND GRUBBING

800.1 Description

This Item shall consist of clearing, grubbing, removing, earth balling 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.

800.2 Construction Requirements

800.2.1 General

The Engineer will establish the limits of work and designate all trees, shrubs, plants and other things to remain in-place. The Contractor shall preserve all objects designated to remain in-place. 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. Earthfill, stockpiling of materials, vehicular parking, and excessive foot or vehicular traffic shall not be allowed within the drip line of vegetation designated to remain in-place. Vegetation damaged by any of these or similar actions shall be replaced with viable vegetation of the same species, similar condition, and like size unless otherwise approved by the Engineer.

Clearing shall extend 1 m 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 as 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).

All other objects designated to be remained shall be preserved and protect from injury or defacement.

For earth balling, a tree survey on the trees in a development project or other associated areas should be conducted to obtain the required information for developing site planning and tree preservation proposals. Proposals to retain or transplant trees should be properly planned and implemented to ensure that sufficient space to accommodate the existing tree and its future growth, and adequate time for preparation of transplanting are available. Tree balling permit must be secure from Department of Environment and Natural Resources (DENR) prior to tree cutting and/or earth balling of the affected trees. The transplanting of such shall be the obligation of the permittee and if it will not survive after 6 months, the permittee shall replace preferably indigenous tree species at a ratio of 1:50 as prescribed under DENR Memorandum Circular 2012-12. Moreover, removal and relocation of trees affected by DPWH Projects shall conform as per DENR Administrative Order No. 2018-16.

For situations where retaining the trees at their existing locations are not practicable, priority should be given to transplant the affected trees to other permanent locations within the project site where appropriate, so as to increase the trees' survival rate after transplanting and minimize the loss of greenery in the local environs; and if not practicable, transplant the affected trees to a suitable permanent location ex-situ. Location of the

receptor site should preferably be in proximity to the project site for retention of amenity effect in the vicinity.

800.2.2 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 mowed as required, except as provided below:

1. Removal of undisturbed stumps and roots and nonperishable solid objects with a minimum depth of 1 m below subgrade or slope of embankment will not be required.

2. 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 above the ground line or low water level.

3. Grubbing of pits, channel changes and ditches will be required only to the depth necessitated by the proposed excavation within such areas.

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.

In areas where Hand Clearing as directed by the Engineer, no requirement of wheels or trucks shall be used. Care shall be taken to insure that the grass, moss cover, or the natural ground is not disturbed.

The materials shall be properly disposed in accordance with the Environmental Compliance Certificate (ECC) requirements.

Materials and debris may be disposed of 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 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 of 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 and faces not exceeding 3,900 mm2 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 mm loose thickness. Diseased trees shall be buried or disposed of 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.

Timber cut inside the area staked for clearing shall be felled within the area to be cleared.

800.2.2.1 Temporary Erosion Control

Prior to the beginning of clearing and grubbing activities, the Contractor shall inspect the area to determine if these activities are likely to cause damage or require access to adjacent private property. Typical damage that may occur to adjacent properties includes cutting through tree roots, pushing excavated material onto adjacent lands, and damaging septic systems or public utilities. Erosion may become a problem after ground cover is disturbed. The Contractor shall install erosion control devices or procedures to protect the project limits, the environment, and private property. These operations shall be in accordance with the Plans or as directed by the Engineer. Temporary Seeding and Silt Fences are some of the temporary erosion control methods that can be used prior to the clearing and grubbing activities.

800.2.3 Earth Balling

Balling is employed in plants and trees to be transplanted or transferred. To ball out the trees, the depth to which the root system reaches is first determined. Digging around the tree is then done, being careful not to cut many roots. Watering the soil before balling is prohibited. The surface of the earth is kept as smooth as possible. After the tree is dug out, the roots and earth is wrapped immediately with the sacking material. The tree could now be tipped over and rolled to a new location. These plants shall be hauled by the ball only and not by the plant itself. The slightest indication of manufactured earth balls or hauling of the plants itself will be a cause for rejection of such plants.

800.3 Method of Measurement

Measurement will be by one or more of the following alternate methods:

1. Area Basis. The work to be paid for shall be the number of square meters and fractions thereof acceptably cleared and grubbed within the limits indicated on the Plans. Areas not within the clearing and grubbing limits shown on the Plans or not staked for clearing and grubbing will not be measured for payment.

2. Lump-Sum Basis. When the Bill of Quantities contains a Clearing and Grubbing lump-sum item, no measurement of area will be made for such item.

3. Individual Unit Basis (Selective Clearing and Earth Balling). The diameter of trees will be measured at a height of 1.4 m from ground. Removal of trees less than 150 mm in diameter are subsidiary in clearing and grubbing.

800.4 Basis of Payment

The accepted quantities, measured as prescribed in Section 800.3, Method of Measurement shall be paid for at the Contract Unit Price for each of the Pay Items listed below that is included in the Bill of Quantities, which price and payment shall be full compensation for furnishing all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
800(1)	Clearing and Grubbing	Square Meter
800(2)	Clearing and Grubbing	Lump Sum
800(3)a1	Individual Removal of Trees, 150 mm to 300 mm dia.	Each
800(3)a2	Individual Removal of Trees, 301 mm to 500 mm dia.	Each
800(3)a3	Individual Removal of Trees, 501 mm to 750 mm dia.	Each
800(3)a4	Individual Removal of Trees, 751 mm to 900 mm dia.	Each
800(4)	Individual Removal of Trees above 900 mm dia.	Each
800(5)a1	Earth Balling, 150-300 mm dia.	Each
800(5)a2	Earth Balling, 301-500 mm dia.	Each
800(5)a3	Earth Balling, 501-750 mm dia.	Each
800(5)a4	Earth Balling, 751-900 mm dia.	Each
800(5)a5	Earth Balling, above 900 mm dia.	Each

XIX. ITEM 803 – STRUCTURE EXCAVATION

803.1 Description

This Item shall consist of the necessary excavation for foundation of buildings, culverts, underdrains, and other structures not otherwise provided for in the Specifications. Except as otherwise provided for pipe culverts, the backfilling of completed structures and the disposal of all excavated surplus materials, shall be in accordance with the Plans and this Specification.

This Item shall include necessary diversion of live streams, dewatering, pumping, draining, sheeting, bracing, and the necessary construction of cribs and cofferdams, and furnishing the materials therefore, and the subsequent removal of cribs and cofferdams and the placing of all necessary backfill.

It shall also include the furnishing and placing of approved foundation fill material to replace unsuitable material encountered below the foundation elevation of structures.

No allowance shall be made for classification of different types of material encountered.

803.2 Construction Requirements

803.2.1 Clearing and Grubbing

Prior to starting excavation operations in any area, all necessary clearing and grubbing in that area shall have been performed in accordance with Item 800, Clearing and Grubbing.

803.2.2 Excavation

1. General, All Structures

The Contractor shall notify the Engineer sufficiently in advance at the beginning of any excavation so that cross-sectional elevations and measurements may be taken on the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the Engineer.

Trenches or foundation pits for structures or structure footings shall be excavated to the lines and grades or elevations shown on the Plans or as staked by the Engineer. They shall be of sufficient size to permit the placing of structures or structure footings of the full width and length shown. The elevations of the bottoms of footings, as shown on the Plans, shall be considered as approximate only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary, to secure a satisfactory foundation.

Boulders, logs, and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed, the Contractor shall notify the Engineer to that effect and no footing, bedding material or pipe culvert shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

2. Structures Other than Pipe Culverts

All rock or other hard foundation materials shall be cleaned of all loose materials, and cut to a firm surface, either level, stepped, or serrated as directed by the Engineer. All seams or crevices shall be cleaned and grouted. All loose and disintegrated rocks and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed. When the foundation material is soft or mucky or otherwise unsuitable, as determined by the Engineer, the Contractor shall remove the unsuitable material and backfill with approved granular material. This foundation fill shall be placed and compacted in 150 mm layers up to the foundation elevation.

When foundation piles are used, the excavation of each pit shall be completed before the piles are driven and any placing of foundation fill shall be done after the piles are driven. After the driving is completed, all loose and displaced materials shall be removed, leaving a smooth, solid bed to receive the footing.

3. Pipe Culverts

The width of the pipe trench shall be sufficient to permit satisfactory jointing of the pipe and thorough tamping of the bedding material under and around the pipe.

Where rock, hardpan, or other unyielding material is encountered, it shall be removed below the foundation grade for a depth of at least 300 mm or 4 mm for each 100 mm of fill over the top of pipe, whichever is greater, but not to exceed three-quarters of the vertical inside diameter of the pipe. The width of the excavation shall be at least 300 mm greater than the horizontal outside diameter of the pipe. The excavation below grade shall be backfilled with selected fine compressible material, such as silty clay or loam, and lightly compacted in layers not over 150 mm in uncompacted depth to form a uniform but yielding foundation.

Where a firm foundation is not encountered at the grade established, due to soft, spongy, or other unstable soil, such unstable soil under the pipe and for a width of at least one diameter on each side of the pipe shall be removed to the depth directed by the Engineer and replaced with approved granular foundation fill material properly compacted to provide adequate support for the pipe, unless other special construction methods are called for on the Plans.

The foundation surface shall provide a firm foundation of uniform density throughout the length of the culvert and, if directed by the Engineer, shall be cambered in the direction parallel to the pipe centerline.

Where pipe culverts are to be placed in trenches excavated in embankments, the excavation of each trench shall be performed after the embankment has been constructed to a plane parallel to the proposed profile grade and to such height above the bottom of the pipe as shown on the Plans or directed by the Engineer.

803.2.3 Utilization of Excavated Materials

All excavated materials, so far as suitable, shall be utilized as backfill or embankment. The surplus materials shall be disposed of in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure. No excavated materials shall be deposited at any time so as to endanger the partly finished structure.

803.2.4 Cofferdams

Suitable and practically watertight cofferdams shall be used wherever water bearing strata are encountered above the elevation of the bottom of the excavation. If requested, the Contractor shall submit drawings showing his proposed method of cofferdam construction, as directed by the Engineer.

Cofferdams or cribs for foundation construction shall in general, be carried well below the bottoms of the footings and shall be well braced and as nearly watertight as practicable. In general, the interior dimensions of cofferdams shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms. Cofferdams or cribs which are tilted or moved laterally during the process of sinking shall be righted or enlarged so as to provide the necessary clearance.

When conditions are encountered which, as determined by the Engineer, render it impracticable to dewater the foundation before placing the footing, the Engineer may require the construction of a concrete foundation seal of such dimensions as he may consider necessary, and of such thickness as to resist any possible uplift. The concrete for such seal shall be placed as shown on the Plans or directed by the Engineer. The foundation shall then be dewatered and the footing placed. When weighted cribs are employed and the mass is utilized to overcome partially the hydrostatic pressure acting against the bottom of the foundation seal, special anchorage such as dowels or keys shall be provided to transfer the entire mass of the crib to the foundation seal. When a foundation seal is placed under water, the cofferdams shall be vented or ported at low water level as directed.

Cofferdams shall be constructed so as to protect green concrete against damage from sudden rising of the stream and to prevent damage to the foundation by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into substructure masonry, without written permission from the Engineer.

Any pumping that may be permitted from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete material being carried away. Any pumping required during the placing of concrete, or for a period of at least 24 h thereafter, shall be done from a suitable sump located outside the concrete forms. Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure.

Unless otherwise provided, cofferdams or cribs, with all sheeting and bracing involved therewith, shall be removed by the Contractor after the completion of the substructure. Removal shall be effected in such manner as not to disturb or mar finished masonry.

803.2.5 Preservation of Channel

Unless otherwise permitted, no excavation shall be made outside of caissons, cribs, cofferdams, or sheet piling, and the natural stream bed adjacent to structure shall not be disturbed without permission from the Engineer. If any excavation or dredging is made at the side of the structure before caissons, cribs, or cofferdams are sunk in place, the Contractor shall, after the foundation base is in place, backfill all such excavations to the original ground surface or stream bed with material satisfactory to the Engineer.

803.2.6 Trimming Works

The excavation shall conform to the lines, grades, cross sections and dimensions shown on the Plans. The Engineer shall order the removal of any soft spots, debris or organic material exposed when excavated areas shall have been trimmed to finished formation levels. Subgrade in earth shall be trimmed cut to an even surface free of loose material and compact as specified by the Engineer to the density prescribed in in the Plans.

803.2.6.1 Trimming and Finishing of Surfaces

Unless otherwise specified, all areas within the limits of clearing and outside the limits of earthworks shall be graded to an even surface. Ridges shall be trimmed and depressions shall be filled as necessary to produce a surface which will drain freely and is suitable for the operation of tractor mounted mowers. Batters in cut and fill shall be trimmed to shapes shown on drawings. Cut and fill batters shall be trimmed as specified in the Plans.

803.3 Method of Measurement

803.3.1 Structure Excavation

The volume of excavation to be paid for shall be the number of cubic meters measured in original position of material acceptably excavated as shown on the Plans or as directed by the Engineer, but in no case, except as noted, shall any of the following volumes be included in the measurement for payment:

1. The volume outside of vertical planes 450 mm outside of and parallel to the neat lines of footings and the inside walls of pipe and pipe-arch culverts at their widest horizontal dimensions.

2. The volume of excavation for culvert and sections outside the vertical plane for culverts stipulated in (1) above.

3. The volume outside of neat lines of underdrains as shown on the Plans, and outside the limits of foundation fill as ordered by the Engineer.

4. The volume included within the staked limits of the excavation, contiguous channel changes, ditches, and the like, for which payment is otherwise provided in the Specification.

5. Volume of water or other liquid resulting from construction operations and which can be pumped or drained away.

6. The volume of any excavation performed prior to the taking of elevations and measurements of the undisturbed ground.

7. The volume of any material rehandled, except that where the Plans indicate or the Engineer directs the excavation after embankment has been placed and except that when installation of pipe culverts by the imperfect trench method specified in Subsection 1718.3.7, Imperfect Trench of Item 1718, Pipe Culverts and Storm Drains is required, the volume of material re-excavated as directed will be included.

8. The volume of excavation for footings ordered at a depth more than 1.5 m below the lowest elevation for such footings shown on the original Contract Plans, unless the Bill of Quantities contains a pay item for excavation ordered below the elevations shown on the Plans for individual footings.

803.3.2 Shoring, Cribbing, and Related Work

Shoring, cribbing and related work whenever included as a pay item in Bill of Quantities shall be paid for at the lump sum bid price. This work shall include furnishing, constructing, maintaining, and removing any and all shoring, cribbing, cofferdams, caissons, bracing, sheeting, water control, and other operations necessary for the acceptable completion of excavation included in the work of this Subsection, to a depth of 1.5 m below the lowest elevation shown on the Plans for each separable foundation structure.

803.3.3 Trimming Works

Trimming shall include all activities associated with the excavation of any material, the haulage of material, and trimming of batters that conform to the lines, grades, cross sections and dimensions shown on the Plans.

803.4 Basis of Payment

The accepted quantities, measured as prescribed in Section 803.3, Method of Measurement shall be paid for at the Contract Unit Price for each of the particular pay items listed below that is included in the Bill of Quantities. The payment shall constitute full compensation for the removal and disposal of excavated materials including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item, except as follows:

1. Any excavation for footings ordered at a depth more than 1.5 m below the lowest elevation shown on the original Contract Plans shall be paid for as provided in the Part K of Volume I Requirements and Conditions of Contract, unless a pay item for excavation ordered below Plan elevation appears in the Bill of Quantities.

2. Concrete will be measured and paid for as provided under Item 900, Structural Concrete. The quantity of structural concrete to be paid for shall be the final quantity placed and accepted in the completed structure. No deduction shall be made for the volume occupied by pipe less than 100 mm in diameter or by reinforcing steel, anchors, conduits, weep holes or expansion joint materials.

3. Any excavation or borrow excavation required in excess of the quantity excavated for structures shall be measured and paid for as provided under Item 802, Excavation.

4. Shoring, cribbing, and related work required for excavation ordered more than 1.5 m below Plan elevation shall be paid for in accordance with Part K.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
803(1)a	Structure Excavation (Common Soil)	Cubic Meter
803(1)b	Structure Excavation (Soft Rock)	Cubic Meter
803(1)c	Structure Excavation (Hard Rock)	Cubic Meter
803(2)a	Building Excavation (Common Soil)	Cubic Meter
803(2)b	Building Excavation (Soft Rock)	Cubic Meter
803(2)c	Building Excavation (Hard Rock)	Cubic Meter
803(3)	Excavation ordered below Plan elevation	Cubic Meter
803(4)a	Shoring, cribbing and drain excavation (Shoring)	Lump Sum
803(4)b	Shoring, cribbing and drain excavation (Cribbing/Cofferdamming)	Lump Sum
803(5)a	Pipe culverts and drain excavation (Common Soil)	Cubic Meter
803(5)b	Pipe culverts and drain excavation (Soft Rock)	Cubic Meter
803(5)c	Pipe culverts and drain excavation (Hard Rock)	Cubic Meter
803(6)	Trimming Works	Square Meter

XX. ITEM 804 – EMBANKMENT

804.1 Description

This Item shall consist of the construction of embankment using suitable materials of various composition and compacted in accordance with this Specification and in conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

804.2 Material Requirements

804.2.1 Suitable Material

Embankments shall be constructed of suitable materials and materials meeting with the following requirements:

1. Selected Borrow – soil of such gradation that all particles will pass a sieve with 75 mm square openings and not more than 15 mass percent will pass the 0.075 mm (No. 200) sieve, as determined by AASHTO T 11, Standard Method of Test for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing. The material shall have a plasticity index

of not more than six (6) as determined by AASHTO T 90, Standard Method of Test for Determining the Plastic Limit and Plasticity Index of Soils and a liquid limit of not more than 30 as determined by AASHTO T 89, Standard Method of Test for Determining the Liquid Limit of Soils.

2. Gravel fill shall consist of crushed, partially crushed, or naturally occurring granular material. The abrasion loss as determined by AASHTO T 96, Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine shall not exceed 40 mass percent.

The gravel fill material grading requirements shall conform to Table 804.1.

Table 804.1 Grading Requirements

Sieve Designation		Mass Percent Passing
Standard, mm	**Alternate US Standard**	**Grading A**
63.5	2 ½"	100
50	2"	65-100
25.0	1"	50-85
4.75	No. 4	26-44
0.425	No. 40	16 max
0.075	No. 200	9 max

3. Rock fill material shall be hard, sound and durable material, free from seams, cracks, and other defects tending to destroy its resistance to weather. Specific gravity of rock fill materials shall be above 2.40.

804.2.2. Unsuitable Material

Materials that are not acceptable for use are the following:

1. Organic soils such as peat and muck.

2. Soils with liquid limit exceeding 80 and/or plasticity index exceeding 55.

3. Soils with a natural water content exceeding 100%.

4. Soils with very low natural density, 800 kg/m3 or lower.

5. Materials containing detrimental quantities of organic materials, such as grass, roots, sewerage, and other materials that cannot be properly compacted as determined by the Engineer.

804.3 Construction Requirements

804.3.1 General

Prior to placing of embankment materials, all necessary clearing and grubbing in that area shall have been performed in conformity with Item 800, Clearing and Grubbing.

Embankment construction shall consist of constructing embankments, including preparation of the areas upon which they are to be placed; the construction of dikes within or adjacent

to any structures; the placing and compacting of approved material within areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits, and other depressions within the area. Embankments and backfills shall contain no muck, peat, sod, roots or other deleterious matter. Rocks, broken concrete or other solid, bulky materials shall not be placed in embankment areas where piling is to be placed or driven.

Where shown on the Plans or directed by the Engineer, the surface of the existing ground shall be compacted to a depth of 150 mm and to the specified requirements of this Item.

Where provided on the Plans and Bill of Quantities the top portions of the roadbed in both cuts and embankments, as indicated, shall consist of selected borrow for topping from excavations.

804.3.2 Methods of Construction

Where there is evidence of discrepancies on the actual elevations and that shown on the Plans, a preconstruction 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 embankment materials.

When embankment is to be placed and compacted on hillsides, or when new embankment is to be compacted against existing embankments, or when embankment is built ½ of the width at a time, the existing slopes that are steeper than 3:1 when measured at right angles to the roadway shall be continuously benched over those areas as the work is brought up in layers. Benching will be subject to the Engineer's approval and shall be of sufficient width to permit operation of placement and compaction equipment. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous cuts. Material thus excavated shall be placed and compacted along with the embankment material in accordance with the procedure described in this Section.

Unless shown otherwise on the Plans or Special Provisions, where an embankment of less than 1.2 m below subgrade is to be made, all sod and vegetable matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surfaced shall be completely broken up by plowing, scarifying, or steeping to a minimum depth of 150 mm except as provided in Subsection 802.2.2, Conservation of Topsoil. This area shall then be compacted as provided in Subsection 804.3.3, Compaction. Sod not required to be removed shall be thoroughly disc harrowed or scarified before construction of embankment. Wherever a compacted embankment containing granular materials lies within 900 mm of the subgrade, such old embankment shall be scarified to a depth of at least 150 mm whenever directed by the Engineer. This scarified material shall then be compacted as provided in Subsection 804.3.3, Compaction.

When shoulder excavation is specified, the shoulders shall be excavated to the depth and width shown on the Plans. The shoulder material shall be removed without disturbing the adjacent existing base course material, and all excess excavated materials shall be disposed of as provided in Subsection 802.2.3, Utilization of Excavated Materials. If necessary, the areas shall be compacted before being backfilled.

Embankment of earth material shall be placed in horizontal layers not exceeding 200 mm, loose measurement, and shall be compacted as specified before the next layer is placed. However, thicker layer maybe placed if vibratory roller with high compacting effort is used provided that density requirement is attained and as approved by the Engineer. Trial section

to this effect must be conducted and approved by the Engineer. Effective spreading equipment shall be used on each lift to obtain uniform thickness as determined in the trial section prior to compaction. 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, discing, or other methods satisfactory to the Engineer.

Where embankment is to be constructed across low swampy ground that will not support the mass of trucks or other hauling equipment, the lower part of the fill may be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than necessary to support the hauling equipment while placing subsequent layers. Fill material shall be placed in a way it effectively displaces unsuitable material from within unstable area of the proposed embankment.

When excavated material contains more than 25 mass percent of rock larger than 150 mm in greatest diameter and cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces resulting from excavation methods, such materials may be placed on the embankment in layers not exceeding in thickness the approximate average size of the larger rocks, but not greater than 600 mm.

Even though the thickness of layers is limited as provided above, the placing of individual rocks and boulders greater than 600 mm in diameter shall be permitted provided that when placed, they do not exceed 1,200 mm 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 150 mm in greatest dimensions shall not be constructed above an elevation 300 mm below the finished subgrade. The balance of the embankment shall be composed of suitable material smoothed and placed in layers not exceeding 200 mm 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 compaction complies with the requirements of Subsection 804.3.3, Compaction.

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.

804.3.3 Compaction

1. Compaction Trials

Before commencing the formation of embankments, the Contractor shall submit in writing to the Engineer for approval his proposals for the compaction of each type of fill material to be used in the works. The proposals shall include the relationship between the types of compaction equipment, the number of passes required and the method of adjusting moisture content. The Contractor shall carry out full scale compaction trials on areas not less than 10 m wide and 50 m long as required by the Engineer and using his proposed procedures or such amendments thereto as may be found necessary to satisfy the Engineer that all the specified requirements regarding compaction can be consistently achieved. The compaction equipment shall be equivalent or higher than the required capacity prescribed

in the Contract. Compaction trials with the main types of fill material to be used in the works shall be completed before work with the corresponding materials shall be allowed to commence. When embankment dimension is less than 10 m wide and 50 m long, the Engineer may waive the construction of compaction trials.

Throughout the periods when compaction of earthwork is in progress, the Contractor shall adhere to the compaction procedures found from compaction trials for each type of material being compacted, each type of compaction equipment employed and each degree of compaction specified.

2. Earth

The Contractor shall compact the material placed in all embankment layers and the material scarified to the designated depth below subgrade in cut sections, until a uniform density of not less than 95 mass percent of the maximum dry density determined by AASHTO T 99, Standard Method of est for Moisture Density Relations of Soils Using a 2.5 kg Rammer and a 305 mm Drop - Method C, is attained, at a moisture content determined by Engineer to be suitable for such density.

The Engineer shall, during progress of the Work, make density tests of compacted material in accordance with AASHTO T 191, Standard Method of Test for Density of Soil In-Place by the Sand-Cone Method, AASHTO T 205, Soil - Field density test sets: Balloon density apparatus or other approved field density tests, including the use of properly calibrated nuclear testing devices. If, by such tests, the Engineer determines that the specified density and moisture conditions have not been attained, the Contractor shall perform additional work as may be necessary to attain the specified conditions.

At least one group of three (3) in-situ density tests shall be carried out for each 500 m2 of each layer of compacted fill.

3. Gravel Fill

Gravel fill shall be constructed below the original ground elevation. The maximum compacted thickness of any layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner. Gravel fill shall be in accordance with the approved Plan and conform to the applicable requirements of earth embankment.

4. Broken Concrete

Pieces of concrete not exceeding 20 cm in diameter can be mixed if approved by the Engineer. Any exposed rebar on broken concrete pieces shall be cut and disposed of properly.

5. Rock

Density requirements will not apply to portions of embankments constructed of materials which cannot be tested in accordance with approved methods. Embankment materials containing rocks shall be deposited, spread and leveled the full width of the fill with sufficient earth or other fine material so deposited to fill the interstices to produce a dense compact embankment. In addition, one of the rollers, vibrators, or compactors shall compact the embankment full width with a minimum of three (3) complete passes for each layer of embankment.

804.3.4 Protection of Embankment During Construction

During the construction, the in-placed embankments shall be maintained in such condition that it will be well drained at all times. Side ditches or gutters emptying from cuts to embankments or otherwise shall be so constructed as to avoid damage to embankments by erosion.

804.3.5 Protection of Structure

If embankment can be deposited on one (1) side of adjoining structure, care shall be taken that the area adjacent to the structure shall not be compacted to the extent that it will cause damages against the structure.

When embankment is to be placed on both sides of a concrete structure, operations shall be so conducted that the embankment is always at approximately the same elevation on both sides of the structure unless otherwise specified in the Plans.

Embankment shall not be placed in areas where the materials will be submerged in water. The area shall be pumped dry and any mud or loose material shall be removed.

804.3.6 Rounding and Warping Slopes

Rounding except in solid rock, the tops and bottoms of all slopes, including the slopes of drainage ditches, shall be rounded as indicated on the Plans. A layer of earth overlaying rock shall be rounded above the rock as done in earth slopes.

Warping adjustments in slopes shall be made to avoid injury in standing trees or marring of weathered rock, or to harmonize with existing landscape features, and the transition to such adjusted slopes shall be gradual. At intersections of cuts and fills, slopes shall be adjusted and warped to flow into each other or into the natural ground surfaces without noticeable break.

804.3.7 Finishing Roadbed and Slopes

After the roadbed has been substantially completed, the full width shall be conditioned by removing any soft or other unstable material that will not compact properly or serve the intended purpose. The resulting areas and all other low sections, holes or depressions shall be brought to grade with suitable selected material. Scarifying, blading, dragging, rolling, or other methods of work shall be performed or used as necessary to provide a thoroughly compacted roadbed shaped to the grades and cross-sections shown on the Plans or as staked by the Engineer.

All earth slopes shall be left with roughened surfaces but shall be reasonably uniform, without any noticeable break, and in reasonably close conformity with the Plans or other surfaces indicated on the Plans or as staked by the Engineer, with no variations there from readily discernible as viewed from the road.

804.3.8 Serrated Slopes

Cut slopes in rippable material (soft rock) having slope ratios between 0.75:1 and 2:1 shall be constructed so that the final slope line shall consist of a series of small horizontal steps. The step rise and tread dimensions shall be shown on the Plans. No scaling shall be

performed on the stepped slopes except for removal of large rocks which will obviously be a safety hazard if they fall into the ditch line or roadway.

804.3.9 Earth Berms

When called for in the Contract, permanent earth berms shall be constructed of well graded materials with no rocks having a maximum diameter greater than 25% the height of the berm. When local material is not acceptable, acceptable material shall be imported, as directed by the Engineer.

Compacted Berm

Compacted berm construction shall consist of moistening or drying and placing material as necessary in locations shown on the drawings or as established by the Engineer. Material shall contain no roots, sod, or other deleterious materials. Contractor shall take precaution to prevent material from escaping over the embankment slope. Shoulder surface beneath berm will be roughened to provide a bond between the berm and shoulder when completed. The Contractor shall compact the material placed until at least 95 mass percent of the maximum density is obtained as determined by AASHTO T 99, Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5 kg Rammer and a 305 mm Drop - Method C. The cross-section of the finished compacted berm shall reasonably conform to the typical cross-section as shown on the Plans.

Uncompacted Berm

Uncompacted berm construction shall consist of drying, if necessary and placing material in locations shown on the Plans or as established by the Engineer. Material shall contain no roots, sod or other deleterious materials. Contractor shall take precautions to prevent material from escaping over the embankment slope.

804.3.10 Visual Inspection

Prior to final acceptance, the inspector shall visually inspect the entire section of the compacted embankment. If visual inspection shows that the course is not uniform or that the test values may not be representative of the entire section, additional tests may be performed and deficiencies shall be corrected by the Contractor. Deficiencies identified by visual inspection, such as laminations, dimensional deficiencies, soft areas, etc. shall be corrected before the section will be accepted. The section must be accepted prior to the placement of the next lift.

804.3.11 Dust Control

Adequate dust control must be maintained by the Contractor at all times during the earth-moving operations. Dust shall be controlled exclusively through the use of water unless otherwise indicated in the Contract documents or authorized by the Engineer.

804.3.12 Stockpiling

The Contractor shall not place stockpiles at locations where they are subject to erosion. The Contractor shall maintain erosion and drainage control near all stockpiles to the satisfaction of the Engineer and shall ensure that surface drainage does not adversely affect adjacent lands, watercourses or future reclamation sites.

Stockpiles shall not be situated at locations or by methods that will interfere or cause damage to any utilities such as power lines, telephone lines, pipelines, and underground utilities, among others.

Sites shall be cleared to the required dimensions. Topsoil and subsoil shall be separately excavated to the full depth or 300 mm, whichever is greater, and stockpiled separately.

Stockpiles shall not be situated within 30 m of a watercourse or permanent structure or within 4 m of adjacent property boundary unless otherwise permitted in writing by the property owner.

804.4 Method of Measurement

The quantity of embankment to be paid for shall be the volume of material compacted in place, accepted by the Engineer and formed with material obtained from an approved source.

The volume of embankment materials can be calculated using cross-sectional end area method or by the prismoidal formula method with the assistance of computer aided design program.

Material from excavation per Item 802, Excavation which is used in embankment and accepted by the Engineer will be paid under Embankment and such payment will be deemed to include the cost of excavating, hauling, stockpiling and all other costs incidental to the work.

Material for Selected Borrow topping will be measured and paid for under the same conditions specified in the preceding paragraph.

804.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 804.4, Method of Measurement shall be paid for at the Contract Unit Price for each of the Pay Items listed below that is included in the Bill of Quantities. The payment shall continue full compensation for placing and compacting all materials including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
804(1)a	Embankment from Roadway/Structure Excavation (Common Soil)	Cubic Meter
804(1)b	Embankment from Roadway/Structure Excavation (Soft Rock)	Cubic Meter
804(1)c	Embankment from Roadway/Structure Excavation (Hard Rock)	Cubic Meter
804(2)a	Embankment from Borrow (Common Soil)	Cubic Meter
804(2)b	Embankment from Borrow (Soft Rock)	Cubic Meter
804(2)c	Embankment from Borrow (Hard Rock)	Cubic Meter
804(2)d	Embankment from Borrow (Granular Coarse Material)	Cubic Meter
804(2)e	Embankment from Borrow (Granular	Cubic Meter

	Fine Material)	
804(3)a	Selected Borrow for Topping (Case 1)	Cubic Meter
804(3)b	Selected Borrow for Topping (Case 2)	Cubic Meter
804(4)	Earth Berm	Cubic Meter
804(5)	Boulder Fill	Cubic Meter
804(6)	Preload, relocated, and compacted (Common Borrow)	Cubic Meter
804(7)	Gravel Fill	Cubic Meter

XXI. ITEM 900 – STRUCTURAL CONCRETE

900.1 Description

900.1.1 Scope

This Item shall consist of furnishing, placing and finishing concrete in buildings and related structures, flood control and drainage, ports, and water supply structures in accordance with this Specification and conforming to the lines, grades, and dimension shown on the Plans.

900.1.2 Classes and Uses of Concrete

Five classes of concrete are provided for in this Item, namely: A, B, C, P andSeal. Each class shall be used in that part of the structure as called for on thePlans.

The classes of concrete will generally be used as follows:

Class A – All superstructures and substructures which include the important parts such as slabs, beams, girders, columns, arch ribs, box culverts, abutments, retaining walls, shearwalls, pedestal and footings.

Class B – Pier shafts, pipe bedding, slab on fill, gravity walls (unreinforced or with only a small amount of reinforcement), and other miscellaneous concretestructures.

Class C – Thin reinforced sections, railings, precast R.C. piles and cribbing and for filler in steel grid floors.

Class P – Prestressed concrete structures and members.Seal – Concrete deposited in water

900.2 Material Requirements

900.2.1 Portland Cement

Cement shall conform to the requirements of the following cited Specificationsfor the type specified or permitted:

Table 900.1 Types of Cement

Type	Specification
Portland Cement	AASHTO M 85, Standard Specifications for Portland

Blended Hydraulic Cements	AASHTO M 240, Standard Specification for Blended Hydraulic Cement (ASTM C595, Standard Specification for Blended Hydraulic Cement)
Masonry Cement	ASTM C91, Standard Specification for Masonry Cement

900.2.2 Concrete Aggregates

Concrete aggregates shall conform to ASTM C33M, Standard Specification for Concrete Aggregates, and lightweight concrete aggregates shall conform to ASTM C330M, Standard Specification for Lightweight Aggregates except that aggregates failing to meet these specifications, but which have been shown by special test or actual service to produce concrete of adequate strength and durability may be used under Method 2 of Subsection 900.3.2, Methods of Determining the Proportions of Concrete, when authorized by the Engineer inwriting.

Except as permitted elsewhere in this Subsection, the maximum size of the aggregate shall be or not larger than 1/5 of the narrowest dimensions between sides of forms of the member for which the concrete is to be used nor larger than 3/4 of the minimum clear spacing between individual reinforcing bars or bundles of bars or pre-tensioning strands.

900.2.2.1 Fine Aggregates

Fine aggregates shall consist of natural and crushed sand, stone screenings or other inert materials with similar characteristics, or combinations thereof, having hard, strong and durable particles. Fine aggregates from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of concrete without the written approval of the Engineer.

It shall not contain more than three (3) mass percent of material passing the 0.075 mm (No. 200 sieve) by washing nor more than one (1) mass percent each of clay lumps or shale. The use of beach sand will not be allowed without the written approval of the Engineer.

If the fine aggregate is subjected to five (5) cycles of the sodium sulfate soundness test in accordance with AASHTO T 104, Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate and ASTM C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate, the weighted loss shall not exceed ten (10) mass percent.

Fine aggregates shall be free from injurious amounts of organic impurities. If subjected to the colorimetric test for organic impurities and a color darker than the standard is produced, it shall be rejected. However, when tested for the effect of organic impurities on strength of mortar by AASHTO T 71, Standard Method of Test for Organic Impurities in Fine Aggregate on Strength of Mortar (ASTM C87, Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar) the fine aggregate may be used if the relative strength at 7 and 28 days is not less than 95%.

The fine aggregate shall be well-graded and shall conform to Table 900.2.

Table 900.2 Grading Requirements for Fine Aggregate

Sieve Designation (mm)	Mass Percent Passing
9.50	100
4.75	95 – 100
2.36	-
1.18	45 – 80
0.60	-
0.30	5 – 30
0.15	0 – 10

900.2.2.2Coarse Aggregates

Coarse Aggregates shall consist of crushed stone, gravel, blast furnace slag, or other approved inert materials of similar characteristics, or combinations thereof, having hard, strong, durable pieces and free from any adherent coatings.

It shall contain no more than one (1) mass percent of material passing the 0.075 mm comment sieve, not more than 0.25 mass percent of clay lumps,nor more than 3.5 mass percent of soft fragments.

If the coarse aggregate is subjected to five (5) cycles of the sodium sulfate soundness test in accordance with AASHTO T 104, Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate and ASTM C88, Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate, the weighted loss shall not exceed 12 mass percent.

Coarse Aggregates shall have a mass percent of wear not exceeding 40 when tested by AASHTO T 96, Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine (ASTM C131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine).

If the slag is used, its density shall not be less than 1,120 kg/m^3.

Gradation shall conform to Table 900.3.

Table 900.3 Grading Requirements for Coarse Aggregate

Sieve Designation (mm)	Mass Percent Passing				
	Class A	Class B	Class C	Class P	Class Seal
63.00					
50.00	100	100			
37.50	95 – 100	-			100
25.00	-	35 – 70		100	95 – 100
19.00	35 – 70	-	100	-	-
12.50	-	10 – 30	90 – 100	-	25 – 60
9.50	10 – 30	-	40 – 70	20 - 55	-
4.75	0 – 5	0 – 5	0 – 15*	0 – 10*	0 – 10*

*Note: * The measured cement content shall be within plus (+) or minus (-) 2 mass percentof the design cement content.*

900.2.2.3 Aggregate Tests

Samples of the fine and coarse aggregates to be used shall be selected by theEngineer for tests at least 30 days before the actual concreting operations shall begin. It shall be the responsibility of the Contractor to designate the sourceor sources of aggregates to give the Engineer sufficient time to obtain the necessary samples and submit them for testing.

No aggregates shall be used unless official advice has been received that it has satisfactorily passed all tests, at which time written authority by the Engineershall be given for its use.

900.2.3 Water

Water used in mixing, curing or other designated application shall be reasonably clean and free of oil, salt, acid, alkali, grass or other substances injurious to the finished product. Water which is drinkable may be used without test. Where the source of water is shallow, the intake shall be so enclosed asto exclude silt, mud, grass or other foreign materials.

If it contains quantities of substance that discolor it or make it smell or tasteunusual or objectionable, or cause suspicion, it shall not be used unless service records of concrete made with it (or other information) indicated that it is not deleterious to the quality, shall be subject to the acceptance criteria as shownin Table 900.4 and Table 900.5 or as designated by the Engineer.

Table 900.4 Acceptance Criteria for Water Supply

Physical Property	Limit
Compressive strength, min. % control at7 days	90
Time of Setting deviation from control, h:minA	from 1:00 earlier to 1:30 later

Note: [A]Comparisons shall be based on fixed proportions for concrete or mortar mixtures. The control mixture shall be made with 100% potable or distilled water. The test mixture shall be made with the mixing water that is being evaluated.

Table 900.5 Chemical Limitation for Water

Chemical Property	Limits (parts per million, ppm), max.	Test Method
A. Chloride as $Cl^{(-1)}$		
1. Prestressed concrete	500	ASTM C114
2. Other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in- place	1000	ASTM C114
B. Sulfate as SO_4	3000	ASTM C114
C. Alkalies as (Na_2O + 0.658 K_2O)	600	ASTM C114
D. Total Solids by mass	50000	ASTM C1603

Note: ASTM C114 - Standard Test Methods for Chemical Analysis of Hydraulic CementASTM C1603 - Standard Test Method for Measurement of Solids in Water

Non-potable water will be tested in accordance with, and shall meet the suggested requirements of ASTM C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.

900.2.4 Metal Reinforcement

Reinforcing steel bars shall conform to the requirements of Subsection 902.2, Material Requirements of Item 902, Reinforcing Steel.

900.2.5 Admixtures

Air-entraining admixtures, if used, shall conform to ASTM C260M, Standard Specification for Air – Entraining Admixtures for Concrete. Air-entraining admixture shall conform to the requirements of AASHTO M 154, Standard Method of Test for Time of Setting of Hydraulic Cement Paste by Gillmore Needles.

Chemical Admixtures, if used, shall conform to the requirements of ASTM C494M, Standard Specification for Chemical Admixtures for Concrete or AASHTO M 194, Standard Specification for Chemical Admixtures for Concrete.

Fly Ash, if specified or permitted as a mineral admixture and not exceeding 20% partial replacement of Portland Cement in concrete mix shall conform to the requirements of ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.

Chemical Admixture/s maybe added to the concrete mix to produce some desired modifications to the properties of concrete if necessary, but not as partial replacement of cement. If specified, monofilament polypropylene synthetic fibrin fibers, which are used as admixture to prevent the formation of temperature/shrinkage cracks and increase impact resistance of concrete slabs shall be applied in the dosage rate recommended by its manufacturer.

900.2.6 Storage of Cement and Aggregates

All cement shall be stored immediately upon delivery at the site in a weatherproof building which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample, and the shipments of cement as received shall be separately stored in such a manner as to allow the earliest deliveries to be used first and to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity for storage of a sufficient quantity of cement to allow sampling at least 12 days before the cement is to be used. For a storage period of less than 60 days, stack the bags no higher than 14 layers, and for longer periods, no higher than seven (7) layers. As an additional precaution the oldest cement shall be used first. Bulk cement, if used, shall be transferred to elevated air tight and weatherproof bins. Stored cement shall meet the test requirements at any time after storage when retest is ordered by the Engineer. At the time of use, all cement shall be free flowing and free of lumps.

The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates be stored on separate platforms at satisfactory locations.

In order to secure greater uniformity of concrete mix, the Engineer may require that the coarse aggregate be separated into two (2) or more sizes. Different sizes of aggregate shall be stored in separate bins or in separate stockpiles sufficiently removed from each other to prevent the material at the edges of the piles from becoming intermixed.

900.2.7 Curing Materials

Curing materials shall conform to the following requirements as specified;

1. Burlap cloth - AASHTO M 182, Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats

2. Liquid membrane forming compounds - ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

3. Sheeting (film) materials - AASHTO M 171, Standard Specification for Sheet Materials for Curing Concrete

900.2.8 Expansion Joint Materials

Expansion joint materials shall be:

1. Preformed Sponge Rubber and Cork, conforming to AASHTO M 153, Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for

Concrete Paving and Structural Construction (ASTM D1752, Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction)

2. Hot-Poured Elastic Type, conforming to ASTM D6690, Standard Specification for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavement.

3. Preformed Fillers, conforming to AASHTO M 213, Standard Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types), ASTM D994M, Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)

900.3 Construction Requirements

The notation used in these regulations is defined as follows:

fc' = compressive strength of concrete

900.3.1 Concrete Quality

All Plans submitted for approval or used for any project shall clearly show the specified strength, fc', of concrete of the specified age for which each part of the structure was designed.

Concrete that will be exposed to sulfate containing or other chemically aggressive solutions shall be proportioned in accordance with "Recommended Practice for Selecting Proportions for Concrete (ACI 613)" and Recommended Practice for Selecting Proportions for Structural Lightweight Concrete (ACI 613A)."

900.3.2 Methods of Determining the Proportions of Concrete

The determination of the proportions of cement, aggregate, and water to attain the required strengths shall be made by one of the following methods:

Method 1. Without preliminary test

Where preliminary test data on the materials to be used in the concrete have not been obtained, the water-cement ratio for a given strength of concrete shall not exceed the values shown in Table 900.6. When strengths in excess of 27.58 MPa are required or when lightweight aggregates or admixtures (other than those exclusively for the purpose of air entraining) are used, the required water-cement ratio shall be determined in accordance with Method 2.

Method 2. For combination of materials previously evaluated or to be established by trial mixtures.

Water-cement ratios for strengths greater than that shown in Table 900.6 may be used provided that the relationship between strength and water-cement ratio for the materials to be used has been previously established by reliable test data and the resulting concrete satisfies the requirements of concrete quality.

Where previous data are not available. Concrete trial mixtures having proportions and consistency suitable for the work shall be made using at least three (3) different water

cement ratios (or cement content in the case of lightweight aggregates) which will produce a range of strengths encompassing those required for the work. For each water-cement ratio (or cement content) at least three (3) specimens for each age to be tested shall be made, cured and tested for strength in accordance with ASTM C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimen and ASTM C192, Standard Practice for Making & Curing Concrete Test Specimens in the Laboratory.

The strength test shall be made at 7, 14 and 28 days at which the concrete is to receive load, as indicated on the Plans. A graph shall be established showing the relationship between water-cement ratio (or cement content) and compressive strength. The maximum permissible water-cement ratio for the concrete to be used in the structure shall be that shown by the curve to produce an average strength to satisfy the requirements of the strength test of concrete.

Where different materials are to be used for different portions of the work, each combination shall be evaluated separately.

Table 900.6 Maximum Permissible Water-Cement Ratios for Concrete (Method No. 1)

Specified compressive strength at 28 days, MPa	Maximum Permissible water-cement ratio			
	Non-air-entrained concrete		Air-entrained concrete	
	Liters per 40 kg bag of cement	Absolute ratio by weight	Liters per 40 kg bag of cement	Absolute ratio by weight
17.24	25.77	0.642	22.22	0.554
20.70	23.11	0.576	18.66	0.465
24.13	20.44	0.510	15.99	0.399
27.58	17.77	0.443	14.22	0.354

900.3.3 Concrete Proportions and Consistency

The proportions of aggregates to cement for any concrete shall be such as to produce a mixture which will work readily into the corners and angles of the form and around reinforcement with the method of placing employed on the work, but without permitting the materials to segregate or excess free water to collect on the surface. The methods of measuring concrete materials shall be such that the proportions can be accurately controlled and easily checked at any time during the work.

900.3.4 Sampling and Testing of Structural Concrete

As work progresses, at least one (1) sample consisting of three (3) concrete cylinder test specimens, 150 mm x 300 mm, shall be taken from each 75 m3 of each class of concrete or fraction thereof placed each day.

Samples from which compression test specimens are molded shall be secured in accordance with ASTM C172M, Standard Practice for Sampling Freshly Mixed Concrete. Specimens made to check the adequacy of the proportions for strength of concrete or as a basis for acceptance of concrete shall be made and laboratory-cured in accordance with ASTM C31M, Standard Practice for Making and Curing Concrete Test Specimen in

the Field. Additional test specimens cured entirely under field conditions may be required by the Engineer to check the adequacy of curing and protection of the concrete. Strength tests shall be made in accordance with ASTM C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimen.

Compliance with the requirements of this Subsection shall be determined in accordance with the following standard methods of AASHTO:

Sampling of fresh concrete	:	AASHTO R 60, Standard Practice for Sampling Freshly Mixed Concrete
Weight per cubic meter and air content (gravi-metric) of concrete	:	AASHTO T 121M, Standard Method of Test for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
Slump of Portland Cement Concrete	:	AASHTO T 119M, Standard Method of Test for Slump of Hydraulic Cement Concrete

Tests for strength shall be made in accordance with the following:

Making and curing of concrete compressive specimen in the field	:	AASHTO T 23, Standard Method of Test for Making and Curing Concrete Test Specimens in the Field (ASTM C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field)
Compressive strength of moldedconcrete Cylinders	:	AASHTO T 22, Standard Method of Test for Compressive Strength of Cylindrical Concrete Specimens (ASTM C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens)

900.3.5 Proportioning and Strength of Structural Concrete

The concrete materials shall be proportioned in accordance with the requirements for each class of concrete as specified in Table 900.7, using the absolute volume method as outlined in the American Concrete Institute (ACI) Standard 211.1, Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete. Other methods of proportioning may be employed in the mix design with prior approval of the Engineer. A change in the source of materials during the progress of work shall necessitate a new mix design.

The strength requirements for each class of concrete shall be as specifiedin Table 900.7.

Table 900.7 Composition and Strength of Concrete for Use in Structures

Class of Concrete	Minimum Cement Content Per m3 40kg/ (bag**)	Maximum Water / Cement Ratio (kg/kg)	Consistency Range in Slump (mm)	Designated Size of Coarse Aggregate Square Opening Std. mm	Minimum Compressive Strength of 150 mm x 300 mm Concrete Cylinder Specimen at 28 days, MN/m2

A	364 (9.1 bags)	0.53	50 – 100	37.50 –4.75	20.7
B	320 (8 bags)	0.58	50 – 100	50.00 –4.75	16.5
C	380 (9.5 bags)	0.55	50 – 100	12.50 –4.75	20.7
P	440 (11 bags)	0.49	100 max.	19.00 –4.75	37.7
Seal	380 (9.5 bags)	0.58	100 - 200	25.00 –4.75	20.7

*Note: * The measured cement content shall be within plus or minus 2 mass percent of thedesign cement content.*
*** Based on 40 kg/bag*

900.3.6 Consistency

Concrete shall have a consistency such that it will be workable in the required position and will flow around the reinforcing steel but individual particles of the coarse aggregates, when isolated, shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be gauged by the ability of the equipment to properly place it and not by the difficulty in mixing and transporting concrete mix. The quantity of mixing water, which shall be determined by the Engineer and shall not be varied without his consent. Concrete as dry as it is practical to place with the equipment specified shall be used.

900.3.7 Strength Test of Concrete

As basis of acceptance, strength test shall generally be made with the frequency of not less than one (1) test [three (3) specimens] for each 75 m3. Each test shall be made from a separate batch. One each day concrete is delivered, at least one (1) strength test shall be made for each class of concrete.

The age for strength tests shall be 28 days or, when specified in the Plan, the earlier age at which the concrete is to receive its full load or maximum stress. Additional test may be made at earlier ages to obtain advance information on the adequacy of strength development where age-strength relationships have been established for the materials and proportions used.

For structures designed in accordance with the ultimate strength design method, and for prestressed structures the average of any three (3) consecutive strength test of the laboratory cured specimens representing each class of concrete shall be equal to or greater than the specified compressive strength, fc' and not more than 10% of the strength tests shall have values less than the specified strength.

When the laboratory-cured specimens failed to conform to the requirements for strength, the Engineer shall have the right to order changes in the concrete sufficient to requirements. If the cured specimen had attained the intended minimum strength requirement, the removal of forms and falseworks may take place and shall conform to the requirements of Item 903, Formworks and Falseworks. When in the opinion of the Engineer, the strengths of the job- cured specimens may not likely be achieved, the Contractor may be required to improve the procedures for protecting and curing the

concrete specimen, or when test of field-cured cylinders indicate deficiencies in protection and curing, the Engineer may require test in accordance with ASTM C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete or order load tests as outlined in the load tests of structures for that portion of the structure where the questionable concrete has been placed.

900.3.8 Batching

Measuring and batching of materials shall be done at a batching plant.

1. Portland Cement

Either sacked or bulk cement may be used. No fraction of a sack of cement shall be used in a batch of concrete unless the cement is weighed. All bulk cement shall be weighed on an approved weighing device. The bulk cement weighing hopper shall be properly sealed and vented to preclude dusting operation. The discharge chute shall not be suspended from the weighing hopper and shall be so arranged that cement will neither be lodged in it nor leak from it.

Accuracy of batching shall be within plus (+) or minus (-) one (1) mass percent.

2. Water

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not more than 1%.

3. Aggregates

Stockpiling of aggregates shall be in accordance with Subsection 900.2.6, Storage of Cement and Aggregate. All aggregates whether produced or handled by hydraulic methods or washed, shall be stockpiled or binned for draining for at least 12 hours prior to batching. Shipment requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. If the aggregates contain high or non-uniform moisture content, storage or stockpile period in excess of 12 hours may be required by the Engineer.

Batching shall be conducted as to result in a two (2) mass percent maximum tolerance for the required materials.

4. Bins and Scales

The batching plant shall include separate bins for bulk cement, fine aggregate and for each size of coarse aggregate, a weighing hopper, and scales capable of determining accurately the mass of each component of the batch.

Scales shall be accurate to 0.5% throughout the range used.

5. Batching

When batches are hauled to the mixer, bulk cement shall be transported either in waterproof compartments or between the fine and coarse aggregate. When cement is placed in contact with moist aggregates, batches will be rejected unless mixed within

one and 1.5 h of such contact. Sacked cement may be transported on top of the aggregates.

Batches shall be delivered to the mixer separate and intact. Each batch shall be dumped cleanly into the mixer without loss, and, when more than one (1) batch is carried on the truck, without spilling of material from one batch compartment into another.

6. Admixtures

The Contractor shall follow an approved procedure for adding the specified amount of admixture to each batch and will be responsible for its uniform operation during the progress of the work. He shall provide separate scales for the admixtures which are to be proportioned by weight, and accurate measures for those to be proportioned by volume. Admixtures shall be measured into the mixer with an accuracy of plus or minus 3%.

The use of Calcium Chloride (CaCl2) as an admixture will not be permitted.

900.3.9 Mixing and Delivery

Concrete may be mixed at the construction site, at a central point or by a combination of central point and truck mixing or by a combination of central point mixing and truck agitating. Mixing and delivery of concrete shall be in accordance with the appropriate requirements of AASHTO M 157, Standard Specification for Ready-Mixed Concrete except as modified in the following paragraphs of this Subsection, for truck mixing or a combination of central point and truck mixing or truck agitating. Delivery of concrete shall be regulated so that placing is at a continuous rate unless delayed by the placing operations. The intervals between deliveries of batches shall not be so great as to allow the concrete in place to harden partially, and in no case, shall such an interval exceed 30 min.

Volumetric measurement shall be used only if by weight batching plant is located more than 1 h travel from the project site.

Concrete mixing, by chute is allowed provided that a weighing scales for determining the batch weight will be used.

For batch mixing at the construction site or at a central point, a batch mixer of an approved type shall be used. Mixer having a rated capacity of less than a one-bag batch shall not be used. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity as shown on the manufacturer's standard rating plate on the mixer except that an overload up to 10% above the mixer's nominal capacity may be permitted, provided concrete test data for strength, segregation, and uniform consistency are satisfactory and provided no spillage of concrete takes place. The batch shall be so charge into the drum that a portion of the water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 s of the mixing period. Mixing time shall be measured from the time all materials, except water, are in the drum. Mixing time shall not be less than 60 s for mixers having a capacity of 1.5 m3 or less. For mixers having a capacity greater than 1.5 m3, the mixing time shall not be less than 90 s. If timing starts, the instant skip reaches its maximum raised position, 4 s shall be added to the specified mixing time. Mixing time ends when the discharge chute opens.

The mixer shall be operated at the drum speed as shown on the manufacturer's name plate on the mixer. Any concrete mixed less than the specified time shall be discarded and disposed of by the Contractor at his own expense.

The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not placed in good working order within 24 h, further use of the mixer will be prohibited until repairs are made.

Retempering concrete will not be permitted. Admixtures for increasing the workability, for retarding the set, or for accelerating the set or improving the pumping characteristics of the concrete will be permitted only when specifically provided for in the Contract, or authorized in writing by the Engineer.

Mixing Concrete: General

All concrete batching plant prior to use shall be accredited by the DPWH- Bureau of Research and Standards.

1. Mixing Concrete at Site

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.

When bulk cement is used and volume of the batch is 0.5 m3 or more, the scale and weigh hopper for Portland cement shall be separated 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 also be interlocked against opening when the amount of cement in the hopper is underweight by more than one (1) mass percent or overweight by more than three (3) mass percent of the amount specified.

When the aggregate contains 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.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregate. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer so that it will not result in loss of cement due to the effect of wind, or in accumulation of cement on surface of conveyors or hoppers, or in other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire content of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than 90 s 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.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer. The time device and discharge mechanics shall be so interlocked that during normal operation no part of the batch will be charged until the specified mixing time has elapsed.

The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat inside of the drum without reducing the required mortar content of the mix. When mixing is to cease for a period of 1 hour or more, the mixer shall be thoroughly cleaned.

2. Mixing Concrete at Central Plant

Mixing at central plant shall conform to the requirements for mixing concreteat site.

3. Mixing Concrete in Truck

Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, water-tight, 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 of which the mixing time can be readily verified by the Engineer.

The maximum size of batch in truck mixers shall not exceed the minimum rated capacity of the mixer as stated by the manufacturer 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.

Mixing shall begin within 30 min 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 oC, this limit shall be reduced to 15 min. 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 judgement of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

When a truck mixer is used for transportation, the mixing time specified herein at a stationary mixer may be reduced to 30 s and the mixing completed in a truck mixer. The mixing time in the truck mixer shall be as specified for truck mixing.

4. Transporting and Delivery of Mixed Concrete

Mixed concrete may only be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturers of the equipment as agitating speed, or in non-agitating hauling equipment, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable point for adequate placement and consolidation in place.

Truck agitators shall be loaded not to exceed the manufacturer's guaranteed capacity. They shall maintain the mixed concrete in a thoroughly mixed and uniform mass during hauling.
No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point.

The rate of discharge of mixed concrete from truck mixers or agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.

When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within 1 h, or before 250 revolutions of the drum or blades, whichever comes first, after the introduction of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete or when the temperature of the concrete is 30°C, or above, a time less than 1 h will be required.

The maximum temperature of concrete produced with heated aggregates, heated water, or both, shall at no time during its production or transportation exceed 32°C.

The Contractor shall have sufficient plant capacity and transportation apparatus to insure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 min. The methods of delivering and handling the concrete shall be such as that will facilitate placing of the minimum handling.

900.3.10 Handling and Placing Concrete: General

Concrete shall not be placed until forms and reinforcing steel have been checked and approved by the Engineer.

If lean concrete is required in the Plan or as directed by the Engineer prior to placing of reinforcing steel bar, the lean concrete should have a minimum compressive strength of 13.8 MPa.

In preparation for the placing of concrete, all sawdust, chips and other construction debris and extraneous matter shall be removed from inside the formwork. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

No concrete shall be used which does not reach its final position in the forms within the time stipulated under “Time of Hauling and Placing Mixed Concrete”.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes, and pipes for conveying concrete to the forms shall be permitted only on written authorization of the Engineer. The Engineer shall reject the use of the equipment for concrete transportation that will allow segregation, loss of fine materials, or in any other way will have a deteriorating effect on the concrete quality.
Open troughs and chutes shall be of metal lined; where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement to avoid segregation.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure.

When placing operations would involve dropping the concrete more than 1.5 m, concrete shall be conveyed through sheet metal or approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower end shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement bars.

The concrete shall be placed as nearly as possible to its final position and the use of vibrators for moving of the mass of fresh concrete shall not be permitted.

900.3.10.1 Placing Concrete by Pneumatic Means

The equipment shall be so arranged that vibration will not damage freshly placed concrete. The capacity of equipment shall be 0.30 to 1.00 m3.

Where concrete is conveyed and placed by pneumatic means, the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the work. The discharge lines shall be horizontal or inclined upwards from the machine. The discharge end of the line shall not be more than 3 m from the point of deposit.

At the conclusion of placing the concrete, the entire equipment shall be thoroughly cleaned.

900.3.10.2 Placing of Concrete by Pumping

The equipment shall be so arranged that vibration will not damage freshly placed concrete. The discharge capacity of the equipment shall be 1.5 to 10.0 m3/h. The minimum pressure capacity of the equipment shall be 0.60 MPa.

Where concrete is conveyed and placed by mechanically applied pressure the equipment shall be suitable in kind and adequate in capacity for the work. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the

pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation, the entire equipment shall be thoroughly cleaned.

900.3.10.3 Placing Concrete in Water

Concrete deposited in water shall be Class Seal concrete with a minimum cement content of 380 kg/m3 of concrete. The slump of the concrete shall be maintained between 4 and 8 cm, whichever is called for in the Bill of Quantities. To prevent segregation, concrete shall be carefully placed in a compact mass, in its final position, by means of a tremie, a bottom-dump bucket, or other approved means, and shall not be disturbed after being placed.

A tremie shall consist of a tube having a diameter of not less than 250 mm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge and over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times. The tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by lightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the work is completed.

When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The buckets shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

900.3.11 Consolidation of Concrete

The consolidation method should be compatible with the concrete mixture, placing conditions, and degree of air removal desired. When concrete comes down the chute and flows into forms it carries entrapped air. The entrapped air shall be removed to prevent voids in concrete. Poorly consolidated concrete will be weak, porous and poorly bonded to the reinforcement.

Poured concrete shall be immediately and thoroughly consolidated. The concrete in walls, beams, columns and the like shall be placed in horizontal layers not more than 30 cm thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and consolidated before the preceding layer has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the layers. Each layer shall be consolidated so as to avoid the formation of a construction joint with a preceding layer.

The consolidation shall be done by mechanical vibration. The concrete shall be vibrated internally unless special authorization of other methods is given or is provided herein. The intensity of vibration shall be such as to visibly affect a mass of concrete with a 3 cm slump over a radius of at least 50 cm. A sufficient number of vibrator shall be provided to properly consolidate each batch immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement

and embedded fixtures and into the corners and angles of the forms and shall be applied at the point of placing and in the area of freely placed concrete. The vibrators shall be inserted into and withdrawn from the concrete slowly. The diameter of the steel tube called poker depends on the spacing between the reinforcing bars in the form-work. In no case shall the vibrator be operated longer than 15 s in any one location. The vibration shall be of sufficient duration and intensity to consolidate the concrete thoroughly but shall not be continued so as to cause segregation and at any one point to the extent that localized areas of grout are formed. Application of vibrators shall be at points uniformly spaced, and not farther apart than twice the radius over which the vibration is visibly effective. Vibration shall not be applied directly or thru the reinforcement to sections or layers of concrete that have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms of troughs or chutes.

900.3.12 Concrete Surface Finishing: General

900.3.12.1 Float Finish

Surface shall be consolidated with power–driven floats or by hand floating. Surfaces shall be left uniform, smooth and granular texture.

Float finish shall be applied to the surfaces indicated, to surfaces to receive trowel finish, and to floor and slab surfaces to be covered with fluid-applied or sheet waterproofing, built-up or membrane roofing, or sand-bed terrazzo.

900.3.12.2 Trowel Finish

After applying float finish, trowel shall be applied first then concrete shall be consolidated by hand or power –driven trowel. Continue troweling passes and restraigthen until surface is free of trowel marks and uniform in texture and appearance. Grind smooth any surface defects that would telegraph through applied coating or floor coverings.

900.3.12.3 Concrete Rubbed Finish

After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Allow the concrete to cure before the final rubbing with a fine carborundum stone and water. The concrete shall be kept damp while rubbing. 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. Surface coating of cementitious material which adds thickness to the original surface is not acceptable.

900.3.13 Curing Concrete

900.3.12.1

All newly placed concrete shall be cured in accordance with this Specification, unless otherwise directed by the Engineer. The curing method shall be one or more of the following:

1. Water Method

The concrete shall be kept continuously wet by the application of water for a minimum period of 7 days after the concrete has been placed.

The entire surface of the concrete shall be kept damp by applying water with an atomizing nozzle. Cotton mats, rugs, carpets, or earth or sand blankets may be used to retain the moisture. At the expiration of the curing period the concrete surface shall be cleared of the curing medium.

2. Curing Compound

Surfaces exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer.

The membrane forming compound used shall be practically colorless liquid. The use of any membrane-forming compound that will alter the natural color of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film and shall be of such character that it will harden within 30 min after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power-operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. In the event of any delay, in the application of the curing compound, which results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under “Water Method”, shall be started immediately and shall be continued until the application of the compound is resumed or started, however, the compound shall not be applied over any resulting free-standing water. Should the film of compound be damaged from any cause before the expiration of 7 days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compound shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within 120 days after the date of manufacture, the Engineer may require additional testing before the use to determine compliance to requirements. An anti-setting agent or a combination of anti-setting agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located on the site. Storage tank shall have a permanent system designed to completely redisperse any settled material without introducing air or any other foreign substance. Containers shall be well-sealed with ring

seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be labeled with a manufacturer's name, specification number, batch number, capacity and date of manufacture, and shall have label warning concerning flammability. The label shall also warn that the curing compound shall be well-stirred before use. When the curing compound is shipped in tanks or tank trunks, a shipping invoice and Material Safety Data Sheet (MSDS) shall accompany each load. The invoice and MSDS shall contain the same information as that required herein for container labels.

Curing compound may be sampled by the Engineer at the source of supply and/or on the site.

3. Waterproof Membrane Method

The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed until the concrete has set, after which a curing membrane of waterproof paper or plastic sheeting shall be placed. The curing membrane shall remain in place for a period of not less than 72 h.

Waterproof paper and plastic sheeting shall conform to the specification of AASHTO M 171, Standard Specification for Sheet Materials for Curing Concrete.

The waterproof paper or plastic sheeting shall be formed into sheets of such width as to cover completely the entire concrete surface.

All joints in the sheets shall be securely fastened together in such a manner as to provide a waterproof joint. The joint seams shall have a minimum lap of 100 mm.

The sheets shall be securely weighed down by placing a bank of earth materials on the edges of the sheets or by other means satisfactory to the Engineer.

Should any portion of the sheets be broken or damaged within 72 hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly fastened in place.

Sections of membrane which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete shall not be used.

4. Forms-in-Place Method

Formed surfaces of concrete may be cured by retaining the form-in-place. The forms shall remain in place for a minimum period of 7 days after the concrete has been placed, except that for members over 50 cm in least dimensions, the forms shall remain in place for a minimum period of 5 days. Wooden forms shall be kept wet by watering during the curing period.

5. Steam Curing Method

Steam curing for pre-cast members shall conform to the following provisions:

a. After placement of the concrete, members shall be held for a minimum 4 h pre-steaming period.

b. To prevent moisture loss on exposed surfaces during the pre-steaming period, members shall be covered immediately after casting or the exposed surface shall be kept wet by fog spray or wet blankets.

c. Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good condition and secured in such a manner to prevent the loss of steam and moisture.

d. Steam at jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During application of the steam, the temperature rise within the enclosure shall not exceed 20°C per hour. The curing temperature throughout the enclosure shall not exceed 65°C and shall be maintained at a constant level for a sufficient time necessary to develop the required compressive strength. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature of the enclosure will be the same as that of the concrete.

e. Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one (1) temperature recording device per 50 m of continuous bed length will be required for checking temperature.

f. Curing of pre-cast concrete will be considered completed after the termination of the steam curing cycle.

900.3.13.2 Curing Concrete

The application for curing method shall be one or more of the following:

1. Curing Cast-In-Situ Concrete

All newly placed concrete for cast-in-situ structures, shall either be cured by the water method, the forms-in-place method, or as permitted herein, by the curing compound method, all in accordance with the requirements of Subsection 900.3.13, Curing Concrete.

The curing compound method may be used on concrete surfaces which are to be buried under ground and surfaces where only Ordinary Surface Finish is to be applied and on which a uniform color is not required, and which will not be visible from public view.

When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surface being cured by the curing compound method or by the forms-in-place method until the Engineer determine that a cooling effect is no longer required.

2. Curing Pre-Cast Concrete (except piles)

Pre-cast concrete members shall be cured for not less than 7 days by the water method, Subsection 900.3.13 (1), Water Method or by steam curing, Subsection 900.3.13 (5), Steam Curing Method.

3. Curing Pre-cast Concrete Piles

All newly placed concrete for pre-cast concrete piles, conventionally reinforced or prestressed shall be cured by the "Water Method" as described in Subsection 900.3.11, Curing Concrete, except that the concrete shall be kept under moisture for at least 14 days. At the option of the Contractor, steam curing may be used in which case the steam curing provisions of Subsection 900.3.13(5), Steam Curing Method shall apply except that the concrete shall be kept wet for at least 7 days including the holding and steaming period.

900.3.14 Acceptance of Concrete

The strength of concrete shall be deemed acceptable if the average of three (3) consecutive strength test results is equal to or exceed the specified strength and no individual test result falls below the specified strength by more than 15%.

Concrete deemed to be not acceptable using the above criteria may be rejected unless the Contractor can provide evidence, by means of core tests, that the quality of concrete represented by the failed test result is acceptable in place. Three (3) cores shall be obtained from the affected area and cured and tested in accordance with AASHTO T 24, Standard Method of Test for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete (ASTM C42, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. Concrete in the area represented by the cores will be deemed acceptable if the average of cores is equal to or at least 85% and no sample core is less than 75% of the specified strength otherwise it shall be rejected.

900.4 Method of Measurement

The quantity of concrete to be paid shall be the number of cubic meters placed and accepted in the completed structure. No deduction will be made for the volume occupied by the pipe less than 101 mm outside diameter nor for reinforcing steel, anchors, weephole(s) or expansion materials.

900.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 900.4, Method of Measurement shall be paid for at the Contract Unit Price for each of pay item listed below that is included in the Bill of Quantities of structural concrete and/or reinforced concrete completed in place will be paid for at the contract unit price for cubic meter as indicated on the Bid Schedule.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
900 (1)a	Structural Concrete, Class A, 3000 psi, 7 days	Cubic Meter

900 (1)b	Structural Concrete, Class A, 3000 psi, 14 days	Cubic Meter
900 (1)c	Structural Concrete, Class A, 3000 psi, 28 days	Cubic Meter
900 (1)d	Structural Concrete, Class A, 4000 psi, 28 days	Cubic Meter
900 (1)e	Structural Concrete, Class A, 5000 psi, 28 days	Cubic Meter
900 (1)f	Structural Concrete, Class A, 6000 psi, 28 days	Cubic Meter
900 (1)g	Structural Concrete, Class A, 7 days	Cubic Meter
900 (1)h	Structural Concrete, Class A, 14 days	Cubic Meter
900 (1)i	Structural Concrete, Class A, 28 days	Cubic Meter
900 (2)a	Structural Concrete, Class B, 7 days	Cubic Meter
900 (2)b	Structural Concrete, Class B, 14 days	Cubic Meter
900 (2)c	Structural Concrete, Class B, 28 days	Cubic Meter
900 (3)a	Structural Concrete, Class C, 7 days	Cubic Meter
900 (3)b	Structural Concrete, Class C, 14 days	Cubic Meter
900 (3)c	Structural Concrete, Class C, 28 days	Cubic Meter
900 (4)a	Structural Concrete, Class P, 7 days	Cubic Meter
900 (4)b	Structural Concrete, Class P, 14 days	Cubic Meter

XXII. ITEM 901 – LEAN CONCRETE

901.1 Description

This Item shall consist of furnishing and placing of lean concrete in accordance with this Specification and in conformance with the lines, grades, and dimensions shown on the Plans.

Lean Concrete shall consist of a mixture of Portland cement, fine aggregate, coarse aggregate, and water mixed in the proportions specified or approved by the Engineer. It is primarily used to provide a suitable base layer for concrete structures. It is produced with cementitious material to obtain the required compressive strength.

901.2 Material Requirements

901.2.1 Portland Cement

Cement shall conform to the applicable requirements of Subsection 900.2.1, Portland Cement of Item 900, Structural Concrete.

901.2.2 Concrete Aggregates

Concrete aggregates shall conform to the applicable requirements of Subsection 900.2.2, Concrete Aggregates of Item 900, Structural Concrete.

901.2.2.1 Fine Aggregates

Fine aggregates shall conform to the applicable requirements of Subsection 900.2.2.1, Fine Aggregates of Item 900, Structural Concrete.

901.2.2.2 Coarse Aggregates

Coarse aggregates shall conform to the applicable requirements of Subsection 900.2.2.2, Coarse Aggregates of Item 900, Structural Concrete, except for the gradation which shall conform to Table 901.1, considering a 50 mm thick lean concrete.

Table 901.1 Grading Requirements for Coarse Aggregate

Sieve Size	Mass Percent Passing
37.5 mm	100
25 mm	87 – 100
19 mm	45 – 100
9.5 mm	35 – 80
4.75 mm	30 – 65
No. 30	6 – 34
No.200	0 – 15

901.2.3 Water

Water shall conform to the applicable requirements of Subsection 900.2.3, Water of Item 900, Structural Concrete.

901.2.4 Curing Materials

The curing compound shall be a wax-base product to provide a bond-breaking membrane between the lean concrete base and overlying concrete which conforms to the requirements of ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.

901.2.5 Storage of Cement and Aggregates

Cement and aggregates shall be stored in accordance to the applicable requirements of Subsection 900.2.6, Storage of Cement and Aggregates of Item 900, Structural Concrete.

901.2.6 Proportioning, Consistency and Strength of Concrete

The Contractor shall prepare the design mix based on the absolute volume method or as outlined in the American Concrete Institute (ACI) Standard 211.1, Recommended Practice for Selecting Proportions for Normal and Heavyweight Concrete.

For lean concrete to be placed prior to placing of reinforcing steel bar or any prefabricated structure shall have a minimum compressive strength of 80% of the required strength of 13.8 MPa at 7 days.

Slump shall be 25 mm to 75 mm and determined using AASHTO T 119, Standard Method of Test for Slump of Hydraulic Cement Concrete.

901.3 Construction Requirements

901.3.1 Quality Control of Concrete

The Contractor shall be responsible for the quality control of all materials during the handling, blending, and mixing and placement operations.

The Contractor shall furnish the Engineer a Quality Control Plan detailing his production control procedures and the type and frequency of sampling and testing to ensure that the concrete produced complies with the Specifications.

The Contractor shall be responsible for determining the gradation of fine and coarse aggregates and for testing the concrete mixture for slump, air content, water-cement ratio and temperature. He shall conduct his operations so as to produce a mix conforming to the approved mix design.

The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiencies found, the quantities approved and rejected, and nature of any corrective action taken.

The Engineer may take independent assurance samples at random location for acceptance purposes as he deems necessary.

901.3.2 Site Preparation

For structures requiring subgrade preparation, it shall be as follows:

1. Subgrade shall conform to the specified lines and grades, elevation as indicated on the Plans and compacted to the required density. Any low areas shall be identified and filled with additional base and that any high areas shall be trimmed as specified. Additional thickness shall be paid for as part of the lower layer and shall not be included in calculating base thickness.

2. Subgrade shall be free of loose or extraneous materials.

3. Subgrade shall be uniformly moist but free of standing or flowing water.

901.3.3 Handling and Placing of Concrete: General

Handling and Placing of Concrete shall conform to the applicable requirements of Subsection 900.3.10, Handling and Placing of Concrete: General of Item 900, Structural Concrete.

901.3.3.1 Placing of Concrete by Pneumatic Means

Placing of concrete by pneumatic means shall conform to the applicable requirements of Subsection 900.3.10.1, Placing Concrete by Pneumatic Means of Item 900, Structural Concrete.

901.3.3.2 Placing of Concrete by Pumping

Placing of concrete by pumping shall conform to the applicable requirements of Subsection 900.3.10.2, Placing of Concrete by Pumping of Item 900, Structural Concrete.

901.3.4 Finishing

Finishing shall conform to the applicable requirements of Subsection 900.3.12, Concrete Surface Finishing: General of Item 900, Structural Concrete.

901.3.5 Curing

Curing of lean concrete shall be in accordance to Subsection 900.3.13, Curing Concrete of Item 900, Structural Concrete.

901.3.6 Sampling, Testing and Acceptance

Sampling and testing shall conform to the applicable requirements of Subsection 900.3.4, Sampling and Testing of Structural Concrete of Item 900, Structural Concrete.

Acceptance of concrete shall conform to the applicable requirements of Subsection 900.3.14, Acceptance of Concrete of Item 900, Structural Concrete.

901.4 Method of Measurement

The quantity of lean concrete to be paid for shall be the final quantity measured in cubic meter, placed and accepted in the completed structure as shown on the approved Plans and accepted to the satisfaction of the Engineer.

901.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 901.4, Method of Measurement shall be for at the Contract Unit Price for each of the Pay Item listed below that is included in the Bill of Quantities.

Payment shall constitute full compensation for furnishing and placing of concrete including labor, materials, equipment, tools and incidentals necessary to complete the work prescribed in the Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
901 (1)	Lean Concrete	Cubic Meter

XXIII. ITEM 902 – REINFORCING STEEL

902.1 Description

This Item shall consist of furnishing, cutting, bending, fabricating, welding, and placing of steel reinforcement with or without epoxy coating of the type, size, shape and grade required in

accordance with this Specification and in conformity with the requirements shown on the Plans.

902.2 Material Requirements

Reinforcing steel shall conform to the requirements of the following Specifications:

Table 902.1 Reinforcing Steel Bars Requirements

Type of Reinforcing Steel	Specification
Deformed Billet Steel Bars for Concrete Reinforcement	AASHTO M 31M, Standard Specification for Deformed and Plain Carbon and Low-Alloy Steel Bars for Concrete Reinforcement
	ASTM A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
	PNS 49, Philippine National Standard, Steel Bars for Concrete Reinforcement - Specification
Deformed Steel Wire for Concrete Reinforcement	AASHTO M 336M, Standard Specification for Steel Wire and Welded Wire, Plain and Deformed, for Concrete Reinforcement (ASTM A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete)
Welded Steel Wire Fabric for Concrete Reinforcement	ASTM A1064M Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
Cold-Drawn Steel Wire for Concrete Reinforcement	AASHTO M 336M, Standard Specification for Steel Wire and Welded Wire, Plain and Deformed, for Concrete Reinforcement (ASTM A1064M, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete)
Fabricated Steel Bar or Rod Mats for Concrete Reinforcement	AASHTO M 54M, Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement (ASTM A184M, Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement)
Welded Deformed Steel Wire	AASHTO M 336M, Standard Specification for Steel Wire and Welded Wire, Plain and Deformed, for Concrete Reinforcement (ASTM 1064M, Standard Specification for
Fabric	of Concrete Reinforcement

Plastic Coated Dowel Bars	AASHTO M 254M, Standard Specification for Corrosion-Resistant Coated Dowel Bars Type A
Low Alloy Steel Deformed Bars for Concrete Reinforcement	ASTM A706M, Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement
Deformed Rail	

If reinforcing bars are to be welded, these ASTM specifications shall be supplemented by requirements assuring satisfactory weldability.

Dowel and tie bars shall conform to the requirements of AASHTO M 31 (ASTM A615)/PNS 49 except that rail steel shall not be used for tie bars that are to be bent and restraightened during construction. Tie bars shall be deformed bars. Dowel bars shall be plain round bars. They shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the site of the work, a minimum of 1/2 the length of each dowel bar shall be painted with one coat of approved lead or tar paint.

The sleeves for dowel bars shall be metal of an approved design to cover 50 mm, plus or minus 6.3 mm of the dowel, with a closed end, and with a suitable stop to hold the end of the sleeve at least 25 mm from the end of the dowel bar. Sleeves shall be of such design that they do not collapse during construction.

Plastic coated dowel bar conforming to AASHTO M 254M may be used.

902.2.1 Wire Rope or Wire Cable

The wire rope or wire cable shall conform to the requirements of AASHTO M 30, Standard Specification for Zinc-Coated Steel Wire Rope and Fittings for Highway Guardrail for the specified diameter and strength class.

902.2.2 Prestressing Reinforcing Steel

Prestressing reinforcing steel shall conform to the requirements of the following Specifications:

High-tensile wire : AASHTO M 204M, Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete ASTM A421M, Standard Specification for Stress-Relieved Steel Wire for Prestressed Concrete

High-tensile wire strand or rope : Strand,

AASHTO M 203 M, Standard Specification for Steel

Uncoated Seven-Wire for Concrete Reinforcement ASTM A416M, Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete

High-tensile-strength alloy bars shall be cold stretched to a minimum of 895.7 MPa. The resultant physical properties shall be as follows:

Table 902.2 Resultant Physical Properties of High Tensile Strength Alloy Bars

Physical Property	Requirement
Minimum ultimate tensile strength	1,000 MPa followed bystress relieving
Minimum yield strength, measured by the 0.7% extension under load method	895.7 MPa
Minimum modulus of elasticity	25,000,000
Minimum elongation in 20 bar diameters after rupture	4%
Diameters tolerance	0.254 mm to 0.762 mm

If shown on the Plans, Type 270 k strand shall be used, conforming to AASHTO M 203M.

Where strands are to be used for post-tensioning, the same shall be cold- drawn and either stress-relieved in the case of uncoated strands, or hot-dip galvanized in the case of galvanized strands.

High strength alloy steel bar for post-tensioning shall be proofstressed to 90% of the granted tensile strength. After proofstressing, the bars shall conform to the following minimum properties:

Table 902.3 Minimum Requirements for High Strength Alloy Steel Bar for Post-Tensioning

Property	Requirement
Tensile Strength, fs’	1000 MPa
Yield Strength (0.2 offset)	0.90 fs’
Elongation at Rupture in 20 diameter	4%
Reduction of Area at Rupture	25%

902.2.3 Epoxy Coated Reinforcing Steel Bars

Epoxy coated reinforcing steel bars shall be applied with protective epoxy coating by the electrostatic spray method to strengthen the concrete and protect against corrosive conditions that will be exposed to the aggressive elements.

Epoxy coated reinforcing steel bars shall conform to ASTM A775M, Standard Specification for Epoxy-Coated Steel Reinforcing Steel Bars for steel bars coated in straight condition and then bent, and ASTM A934M, Standard Specification for Epoxy-Coated Prefabricated Steel Bars for steel bars that are bent prior to coating.

The powder coating shall be of organic composition except for the pigment which may be inorganic if used.

The following kinds of reinforcing steel bars are allowed to be applied with epoxy coating.

Table 902.4 Kinds of Reinforcing Steel Bars are allowed to be applied with epoxy coating

Reinforcing Steel	Standard Designation
Deformed and Plain Carbon-Steel Barsfor Concrete Reinforcement	ASTM A615/AASHTO M 31
Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement	ASTM A706
Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcements	ASTM A996/AASHTO M 322

902.2.3.1 Surface Preparation

The surface of the steel reinforcing bars to be coated shall be cleaned by abrasive blast cleaning to a near white metal. It is recommended that reinforcing steel bars and blast media be checked for contamination by any foreign materials and oil impurities prior to use. Blast media found to be salt contaminated should be rejected. Reinforcing steel bars and blast media found to be contaminated shall be rejected or washed cleaned prior to heating thru the use of methods suitable to remove the contamination.

Manufacturers shall be permitted to use a chemical wash or blast-cleaned steel reinforcing bar surface, or both, to enhance coating adhesion. This pretreatment shall be applied after abrasive cleaning and before epoxy coating, in accordance with the written application instructions specified by the pretreatment manufacturer.

902.2.3.2 Coating Application

If pretreatment is used in the preparation of the surface, the powder coating shall be applied to the cleaned and pretreated steel reinforcing bar surface as soon as possible after surface treatments have been completed, and before visible oxidation of the surface occurs as discernible to a person with normal or corrected vision. In no case shall application of the coating be delayed more than 3 hours after cleaning.

The fusion-bonded epoxy powder coating shall be applied in accordance with the written recommendations of the manufacturer of the powder coating for initial surface temperature range and post application curing requirements. During continuous operations, the temperature of the surface immediately prior to coating shall be measured using infrared guns or temperature indicating crayons, or both, at least once every 30 minutes. The powder coating shall be applied by electrostatic spray or other suitable method.

902.2.3.3 Curing

Following powder application, the coating is allowed to cure at approximately 30 seconds during which time it hardens to a solid. In some plants, the curing is often followed by an air or water quench that quickly reduces the bar temperature to facilitate handling.

902.2.3.4 Requirements for Epoxy-Coated Reinforcing Steel Bars

1. Coating Thickness

For acceptance purpose, at least 90% of all recorded thickness measurements of the coating after curing shall be 175 µm to 300 µm. Thickness measurements below 125 µm shall be considered cause for rejection. The upper thickness limit does not apply to repaired areas of damaged coating.

A single recorded coated reinforcing steel bar thickness measurement is the average of three (3) individual gauge readings obtained between four (4) consecutive deformations. A minimum of five (5) recorded measurements shall be obtained approximately evenly spaced along each side of the test bar (a minimum of ten (10) recorded measurements per bar).

The coating thickness shall be measured on the body of a straight length of reinforcing steel bar between the deformations.

2. Coating Continuity

Holiday checks to determine the acceptability of the reinforcing steel bars prior to shipment shall be made at the manufacturer's plant with a 67.5 V, 80,000 Ω, wet-sponge type direct-current holiday detector or equivalent method.

On average, there shall not be more than three (3) holidays per meter on a coated steel reinforcing bar. The average applies to the full production length of a bar.

A wetting agent shall be used as per applicable requirements of Test Method of ASTM G62, Standard Test Methods for Holiday Detection in Pipeline Coatings in the inspection for holidays on the coated steel reinforcing bars.

3. Coating Flexibility

a. The coating flexibility shall be evaluated by bending production coated reinforcing steel bars at a uniform rate around a mandrel of specified size within a maximum specified time as prescribed in the applicable requirements of bend test requirements of ASTM A775M, Standard Specification for Epoxy-Coated Steel Reinforcing Bars. The two (2) longitudinal ribs shall be placed in a plane perpendicular to the mandrel radius. The test specimen shall be between 20° C and 30° C.

b. No cracking or disbonding of the coating shall be visible to the unaided eye on the outside radius of the bent bar. Evidence of cracking or disbanding of the coating shall be considered cause for rejection of the coated reinforcing steel bars represented by the bend test sample.

c. Fracture or partial failure of the reinforcing steel bar, or cracking or disbonding caused by imperfections in the bar surface visible after performing the bend test shall not be considered a flexibility failure of the coating, but shall require testing two (2) additional specimens. These two (2) specimens shall then meet the requirements of (b).

d. The requirements for coated reinforcing steel bars shall be met at the manufacturer's plant prior to shipment.

902.3 Construction Requirements

902.3.1 Order Lists

Before materials are ordered, all order lists and bending diagrams shall be furnished by the Contractor, for approval of the Engineer. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the Contractor of responsibility for the correctness of such lists and diagrams. Any expense incident to the revisions of materials furnished in accordance with such lists and diagrams to make them comply with the Plans shall be borne by the Contractor.

902.3.2 Protection of Material

1. Steel Reinforcement

Steel reinforcement shall be stored above the surface of the ground upon platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, detrimental rust, loose scale, paint, grease, oil, or other foreign materials. Reinforcement shall be free from injurious defects such as cracks and laminations. Rust, surface seams, surface irregularities or mill scale will not be cause for rejection, provided the minimum dimensions, cross sectional area and tensile properties of a hand wire brushed specimen meets the physical requirements for the size and grade of steel specified.

2. Epoxy-Coated Reinforcing Steel Bars

a. Epoxy coated steel stored at the site shall be placed on timber sills suitably spaced so that no steel shall be laid upon or come in contact with the ground and elevated sufficiently to prevent sags in the bundles and from workers walking on the steel.

b. If rainy or exceptionally humid weather occurs or is anticipated, bars shall be stored under cover immediately upon delivery to site. Epoxy bars shall be covered with polyethylene or other materials to prevent exposure to direct sunlight.

c. Reinforcement steel bars shall be handled and stored in manner to prevent damage to bars or the epoxy coating.

d. Coated reinforcing steel bars, whether individual bars or bundles of bars or both, shall be covered with opaque polyethylene sheeting or other suitable opaque protective material. For stacked bundles, the protective covering shall be draped around the perimeter of the stack. The covering shall be secured adequately, and allow for air circulation around the bars to minimize condensation under the covering.

e. All systems for handling the epoxy coated bars shall have padded contact areas to eliminate damage.

f. All bundling bands shall be padded or suitable banding shall be used to prevent damage to the coating. All bundles of coated reinforcing steel bars shall be lifted with a strong back, spreader bar, multiple supports, or a platform bridge to prevent bar to bar abrasion from sags in the bundles of coated reinforcing steel bars.

902.3.3 Bending

All reinforcing bars requiring bending shall be cold-bent to the shapes shown on the Plans. Bars shall be bent around a circular pin having the following diameters (D) in relation to the nominal diameter of the bar (d) as shown in Table 902.5.

Table 902.5 Pin Diameter for Bending Bars

Nominal Diameter (d), mm	Pin Diameter (D)
10 to 20	6d
25 to 28	8d
32 and greater	10d

Bends and hooks in stirrups or ties may be bent to the diameter of the principal bar enclosed therein.

902.3.4 Placing and Fastening

All steel reinforcement shall be accurately placed in the position shown on the Plans and firmly held there during the placing and setting of the concrete. Bars shall be tied at all intersections except where spacing is less than 300 mm in each direction, in which case, alternate intersections shall be tied. Ties shall be fastened on the inside.

Distance from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports, so that it does not vary from the position indicated on the Plans by more than 6 mm. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shapes and dimensions. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks shall not be permitted. Unless otherwise shown on the Plans or as required by the Engineer, the minimum distance between bars shall be 40 mm. Reinforcement in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete reinforcement placed in violation of this provision shall be rejected and removal shall be required unless otherwise structural integrity of the structure was proved adequate by the Contractor in writing and approved by the Engineer. If fabric reinforcement is shipped in rolls, it shall be straightened before being placed. Bundled bars shall be tied together at not more than 1.80 m intervals.

902.3.5 Splicing

All reinforcement shall be furnished in the full lengths indicated on the Plans. Splicing of bars, except where shown on the Plans, will not be permitted without the written approval of the

Engineer. Splices shall be staggered as far as possible and with a minimum separation of not less than 40 bar diameters.

Bars shall be lapped in accordance to Table 902.6.

Table 902.6 Bars Minimum Lap Distance

Splice Type	Grade 280 (40)	Grade 420 (60)	But no less than
Tension	24 bar dia.	36 bar dia.	300 mm
Compression	20 bar dia.	24 bar dia.	300 mm

In lapped splices, the bars shall be placed in contact and wired together. Lapped splices will not be permitted at locations where the concrete section is insufficient to provide minimum clear distance of 1 1/3 the maximum size of coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the Plans. Spiral reinforcement shall be spliced by lapping at least 1 ½ turns or by butt welding unless otherwise shown on the Plans.
Splicing shall conform to the following requirements unless otherwise shown on the Plans.

1.Lap splices shall not be permitted for bars larger than 36 mm Ø.

2.For contact lap splices, minimum clear spacing between the contact lap splice and adjacent splices or bars shall be in accordance with the requirements below.

a.For parallel non-prestresed reinforcement in a horizontal layer, clear spacing shall be at least the greatest of 50 mm, nominal diameter of bar(db) and (4/3) nominal maximum size of coarse aggregates (dagg).

3. For non-contact splices in flexural members, the transverse center-to- center spacing of spliced bars shall not exceed the lesser of one-fifth the required lap splice length and 150 mm.

4.Lap splices of bundled bars shall be in accordance with the requirements below.

a.Lap splices of bars in the bundle shall be based on the lap splice length required for the individual bars within the bundle.

b.Individual bar splices within a bundle shall not overlap.

c.Entire bundles shall not be lap spliced.

902.3.6 Lapping of Bar Mat

Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The overlap shall not be less than one (1) mesh in width.

902.3.7 Welding

Welding of reinforcing steel bars shall conform to American Welding Society, AWS D1.4M, Structural Welding Code - Reinforcing Steel.

For steel bars conforming to ASTM A706M, Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement the bars can be welded without preheating. Steel bars conforming to ASTM A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement shall be preheated to 260°C.

After completion of welding on epoxy-coated bars, the damaged areas shall be repaired using patch materials conforming to ASTM A47M, Standard Specification for Ferritic Malleable Iron Castings.

902.4 Method of Measurement

The quantity of reinforcing steel to be paid for will be the final quantity placed and accepted in the completed structure as shown on the Plans.

902.5 Basis of Payment

The accepted quantity, measured as prescribed in Section 902.4, Method of Measurement shall be paid for at the Contract Unit Price for reinforcing steel which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
902 (1) a1	Reinforcing Steel (Deformed) Grade 40	Kilogram
902 (1) a2	Reinforcing Steel (Deformed) Grade 60	Kilogram
902 (1) b	Reinforcing Steel (Plain/Round)	Kilogram
902 (2) a1	Epoxy-Coated Reinforcing Steel (Deformed) Grade 40	Kilogram
902 (2) a2	Epoxy-Coated Reinforcing Steel (Deformed) Grade 60	Kilogram
902 (2) b	Epoxy-Coated Reinforcing Steel (Plain/Round)	Kilogram

XXIV. ITEM 903 – FORMWORKS AND FALSEWORKS

903.1 Description

This Item covers the furnishing, fabrication, installation, erection, and removal of forms and falseworks for cast-in-place concrete.

903.2 Material Requirements

Forms shall be constructed with metal or timber. For timber forms, it is important that the moisture content of the timber that will be used to make the formwork in between 15% to 20%. Low moisture content means the timber is very dry thus it can absorb moisture from the wet concrete resulting to swelling and bulging of timber and weak hardened concrete. Use of tough resin as wood coating is the treatment used to overcome the moisture problem in timber formworks though painting the wood with varnish is an alternative cheaper treatment. Forms for surfaces which will be exposed to view when construction is completed shall be

prefabricated plywood panel forms, job-built plywood forms, or forms that are lined with plywood or fiber board.

For metal forms, it is important that the metal used as sheating should be free from rust and nonreactive to concrete or concrete containing calcium oxide. Plywood or lined forms will not be required for surfaces which are normally submerged or not ordinarily exposed to view. Other types of forms, such as steel or unlined wooden forms, may be used for surfaces which are not restricted to plywood or lined forms, and may be used as backing for form linings. Forms are required above all extended footings.

903.3 Construction Requirements

903.3.1 General

Forms shall be furnished, fabricated, installed, erected, and removed as specified herein and shall be of a type, size, shape, quality and strength to produce hardened concrete having the shape, lines and dimensions indicated on the drawings. The forms shall be true to line and grade in accordance with the tolerances as specified for cast-in-place concrete and shall be mortar tight and sufficiently rigid to resist deflection during concrete placement. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes that would deface the finished surfaces.

The minimum thickness used for metal forms shall be 2.5 mm or 3 mm thick or of such thickness that the forms remain true to shape. For timber formworks plywood is used for sheating with a minimum thickness of 18 mm to 25 mm though the thickness of the plywood to be used will depend on the pressure that the wet concrete will put on the formwork. The design of formwork will specify the thickness of the plywood that will be incorporated in the project. All tie bars with bolts used in fastening forms should be countersunk to a depth similar to the required concrete covering and patched with cement mortar. The use of approved internal steel ties or steel or plastic spacers shall be permitted. The fabricated spacer blocks shall have an embedded No. 16 G.I. Tie Wire with sufficient length to be attached to the reinforcing steel bars to hold the spacers in place after closure of forms and during pouring. Structural steel tubes used as support for forms shall have a minimum wall thickness of 4 mm.

The design and construction of the formworks and falseworks shall be the responsibility of the Contractor and for approval of the Engineer. The Contractor shall employ competent professional engineering services to design forms to be approved by the Engineer and supervise the erection of all formworks needed for the completion of the project. All materials to be incorporated to the site shall be inspected and approved by the Engineer.

903.3.2 Fabrication and Erection

Formworks to be used shall conform to ACI 347 - Guide to Formwork for Concrete. Forms shall be substantial and sufficiently tight to prevent leakage of mortar. Forms shall be braced or tied to maintain the desired position, shape, and alignment during and after concrete placement. Walers, studs, internal ties, and other form supports shall be sized and spaced so that proper working stresses are not exceeded. Joints in forms shall be bolted tightly and shall bear on solid construction. Forms shall be constructed so they can be removed without hammering, wedging, or prying against the concrete. Form ties shall be approved by the Engineer and shall be of the snap cone or she-bolt with cone type. The spacing of form ties shall be designed to withstand concrete pressures without bulging, spreading, or lifting of the

forms. The forms shall produce finished surfaces that are free from off-sets, ridges, waves, and concave or convex areas.

Forms to be reused shall be thoroughly cleaned and repaired. Split, frayed, delaminated, or otherwise damaged forms shall not be used. All form panels shall be placed in a neat, symmetrical pattern with level and continuous horizontal joints. The Contractor shall place special attention on mating forms to previously placed walls so as to minimize steps or rough transitions. Form panels shall be of the largest practical size to minimize joints and to improve rigidity which is to be designed by the formworks engineer of the Contractor. For engineered wood, available panels sizes of 1.20 m x 2.70 m and 3.00 m x 2.40 m can be ordered. Beams and slabs supported by concrete columns shall be formed in a way that the column forms can be removed without disturbing the supports of the beams or slabs.

Wherever the top of a wall will be exposed to weathering, the forms on at least one side shall not extend above the top of the wall and shall be brought to true line and grade. At other locations, forms for concrete which is to be finished to a specified elevation, slope, or contour, shall be brought to a true line and grade, or a wooden guide strip shall be provided at the proper location on the forms so that the top surface can be finished with a screed or template. At horizontal construction joints in walls, the forms on one side shall not extend more than 7 m above the joints.

When necessary, temporary openings shall be provided at the bottom of column and wall forms and at other points in order to facilitate cleaning and inspection prior to concrete placement. Unless otherwise shown on the drawings, all salient corners and edges of beams, columns, walls, slabs, and curbs shall be provided with a 25 mm x 25 mm chamfer formed by a wood or metal chamfer strip.

Forms for exposed surfaces and all steel forms shall be coated with non- staining form release agent which shall be applied just prior to placement of steel reinforcement. After coating with industrial lubricants such as form oil, any surplus form release coating on the form surface shall be removed. Wood forms for unexposed surfaces may be thoroughly wetted with water in lieu of coating with industrial lubricant immediately before concrete placement, except in freezing weather form release coating shall be used. Should misalignment of forms or screeds, excessive deflection of forms, or displacement of reinforcement occur during concrete placement, immediate corrective measure shall be taken to ensure acceptable lines and surface to required dimensions and cross sections. If any forms bulge or show excessive deflection, in the opinion of the Engineer, the concrete shall be removed and the forms shall be rebuilt and strengthened.

903.3.2.1 Foundations for Formwork

Proper foundations on ground, such as mudsills, spread footings, or pile footings should be provided. If soil under mudsills is or may become incapable of supporting superimposed loads without appreciable settlement, it should be stabilized or other means of support should be provided.

903.3.3 Safety

Forms must be strong and sound (made of good quality and durable materials) in order to carry the full load and side pressure from freshly placed concrete. To ensure that forms are safe, correctly designed and strong enough for the expected load, Occupational Safety and

Health Administration (OSHA) regulations under Section 1926.703 Safety and Health Regulations for Construction, American Concrete Institute 347 (ACI 347) – Guide to Formwork recommendations under Section 3.1 Safety Precautions in Construction and Section 3.2 Construction Practices and Workmanship, and local code requirements for formwork should be followed.

903.3.4 Delivery, Storage, Maintenance and Handling

Any formwork with steel components should be stored in a dry place. Avoid direct sunlight on timber forms. Store form materials and accessories above ground with a minimum height of 100 mm on framework or blocking without twist or bend, and shall be covered with a suitable waterproof of covering providing adequate air circulation and free from dirt. Store and handle form coating to prevent contamination in accordance with manufacturer's recommendation. For maintenance of the forms, use stiff brush and clean water for the cleaning of forms. Use scrapers only as a last resort for maintenance purposes. Keep forms well-oiled to prevent delamination of plywood or rusting of steel and always oil the edges.

903.3.5 Removal of Forms

Forms, falseworks and centering shall not be removed or disturbed until the concrete has attained sufficient strength to safely support all dead and live loads, or until the concrete has attained the minimum percentage of specified design strength listed in the Table below. Shoring beneath beams or slabs shall be left in place and reinforced as necessary to carry any construction equipment or materials placed thereon.

No forms shall be removed without the approval of the Engineer. In general and under normal conditions, the Engineer will approve removal of forms after the following time has elapsed:

Description of StructuralMember	Period of time (days)	Minimum % of Design Strength
Walls, column and vertical sides of beams	1 to 2	70%
Beam soffits (steel formwork props/shoring left under)	7	80%
Soffits of slabs (steel formwork props/shoring left under)	7	70%
Removal of steel formwork props/shoring to slabs: Soffits of slabs, for slabs spanning up to 4.5 m	7	70%
Removal of steel formwork props/shoring to slabs: Soffits of slabs, for slabs spanning over 4.5 m	14	70%

Removal of steel formwork props/shoring to beams and arches: Centering under girders, beam frames and arches spanning up to 6.0 m	14	80%
Removal of steel formwork props/shoring to beams and arches: Centering under girders, beam frames and arches spanning over 6.0 m	21	80%

Order and method of removing formwork:

1. Shuttering forming the vertical faces of walls, beams and columns sides shall be removed first as they bear no load but only retain the concrete.

2. Shuttering forming soffit of slabs shall be removed next.

3. Shuttering forming soffit of beams, girders or other heavily loaded shuttering shall be removed in the end.

Care shall be taken into consideration during form removal to avoid surface gouging, corner or edge breakage, or other damage to the concrete. Immediately after form removal, any damaged or imperfect work shall be repaired as specified by the Engineer.

903.3.5.1 Removal of Forms for Special Structures

In continuous structures, support should not be released in any span until the first and second adjoining spans on each side have reached the specified strength. For prestressed concrete construction, pre-tensioning and post- tensioning of strands, cables or rods can be done with or without side forms of the member in place. Bottom forms and supporting shores or falsework should remain in place until the member is capable of supporting its dead load and anticipated construction loads, as well as any formwork carried by the member. Side forms that remain in place during the transfer of pre-stressing force should be designed to allow for vertical and horizontal movements of the cast member during the prestressing operation. In all cases, the deflections of members due to pre-stressing force and the elastic deformation of forms or falsework should be considered in the design and removal of the forms. For reasons of safety, when using post-tensioned, cast-in-place elevated slabs, the Contractor should be careful to ensure that supporting shores do not fall out due to lifting of the slab during tensioning. For large structures where the dead load of the member remains on the formwork during pre-stressing, displacement of the dead load toward end supports should be considered in the design of the forms and shoring, including sills or other foundation support.

For concrete structures with direct or indirect contact with sea water, sea water or brackish water shall not come in direct contact with concrete prior to the age in days indicated in the Table shown below.

Requirements for the Removal of Formwork for Concrete inContact with Sea Water or Brackish Water	
Water Salinity (ppm dissolved salts) (parts per million or mg/L of dissolved salts)	**Days to Elapse prior to Salt Water Contact (days)**
0 to 10,000	Normal Curing
10,000 to 20,000	15
20,000 to 30,000	25
Over 30,000	30

903.3.6 Quality Control and Inspection

Materials and components used for formworks shall be examined for damage or excessive deterioration before use. Reuse of forms shall be allowed only if found suitable after necessary repairs. In case of timber forms, the inspection shall not only cover physical damages but also signs of attacks by decay, rot or insect attack or the development of splits. Reuse of job-built forms shall be permitted only when specifically approved by the Engineer.

The Engineer shall inspect the completed formwork, before carrying out any work, including fixing of reinforcing support.

903.4 Method of Measurement

Forms installed for the cast-in-place concrete in accordance to shop drawings and design calculations shall be measured in square meters or when the contract stipulates that the payment for formworks and falseworks will be on lump sum basis, the Pay Item will include all materials and components used for furnishing, fabrication, installation, erection and removal of forms. The quantity to be paid for shall be the square meters of formwork used and accepted by the Engineer or the lump sum bid price in the Contract.

903.5 Basis of Payment

The quantity measured as prescribed above shall be paid for at the Contract Unit Price or lump sum price bid for the pay item listed below that is included in the Bill of Quantities. This unit price shall cover full compensation for all materials, labor, tools, equipment, and related services necessary for the design, construction and removal of formwork and falsework. Properly supported members as required until the concrete is cured, set and hardened is also part of the Contract Unit Price.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
903 (1)	Formworks and Falseworks	Lump Sum
903 (2)	Formworks and Falseworks	Square Meter

XXV. ITEM 1000 – TERMITE CONTROL WORK

1000.1 Description

This Item shall consist of furnishing and applying termite control chemicals, including the use of equipment and tools in performing such operations in accordance with this Specification.

1000.2 Material Requirements

Termite control chemicals or toxicants shall be able to immediately exterminate termites or create barriers to discourage entry of subterranean termites into the building areas. Chemical or toxicants to be used shall be in accordance with the governing laws and the manufacturer shall be accredited by the Department of Health through Food and Drug Administration (FDA). The toxicants may be classified into the following types and according to use:

Type I. Liquid Termicide Concentrate

This type of toxicant shall be specified for drenching soil beneath foundations of proposed buildings. The concentrate shall be diluted with water in the proportion of 1 L of concentrate material to 65 L of water or as specified by the manufacturer.

Type II. Liquid Termicide Ready Mixed Solution

This type of toxicant which comes in ready mixed solution shall be used as wood preservative by drenching wood surfaces to the point of run-off.

Type III. Powder Termicide

This type of toxicant shall be applied to visible or suspected subterranean termite mounds and tunnels where termites are exterminated through Trophallaxes method (exchange or nourishment between termites while greeting each other upon meeting).

1000.3 Construction Requirements

Before any termite control work is started, thorough examination of the site shall be undertaken by the Contractor so that the appropriate method of soil poisoning can be applied.

The Contractor shall coordinate with other related trades through the Engineer to avoid delay that may arise during the different phases of application of the termite control chemicals.

This work shall be done by trained personnel with a minimum two (2) years' experience for proper execution of the work of this Specification.

1000.3.1 Soil Poisoning

There are two (2) methods usually adopted in soil poisoning which are as follows. Other methods as recommended by the manufacturers and approved by the Engineer may also be used.

1. Cordoning

This method is usually adopted when there is no visible evidence of termite infestation. Trenches in concentric circles, squares or rectangles are dug 150 mm to 220 mm wide and at least 1 m apart and applied with Type I working solution at the rate of 8 L/l.m within the cordoned area.

2. Drenching

When soil show termite infestation, this method shall be applied. The building area shall be thoroughly drenched with Type I working solution at the rate of 24 L/m².

1000.3.2 Surface Preparation

All organic matter, construction debris, rubbish, etc. which could decrease effectiveness of treatment on areas to be treated shall be removed. Water logged foundations shall be treated after drying when the soil is absorbent. For low penetration and sloping sites, surface to be scarified shall be 75 mm deep. Cutting, excavation, leveling and grading shall be completed before starting treatment. Loosen, rake and level soil to be treated, except previously compacted areas under slabs and foundations.

1000.3.3 Application

Before the application of soil treatment, the Contractor shall coordinate with the Engineer prior to excavating, filling, grading and concreting works.

At the time soil poisoning is to be applied, the soil to be treated shall be in friable condition with low moisture content so as to allow uniform distribution of the toxicant agents. Toxicant shall be applied at least 12 h prior to placement of concrete which shall be in contact with treated materials.

Treatment of the soil on the exterior sides of the foundation walls, grade beams and similar structures shall be done prior to final grading and planting or landscaping work to avoid disturbance of the toxicant barriers by such operations.

Areas to be covered by concrete slab shall be treated before placement of granular fill used as capillary water barrier at a rate of 12 L/m² with Type I working solution after it has been compacted and set to required elevation. Additional treatment shall be applied as follows:

1. In critical areas, such as utility openings for pipes, conduits and ducts, apply additional treatment at the rate of 6 L/l.m. in a strip 150 mm to 200 mm wide.

2. Along the exterior perimeter of the slab and under expansion joint, at the rate of 2.5 L/l.m. in a strip 150 mm to 200 mm wide in a shallow trench.

Apply an overall treatment under entire building slab, and moving strips adjacent to the building. Treat sidewalks or other such paved areas abutting the building for a distance not less than 1 m from the building. Apply along each side of foundation walls and at penetrations through slabs such as pipes, ducts, etc. apply at application rate of 5 L per linear meter around the perimeter of the building.

Post signs in areas of application to warn workers that soil termicide treatment has been applied. Remove signs when areas are covered by other construction.

1000.3.4 Wood Protection

Where the application of wood preservative is necessary, the Contractor shall use Type II working solution as recommended by the manufacturer.

All wood materials not pressure treated as specified in Item 1003, Carpentry and Joinery shall be treated with Type II ready mixed solution as herein called for or as directed by the Engineer.

Wood treatment shall be applied after framing, sheathing, and exterior weather protection is completed but before the electrical and mechanical systems are installed.

1000.3.5 Powder Termicide

When powder termicide is to be applied to eradicate subterranean termites, extreme caution and care shall be done at the time of application. It shall not be allowed to enter drains, waterways, streams or rivers. It shall not be used if rain is expected to occur within 48 h of application. All heating and air conditioning ducts, air vents, floor drains, and edible plants shall be covered prior to application of powder termicide.

1000.3.6 Delivery, Storage and Handling

Deliver termicides to the project site in sealed and labeled containers in good condition as supplied by the manufacturer. Store, handle and use termicides in accordance with manufacturer's labels. Labels shall bear evidence of registration and Material Safety Data Sheet (MSDS) shall also be provided.

1000.3.7 Safety Requirements

Formulate, treat and dispose of termicides and their containers in accordance with label directions. Draw water for formulating only from sites designated by the Engineer and fit the filing hose with backflow preventer meeting local plumbing codes or standards. The filling operation shall be under the direct and continuous observation of the Contractor to prevent overflow. Secure pesticides and related materials under lock and key when unattended. Ensure that proper protective clothing and equipment are worn and used during all phases of termiticide operation.

Disposal of used pesticide containers off the project site shall comply with the latest requirements of DENR Administrative Order for Revised Procedures and Standards for Management of Hazardous Waste, Material Safety Data Sheet (MSDS) shall also be strictly followed.

1000.3.8 Warranty

Upon completion and acceptance of the work, the Contractor shall furnish the Engineer a written guarantee stating that termite control is guaranteed for a minimum period of three (3) years and annual inspections or as requested by the Engineer shall be done by both the Contractor and Engineer to ensure the quality of their work.

1000.4 Method of Measurement

Liquid termite control chemicals or toxicants shall be measured by actual number of liters used in the cordoning and drenching of lot areas and soil poisoning of granular fill or actual number of liters used in drenching wood surfaces, while powder chemical/toxicant shall be measured by kilograms applied to suspected subterranean termite mounds and tunnels. The quantity to be paid for shall be determined and accepted by the Engineer.

1000.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 1000.4, Method of Measurement shall be paid for at the Contractor Unit Price for Termite Control Work which price and payment shall be full compensation for furnishing and applying termite control chemicals including the use of equipment and tools, labor and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1000 (1)	Soil Poisoning	Liter
1000 (2)	Wood Preservative	Liter
1000 (3)	Powder Termicide	Kilogram

XXVI. ITEM 1052 – PILING

1052.1 Description

1052.1.1 Scope

This Item shall consist of piling, furnishing, driving, placing, cutting and splicing in accordance with the Plans and this Specification.

1052.1.2 Test Piles

The Contractor shall drive the test pile at the location indicated on the Plans and it shall be considered as one of the regular piles. The Contractor shall furnish the test piles of the required dimensions and shall be driven up to refusal. Test piles shall be driven with the same hammer to be used for driving regular piles.

When the Engineer requests a load test for timber piles to determine a bearing value, the first load test pile shall be driven to the specified bearing value as determined by the applicable formula for Timber Pile Bearing Value by Formula. Subsequent piles to be load-tested shall be driven to the specified bearing value as determined by the applicable formula modified by the results of prior test loads and foundation data. The ground at each pile shall be excavated to the elevation of the bottom of the footing before the pile is driven or as directed by the Engineer.

1052.1.3 Load Tests

Load tests for piles shall be either Static or Pile Testing by Low-Strain Dynamic Method, High-Strain Dynamic Method and Cross-Hole Sonic Logging.

When load tests are specified, the number and location of piles to be tested will be designated by the Engineer or as indicated on the Plans. Load tests shall be done by methods specified in the Plans. The Contractor shall submit to the Engineer for the approval of the detailed Plans of the loading apparatus he intends to use. The apparatus shall allow the various increments of the load to be placed gradually without vibration to the piles to be tested. If the approved method requires the use of tension or anchor piles, the same shall be of the same type and diameter as the permanent piles and shall be driven in the location of permanent piles when feasible. Piles that are not part of the permanent structure shall be removed or cut-off at least 300 mm below the bottom of the footing or finished elevation of the ground upon completion of the test load. Permanent piles used as anchor piles which are raised during the test load shall be re-driven to the original grade and bearing as specified in the Plans.

1052.1.3.1 Static Pile Testing

Suitable approved apparatus for determining accurately the load on pile and the settlement of the pile under increment of load shall be supplied by the Contractor.

Test loading shall consist of the application of incremental static loads to a pile and measuring the resultant settlement. The loads shall be applied by a hydraulic jack acting against suitable anchorage, transmitting the load directly to the pile, or other methods designated on the Plans or approved by the Engineer.

The load shall be applied in increments of 5 t or 10 t as directed by the Engineer or as specified in the Plans. Gross settlement readings, loads and other data shall be recorded by the Engineer immediately before and after the applications of each load increment.

Each load increment shall be held for an interval of 2 ½ min. Each succeeding increment shall be as directed by the Engineer or as shown on the Plans and shall be applied immediately after the 2 ½ min interval readings have been made.

When a load-settlement curve obtained from these data shows that the pile has failed; i.e., the load can be held only by the constant pumping and the pile or shaft is being driven into the ground, pumping shall cease. Gross settlement readings, loads and other data shall be recorded immediately after pumping has ceased and again after an interval of 2 ½ min for a total period of 5 min. All loads shall then be removed and the member allowed to recover. Gross settlement readings shall be made immediately after all loads have been removed and at each interval of 2 ½ min for a total period of 5 min.

All load tests shall be carried to failure or to the capacity of the equipment, unless otherwise noted on the Plans.

After the completion of loading tests, the load used shall be removed and the piles including tension piles, shall be utilized in the structure if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilized similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for utilization in the structure, it shall be removed if so ordered by the Engineer or shall be cut-off below the ground line of footings, whichever is applicable.

When diesel or other types of hammers requiring calibration are to be used, the Contractor shall make load tests even though no load tests are called for in the BOQ, except that load

tests will not be required when the hammer is to be used only for driving piles to refusal, rock or a fixed tip elevation or the hammer is of a type and model that has been previously calibrated for similar type, size and length of pile, and foundation material. Calibration data shall have been obtained from sources acceptable to the Engineer.

1052.1.3.2 Dynamic Pile Testing

Pile testing shall be done by Bearing Capacity Test by means of High-Strain Pile Dynamic Test Method, and Pile Integrity Test by means of Cross-Hole Sonic Logging Test (CSL) Method or Low-Strain Pile Dynamic Test Method.

Bearing Capacity Test shall be conducted at locations of piles to be tested as specified in the Plans or designated by the Engineer to determine/check the actual bearing capacity of the completed bored piles against the required ultimate bearing capacity. For buildings, at least 5% of the total number of bored piles shall be tested. The total number of bored piles to be tested in a particular project shall be indicated on the Plans and included in the summary of quantities. Additional tests may be conducted upon recommendation of the Engineer where deemed necessary. The testing of bored pile foundation shall be undertaken on the first completed pile in a particular foundation. Construction of succeeding similar piles may be allowed only after acceptance of the test pile based on the results of bearing capacity test.

Pile Integrity Test shall be conducted on at least 50% of the total number of bored piles at the entire foundation area of the project to verify and check the actual length and the concrete homogeneity, and to locate/evaluate any irregularity in the completed bored piles.

1. Low-Strain Dynamic Method

Pile integrity testing by Low-Strain Dynamic Method shall conform to ASTM D5882, Standard Test Method for Low Strain Impact Integrity Testing of Deep Foundations. It is a so-called Low Strain Method, since it requires the impact of only a small hand-held hammer, and also referred to as a Non-Destructive Test Method.

2. High-Strain Dynamic Testing

Bearing Capacity Testing by High-Strain Dynamic Method using Pile Driving Analyzer (PDA) or equivalent method shall conform to ASTM D4945, Standard Test Method for High-Strain Dynamic Testing of Deep Foundations. High-Strain Dynamic Method shall be applied to confirm the design parameters and capacities assumed for the piles as well as to confirm the normal integrity of testing of the piles. It is considered supplemental to the low-strain and sonic- type integrity testing of the cast-in-place piles. It is a relatively non-destructive quick test and it is intended that the test shaft be left in a condition suitable for use in production. The shaft used for the test shall be instrumented and tested by the testing specialist, as approved by the Engineer, meeting requirements in accordance to ASTM D4945.

3. Cross-Hole Sonic Logging of Bored Holes

Cross-hole Sonic Logging Test (CSL) using Cross-Hole Sonic Analyzer is a downhole variation of the ultrasonic-pulse velocity test. The methodology and equipment shall conform to ASTM D6760, Standard Test Method for Integrity Testing of Concrete Deep Foundations by Ultrasonic Cross-Hole Testing. This test is recommended for bored piles with embedded length of more than 30 m.

By sending ultrasonic pulses through concrete from one probe to another (probes located in parallel tubes), the Cross-hole Sonic Logging (CSL) procedure inspects the drilled shaft structural integrity, and extent and location of defects. Defects indicated by late pulse arrival times and significantly lower amplitude/energy signal shall be immediately reported to the Engineer. For equidistant tubes, uniform concrete yields consistent arrival times with reasonable pulse wave speed and signal strengths. Non-uniformities such as contamination, soft concrete, honeycombing, voids, or intrusions of foreign objects exhibit delayed arrival time with reduced signal strength.

1052.1.4 Timber Pile Bearing Value by Formula

When load tests are called for in the Bill of Quantities and when diesel or other hammers to be calibrated are used, the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing value of piles shall be determined by load tests, as provided in Subsections 1052.1.2 and 1052.1.3. In the absence of load tests, the safe bearing value of each timber pile shall be determined by whichever of the following approximate formulas is applicable:

$$\text{For gravity hammer, } P = \frac{1000}{6} \times \frac{WH}{S+25.4}$$

For single-action steam or air hammers, and for diesel hammers having unrestricted rebound of ram,

$$P = \frac{1000}{6} \times \frac{WH}{S+2.54}$$

For double-action steam or air hammers, and diesel hammers having enclosed ram,

$$P = \frac{1000}{6} \times \frac{E}{S+2.54}$$

For diesel or steam hammers on very heavy piles,

$$P = \frac{1000}{6} \times \frac{E}{S+2.54(Wp/W)}$$

Where:

P	=	Safe load per pile in Newton or kg
W	=	Weight of the striking part of the hammer in Newton or kg
H	=	Height of fall of ram in meters
S	=	Average penetration per blow in mm for th e last 5 to 10 blows for gravity hammers and the last 10 to 20 blows for steam hammers
E	=	Hammer energy, N.m or kg.m
Wp	=	Weight of pile

The above formula shall be applicable only when:

1. The hammer has a free fall.
2. The head of the pile is free from broomed or crushed wood fiber or other serious impairment.
3. The penetration is reasonably quick and uniform.
4. There is no measurable bounce after the blow.
5. A follower is not used.

If there is a measurable bounce, twice the height of bounce shall be deducted from H to determine its value in the formula.

The bearing power as determined by the appropriate formula listed in this Subsection, will be considered effective only when it is less than the crushing strength of the pile. Other recognized formulas may be used if fully detailed in the Special Provisions.

When bearing power is determined by a formula, timber piles shall be driven until a computed safe bearing power of each is not less than 18 t.

1052.1.5 Concrete and Steel Pile Bearing Values

The bearing values for concrete and steel pile will be determined by the Engineer using the following formulas:

1. Modified Hiley's Formula or any formula from brochures of the equipment used, shall be used when the ratio of weight of ram or hammer to weight of pile is greater than one fourth (1/4).

$$Ru = \frac{2WH\,(W)}{(S+K)\,(W+Wp)}$$

$$Ra = \frac{Ru}{FS}$$

Where:

Ru	=	ultimate capacity of piles (KN)
Ra	=	capacity of pile (KN)–shall be greater than the required
W	=	weight of ram or hammer (KN)
H	=	height of fall of ram (mm)
Wp	=	weight of pile (KN)
S	=	average penetration for the last ten blows (mm)
K	=	10 mm (unless otherwise observed/computed during driving)
FS	=	factor of safety (min. = 3)

Hiley's Formula shall be used when the ratio of the weight of ram or hammer to weight of pile is less than one fourth (1/4).

$$Ru = \frac{efWH\,(W)}{S+1/2\,(C1+C2+C3)} \times \frac{(W \times n^2\, Wp)}{(W + Wp)}$$

$$Ra = \frac{Ru}{FS}$$

where:

Ru	=	ultimate capacity of pile (KN) Ra=
Ra	=	capacity of pile (KN)
ef	=	efficiency of hammer (refer to table)
W	=	weight of ram (KN)
Wp	=	weight of pile (KN)
H	=	height of fall of ram (mm)
S	=	average penetration for last ten blows (mm)
C1	=	temporary compression allowance for pile head and cap (refer to table)
C2	=	RuL/AEp
C3	=	range from 2.54mm to 5.08mm for resilient soil to 0 for hard pan (rock, very dense sand and gravel)
L	=	length of pile
A	=	cross-sectional area of pile
Ep	=	modulus of elasticity of pile
N	=	coefficient of restitution (refer to table)
FS	=	factor of safety (min. = 3)

Required minimum penetration of all piles shall be 6 m. However, for exposed piles, the embedded length shall be equal or greater than the exposed length but not less than 6 m.

Note:
Formula for other pile hammers with suggested factor of safety shall be as provided/recommended by the manufacturer.

Table 1052.1 Values of C1 for Hiley Formula Temporary Compression Allowance C1 for Pile Head and Cap

Materials towhich blow is applied	Easy Driving: P1 = 3.45 MPa on Pile Butt If no cushion, mm	Medium Driving: P1 = 6.90 MPa on Head or Cap. mm	Hard Driving: P1 = 10.34 MPa on Head or Cap. mm	Very Hard Driving:P1 = 13.88 MPa on Head or Cap. mm
Head of timber pile	1.27	2.54	3.81	5.08
76–100 mm packing inside cap on head of precast concrete piles	1.27 + 1.778b	2.54 + 3.81b	3.81 + 5.588b	5.08 + 7.62b
Concrete Pile	0.635	1.27	1.905	2.54
Steel-covered cap containing wood packing but steel piling at pipe.	1.016	2.032	3.048	4.064
4.76 mm red electrical tuber disk between 2 mm - 10 mm steel plates, for use with severe driving on Monotube pile	0.508	1.016	1.524	2.032
Head of steel piling of pipe	0	0	0	0

Note: bThe first figure represent the compression of the cap and wood dolly or packing above the cap, whereas the second figure represent the compression of the wood packing between the cap and the pile head.

P1 = Ru/A

Table 1052.2 Values of Efficiency of Hammer, ef

Hammer Type	ef
Drop Hammer released by trigger	1.00
Drop Hammer actuated by rope and friction winch	0.75
McKiernan-Terry Single-acting hammers	0.85
Warrington-Vulcan Single-acting hammers	0.75
Differential-acting hammers	0.75
McKiernan-Terry, Industrial B. Ownhoist, National and Union double-acting hammers	0.85
Diesel Hammers	1.00

Table 1052.3 Values of Coefficient of Restitution, n

Pile Type	Head Condition	Drop, Single Acting or Diesel Hammer	Double Acting Hammers
Reinforced Concrete	Helmet with composite plastic or green heart dolly on top of pile	0.40	0.50
	Helmet with Timber dolly, and packing on top of pile	0.25	0.40
	Hammer direct on pile with pad only	-	0.50
Steel	Driving cap with Standard plastic or greenheart dolly	0.50	0.50
	Driving cap with Timber dolly	0.30	0.30
Timber	Hammer direct on pile	-	0.50
	Hammer direct on pile	0.25	0.40

The formulas specified in the preceding Subsection for timber piling may be used in determining a rough approximation for the bearing power of precast and cast-in-place concrete piles and of steel piles.

In all cases when the bearing capacity of concrete and steel piles is determined by formula, the piles shall be driven until the safe bearing capacity of each is computed to be not less than 27 t.

1052.1.6 Safe Loads

When the safe bearing capacity of any pile is found by test or computation to be less than the design load, longer piles or additional piles shall be driven as ordered in writing by the Engineer or as specified in the Plans.

1052.1.7 Jetted Piles

The safe bearing capacity of jetted piles shall be determined by actual tests or by the appropriate methods and formulas given in the preceding Subsections. No jet shall be used during the test blows.

1052.1.8 Micropiles

These are cast-in-place piles with maximum diameter of 300 mm or as indicated on the Plans. They are constructed using high strength small diameter casing, grouted, and installed thread bars. The thread on the bars ensures grout to bond with steel as well as to allow the bar to be cut at any point and joined with a coupler to provide full tension/compression capacity. Typically the casing is advanced to the design depth using a drilling technique. Reinforcing steel in the form of an all-thread bar is typically inserted into the micropile casing, however, deformed bars maybe used when the length are commercially available. Further, deformed reinforcing steel bars are threaded to join using a coupling to obtain the designed length. The casing may extend to the full depth with the reinforcement above the bond zone with the

reinforcing bars extending to the full depth. The finished micropile shall resist compression, uplift or tension loads and lateral loads.

Micropiles shall be used as alternatives to conventional piles and as anchors in retaining systems and slopes. Particularly, micropiles are suitable for:

1. Supporting structural loads at sites with restricted access or low headroom.
2. Retrofitting/rehabilitating distressed structures.
3. Underpinning.
4. Excavation and retention systems with restricted access.
5. Seismic retrofit.
6. Expansive soils.

The Contractor shall supply, install and test micropiles including all necessary operation requirements as shown on the Plans or specified herein.

1052.2 Material Requirements

The kind and type of piles shall be as specified in the Plans and Bill of Quantities (BOQ). No alternative type or kind of piling shall be used.

1052.2.1 Untreated Timber Piles

Structural timber, lumber and piling shall conform to the applicable requirements of AASHTO M 168, Standard Specification for Wood Products or equivalent specification. No boxed heart pieces of Douglas fir or redwood shall be used in outside stringers, floor beams, caps, posts, sills or rail posts. Boxed heart pieces are defined as timber so sawed that any point in the length of a sawed piece, the pith lies entirely inside the four faces.

Yard lumber shall be of the kind and grade called for on the Plans. Round poles and posts shall be of the kind indicated on the Plans.

The species shall be specified on the Plans. Unless otherwise noted on the Plans or Special Provisions, only the best grade shall be used. It shall be free from loose knots, splits, wormholes, decay, warp, ring separation or any defect which will impair its strength or render it unfit for its intended use. Any species specified on the Plans may be used for untreated timber and if the species is not available, a species of equivalent strength and durability may be used if authorized by the Engineer.

Round piles shall be cut above the ground swell and shall taper from butt to tip. A line drawn from the center of the tip to the center of the butt shall not fall outside of the cross-section of the pile at any point more than 1% of the length of the pile.

In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4% of the length of the bend or a maximum of 65 mm.

Unless otherwise specified, all piles shall be peeled removing all rough bark and at least 80% of the inner bark. Not less than 80% of the surface on any circumference shall be clean wood. No strip of inner bark remaining on the pile shall be more than 20 mm wide and 200 mm long. All knots shall be trimmed close to the body of the pile.

The pile sizes shall conform to the dimensions shown in Table 1052.4.

Table 1052.4 Dimension of Piles

Length of Pile	Diameter (1 meter from the Butt)		Minimum Tip Diameter, mm
	Minimum, mm	Maximum, mm	
Less than 12 meters	300	450	200
12 to 18 meters	320	450	200
More than 18 meters	350	500	150

The diameter of the piles shall be measured in their peeled condition. When the pile is not exactly round, the average of three measurements may be used. For any structure, the butt diameters for the same lengths of pile shall be as uniform as possible.

Square piles shall have the dimensions shown on the Plans.

1052.2.2 Treated Timber Piles

Structural timber, lumber and piling to be treated shall conform to the applicable requirements of AASHTO M 168, Standard Specification for Wood Products and AASHTO M 133, Standard Specification for Preservatives and Pressure Treatment Processes for Timber or equivalent specification. The minimum penetration of the preservative into the surface of the timber shall be 20 mm. All piles shall retain the minimum amount of preservative specified in Table 1052.5.

Table 1052.5 Minimum Preservative per Cubic Meter of Wood

Use	Type of Processing	
	Empty Cell Process	Full Cell Process
General Use	195 kg	-
Marine Use	-	320 kg

The Engineer shall inspect the timber prior to the treatment to determine conformance with the Specifications and suitability of conditions for treatment. He shall be permitted free access to the plant in order that temperatures, pressures, quantities and type of treatment materials used may be observed. Samples of the creosote or creosote petroleum mixtures shall be furnished as required for test.

The timber shall be checked to determine penetration of treatment, quantity of free preservative remaining on the timber and any visual evidence that the treatment has been performed in a satisfactory manner. The penetration of treatment shall be determined by boring a sufficient number of well-distributed holes to determine the average penetration. All such holes shall be plugged with plugs approximately 2 mm larger in diameter than the bit used in boring the holes.

If the penetration of preservative is less than the required amount, the entire charge, or such parts thereof shall be retreated. If after treatment the penetration is still insufficient, the treated pieces shall be rejected.

1052.2.3 Concrete Piles

Concrete shall conform to the requirements of Item 900, Structural Concrete. Concrete shall be Class "C" unless otherwise specified on the Plans.

Concrete shall be proportioned to achieve a range of 150 mm to 200 mm slump, self-compacting mix.

The use of appropriate plasticizer/additives to assure mix fluidity and consistency shall be allowed upon approval by the Engineer. A retardant of proven adequacy and approved by the Engineer may be used to ensure that early hardening of concrete during operation will not occur.

Reinforcing steel shall conform to the requirements of Item 902, Reinforcing Steel. Prestressing reinforcing steel shall be high-tensile steel wire conforming to AASHTO M 204M, Standard Specification for Uncoated Stress-Relieved Steel Wire for Prestressed Concrete.

1052.2.4 Steel Shells

1. Shells Driven Without a Mandrel

Unless otherwise shown on the Plans or Special Provisions, shells for cast-in- place concrete piles shall have a minimum diameter of 305 mm at cut-off and a minimum diameter of 203 mm at tip: made from not less than 4.55 mm thick plate stock conforming to ASTM A36M, Standard Specification for Carbon Structural Steel. Shells shall either be spirally or longitudinally welded and shall either be tapered or constant in section. Tips shall be sealed as shown on the Plans.

2. Shells Driven With a Mandrel

The shell shall be of sufficient strength and thickness to withstand driving without injury and to resist harmful distortion and/or buckling due to soil pressure after driven and the mandrel removed. Butt and tip dimension shall be as shown on the Plans or Special Provisions.

1052.2.5 Steel Pipes Piles / Steel Pipe Sheet Piles

Filled Steel Pipes (filled with concrete) shall conform to the requirements of ASTM A252, Standard Specification for Welded and Seamless Steel Pipe Piles. Closure Plates for closed piles shall conform to the requirements of ASTM A36M.

Unfilled Tubular Steel Piles shall conform to the requirements of ASTM A252, with chemical requirements meeting ASTM A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless, Grade B. The wall thickness shall not be less than 4.76 mm.

Reinforcing Bar Stud for connection between top slab concrete and steel pipe piles and steel pipe sheet piles shall conform to Item 902, Reinforcing Steel.

The materials for concrete and grout shall conform to Item 900, Structural Concrete. The Concrete shall be Class P as specified in Subsection 900.1.2, Classes and Uses of Concrete of Item 900, Structural Concrete unless otherwise shown on the Plans or specified in the Special Provisions. The grout shall consist of Portland cement, water and an expansive admixture approved by the Engineer.

1052.2.6 Steel H-Piles

Steel H-Piles shall be rolled steel sections of the weight and shape shown on the Plans. They shall be structural steel meeting the requirements of ASTM A36M provided that, where the Special Provisions called for copper-bearing structural steel, the steel shall not contain less than 0.2% nor more than 0.35% of copper, except that steel manufactured by the acid bessemer process shall not be used.

1052.2.7 Steel Sheet Piles

Steel sheet piles shall meet the requirements of AASHTO M 202 (ASTM A328), Standard Specification for Steel Sheet Piling or ASTM A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel. The joints shall be practically water-tight when the piles are in place.

1052.2.8 Polyvinyl Chloride (PVC) Sheet Piles

PVC sheet piles shall meet the requirements of ASTM D638, Standard Test Method for Tensile Properties of Plastics, ASTM D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials, ASTM D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics, and ASTM D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position. The joints shall be practically water-tight when the piles are in place.

1052.2.9 Pile Shoes

Pile shoes shall be as called for on the Plans. Steel pile shoes shall be fabricated from cast steel conforming to ASTM A148, Standard Specification for Steel Castings, High Strength, for Structural Purpose.

When shoes are required by soil conditions, piles shall conform to the approved steel shoes to ensure a firm uniform contact and prevent local stress concentrations.

1052.2.10 Splices

Full length piles shall be used when practicable; but if splices cannot be avoided, piles or shells for cast-in-place piles may be spliced in accordance with the requirements of the Plans. Piles shall not be spliced except with the approval of the Engineer.

1052.2.11 Paint

Paint shall conform to Item 1032, Painting, Varnishing and Other Related Works.

1052.2.12 Mortar for Steel Pipe Piles/Steel Pipe Sheet Piles

Mortar shall consist of sand, cement, and water conforming to the requirements given under Item 1710, Riprap and Grouted Riprap, mixed in the proportion of one-part cement to three-parts sand by volume, and sufficient water to obtain the required consistency.

1052.2.13 Slurry

The mineral slurry shall be premixed thoroughly with clean fresh water and adequate time allotted for hydration prior to introduction into the shaft excavation. Adequate slurry tanks shall be required when specified. No excavated slurry pits shall be allowed when slurry tanks are required on the project without written permission of the Engineer. Adequate desanding equipment shall be required when specified. Steps shall be taken as necessary to prevent the slurry from "setting up" in the shaft excavation, such as agitation, circulation, and adjusting the properties of the slurry.

Control tests using suitable apparatus shall be carried out by the Contractor on the mineral slurry to determine density, viscosity, and pH. An acceptable range of values for those physical properties is shown in Table 1052.6.

Table 1052.6 Range of Values (At 20°C)

Property Units	Time of Slurry Introduction	Time of Concreting (In Hole)	Test Method
Density (KN/m3)	10.10 to 10.86	10.10 to 11.79	Density Balance
Viscosity (s/L)	28 to 45	28 to 45	Marsh Cone
pH	8 to 11	8 to 11	pH Paper or Meter

Note:
a. Increase density values by 0.314 KN/m3 in salt water.
b. If desanding is required; sand content shall not exceed 4% (by volume) at any point in the shaft excavation as determined by the American Petroleum Institute sand content test.

Tests to determine density, viscosity and pH values shall be done during the shaft excavation to establish a consistent working pattern.

1052.3 Construction Requirements

1052.3.1 Location and Site Preparation

Piles shall be driven where indicated on the Plans or as directed by the Engineer.

All excavations for the foundation through which the piles are to be driven shall be completed before the pile driving, unless otherwise specified or approved by the Engineer. After driving is completed, all loose and displaced materials shall be removed from around the piles by

manual excavation, leaving clean solid surface to receive the concrete of the foundation. Any requirement for granular fill and lean concrete shall be indicated on the Plans or as directed by the Engineer.

1052.3.2 Determination of Pile Length

Pile length and bearing capacity shall be determined by the Engineer from the results of the test piling and load tests.

The criterion for pile length may be one of the following:

1. Piles in sand and gravel shall be driven to a bearing capacity determined by the use of the pile driving formula or as decided by the Engineer.

2. Piles in clay shall be driven to the depth ordered by the Engineer. However, the bearing capacity shall be controlled by the pile driving formula if called for by the Engineer.

3. Piles shall be driven to the allowable bearing capacity or refusal on rock/hard layer when so ordered by the Engineer.

The bottom of piles shall be embedded at least three times the diameter (3D) into hard strata with an N-Value of at least 40 capable of developing the required ultimate bearing capacity, if the above condition cannot be met during construction, the designer shall be notified for adjustment of pile length if necessary.

The Contractor shall be responsible for obtaining the correct pile length and bearing capacity according to the agreed criteria indicated in this Specification.

1052.3.3 Pile Driving

All piles shall be driven as shown on the Plans. Piles shall be driven within an allowed variation of 20 mm per meter of pile length from the vertical or batter as shown on the Plans. The maximum allowable variation at the butt end of the pile shall be 75 mm in any direction from the location shown on the Plans. Each pile, after driving, shall be within 150 mm from the theoretical location underneath the pile cap or underneath the superstructure in case of pile bents. All piles pushed up by the driving of adjacent piles or any other cause shall be re-driven.

Piles shall be used only in places where the minimum penetration of 3 m in firm materials, or 5 m in soft materials can be obtained. Whereas soft upper stratum overlies a hard stratum, the piles shall penetrate the hard materials at sufficient depths to fix the ends rigidly.

All pile driving equipment shall be subject to the Engineer’s approval. The Contractor shall be responsible for sufficient weight and efficiency of the hammers to drive the piles down to the required depth and bearing capacity. Hammers shall be gravity hammers, single and double acting steam or pneumatic hammers or diesel hammers. Gravity hammers shall not weigh less than 60% of the combined weight of the pile and driving head but not less than 2,000 kg. The fall shall be regulated so as to avoid injury to the pile and shall in no case exceed 4.50 m for timber and steel piles, and 2.50 m for concrete piles unless otherwise specified or approved by the Engineer.

The plant and equipment furnished for steam hammers shall have sufficient capacity to maintain, under working condition, the pressure at the hammer specified by the manufacturer. The boiler or pressure tank shall be equipped with an accurate pressure gauge and another gauge shall be supplied at the hammer intake to determine the drop in pressure between the gauges. When diesel hammers or any other types requiring calibration are used, they shall be calibrated with test piling and/or test loads in accordance with Subsection 1052.1.2, Test Piles.

Water jets shall be used only when permitted in writing by the Engineer. When water jets are allowed, the number of jets and the nozzle volume and pressure shall be sufficient to clear the material adjacent to the pile. The ultimate pile capacity shall be determined from the results of driving after the jets have been withdrawn. The pump shall have sufficient capacity to deliver a pressure equivalent to at least 690 KPa for two 19 mm diameter jet nozzles. The jets shall be shut off before the required penetration is reached and the piles shall be driven solely by hammers to final penetration as required by the Engineer.

Piles shall be supported in line and position with leads while being driven. Pile driving leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and shall be held in position by workers or steel braces to ensure rigid lateral support to the pile during driving. The leads shall be of sufficient length to make the use of a follower unnecessary and shall be so designed as to permit proper placing of batter piles. The driving of the piles with followers shall be avoided if practicable and shall be done only under written permission from the Engineer.

The method used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of the concrete, injurious splitting, splintering and brooming of the wood or deformation of the steel. Manipulation of piles to force them into proper position if considered by the Engineer too excessive will not be permitted.

The pile tops shall be protected by driving heads, caps or cushions in accordance with the recommendation of the manufacturer of the pile hammer and to the satisfaction of the Engineer. The driving head shall be provided to maintain the axis of the pile with the axis of the hammer and provide a driving surface normal to the pile.

Full length piles shall be used where practicable. Splicing of piles when permitted, shall be in accordance with the provisions of Subsection 1052.3.7 and 1052.3.9. All piles shall be continuously driven unless otherwise allowed by the Engineer.

Piles shall not be driven unless required strength is reached or attained.

1052.3.4 Timber Piles

Piles shall be strapped with three (3) metal straps: one about 450 mm from the butt, one about 600 mm from the butt, and the third, about 300 mm from the tip. Additional straps shall be provided at about 4.5 m on centers between tip and butt. Strapping shall encircle the pile once and be tensioned as tightly as possible. Straps shall be 38 mm wide, 0.8 mm thick, cold rolled, fully heat treated, high tensile strapping, painted and waxed. Treated piles shall be strapped after treatment.

Point protection shall be considered for all timber piles. Where timber piles must penetrate dump fill, or may encounter obstructions or be driven to hard strata, point protection shall be used. A boot that encompasses and utilizes the entire end area of the pile is preferred.

1052.3.5 Timber Pile Bents

Piles for any one (1) bent shall be carefully selected as to size, to avoid undue bending or distortion of the sway bracing. Care shall be exercised in the distribution of piles of various sizes to obtain uniform strength and rigidity in the bents of any given structure. Cut offs shall be made accurately to ensure full being between caps and piles of bents.

1052.3.6 Precast/Prestressed Concrete Piles

Precast concrete piles shall be of the design shown on the Plans. The method of prestressing to be used shall be optional with the Contractor subject to all requirements hereinafter specified.

The Contractor, prior to casting any members to be prestressed, shall submit to the Engineer for approval complete details of the methods, materials and equipment he proposes to use in the prestressing operations. Such details shall outline the method and sequence of stressing, complete specifications and details of the prestressing, steel and anchoring devices proposed for use, anchoring stresses, type of enclosures and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, pressure grouting materials and equipment.

The piles shall be caste separately and concrete in each pile shall be placed continuously. The completed piles shall be free from stone pockets, honeycombs, or other defects, and shall be straight and true to the form specified. The forms shall be true to line and built of metal, plywood or dressed lumber. A 25 mm chamfer strip shall be used in all corners. Form shall be water-tight and shall not be removed until at least 24 h after the concrete is placed.

Piles shall be cured and finished in accordance with Subsection 900.3.13, Curing Concrete of Item 900, Structural Concrete.

Cylinder specimens shall be made and tested in accordance with Item 900, Structural Concrete. Piles shall not be moved until the tests indicate that the concrete has attained a compressive strength of at least 80% of the design 28- day compressive strength and they shall not be transported or driven until the design 28-day compressive strength has been attained.

If testing equipment is not available, as in isolated areas, piles shall not be moved until after 14 days after casting and shall not be transported or driven prior to 28 days after casting. If high early strength cement is used, piles shall not be moved, transported or driven prior to 7 days after casting.

When concrete piles are lifted or moved, they shall be supported at the points shown on the Plans; if not shown, they shall be supported at the quarter points.

1052.3.7 Cast-in-place Concrete Piles

1. Drilled Holes

All holes for concrete piles shall be drilled dry to tip elevation as shown on the Plans. Suitable casings shall be furnished and placed when required to prevent cave-in before concrete is placed.

All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed before placing concrete.

The use of water for drilling operations or for any other purpose where it may enter the hole will not be permitted. All necessary action shall be taken to prevent surface water from entering the hole and all water which may have infiltrated into the hole shall be removed before placing concrete.

Concrete shall be placed by means of suitable tubes. Prior to the initial concrete set, the top 3 m of the concrete filled pile or the depth of any reinforcing cage, whichever is greater, shall be consolidated by acceptable vibratory equipment.

Casing, if used in drilling operations, may be left in place or removed from the hole as concrete is placed. The bottom of the casing shall be maintained not more than 1.5 m nor less than 0.3 m below the top of the concrete during withdrawal and placing operations unless otherwise permitted by the Engineer. Separation of the concrete during withdrawal operations shall be avoided by vibrating the casing.

2. Steel Shells and Pipes

The inside of shells and pipes shall be cleaned and all loose materials removed before concrete is placed. The concrete shall be placed in one continuous operation from tip to cut-off elevation and shall be carried on in such a manner as to avoid segregation.

The top 3 m of concrete filled shells, or to the depth of any reinforcing cage, whichever is greater, shall be consolidated by acceptable vibratory equipment.

Pipes shall be of the diameter shown on the Plans. The pipe wall thickness shall not be less than that shown on the Plans but in no case less than 5 mm. The pipe, including end closures, shall be of sufficient strength to be driven by the specified methods without distortion.

Closure plates and connecting welds shall not project more than 12.5 mm beyond the perimeter of the pile tips.

No shell or pipe shall be filled with concrete until all adjacent shells, pipes, or piles within a radius of 1.5 m or 4 ½ times the average pile diameter, whichever is greater, have been driven to the required resistance.

After a shell or pipe has been filled with concrete, no shell, pipe or pile shall be driven within 6 m thereof until at least seven (7) days have elapsed.

3. Drilled Shafts

Drilled shafts shall be deep foundations formed by boring a cylindrical hole into soil and/or rock and filling the hole with concrete. Drilled shafts are also commonly referred to as caissons, bored piles or drilled piers.

Drilled shafts, like driven piles, transfer structural loads to bearing stratum well below the base of the structure by passing soils having insufficient strength to carry the design loads.

Drilled shafts shall be classified according to their primary mechanism for deriving load resistance either as floating shafts (i.e., shafts transferring load primarily by side resistance), or end-bearing shafts (i.e., shafts transferring load primarily by tip resistance). Occasionally, the bases of shafts shall be enlarged (i.e., belled or underreamed) to improve the load capacity of end bearing shafts on less than desirable soils, or to increase the uplift resistance of floating shafts.

Effects of ground and ground water conditions on shaft construction operations shall be considered and delineated, when necessary. Because shafts derive their capacity from side and tip resistance which are a function of the condition of the materials in direct contact with the shaft, it is important that the construction procedures be consistent with the material conditions assumed in the design. Softening, loosening or other changes in soil and rock conditions caused by the construction method could result in a reduction in shaft capacity and an increase in shaft displacement. Therefore, evaluation of the effects of shaft construction procedure on load capacity shall be considered an inherent aspect of the design.

Drilled shafts shall be normally sized in 15.24 cm diameter increments with a minimum diameter of 45.72 cm. The diameter of a shaft socketed into rock shall be a minimum of 15.24 cm larger than the socket diameter. If a shaft must be inspected by the entry of a person, the shaft diameter shall not be less than 76.20 cm.

Drilled shafts constructed in dry, non-caving soils can usually be excavated without lateral support of the hole. Other ground conditions where caving, squeezing or sloughing soils are present require installation of a steel casing or use of a slurry for support of the hole. Such conditions and techniques may result in loosening of soil around the shaft, or altering of frictional resistance between the concrete shafts and surrounding soil.

The center-to-center spacing between shafts is normally restricted to a minimum of 3B to minimize the effects of interaction between adjacent shafts during construction or in service. However, larger spacing may be required where drilling operations are difficult or where construction must be completed in very short time frames.

Particular attention shall be given to the potential for deposition of loose or wet material in the bottom of the hole, or the buildup of a cake of soft material around the shaft perimeter prior to concrete placement. Adequate cleaning and inspection of rock sockets shall always be performed to assure good contact between the rock and shaft concrete. If good contact along the shaft cannot be confirmed, it may be necessary to assume that all load is transferred to the tip. If the deposition of soft or loose material in the bottom of the hole is expected, the shaft may have to be designed to carry the entire design load through side resistance.

A number of methods can be used to prevent cave-in during the drilling of holes and the placement of concrete. It is preferred that drilled shafts be constructed in stable non-sloughing soil without excessive ground water. If impossible, consider the following three different construction methods:

a. The construction of the pile or shaft in a wet condition while the walls of the excavation are stabilized by hydrostatic pressure of water or a mineral slurry until the concrete is placed

by tremie methods for the full length of the pile. This method consist of using water or mineral slurry to maintain stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage and concreting the shaft.

Mineral slurry used in the drilling process shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. The level of the slurry shall be maintained at a height sufficient to prevent cave-in of the hole.
Prior to placing shaft concrete, slurry samples shall be taken from the bottom and at intervals not exceeding 3.05 m for the full height of slurry. Any heavily contaminated slurry that has accumulated at the bottom of the shaft shall be eliminated. The mineral slurry shall be within Specification requirements immediately before shaft concrete placement.

Excavation Inspection

The Contractor shall provide equipment for checking the dimensions and alignment of each shaft excavation. The Contractor under the direction of the Engineer shall determine the dimensions and alignment of the drilled shaft. Final shaft depth shall be measured prior to concrete pouring.

The base of the shaft excavation may be cleaned using a cleaning bucket followed by airlifting clean-up method. Reverse circulation techniques may also be used to clean the base of the shaft.

The shaft excavation shall be cleaned so that a minimum of 50% of the base will have less than 12.5 mm of sediment and at no place on the base more than 37.5 mm of sediment. The Engineer will determine shaft cleanliness.

b. The use of steel casing which is installed during drilling operations to hold the hole open and usually withdrawn during concrete placement.

Casing, if used in operation, shall be metal, smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified size of the shaft. It shall conform to ASTM A709, Standard Specification for Structural Steel for Bridges, Grade 36 unless otherwise specified.

Temporary casings shall be removed while the concrete remains workable. Generally the removal of temporary casing shall not be started until concrete placement in the shaft is at or above ground surface. Movement of casing by rotating, exerting downward pressure and tapping to facilitate extraction or extraction with a vibratory hammer shall be permitted. Casing

extraction shall be at a slow, uniform rate with the pull in line with the shaft axis.

A sufficient head of concrete shall be maintained above the bottom of the casing to overcome the hydrostatic pressure of water or drilling fluid outside of the casing.

c. The use of a permanent casing which is left in place within the portion of the pile which is in unstable material.

A permanent casing is applied as protection from the presence of surface water during drilling and as support later for the installation of the rebar cage and as a concrete form in drilling under water.

Standard weight pipe shall be furnished unless otherwise shown on the Plans.

Reinforcing Steel Cage Construction and Placement

The reinforcing steel cage consisting of the steel shown on the Plans plus cage stiffener bars, spacers, centralizers and any other necessary appurtenances shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted prior to shaft concrete placement.

Where the reinforcing cage length is too long for placement as a single unit, the cage may be placed in separate units such that appropriate means of splicing the longitudinal steel is provided for. The Contractor shall submit his Plans for such splices to the Engineer for approval.

The reinforcing steel in the hole shall be tied and supported so that the reinforcing steel will remain within allowable tolerances until the concrete will support the reinforcing steel. When concrete is placed by suitable tubes, temporary hold-down devices shall be used to prevent uplifting of the steel cage during concrete placement. Concrete spacers or other approved noncorrosive spacing devices shall be used at sufficient intervals not exceeding 1.50 m along the shaft to insure concentric location of the cage within the shaft excavation. When the size of the longitudinal reinforcing steel exceeds 25 mm, such spacing shall not exceed 3 m.

Concrete Placement, Curing and Protection

Concrete shall be placed as soon as possible after reinforcing steel cage placement. Concrete placement shall be continuous in the shaft to the top elevation of the shaft. Placement shall continue after the shaft is full until good quality concrete is evident at the top of the shaft. Concrete shall be placed through a suitable tube.
For piles less than 2.5 m in diameter, the elapsed time from the beginning of concrete placement in the shaft to the completion of placement shall not exceed 2 h. For piles 2.50 m and greater in diameter, the concrete placing rate shall not be less than 9 m of pile height per each 2-hour period. The concrete mix shall be of such design that the concrete remains in a workable plastic state throughout the 2-hour placement limit.

When the top of pile elevation is above ground, the portion of the pile above ground shall be formed with a removable form or permanent casing when specified.

The upper 1.5 m of concrete shall be vibrated or rodded to a depth of 1.5 m below the ground surface except where soft uncased soil or slurry remaining in the excavation will possibly mix with the concrete.

After placement, the temporarily exposed surfaces of the shaft concrete shall be cured in accordance with the provision in Subsection 900.3.13, Curing Concrete Item 900, Structural Concrete.

For at least 48 h after pile concrete has been placed, no construction operations that would cause soil movement adjacent to the shaft, other than mild vibration, shall be conducted.

Construction Tolerances:

The following tolerances shall be maintained in constructing drilled shaft:

1. The drilled shaft shall be within 15.24 cm of the plan position in the horizontal plane at the plan elevation for the top of the shaft.

2. The vertical alignment of the shaft excavation shall not vary from the plan alignment by more than 20.83 mm/m of depth.

3. After all the shaft concrete is placed, the top of the reinforcing steel cage shall be no more than 15.24 cm above and no more than 7.62 cm below plan position.

4. When casing is used, its outside diameter shall not be less than the shaft diameter shown on the Plans. When casing is not used, the minimum diameter of the drilled shaft shall be the diameter shown on the Plans for diameters 60.96 cm or less, and not more than 2.54 cm less than the diameter shown on the Plans for diameters greater than 60.96 cm.

5. The bearing area of bells shall be excavated to the plan bearing area as a minimum. All other plan dimensions shown for the bells may be varied, when approved, to accommodate the equipment used.

6. The top elevation of the shaft shall be within 2.54 cm of the plan top of shaft elevation.

7. The bottom of the shaft excavation shall be normal to the axis of the shaft within 62.5 mm/m of shaft diameter.

8. Drilled shaft excavations constructed in such a manner that the concrete shaft cannot be completed within the required tolerances are unacceptable.

1052.3.8 Steel Pipe Piles /Steel Pipe Sheet Piles

Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs) shall be driven to the elevation shown on the Plans/Drawings. Where, due to subsurface conditions, it is impractical to drive the piles to design depth, the piles may be stopped at a higher elevation with the written permission of the Engineer. Where, due to subsurface conditions, it is necessary to drive the piles to below the design depth, for normal and low headroom working or other site conditions, the piles may be spliced in accordance with Subsection 1052.3.12(3), Splicing. Where obstacles to driving exist and the Engineer decides that the obstacles may be removed, the Contractor shall extract the piles, remove the obstacles in an approved manner and re-drive the piles.

1052.3.9 Steel H-Pile

Steel H-Pile shall consist of structural steel shapes of the sections indicated on the Plans.

When placed in the leads, the pile shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise damaged shall be rejected.

The loading, transporting, unloading, storing and handling of steel H-pile shall be conducted so that the metal will be kept clean and free from damage.

1052.3.10 Unfilled Tubular Steel Piles

The minimum wall thickness shall be as indicated in the following table:

Table 1052.7 Minimum Wall Thickness of Unfilled Tubular Steel Piles

Outside Diameter	Less than 355 mm	355 mm and over
Minimum wall thickness	6.5 mm	9.5 mm

Cutting shoes for piles driven open end may be inside or outside of the pipe. They may be high carbon structural steel with a machined ledged for pile bearing or cast steel with a ledge, designed for attachment with a simple weld.

1052.3.11 PVC Sheet Piles

All PVC sheet piles shall be driven as shown on the Plans. If it is determined that the soil conditions warrant a mandrel, then holes shall be drilled in the appropriate locations to bolt the sheets to the top of the mandrel. Drive the initial sheet piles with the male lock leading, since the female lock fill up with soil and hinder driving if used as the leading edge. Make certain that the initial sheets are properly positioned, square and plumb, as it will influence the orientation of subsequent sheets. Also ensure that the sheets are placed up against the pile guide as they are positioned for driving. The sheets shall be driven as close to plumb as possible. Deviation in plumbness in any direction shall not be more than three (3) degrees.

1052.3.12 Splicing

Splicing when permitted shall be made as shown on the Plans and in accordance with this Subsection.

1. Precast Concrete Piles

a. By using prefabricated joints mounted in the forms and cast together with the piles sections and joined together as specified by the manufacturer and approved by the Engineer. The joints shall be of the design and type as specified or shown on the Plans.

By cutting away the concrete at the end of the pile, leaving the reinforcing steel exposed for a length of 40 times bar diameters for corrugated or deformed bars and 60 times bar diameters for plain bars. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement of the same size as that used in the pile shall be spliced to the projecting steel in accordance with Item 902, Reinforcing Steel, and the necessary splice box shall be placed, care being taken to prevent leakage along the pile.

b. By any other method shown on the Plans or approved by the Engineer, curing and finishing of extensions shall be the same as in the original pile.

2. Prestressed Piles

Splicing of prestressed precast piles will generally not be permitted, but when permitted, it shall be made in accordance with (1) above, but only after driving has been completed. Reinforcement bars shall be included in the pile head for splicing to the extension bars. No additional driving shall be permitted. The Contractor, at his option, may submit alternative plans of splicing for consideration by the Engineer.

3. Steel Piles, Shells or Pipes

If the length of the steel pile, shell or pipe driven is insufficient to obtain the specified bearing capacity, an extension of the same cross-section shall be spliced to it. Unless otherwise shown on the Plans, splices shall be made by butt-welding the entire cross-sections to form an integral pile using the electric arc method. The sections connected shall be properly aligned so that the axis of the pile shall be straight. Bent and/or damaged piles shall be rejected.

1052.3.13 Cutting Off and Capping Piles

The top of foundation piles shall be embedded in the concrete footing as shown on the Plans.

Concrete piles shall, when approved by the Engineer, be cut off at such a level that at least 300 mm of undamaged pile can be embedded in the succeeding structure. If a pile is damaged below this level, the Contractor shall repair the pile to the satisfaction of the Engineer. The longitudinal reinforcement of the piles shall be embedded in the structure above to a length equal to at least 40 times the diameter of the main reinforcing corrugated bars and 60 times diameters for plain bars. The distance from the side of any pile to the nearest edge of the cap shall not be less than 200 mm.

When the cut off elevation for a precast pile or for the steel shell or pile for a cast in place concrete pile is below the elevation of the bottom of the pile cap, the pile may be built-up from the butt of the pile to the elevation of the bottom of the cap by means of reinforced concrete extension constructed in accordance with Subsection 1052.3.12 or as approved by the Engineer.

Cut-offs of structural steel piles shall be made at right angles to the axis of the pile. The cuts shall be made in clear, straight lines and any irregularity due to cutting or burning shall be leveled-off with deposits of weld metal prior to placing bearing caps.

1052.3.14 Defective Piles

Any pile delivered with defects, or damaged in driving due to internal defects or by improper driving, or driven out of its proper location, or driven below the elevation fixed by the Plans or by the Engineer, shall be corrected at the Contractor's expense by one of the following methods approved by the Engineer for the pile in question:

1. Any pile delivered with defects shall be replaced by a new pile.

2. Additional pile shall be driven/casted at the location adjacent to the defective pile as directed by the Engineer.

3. The pile shall be spliced or built-up or as otherwise provided herein on the underside of the footing lowered to the properly embedded pile. Manipulation of piles to force them into proper position, considered by the Engineer to be excessive, shall not be permitted.

A precast concrete pile shall be considered defective if it has a visible crack, extending around the four (4) sides of the pile, or any defect which, in the opinion of the Engineer, affects the strength or life of the pile.

When a new pile is driven or cast to replace a rejected one, the Contractor at his own expense, shall enlarge the footing as deemed necessary by the Engineer.

1052.3.15 Protecting Untreated Timber Trestle Piles

The sawed surface of the heads of untreated piles shall be thoroughly brush- coated with two (2) applications of hot creosote oil or other approved preservative.

1052.3.16 Protecting Treated Timber Trestle Piles

All cuts and abrasions in treated timber piles shall be protected by a preservative approved by the Engineer.

1052.3.17 Painting Steel Piles

Unless otherwise provided, when required steel piles extend above the ground surface or water surface, they shall be protected by paint as specified for cleaning and painting metal surfaces in accordance with Item 1047, Metal Structures. This protection shall extend from the elevation shown on the Plans to the top of the exposed steel.

1052.3.18 Pile Records

The Contractor shall keep records of all piles driven or installed. A copy of the record shall be given to the Engineer within 2 days after each pile is driven. The record form to be used shall be approved by the Engineer. The pile records shall not be limited to the following:

Driven Piles	Cast-In-Place Piles
1. Pile type and dimension 2. Date of casting and concrete quality (for concrete piles) 3. Date of driving 4. Driving equipment: type, weight & efficiency of hammer, etc. 5. Description of cushion on pile head 6. Depth driven and tip elevation 7. Final set for the last 20 blows (for every (ten) 10 piles and when the Engineer so requires the penetration along the whole depth driven shall be recorded)	1. Date of boring or driving (For steel shell) & casting 2. Date of test 3. Pile identification number, elevation and location 4. Pile type and nominal dimension 5. Length of finished pile and tip elevation 6. Details of penetration during boring or driving of steel shell (driving records as for drivenpiles) 7. Test load achieved 8. Concrete quality and consistency 9. Time interval between boring ordriving

8. For gravity and single-acting hammers: the height of drop 9. For double acting-hammers - the frequency of blows 10. Details of any interruption in driving 11. Level of pile top immediately after driving and the level when all piles in the group are driven 12. Details of re-driving	and concreting 10. Volume of concrete placed inconcrete 11. Installation logs with supportingdata 12. Instrumentation types and locations 13. Load cell calibrations and instrument calibrations 14. Load vs Displacement graph, plotting load transfer along the length of the pile using instrumentation data 15. The skin friction/adhesion pressure and end bearing shaft bearing pressure at 12 mm displacement of the pile during testing

1052.3.19 Micropiles

1052.3.19.1 Drilling Operations

1. Boring near recently Cast Piles

The maximum allowable deviation of center point location for Micropile shall be 40 mm and a verticality of 1:50. Piles shall not be bored next to other piles which have recently been cast within 24 h and contain unset grout.

2. Stability of Drill Holes

The Contractor shall be responsible in providing materials, labour and plant, to maintain the stability of the sides of boreholes during Micropile installation and successful completion of the piles. The Contractor shall submit his proposed methods for boring operations.

Considering the existing ground water, the sides of all borehole shall be kept intact and no loose material shall be permitted to fall into the bottom of the boreholes. The Contractor's boring equipment shall be capable in sinking a steel casing to support the sides of all boring.

If the sides of boreholes are unstable, temporary steel casing shall be driven until the stable stratum is reached. The borehole shall be filled with drilling fluid to a level sufficiently to stabilize the boreholes.

Depth of anchorage shall be as shown on the Plans.

Drill holes shall not be exposed longer than is necessary and shall be covered at all times when work is not in progress. Pile shall be casted within 24 h unless otherwise approved by the Engineer.

In case of a rapid loss of drilling fluid from the borehole excavation causing instability of borehole, the Contractor shall install temporary casing prior to resumption of boring at that location at the expense of the Contractor.

3. Stability of Borehole by Temporary Casing Method

Where the use of temporary casing is required to maintain the stability of a borehole, the bottom of casing shall be kept at a minimum of 1 m below the unstable strata to prevent the caving-in of soil and the formation of cavities in the surrounding ground.

Temporary casings shall be thin-walled mild steel. The dimensions and quality of the casing shall be adequate to withstand pressures to which they will be subjected. The casings shall have an internal diameter not less than the specified pile diameter. The joints of casings shall be watertight.

1052.3.19.2 Grouting Operations

The Contractor shall provide details of the method and equipment to be used in grout mixing. Further information such as grouting pressure, grouting procedure, grouting equipment and technique employed in grouting underwater shall also be furnished for approval.

Grout shall be mixed on site and shall be free from segregation, clumping and bleeding. Grout shall be pumped into its final position in one continuous operation as soon as possible and in no case more than half an hour after mixing.

Micropile shall be grouted in one continuous process. If there is significant loss of grout, the Contractor may choose to carry out pre-grouting in stages as necessary to prevent further loss of grout for the construction of micropile. Method statement for pre-grouting including details of equipment, materials and procedures shall be reviewed and approved by the Engineer. If after the process of pre-grouting and re-drilling of the hole is required, the Contractor shall bear the cost and time of the pre-grouting and re-drilling.

1052.3.19.3 Construction of Pile Heads

When lengthening is required, the pile reinforcement unit shall be connected on site to the details shown on the Plans. Other means of jointing reinforcement shall be to the approval of the Engineer. Pile heads shall be constructed to the details as shown on the Plans.

1052.3.19.4 Standard Load Tests

Load test of two (2) times the working loads shall be carried out on piles designated by the Engineers and in accordance with ASTM D 1143, Standard Test Methods for Deep Foundations Under Static Axial Compressive Load. The Contractor shall submit detailed proposal of the load tests to the Engineer for approval prior to commencement on site. Upon completion of the test, the Contractor shall submit to the Engineer complete results including graphs showing load and settlement versus time, and settlement versus load.

The format of the test report shall be approved by the Engineer which shall contain the following:

1. Pile designation, date completed, weather condition, pile length, pile size, volume of grout intake, time of drilling at intervals not greater than 4 m and time to grout the pile
2. Designation of the apparatus used for testing, loading system and procedure for measuring settlement
3. Field data
4. Time vs Settlement Curve
5. Load vs Settlement Curve

6. Remarks containing unusual event or data and movement of piles
7. Calibration certificates of dial gauges and pressure gauges
8. The format of record shall be approved by the Engineer

1052.3.19.5 Damaged or Displaced Piles

Should the deviation exceed the tolerance provided in the specification, the Contractor shall submit his remedial proposal subject to approval of the Engineer. The faulty pile shall be replaced by additional piles as necessary in position as determined by the Engineer at the expense of the Contractor.

Where piles have not been positioned within the specified limits, no method of forcible correction shall be permitted.

1052.3.19.6 Piling Records

Complete piling records shall be kept by the Contractor during piling works. The Contractor shall submit the following in duplicate copy to the Engineer.

1. Records of all piles as the work proceeds.
2. Upon completion, a record of the work as carried out and as-built drawing.

The format of the record shall be approved by the Engineer and shall contain the following where applicable:

1. Reference number and position of pile
2. Type and dimension
3. Date of boring and nature of strata where each pile is bored
4. Details of the equipment used
5.Ground level and base of excavation level
6. Total penetration
7. Length and position of cavity/cavities in each pile
8. Penetration in rock
9. Time of drilling at intervals not exceeding 5 m
10. Details of all splicing or jointing operations, locations of sleeves, etc.
11. Details of grouting operation for tremie grouting and time tables
12. Weather
13. Top level of pile immediately after completion
14. Errors in position and inclination
15. Amount of grout and the pressure used
16. Size and position of boulder/s in each pile
17. Detailed drilling speed (m/min)
18. Description of drilled material

1052.4 Method of Measurement

In determining lengths of piles for ordering and to be included for payment, the lengths given in the order list shall be based on the lengths which are assumed to remain in the completed structure. The Contractor shall, without added compensation, increase the lengths to provide for the fresh heading and for such additional length as maybe necessary to suit the Contractor’s method of operation.

1052.4.1 Steel, Precast Concrete Piles, Micropile, and Timber Piles

1. Piles Furnished

The quantity to be paid for shall be the sum of the lengths in meters of the piles of the several types and lengths ordered in writing by the Engineer, furnished in compliance with this Specifications and stockpiled in good condition at the project site by the Contractor and accepted by the Engineer. The length to be paid for shall include test and tension piles ordered by the Engineer, but not those furnished by the Contractor at his option. No allowance shall be made for piles, including test piles, furnished by the Contractor to replace piles previously accepted by the Engineer that are subsequently lost or damaged while in stockpile, or during handling or driving, and are ordered by the Engineer to be removed from the site of work.

In case extensions of piles are necessary, the extension length shall be included in the length of pile furnished, except for cut off lengths used for extensions and already measured for payment.

2. Piles Driven

The quantity to be paid for shall be the sum of the lengths in meters of the piles driven in the completed work measured from the pile tip elevation to the bottom of pile caps, footings or bottom of concrete superstructure in the case of pile bents. Measurement shall not include additional piles or test piles driven that may be necessary to suit the Contractor's method of construction and were driven at his option.

Unless otherwise provided for, preboring, jetting or other methods used for facilitating pile driving operations shall not be measured directly but will be considered subsidiary to Pay Items.

1052.4.2 Steel Pipes/Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs)

The quantity to be paid for shall be the sum of actual lengths in meters of the steel pipes/ Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs) left in- place in the completed and accepted work. Measurements shall be by linear meter of installed as Permanent Works as the approved working Plans/drawings and measurement from the design pile tip elevation or higher elevation allowed by the Engineer to the design top level after cut off complete in place and accepted work.

Measurement shall not include additional piles, rejected piles or test piles installed that may be necessary to suit the Contractor's method of construction and installed at his option. All necessary methods of installation and pre-boring, jetting or other methods used for facilitating pile driving operations shall not be measured directly but shall be considered subsidiary to Pay Items.

Steel Pipe Piles and Steel Pipe Sheet Piles (SPPs/SPSPs) to be installed as Temporary Works for the purpose of forming cofferdams or as temporary supports to bridges or staging etc. shall be measured as a Lump Sum and included in the Item B.24 General Scaffolding and Shoring (including Cofferdamming) in Part B. Other General Requirements and strictly in accordance with the requirements, Standard Specifications and Special Specifications included in Part 2- Works Requirements.

1052.4.3 Cast-In-Place Concrete Piles

The quantity to be paid for shall be the sum of actual lengths in meters of the piles cast and left in-place in the completed and accepted work. Measurements shall be from the pile tip to the bottom of cap or footing. Portions of piles cast deeper than the required length through over-drilling shall not be measured for payment.

1052.4.4 PVC Sheet Piles

The quantity to be paid for shall be the sum of actual lengths in meters of the PVC sheet piles furnished and driven in the completed and accepted work measured from the pile tip elevation to the bottom of pile caps. Measurement shall not include additional PVC sheet piles or test piles driven that may be necessary to suit the Contractor's method of construction and were driven at his option.

1052.4.5 Pile Shoes

The quantity to be paid for, including test pile shoes, shall be the number of pile shoes driven shown on the Plans or as ordered in writing by the Engineer, furnished by the Contractor in accordance with this Specification and accepted by the Engineer. Pile shoes furnished by the Contractor at his option or to replace those that are lost or damaged in stockpile or handling shall not be measured for payment.

1052.4.6 Load Tests

The quantity of the load tests to be paid for shall be the number of tests completed and accepted except that load tests made to calibrate different types of hammers, if not included in the Bill of Quantities, shall not be measured for payment.

Anchor and test piling which are not part of the completed structure, shall be included in the unit bid price for each "Load Test". Anchor and test piling or anchor and test shafts which are a part of the permanent structure will be paid for under the appropriate Item.

1052.4.7 Splices

The quantity to be paid for shall be the number of splices which may be required to drive the pile in excess of the estimated length shown on the Plans for cast-in-place steel pipes or shells or in excess of the order length furnished by the Engineer for all other types of piling. Splices made for the convenience of the Contractor or to fabricate piles cut offs shall not be paid for.

1052.4.8 Permanent Casing

The quantity of permanent casing to be paid for shall be the number of kilograms or meter installed in place and accepted.

1052.5 Basis of Payment

The accepted quantities, measured as prescribed in Section 1052.4, Method of Measurement shall be paid for at the contract unit price for each of the particular item listed below that is included in the Bill of Quantities, which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment tools and incidentals as well

as temporary works, staging areas or craneway necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1052 (1)	Untreated Timber Piles, furnished	Meter
1052 (2)	Treated Timber Piles, preservative, furnished	Meter
1052 (3)a	Steel H-Piles, furnished, 305mmx305mm, 79 kg/m	Meter
1052 (3)b	Steel H-Piles, furnished, 305mmx305mm, 94 kg/m	Meter
1052 (3)c	Steel H-Piles, furnished, 305mmx305mm, 110 kg/m	Meter
1052 (3)d	Steel H-Piles, furnished, 305mmx305mm, 125 kg/m	Meter
1052 (4) a1	Precast Concrete Piles, furnished (400x400 mm)	Meter
1052 (4) a2	Precast Concrete Piles, furnished (450x450 mm)	Meter
1052 (5) a1	Precast, Prestresssed Concrete Piles, furnished (400x400 mm)	Meter
1052 (5) a2	Precast, Prestresssed Concrete Piles, furnished (450x450 mm)	Meter
1052 (6)	Structural Steel Sheet Piles, furnished	Meter
1052 (7)	Precast Concrete Sheet Piles, furnished	Meter
1052 (8)	Untreated Timber Piles, driven	Meter
1052 (1)	Untreated Timber Piles, furnished	Meter
1052 (2)	Treated Timber Piles, preservative, furnished	Meter
1052 (3)a	Steel H-Piles, furnished, 305mmx305mm, 79 kg/m	Meter
1052 (3)b	Steel H-Piles, furnished, 305mmx305mm, 94 kg/m	Meter
1052 (3)c	Steel H-Piles, furnished, 305mmx305mm, 110 kg/m	Meter
1052 (3)d	Steel H-Piles, furnished, 305mmx305mm, 125 kg/m	Meter
1052 (4) a1	Precast Concrete Piles, furnished (400x400 mm)	Meter

1052 (4) a2	Precast Concrete Piles, furnished (450x450 mm)	Meter
1052 (5) a1	Precast, Prestresssed Concrete Piles, furnished (400x400 mm)	Meter
1052 (5) a2	Precast, Prestresssed Concrete Piles, furnished (450x450 mm)	Meter
1052 (6)	Structural Steel Sheet Piles, furnished	Meter
1052 (7)	Precast Concrete Sheet Piles, furnished	Meter
1052 (8)	Untreated Timber Piles, driven	Meter
1052 (1)	Untreated Timber Piles, furnished	Meter
1052 (2)	Treated Timber Piles, preservative, furnished	Meter
1052 (3)a	Steel H-Piles, furnished, 305mmx305mm, 79 kg/m	Meter
1052 (3)b	Steel H-Piles, furnished, 305mmx305mm, 94 kg/m	Meter
1052 (3)c	Steel H-Piles, furnished, 305mmx305mm, 110 kg/m	Meter
1052 (3)d	Steel H-Piles, furnished, 305mmx305mm, 125 kg/m	Meter
1052 (4) a1	Precast Concrete Piles, furnished (400x400 mm)	Meter
1052 (4) a2	Precast Concrete Piles, furnished (450x450 mm)	Meter
1052 (5) a1	Precast, Prestresssed Concrete Piles, furnished (400x400 mm)	Meter
1052 (5) a2	Precast, Prestresssed Concrete Piles, furnished (450x450 mm)	Meter
1052 (6)	Structural Steel Sheet Piles, furnished	Meter
1052 (7)	Precast Concrete Sheet Piles, furnished	Meter
1052 (8)	Untreated Timber Piles, driven	Meter
1052 (1)	Untreated Timber Piles, furnished	Meter
1052 (2)	Treated Timber Piles, preservative, furnished	Meter
1052 (9)	Treated Timber Piles, driven	Meter
1052 (10)	Steel H-Piles, driven	Meter
1052 (11)	Steel Pipes Piles	Meter

1052 (12)	Structural Steel Sheet Piles, driven	Meter
1052 (13)	Precast Concrete Sheet Piles, driven	Meter
1052 (14)	Precast Concrete Piles, driven	Meter
1052 (15)	Precast, Prestresssed Concrete Piles,driven	Meter
1052 (16)	Test Piles, furnished and driven	Meter
1052 (17)a	Concrete Piles cast in Drilled Holes (dia. 0.80 m)	Meter
1052 (17)b	Concrete Piles cast in Drilled Holes (dia. 0.90 m)	Meter
1052 (17)c	Concrete Piles cast in Drilled Holes (dia. 1.00 m)	Meter
1052 (17)d	Concrete Piles cast in Drilled Holes (dia. 1.10 m)	Meter
1052 (17)e	Concrete Piles cast in Drilled Holes (dia. 1.20 m)	Meter
1052 (17)f	Concrete Piles cast in Drilled Holes (dia. 1.30 m)	Meter
1052 (17)g	Concrete Piles cast in Drilled Holes (dia. 1.40 m)	Meter
1052 (17)h	Concrete Piles cast in Drilled Holes (dia. 1.50 m)	Meter
1052 (17)i	Concrete Piles cast in Drilled Holes (dia. 1.60 m)	Meter
1052 (17)j	Concrete Piles cast in Drilled Holes (dia. 1.70 m)	Meter
1052 (17)k	Concrete Piles cast in Drilled Holes (dia. 1.80 m)	Meter
1052 (17)l	Concrete Piles cast in Drilled Holes (dia. 1.90 m)	Meter
1052 (17)m	Concrete Piles cast in Drilled Holes (dia. 2.00 m)	Meter
1052 (17)n	Concrete Piles cast in Drilled Holes (dia. 2.10 m)	Meter
1052 (17)o	Concrete Piles cast in Drilled Holes (dia. 2.20 m)	Meter
1052 (17)p	Concrete Piles cast in Drilled Holes (dia. 2.30 m)	Meter
1052 (17)q	Concrete Piles cast in Drilled Holes (dia. 2.40 m)	Meter
1052 (17)r	Concrete Piles cast in Drilled Holes (dia. 2.50 m)	Meter

1052 (17)s	Concrete Piles cast in Drilled Holes (dia.2.60m)	Meter
1052 (17)t	Concrete Piles cast in Drilled Holes (dia. 2.70 m)	Meter
1052 (17)u	Concrete Piles cast in Drilled Holes (dia. 2.80 m)	Meter
1052 (17)v	Concrete Piles cast in Drilled Holes (dia. 2.90 m)	Meter
1052 (17)w	Concrete Piles cast in Drilled Holes (dia. 3.00 m)	Meter
1052 (17)x	Concrete Piles cast in Drilled Holes (dia. 3.50 m)	Meter
1052 (17)y1	Concrete Piles cast in Drilled Holes (3.0mx6.50m), Oval	Meter
1052 (17)y2	Concrete Piles cast in Drilled Holes (3.0mx7.00m), Oval	Meter
1052 (17)z	Concrete Piles cast in Drilled Holes, rectangular	Meter
1052 (17)aa	Concrete Piles cast in Drilled Holes (dia. 0.60 m)	Meter
1052 (18)a	Concrete Piles cast in Steel Shells (dia. 400 mm)	Meter
1052 (18)b	Concrete Piles cast in Steel Shells (dia. 500 mm)	Meter
1052 (19)a	Concrete Piles cast in Steel Shells (dia.400 mm)	Meter
1052 (19)b	Concrete Piles cast in Steel Shells (dia. 500 mm)	Meter
1052 (20)	Pile Shoes	Each
1052 (21)	Splices	Each
1052 (22)	Load Tests	Each
1052 (23)a1	Permanent Casing (dia. 0.80 m; 10 mm thick)	Meter
1052 (23)a2	Permanent Casing (dia. 0.80 m; 12 mm thick)	Meter
1052 (23)a3	Permanent Casing (dia. 0.80 m; 16 mm thick)	Meter
1052 (23)b1	Permanent Casing (dia. 0.90 m; 10 mm thick)	Meter
1052 (23)b2	Permanent Casing (dia. 0.90 m; 12 mm thick)	Meter
1052 (23)b3	Permanent Casing (dia. 0.90 m; 16 mm thick)	Meter

1052 (23)c1	Permanent Casing (dia. 1.00 m; 10 mm thick)	Meter
1052 (23)c2	Permanent Casing (dia. 1.00 m; 12 mm thick)	Meter
1052 (23)c3	Permanent Casing (dia. 1.00 m; 16 mm thick)	Meter
1052 (23)d1	Permanent Casing (dia. 1.10 m; 10 mm thick)	Meter
1052 (23)d2	Permanent Casing (dia. 1.10 m; 12 mm thick)	Meter
1052 (23)d3	Permanent Casing (dia. 1.10 m; 16 mm thick)	Meter
1052 (23)e1	Permanent Casing (dia. 1.20 m; 10 mm thick)	Meter
1052 (23)e2	Permanent Casing (dia. 1.20 m; 12 mm thick)	Meter
1052 (23)e3	Permanent Casing (dia. 1.20 m; 16 mm thick)	Meter
1052 (23)f1	Permanent Casing (dia. 1.30 m; 10 mm thick)	Meter
1052 (23)f2	Permanent Casing (dia. 1.30 m; 12 mm thick)	Meter
1052 (23)f3	Permanent Casing (dia. 1.30 m; 16 mm thick)	Meter
1052 (23)g1	Permanent Casing (dia. 1.40 m; 10 mm thick)	Meter
1052 (23)g2	Permanent Casing (dia. 1.40 m; 12 mm thick)	Meter
1052 (23)g3	Permanent Casing (dia. 1.40 m; 16 mm thick)	Meter
1052 (23)h1	Permanent Casing (dia. 1.50 m; 10 mm thick)	Meter
1052 (23)h2	Permanent Casing (dia. 1.50 m; 12 mm thick)	Meter
1052 (23)h3	Permanent Casing (dia. 1.50 m; 16 mm thick)	Meter
1052 (23)i1	Permanent Casing (dia. 1.60 m; 12 mm thick)	Meter
1052 (23)i2	Permanent Casing (dia. 1.60 m; 16 mm thick)	Meter
1052 (23)j1	Permanent Casing (dia. 1.70 m; 12 mm thick)	Meter
1052 (23)j2	Permanent Casing (dia. 1.70 m; 16 mm thick)	Meter

1052 (23)k1	Permanent Casing (dia. 1.80 m; 12 mm thick)	Meter
1052 (23)k2	Permanent Casing (dia. 1.80 m; 16 mm thick)	Meter
1052 (23)l1	Permanent Casing (dia. 1.90 m; 12 mm thick)	Meter
1052 (23)l2	Permanent Casing (dia. 1.90 m; 16 mm thick)	Meter
1052 (23)m1	Permanent Casing (dia. 2.00 m; 12 mm thick)	Meter
1052 (23)m2	Permanent Casing (dia. 2.00 m; 16 mm thick)	Meter
1052 (23)n1	Permanent Casing (dia. 2.10 m; 12 mm thick)	Meter
1052 (23)n2	Permanent Casing (dia. 2.10 m; 16 mm thick)	Meter
1052 (23)o1	Permanent Casing (dia. 2.20 m; 12 mm thick)	Meter
1052 (23)o2	Permanent Casing (dia. 2.20 m; 16 mm thick)	Meter
1052 (23)p1	Permanent Casing (dia. 2.30 m; 12 mm thick)	Meter
1052 (23)p2	Permanent Casing (dia. 2.30 m; 16 mm thick)	Meter
1052 (23)q1	Permanent Casing (dia. 2.40 m; 12 mm thick)	Meter
1052 (23)q2	Permanent Casing (dia. 2.40 m; 16 mm thick)	Meter
1052 (23)r1	Permanent Casing (dia. 2.50 m; 16 mm thick)	Meter
1052 (23)r2	Permanent Casing (dia. 2.50 m; 20 mm thick)	Meter
1052 (23)s1	Permanent Casing (dia. 2.60 m; 16 mm thick)	Meter
1052 (23)s2	Permanent Casing (dia. 2.60 m; 20 mm thick)	Meter
1052 (23)t1	Permanent Casing (dia. 2.70 m; 16 mm thick)	Meter
1052 (23)t2	Permanent Casing (dia. 2.70 m; 20 mm thick)	Meter
1052 (23)u1	Permanent Casing (dia. 2.80 m; 16 mm thick)	Meter
1052 (23)u2	Permanent Casing (dia. 2.80 m; 20 mm thick)	Meter

1052 (23)v1	Permanent Casing (dia. 2.90 m; 16 mm thick)	Meter
1052 (23)v2	Permanent Casing (dia. 2.90 m; 20 mm thick)	Meter
1052 (23)w1	Permanent Casing (dia. 3.00 m; 16 mm thick)	Meter
1052 (23)w2	Permanent Casing (dia. 3.00 m; 20 mm thick)	Meter
1052 (23)x1	Permanent Casing (dia. 3.50 m; 16 mm thick)	Meter
1052 (23)x2	Permanent Casing (dia. 3.50 m; 20 mm thick)	Meter
1052 (23)y	Permanent Casing (dia. 0.60 m; 6 mm thick)	Meter
1052 (24)	Permanent Casing	Kilogram
1052 (25)	Splicing of RC Piles with Epoxy	Each
1052 (26)a	Pile Integrity Testing (Crosshole-Sonic)	Each
1052 (26)b	Pile Integrity Testing (Low-Strain)	Each
1052 (27)	High-Strain Dynamic Testing (PDA)	Each
1052 (28)a	Micro Piles, 0.20	Meter
1052 (28)b	Micro Piles, 0.25	Meter
1052 (28)c	Micro Piles, 0.30	Meter
1052 (29)a	Permanent Casing (Micro Piles), 0.20	Kilogram
1052 (29)b	Permanent Casing (Micro Piles), 0.25	Kilogram
1052 (29)c	Permanent Casing (Micro Piles), 0.30	Kilogram
1052 (34)a	Temporary Steel Casing, Furnish/Driven	Meter
1052 (34)b	Temporary Steel Casing, Extraction	Meter
1052 (35)a1	Steel Pipe Piles , Furnished & Driven, Normal Headroom, Press-In Method (318.5mm dia. x 10.3mm thick)	Meter
1052 (35)a2	Steel Pipe Piles , Furnished & Driven, Normal Headroom, Press-In Method (800mm dia. x 8mm thick)	Meter
1052 (35)a3	Steel Pipe Piles , Furnished & Driven, Normal Headroom, Press-In Method (1200mm dia. x 16mm thick)	Meter
	Steel Pipe Piles , Furnished & Driven,	Meter

1052 (35)a4	Normal Headroom, Press-In Method (1200mm dia. x 19mm thick)	
1052 (35)b1	Steel Pipe Piles , Furnished & Driven, Low Headroom, Press-In Method (318.5mm dia. x 10.3mm thick)	Meter
1052 (35)b2	Steel Pipe Piles , Furnished & Driven, Low Headroom, Press-In Method (800mm dia. x 8mm thick)	Meter
1052 (35)b3	Steel Pipe Piles , Furnished & Driven, Low Headroom, Press-In Method (1200mm dia. x 16mm thick)	Meter
1052 (35)b4	Steel Pipe Piles , Furnished & Driven, Low Headroom, Press-In Method (1200mm dia. x 19mm thick)	Meter
1052 (36)a1	Steel Pipe Sheet Piles , Furnished & Driven, (800mm dia. x 8mm thick)	Meter
1052 (36)a2	Steel Pipe Sheet Piles , Furnished & Driven, (1200mm dia. x 19mm thick)	Meter
1052 (37)a	PVC Sheet Piles, Furnished	Meter
1052 (37)b	PVC Sheet Piles, Driven	Meter

XXVII. ITEM 1100 – CONDUITS, BOXES AND FITTINGS

1100.1 Description

This Item shall consist of furnishing and installation of the complete conduit work consisting of electrical conduits; conduit boxes; conduit fittings and other electrical materials in accordance with the Plans and this Specification.

1100.2 Material Requirements

All materials shall be of the approved type in accordance with the requirements of the Philippine Electrical Code (PEC), Part I and bearing the Philippine Standard (PS) mark for locally manufactured and Import Commodity Clearance (ICC) certification marks duly issued by Bureau of Philippine Standards (BPS) for imported materials.

1100.2.1 Rigid Metal Conduit (RMC)

A threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings.

RMC shall be made of steel with protective coatings, aluminum, red brass or stainless steel.

Markings in each length of RMC shall be clearly and durably identified in every 3,000 mm as required in the Subsection 1.10.1.21 (A) of Article 1.10, Requirements for Electrical Installations of PEC, Part I. Nonferrous conduit of corrosion-resistant material shall have suitable markings.

The standard length of RMC shall be 3,000 mm, including an attached coupling, and each end shall be threaded. Longer or shorter lengths with or without coupling and threaded or unthreaded shall be permitted.

RMC shall have a minimum size of metric designator 16 (trade size ½) and a maximum size of metric designator 155 (trade size 6).

1100.2.2 Intermediate Metal Conduit (IMC)

A steel threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings.

IMC shall be made of either steel with protective coatings or stainless steel.

Markings in each length of IMC shall be clearly and durably marked at least every 1,500 mm with the letters IMC. Each length shall be marked as required

in Subsection 1.10.1.21 of Article 1.10, Requirements for Electrical Installations of PEC, Part I.

The standard length of IMC shall be 3,000 mm, including an attached coupling, and each end shall be threaded. Longer or shorter lengths with or without coupling and threaded or unthreaded shall be permitted.

IMC shall have a minimum size of metric designator 16 (trade size ½) and a maximum size of metric designator 103 (trade size 4).

1100.2.3 Flexible Metal Conduit (FMC)

A raceway of circular cross section made of helically wound, formed, interlocked metal strip.

Sizes of FMC shall comply with the requirements of subsection 3.48.2.11, Size of Article 3.48, Flexible Metal Conduit: Type FMC of PEC, Part I.

1100.2.4 Electrical Metallic Tubing (EMT)

An unthreaded thin-wall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed utilizing appropriate fittings. EMT is generally made of steel (ferrous) with protective coatings or aluminum (nonferrous).

EMT shall be clearly and durably marked at least every 3,000 mm as required in the Subsection 1.10.1.21 (A) of Article 1.10, Requirements for Electrical Installations of PEC, Part I.

EMT shall have a minimum size of metric designator 16 (trade size ½) and a maximum size of metric designator 103 (trade size 4).

1100.2.5 Rigid Polyvinyl Chloride Conduit (PVC)

PVC Conduit shall be made of rigid (nonplasticized) polyvinyl chloride (PVC). PVC conduit and fittings shall be composed of suitable nonmetallic material that is resistant to moisture and

chemical atmospheres. For use above ground, it shall also be flame retardant, resistant to impact and crushing, resistant to distortion from heat under conditions likely to be encountered in service, and resistant to low temperature and sunlight effects.Where intended for direct burial, without encasement in concrete, the material shall also be capable of withstanding continued loading that is likely to be encountered after installation.

Markings in each length of PVC conduit shall be clearly and durably marked at least every 3,000 mm as required in the Subsection 1.10.1.21 (A) of Article 1.10, Requirements for Electrical Installations of PEC, Part I. The type of material shall also be included in the marking unless it is visually identifiable. For conduit recognized for use aboveground, these markings shall be permanent. For conduit limited to underground use only, these markings shall be sufficiently durable to remain legible until the material is installed. Conduit

shall be permitted to be surfaced marked to indicate special characteristics of the material.

The physical and mechanical properties of PVC conduit shall conform to the requirements of PNS 14:2005, Unplasticized Polyvinyl Chloride (uPVC) electrical conduit – Specification.

PVC shall have a minimum size of metric designator 16 (trade size ½) and a maximum size of metric designator 155 (trade size 6).

1100.2.6 Liquidtight Flexible Nonmetallic Conduit (LFNC)

A raceway of circular cross section of various types as follows:

1. A smooth seamless inner core and cover bonded together and having one or more reinforcement layers between the core and covers, designated as Type LFNC-A.

2. A smooth inner surface with integral reinforcement within the conduit wall, designated as Type LFNC-B.

3. A corrugated internal and external surface without integral reinforcement within the conduit wall, designated as LFNC-C.

LFNC-B as a prewired manufactured assembly shall be provided in continuous lengths capable of being shipped in a coil, reel, or carton without damage.

LFNC shall be marked at least in every 600 mm in accordance with Subsection
1.10.1.21 (A) of Article 1.10, Requirements for Electrical Installations of PEC, Part I. The marking shall include a type designation and the trade size. Conduit that is intended for outdoor use or direct burial shall be marked.

The type, size and quantity of conductors used in prewired manufactured assemblies shall be identified by means of a printed tag or label attached to each end of the manufactured assembly and either the carton, coil or reel. The enclosed conductors shall be marked in accordance with Subsection 3.10.3.17, Markings of Article 3.10, Conductors for General Wiring of PEC, Part I.

Sizes of LFNC shall comply with the requirements of subsection 3.56.2.11, Size of Article 3.56, Liquidtight Flexible Nonmetallic Conduit: Type LFNC of PEC, Part I.

1100.2.7 Weatherhead

Weatherhead is installed at the point of connection to service-drop connectors to protect the service raceways and service cables from exposure to weather or rain.

Weatherhead material shall be of the same material as conduit where it will be connected.

1100.2.8 Conduit Boxes, Fittings and Accessories

Conduit boxes, fittings and accessories shall comply with the applicable requirements of Article 3.14 – Outlet, Device, Pull and Junction Boxes; Conduit Bodies; Fittings; and Handhole Enclosures of PEC, Part I.

1100.3 Construction Requirements

All works throughout shall be executed satisfactorily by qualified electricians under the supervision of a duly Registered Electrical Engineer and shall be in accordance with the requirements of PEC, Part I.

1100.3.1 Rigid Metal Conduit (RMC) 1100.3.1.1 Uses Permitted

1. Atmospheric Conditions and Occupancies

a. Galvanized Steel and Stainless Steel RMC. Galvanized steel and stainless steel RMC shall be permitted under all atmospheric conditions and occupancies.

b. Red Brass RMC. Red brass RMC shall be permitted to be installed for direct embedment and swimming pool applications.

c. Aluminum RMC. Aluminum RMC shall be permitted to be installed where approved for the environment. Rigid aluminum conduit encased in concrete or in direct contact with the earth shall be provided with approved supplementary corrosion protection.

d. Ferrous Raceways and Fittings. Ferrous raceways and fittings protected from corrosion solely by enamel shall be permitted only indoors and in occupancies not subject to severe corrosive influences.

2. Corrosive Environments

a. Galvanized Steel, Stainless Steel and Red Brass RMC, Elbows, Couplings and Fittings. Galvanized steel, stainless steel and red brass RMC, elbows, couplings and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection approved for the condition.

b. Supplementary Protection of Aluminum RMC. Aluminum RMC shall be provided with approved supplementary corrosion protection where encased in concrete or in direct contact with the earth.

3. Cinder Fill

Galvanized steel, stainless steel and red brass RMC shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 50 mm thick; where the conduit is not less than 450 mm under the fill; or where protected by corrosion protection and judged suitable for the condition.

4. Wet Locations

All supports, bolts, straps, screws, and so forth, shall be of corrosion-resistant materials or protected by corrosion-resistant materials exposed to moisture.

1100.3.1.2 Dissimilar Metals

Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Aluminum fittings and enclosures shall be permitted to be used with galvanized steel RMC, and galvanized steel fittings and enclosures shall be permitted to be used with aluminum RMC where not subject to severe corrosive influences. Stainless steel RMC shall only be used with stainless steel fittings and approved accessories, outlet boxes, and enclosures.

1100.3.1.3 Number of Conductors

The number of conductors in a conduit and tubing shall not exceed the permitted percentage fill specified in table below.

Table 1100.1. Percent of Cross Section of Conduit and Tubing for Conductors

Number of Conductors and/or Cables	Cross-sectional Area (%)
1	53
2	31
Over 2	40

Notes:

1. Table 1100.1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. It should be recognized that, for certain conditions, a larger size conduit or lesser conduit fill should be considered.
2. When pulling three (3) conductors or cables into a raceway, if the ratio of the inside diameter (raceway) to the outside diameter (conductor or cable) is between 2.8 and 3.2, jamming can occur. While jamming can occur when pulling four (4) or more conductors into a raceway, the probability is very low.
3. Table 1100.1 applies only to complete conduit or tubing systems and is not intended to apply to sections of conduit or tubing used to protect exposed wiring from physical damage.

Cables shall be permitted to be installed where such use is not prohibited by the respective cable articles of PEC, Part I. The number of cables shall not exceed the allowable percentage fill specified in Table 1100.1.

1100.3.1.4 Bends

Bends of RMC shall be so made that the conduit will not be damaged and so that the internal diameter of the conduit will not be effectively reduced. The radius of the curve of any field bend to the centerline of the conduit shall not be less than indicated in Table 1100.2.

Table 1100.2. Radius of Conduit and Tubing Bends

Conduit or TubingSize	One Shot and Full Shoe Benders	Other Bends
Raceway Size (mm)	(mm)	(mm)
15	100	100
20	115	125
25	145	150
32	180	200
40	210	250
50	240	300
65	265	375
80	325	450
90	375	525
100	400	600
125	600	750
150	750	900

There shall not be more than the equivalent of four (4) quarter bends (360 degrees total) between pull points, for example, conduit bodies and boxes.

1100.3.1.5 Reaming and Threading

All cut ends shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with a one (1) in 16 taper (62.5 mm per meter) shall be used.

1100.3.1.6 Securing and Supporting

RMC shall be installed as a complete system in accordance with Subsection 3.0.1.18, Raceway Installations of Article 3.0, General Requirements for Wiring Methods and Materials of PEC, Part I and shall be securely fastened in place and supported in accordance with the following:

1. Securely Fastened. RMC shall be secured in accordance with the following:

    a. RMC shall be securely fastened within 0.90 m of each outlet box, junction box, device box, cabinet, conduit body, or other conduit termination.

    b. Fastening shall be permitted to be increased to a distance of 1.50 m where structural members do not readily permit fastening within 0.90 m.

    c. Where approved, conduit shall not be required to be securely fastened within 0.90 m of the service head for above-the-roof termination of a mast.

2. Supports. RMC shall be supported in accordance with one of the following:

a. Conduit shall be supported at intervals not exceeding 3.0 m.

b. The distance between supports for straight runs of conduit shall be permitted in accordance with Table 1100.3, provided the conduit is made up with threaded couplings, and such supports prevent transmission of stresses to termination where conduit is deflected between supports.

Table 1100.3 Supports for Rigid Metal Conduit

Conduit size		Maximum Distance Between Rigid Metal Conduit Supports
Metric Designator	**Trade Size**	**(m)**
16 - 21	1/2 - 3/4	3.0
27	1	3.6
35 - 41	1 ¼ - 1 ¼	4.2
53 - 63	2 - 2 ½	4.8
73 and larger	3 and larger	6.0

c. Exposed vertical risers from industrial machinery or fixed equipment shall be permitted to be supported at intervals not exceeding 6.0 m if the conduit is made up with threaded couplings, the conduit is supported and securely fastened at the top and bottom of the riser and no other means of intermediate support are readily available.

d. Horizontal runs of RMC supported by openings through framing members at intervals not exceeding 3.0 m and securely fastened within 0.90 m of termination points shall be permitted.

1100.3.1.7 Couplings and Connectors

Threadless couplings and connectors used with conduit shall be made tight. Where embedded in masonry or concrete, they shall be the concrete tight type. Where installed in wet locations, they shall comply with Subsection 3.14.2.1, Damp or Wet Locations of Article 3.14, Outlet, Device, Pull Junction Boxes; Conduit Bodies; Fittings; and Handholes Enclosures of PEC, Part I. Threadless couplings and connectors shall not be used on threaded conduit ends unless listed for the purpose.

Running threads shall not be used on conduit for connection at couplings.

1100.3.1.8 Locknut and Bushings

Where a conduit enters a box, fitting, or other enclosure, a locknut and bushing shall be provided to protect the wire from abrasion unless the design of the box, fitting, or enclosure is such as to afford equivalent protection.

1100.3.2 Intermediate Metal Conduit (IMC)

1100.3.2.1 Uses Permitted

1. All Atmospheric Conditions and Occupancies

Use of IMC shall be permitted under all atmospheric conditions and occupancies.

2. Corrosion Environments

IMC, elbows, couplings and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection approved for the condition.

3. Cinder fill

IMC shall be permitted to be installed in or under cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 50 mm thick; where the conduit is less than 450 mm under the fill; or where protected by corrosion protection approved for the condition.

4. Wet locations

All supports, bolts, straps, screws, and so forth, shall be of corrosion-resistant materials or protected against corrosion by corrosion-resistant materials.

1100.3.2.2 Dissimilar Metals

Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action.

Aluminum fittings and enclosures shall be permitted to be used with galvanized steel IMC where not subject to severe corrosive influences. Stainless steel IMC shall only be used with stainless steel fittings and approved accessories, outlet boxes, and enclosures.

1100.3.2.3 Number of Conductors

It shall comply with the requirements of Subsection 1100.3.1.3, Number of Conductors.

1100.3.2.4 Bends

It shall comply with the requirements of Subsection 1100.3.1.4, Bends.

1100.3.2.5 Reaming and Threading

It shall comply with the requirements of Subsection 1100.3.1.5, Reaming and Threading.

1100.3.2.6 Securing and Supporting

It shall comply with the requirements of Subsection 1100.3.1.6, Securing and Supporting.

1100.3.2.7 Couplings and Connectors

It shall comply with the requirements of Subsection 1100.3.1.7, Couplings and Connectors.

1100.3.2.8 Bushings

It shall comply with the requirements of Subsection 1100.3.1.8, Locknut and Bushings.

1100.3.3 Flexible Metal Conduit

1100.3.3.1 Uses Permitted

FMC shall be permitted to be used in exposed and concealed locations.

1100.3.3.2 Uses Not Permitted

FMC shall not be used in the following:

1. In wet locations.

2. In hoistways, other than as permitted in Subsection 6.20.3.1(A) (1), Hoistways and Pits of Article 6.20, Elevators, Dumbwaiters, Escalators, Moving Walks, Platforms Lifts of PEC, Part I.

3. In storage battery rooms.

4. In any hazardous (classified) location except as permitted by other articles in the PEC, Part I.

5. Where exposed to materials having a deteriorating effect on the installed conductors, such as oil or gasoline.

6. Underground or embedded in poured concrete or aggregate.

7. Where subject to severely physical damage.

1100.3.3.3 Number of Conductors

The number of conductors shall not exceed that permitted by the percentage fill specified in Table 1100.1 or as permitted in Table 3.48.2.13, Maximum Number of Insulated Conductors in Metric Designator 12 (Trade Size) Flexible Metal Conduit of Article 3.48, Flexible Metal Conduit: Type FMC of PEC, Part I or for metric designator 12 (trade size 3/8).

Cable shall be permitted to be installed where such use is not prohibited by the respective cable articles of PEC, Part I. The numbers of cables shall not exceed the allowable percentage fill specified in Table 1100.1.

1100.3.3.4 Bends

Bends in conduit shall be made so that the conduit is not damaged and the internal diameter of the conduit is not effectively reduced. Bends shall be permitted to be made manually without auxiliary equipment. The radius of the curve to the centerline of any bend shall not be less than as shown in Table 1100.2 using the column “Other Bends”.

There shall not be more than the equivalent of four (4) quarter bends (360 degrees total) between pull points, for example, conduit bodies and boxes.

1100.3.3.5 Trimming

All cut ends shall be trimmed and smoothened.

1100.3.3.6 Securing and Supporting

FMC shall be secured and supported in accordance with the requirements of Subsection 3.48.2.21, Securing and Supporting of Article 3.48, Flexible Metal Conduit: Type FMC of PEC, Part I.

1100.3.3.7 Couplings and Connectors

Angle connectors shall not be used for concealed raceway installations.

1100.3.4 Electrical Metallic Tubing (EMT)

1100.3.4.1 Uses Permitted

1. Exposed and Concealed. The use of EMT shall be permitted for both exposed and concealed work for the following:

a. In concrete, in direct contact with the earth or in areas subject to severe corrosive influences where installed in accordance with Subsection 1100.3.4.1 (b).

b. In dry, damp and wet locations.

c. In any hazardous (classified) location as permitted by other articles in the PEC, Part 1.

2. Corrosive Environments

a. Galvanized Steel and Stainless Steel EMT, Elbows and Fittings. Galvanized steel and stainless steel EMT, elbows and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by corrosion protection and approved as suitable for the condition.

b. Supplementary Protection of Aluminum EMT. Aluminum EMT shall be provided with approved supplementary corrosion protection where encased in concrete or in direct contact with the earth.

3. Cinder Fill

Galvanized steel and stainless steel EMT shall be permitted to be installed in cinder concrete or cinder fill where subject to permanent moisture where protected on all sides by a layer of noncinder concrete not less than 50 mm thick or when the tubing is installed at 450 mm under the fill.

4. Wet Locations

It shall comply with the requirements of Subsection 1100.3.1.1 (4), Wet Locations.

1100.3.4.2 Uses Not Permitted

EMT shall not be used under the following conditions:

1. Where subject to severe physical damage.
2. Where protected from corrosion solely by enamel.

1100.3.4.3 Number of Conductors.

It shall comply with the requirements of Subsection 1100.3.1.3, Number of Conductors.

1100.3.4.4 Bends

It shall comply the requirements of Subsection 1100.3.1.4, Bends.

1100.3.4.5 Reaming and Threading

All cut ends of EMT shall be reamed or otherwise finished to remove rough edges.

EMT shall not be threaded.

1100.3.4.6 Securing and Supporting

EMT shall be securely fastened in place at least every 3.0 m. In addition, each EMT run between termination points shall be securely fastened within 0.90 m of each outlet box, junction box, device box, cabinet, conduit body, or other tubing termination except to the following conditions:

1.Fastening of unbroken lengths shall be permitted to be increased to a distance of 1.5 m where structural members do not readily permit fastening within 0.90 m.

2. For concealed work in finished buildings or prefinished wall panels where such securing is impracticable, unbroken lengths (without coupling) of EMT shall be permitted to be fished.

3. Horizontal runs of EMT supported by openings through framing members at intervals not greater than 3.0 m and securely fastened within 0.90 m of termination points shall be permitted.

1100.3.4.7 Couplings and Connectors

Couplings and connectors used with EMT shall be made up tight when embedded in masonry or concrete. Where installed in wet locations, they shall comply with Subsection 3.14.2.1, Damp or Wet Locations of Article 3.14, Outlet, Device, Pull, and Junction Boxes; Conduit Bodies; Fittings; and Handhole Enclosures of PEC, Part I.

1100.3.5 Rigid Polyvinyl Chloride Conduit

1100.3.5.1 Uses Permitted

The use of PVC conduit shall be permitted in accordance with the following:

1. Concealed. PVC conduit shall be permitted in walls, floors and ceilings.

2. Corrosive Influences. PVC conduit shall be permitted in location subject to severe corrosive influences as covered in Subsection 3.0.1.6, Protection against Corrosion and Deterioration of Article 3.0, General Requirements for Wiring Methods and Materials of PEC Part I.

3. Cinders. PVC conduit shall be permitted in cinder fill.

4. Wet Locations. PVC conduit shall be permitted in portions of dairies, laundries, canneries, or other wet locations, and in locations where walls are frequently washed, the entire conduit system, including boxes and fittings used therewith, shall be installed and equipped so as to prevent water from entering the conduit. All supports, bolts, straps, screws, and so forth, shall be of corrosion-resistant materials or be protected against corrosion by approved corrosion-resistant materials.

5. Exposed. PVC conduit shall be permitted for exposed work. PVC conduit used exposed in areas of physical damage shall be identified for the use.

6. Underground Installations. For underground installations, PVC shall be permitted for direct embedment and underground encased in concrete in accordance with Subsections 3.0.1.5 and 3.0.2.20, Underground Installations of Article 3.0, General Requirements for Wiring Methods and Materials of PEC, Part I.

7. Support of Conduit Bodies. PVC conduit shall be permitted to support nonmetallic conduit bodies not larger than largest trade size of an entering raceway. These conduit bodies shall not support devices other than splicing devices as permitted by Subsection 1.10.1.14 (B), Mounting and Cooling of Equipment of Article 1.10, Requirements for Electrical Installations and Subsection 3.14.2.2(C)(2), Conduit Bodies of Article 3.14, Outlet, Device, Pull, and Junction boxes; Conduit Bodies; Fittings; and Handhole Enclosures of PEC, Part I.

8. Insulations Temperature Limitations. Conductors or cables rated at a temperature higher than the listed temperature rating of PVC conduit shall be permitted to be installed in PVC conduit, provided the conductors or cables are not operated at a temperature higher than the listed temperature rating of the PVC conduit.

1100.3.5.2 Uses Not Permitted

PVC conduit shall not be used under the conditions specified in the following:

1. Hazardous (Classified) Locations. In any hazardous (classified) location, except as permitted by other articles of the PEC, Part I.

2. Support of Luminaires. For the support of luminaires or other equipment not described in Subsection 1100.3.5.1 (7) Support of Conduit Bodies.

3. Physical Damage. Where subject to physical damage unless identified for such use.

4. Ambient Temperatures. Where subject to ambient temperatures in excess of 50˚ C unless listed otherwise.

5. Theaters and Similar Locations. In theaters and similar locations, except as provided in Subsection 5.18.1.4, Wiring Methods of Article 5.18, Assembly Occupancies and Subsection 5.20.1.5, Wiring Methods of Article 5.20, Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations of PEC, Part I.

1100.3.5.3 Number of Conductors

It shall comply with the requirements of Subsection 1100.3.1.3, Number of Conductors.

1100.3.5.4 Bends

It shall comply the requirements of Subsection 1100.3.1.4, Bends.

1100.3.5.5 Trimming

All cut ends shall be trimmed and smoothened.

1100.3.5.6 Securing and Supporting

PVC Conduit shall be installed as a complete system as provided in Subsection 3.0.1.18, Raceway Installations of Article 3.0, General Requirements for Wiring Methods and Materials of PEC, Part I and shall be fastened so that movement from thermal expansion or contraction is permitted. PVC conduit shall be securely fastened and supported in accordance with the following:

1. Securely Fastened. PVC conduit shall be securely fastened within 900 mm of each outlet box, junction box, device box, conduit body, or other conduit

termination. Conduit listed for securing at other than 900 mm shall be permitted to be installed in accordance with the listing.

2. Supports. PVC conduit shall be supported as required in Table 1100.4 listed for support at spacings other than as shown in Table 1100.4 shall be permitted to be installed in accordance with the listing. Horizontal runs of PVC conduit supported by openings through framing members at intervals not exceeding those in Table 1100.4 and securely fastened within 900 mm of termination points shall be permitted.

Table 1100.4 Support of Rigid Polyvinyl Chloride Conduit (PVC)

Conduit size		**Maximum Spacing Between Supports**
Metric Designator	**Trade Size**	**(m)**
16 - 27	½ - 1	0.90
35 - 53	1 ¼ - 2	1.5
63 - 78	22 ½ - 3	1.8
91 - 129	3 ½ - 5	2.1
155	6	2.4

1100.3.5.7 Expansion Fittings.

Expansion fittings for PVC conduit shall be provided to compensate for thermal expansion and contraction where the length change, in accordance with Table 3.52.2.35, Expansion Characteristics of PVC Rigid Nonmetallic Conduit Coefficient of Thermal Expansion = 6.084 x 10-5mm/mm/˚ C, of PEC, Part 1 is expected to be 6 mm or greater in a straight run between securely mounted items such as boxes, cabinets, elbows, or other conduit terminations.

1100.3.5.8 Locknut and Bushings

Where a conduit enters a box, fitting, or other enclosure, a bushing or PVC adapter shall be provided to protect the wire from abrasion unless the box, fitting, or enclosures designs provides equivalent protection.

1100.3.5.9 Joints

All joints between lengths of conduit, and between conduit and couplings, fittings, and boxes, shall be provided with PVC solvent and made by an approved method.

1100.3.6 Liquid tight Flexible Nonmetallic Conduit (LFNC)

1100.3.6.1 Uses Permitted

LFNC shall be permitted to be used in exposed or concealed locations for the following purposes:

1. Where flexibility is required for installation, operation or maintenance.

2. Where protection of the contained conductors is required from vapors, liquids or solids.

3. For outdoor locations where listed and marked as suitable for the purpose.

4. For direct embedment where listed and marked for the purpose.

5. Type LFNC-B shall be permitted to be installed in lengths longer than 1.8 m where secured in accordance Subsection 1100.3.6.7, Securing and Supporting.

6. Type LFNC-B as a listed manufactured prewired assembly, metric designator 16 through 27 (trade size ½ through 1) conduit.

7. For encasement in concrete where listed for direct embedment and install in accordance with Subsection 1100.3.6.8, Couplings and Connectors.

1100.3.6.2 Uses Not Permitted

LFNC shall not be used as follows:

1. Where subject to severe physical damage.

2. Where any combination of ambient and conductor temperatures is in excess of that for which the LFNC is approved.

3. In lengths longer than 1.8 m, except as permitted by Subsection 1100.3.6.1
(5) or where a longer length is approved as essential for a required degree of flexibility.

4. In any hazardous (classified) location, except as permitted by other articles in PEC, Part I.

1100.3.6.3 Number of Conductors

It shall comply with the requirements of Subsection 1100.3.1.3, Number of Conductors.

1100.3.6.4 Bends

It shall comply with the requirements of Subsection 1100.3.3.4, Bends.

1100.3.6.5 Trimming

All cut ends of conduit shall be permitted inside and outside to remove rough edges.

1100.3.6.6 Securing and Supporting

LFNC shall be securely fastened and supported in accordance with Subsection 3.56.2.21, Securing and Supporting of Article 3.56, Liquidtight Flexible Nonmetallic Conduit: Type LFNC of PEC, Part I.

1100.3.6.7 Couplings and Connectors

Only fittings listed for use with LFNC shall be used. Angle connectors shall not be used for concealed raceway installations. Straight LFNC fittings are permitted for direct burial or encasement in concrete.

1100.3.7 Weatherhead

Weatherhead shall be installed in accordance with the PEC, Part I.

1100.3.8 Test and Guarantee

Upon completion of the electrical construction work, the Contractor shall provide all test equipment, materials and personnel for conducting the test and shall submit written copies of all test results to the Engineer.

The Contractor shall guarantee that the electrical installations are done in accordance with the approved Plans and Specifications.

The Contractor shall furnish a guaranty or warranty covering all labor and materials for period of 1 year from the date of the final acceptance of works and shall agree to repair all defects and any part of the work not satisfactory to the Engineer which may develop during the defects liability period arising from defective workmanship or materials at his own expenses.

1100.4 Method of Measurement

The work under this Item shall be measured either by lengths, pieces, and lump sum actually placed and installed as shown on the approved Plans.

1100.5 Basis of Payment

All works performed and measured in Section 1100.4, Method of Measurement and as provided for in the Bill of Quantities shall be paid for at the Unit Bid or Contract Unit Price which payment shall constitute full compensation including labor, materials, tools and incidentals necessary to complete this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1100 (1)a	Rigid Steel Conduit (RSC), 15 mm dia	Meter
1100 (1)b	Rigid Steel Conduit (RSC), 20 mm dia	Meter
1100 (1)c	Rigid Steel Conduit (RSC), 25 mm dia	Meter
1100 (1)d	Rigid Steel Conduit (RSC), 32 mm dia	Meter
1100 (1)e	Rigid Steel Conduit (RSC), 40 mm dia	Meter
1100 (1)f	Rigid Steel Conduit (RSC), 50 mm dia	Meter
1100 (1)g	Rigid Steel Conduit (RSC), 65 mm dia	Meter
1100 (1)h	Rigid Steel Conduit (RSC), 80 mm dia	Meter
1100 (1)i	Rigid Steel Conduit (RSC), 90 mm dia	Meter
1100 (1)j	Rigid Steel Conduit (RSC), 100 mm dia	Meter
1100 (1)k	Rigid Steel Conduit (RSC), 125 mm dia	Meter
1100 (1)l	Rigid Steel Conduit (RSC), 150 mm dia	Meter
1100 (2)a	Intermediate Metal Conduit (IMC), 15 mm dia	Meter
1100 (2)b	Intermediate Metal Conduit (IMC), 20 mm dia	Meter
1100 (2)c	Intermediate Metal Conduit (IMC), 25 mm dia	Meter
1100 (2)d	Intermediate Metal Conduit (IMC), 32 mm dia	Meter
1100 (2)e	Intermediate Metal Conduit (IMC), 40 mm dia	Meter
1100 (2)f	Intermediate Metal Conduit (IMC), 50 mm dia	Meter
1100 (2)g	Intermediate Metal Conduit (IMC), 65 mm dia	Meter
1100 (2)h	Intermediate Metal Conduit (IMC), 80 mm dia	Meter
1100 (2)i	Intermediate Metal Conduit (IMC), 90 mm dia	Meter
1100 (2)j	Intermediate Metal Conduit (IMC), 100 mm dia	Meter
1100 (3)a	Flexible Metal Conduit, 15 mm dia	Meter

1100 (3)b	Flexible Metal Conduit, 20 mm dia	Meter
1100 (3)c	Flexible Metal Conduit, 25 mm dia	Meter
1100 (3)d	Flexible Metal Conduit, 32 mm dia	Meter
1100 (3)e	Flexible Metal Conduit, 40 mm dia	Meter
1100 (3)f	Flexible Metal Conduit, 50 mm dia	Meter
1100 (3)g	Flexible Metal Conduit, 65 mm dia	Meter
1100 (3)h	Flexible Metal Conduit, 80 mm dia	Meter
1100 (3)i	Flexible Metal Conduit, 90 mm dia	Meter
1100 (3)j	Flexible Metal Conduit, 100 mm dia	Meter
1100 (4)a	Electrical Metallic Tubing (EMT), 15 mm dia	Meter
1100 (4)b	Electrical Metallic Tubing (EMT), 20 mm dia	Meter
1100 (4)c	Electrical Metallic Tubing (EMT), 25 mm dia	Meter
1100 (4)d	Electrical Metallic Tubing (EMT), 32 mm dia	Meter
1100 (4)e	Electrical Metallic Tubing (EMT), 40 mm dia	Meter
1100 (4)f	Electrical Metallic Tubing (EMT), 50 mm dia	Meter
1100 (4)g	Electrical Metallic Tubing (EMT), 65 mm dia	Meter
1100 (4)h	Electrical Metallic Tubing (EMT), 80 mm dia	Meter
1100 (4)i	Electrical Metallic Tubing (EMT), 90 mm dia	Meter
1100 (4)j	Electrical Metallic Tubing (EMT), 100 mm dia	Meter
1100 (5)a	Liquidtight Flexible Non-Metallic Conduit, 10 mm dia	Meter
1100 (5)b	Liquidtight Flexible Non-Metallic Conduit, 15 mm dia	Meter
1100 (5)C	Liquidtight Flexible Non-Metallic Conduit, 20 mm dia	Meter
1101 (5)d	Liquidtight Flexible Non-Metallic Conduit, 25 mm dia	Meter
1100 (5)e	Liquidtight Flexible Non-Metallic Conduit, 32 mm dia	Meter
1100 (5)f	Liquidtight Flexible Non-Metallic Conduit, 40 mm dia	Meter
1100 (5)g	Liquidtight Flexible Non-Metallic	Meter

	Conduit, 50 mm dia	
1100 (6)a	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 20 mm dia	Meter
1100 (6)b	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 25 mm dia	Meter
1100 (6)c	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 32 mm dia	Meter
1100 (6)d	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 40 mm dia	Meter
1100 (6)e	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 50 mm dia	Meter
1100 (6)f	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 65 mm dia	Meter
1100(6)g	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 75 mm dia	Meter
1100 (6)h	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 90 mm dia	Meter
1100 (6)i	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 100 mm dia	Meter
1100 (6)j	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 110 mm dia	Meter
1110 (6)k	Rigid Polyvinyl Chloride Pipes (PVC/uPVC) 160 mm dia	Meter
1100 (7)a1	Weatherhead, 15 mm dia	Piece
1100 (7)a2	Weatherhead, 20 mm dia	Piece
1100 (7)a3	Weatherhead, 25 mm dia	Piece
1100 (7)a4	Weatherhead, 32 mm dia	Piece
1100 (7)a5	Weatherhead, 40 mm dia	Piece
1100 (7)a6	Weatherhead, 50 mm dia	Piece
1100 (7)a7	Weatherhead, 65 mm dia	Piece
1100 (7)a8	Weatherhead, 80 mm dia	Piece
1100 (7)a9	Weatherhead, 90 mm dia	Piece
1100 (7)a10	Weatherhead, 100 mm dia	Piece
1100 (7)a11	Weatherhead, 125 mm dia	Piece
1100 (7)a12	Weatherhead, 150 mm dia	Piece
1100(8)	Boxes/Wire Gutter	Lump Sum
1100(9)	Fittings and Accessories	Lump Sum
1100(10)	Conduits, Boxes & Fittings (Conduit Works/Conduit Rough-In)	Lump Sum

XXVIII.ITEM 1101 – WIRES, CABLES AND WIRING DEVICES

1101.1 Description

This Item shall consist of furnishing and installation of all wires and wiring devices consisting of electric wires and cables, wall switches, convenience receptacles, heavy duty receptacles and other devices in accordance with the approved Plans and this Specification.

1101.2 Material Requirements

1101.2.1 Wires and Cables

1101.2.1.1 Wires

All wires shall meet the requirements specified in the Philippine Electrical Code (PEC), Part 1 and PNS 35-1, Electric wires and cables – Thermoplastic- insulated copper wires and cables rated 600 volts – Part 1: General Specifications, and shall bear the Philippine Standard (PS) mark unless specified or indicated otherwise and shall be marked to indicate the following information:

1. The maximum rated voltage

2. The proper type letter or letters for the type of wire or cable as specified in the PEC Part 1

3. The manufacturer's name, trademark, or other distinctive marking by which the organization responsible for the product can be readily identified

4. The size in square millimeter or millimeter diameter

5. Cable assemblies where the neutral wire is smaller

The letters such as TW, THHN, THWN and THW represent the main insulation types of individual wires. These letters depict the following requirements:

1. T – Thermoplastic Insulation
2. H – Heat Resistance
3.HH – High Heat Resistance
4. W – Suitable for Wet locations
5. N – Thermoplastic Polyester, Tough and Very Resistant to Gas and Oil
6. X – Flame-Resistant Synthetic Polymer
7. Z – Modified ethylene tetrafluoroethylene

Conductors shall be insulated for 600 V and shall be aluminum, copper-clad aluminum, or copper unless otherwise specified. The minimum diameter size of conductors shall be 1.6 mm (2.0 mm2) for copper and 2.0 mm (3.5 mm2) for aluminum or copper-clad aluminum conductors. Solid aluminum conductors of diameters 3.2 mm, 2.6 mm, and 2.0 mm shall be made of an AA-8000 series

electrical grade aluminum alloy conductor material. Stranded aluminum conductors 8.0 mm2 through 500 mm2 marked as Type RHH, RHW, XHHW, THW, THHW, THWN, THHN, service-

entrance Type SE Style U and SE Style R shall be made of an AA-8000 series electrical grade aluminum alloy conductor material.

Ampacities for conductors shall be as specified in the PEC Part 1. Where bare or covered conductors are used with insulated conductors, their allowable ampacities shall be limited to those permitted for the adjacent insulated conductors.

1101.2.1.2 Cables

1. Armored Cables (Type AC)

Type AC shall have ready identification of the manufacturer by distinctive external markings on the cable sheath throughout its entire length.

Type AC cable shall have an armor of flexible metal tape and shall have an internal bonding strip of copper or aluminum in intimate contact with the armor for its entire length. Insulated conductors of type AC shall be of type listed in the PEC Part 1. In addition, the conductors shall have an overall moisture- resistant fibrous covering and fire-retardant fibrous covering. For Type ACT, a moisture-resistant fibrous covering shall be required only on the individual conductors.

2. Flat Cable Assemblies (Type FC)

Flat cable assemblies shall consist of two, three, four, or five conductors. The conductors shall be 5.5 mm2 (2.6 mm dia.) special stranded copper wires. Type FC cable shall have the temperature rating durably marked on the surface at intervals not exceeding 600 mm.

3. Flat Conductor Cable (Type FCC)

Type FCC cable shall be clearly and durably marked on both sides at intervals of not more than 600 mm with the information required by the PEC Part 1. It shall consist of three (3), four (4), or five (5) flat copper conductors, one of which shall be an equipment grounding conductor. The insulating material of the cable shall be moisture resistant and flame retardant.

4. Integrated Gas Spacer Cable (Type IGS)

The conductors shall be solid aluminum rods, consisting of one to nineteen 13 mm diameter rods. The minimum conductor size shall be 125 mm2, and the maximum size shall be 2375 mm2. The insulation shall be dry kraft paper tapes and a pressurized sulfur hexafluoride gas (SF6), both approved for electrical use. The nominal gas pressure shall be 138 kPa gauge.

5. Medium Voltage Cable (Type MV)

Type MV cables shall have copper, aluminum, or copper-clad aluminum conductors and shall be marked as required by the PEC Part 1.

6. Metal-Clad Cable (Type MC)

The conductors for type MC shall be of copper, aluminum, or copper-clad aluminum, solid or stranded. The minimum conductor size shall be 0.75 mm2 (1.0 mm dia.) copper and 3.5 mm2 (2.0 mm dia.) aluminum or copper-clad aluminum. Metallic covering shall be one of the

following types: smooth metallic sheath, corrugated metal sheath, interlocking metal tape armor. The metallic sheath or armor shall be used on single conductor type MC. Supplemental protection of an outer covering of corrosion-resistant material shall be permitted and shall be required where such protection is needed. The sheath shall not be used as current-carrying conductor.

7. Mineral-Insulated, Metal-Sheathed Cable (Type MI)

Type MI cable conductors shall be of solid copper, nickel, or nickel-coated copper with a resistance corresponding to standard mm2 and mm dia. sizes. The conductor insulation in Type MI cable shall be a highly compressed refractory mineral that provides proper spacing for all conductors.

8. Non-metallic - Sheathed Cable (Types NM, NMC, and NMS)

The 600 volt insulated conductors shall be sizes 2.0 mm2 (1.6 mm dia.) through 30 mm2 copper conductors or sizes 3.5 mm2 (2.0 mm dia.) through 2.0 mm2 aluminum or copper-clad aluminum conductors. The signaling and communication conductors shall comply with the PEC Part 1. The insulated power conductors shall be one of the types listed in the PEC Part 1 that are suitable for branch circuit wiring or one that is identified for use in these cables. Conductor insulation shall be rated at 90°C.

The outer sheath of non-metallic-sheathed cable shall comply with the following:

a. Type NM – The overall covering shall be flame retardant and moisture resistant.

b. Type NMC – The overall covering shall be flame retardant, moisture resistant, fungus resistant, and corrosion resistant.

c. Type NMS – The overall covering shall be flame retardant and moisture resistant. The sheath shall be applied so as to separate the power conductors from the communications and signaling conductors. The signaling conductors shall be permitted to be shielded. An optional outer jacket shall be permitted.

9. Power and Control Tray Cable (Type TC)

A metallic sheath or armor shall not be permitted either under or over the nonmetallic jacket. Metallic shield(s) shall be permitted over groups of conductors, under the outer jacket, or both. The insulated conductors of Type TC tray cable shall be in sizes 0.75 mm2 (1.0 mm dia.) through 500 mm2 aluminum or copper-clad aluminum. Insulated conductors of sizes 2.0 mm2 (1.6 mm dia.) and larger copper and sizes 3.5 mm2 (2.0 mm dia.) and larger aluminum or copper-clad aluminum shall be one of the types listed in the PEC Part 1 that is suitable for branch circuit and feeder circuits or one that is defined for such use.

The outer jacket for Type TC shall be a flame-retardant, nonmetallic material. There shall be no voltage marking on a Type TC cable employing thermocouple extension wire.

10. Service-Entrance Cable (Type SE and USE)

Cabled, single-conductor, Type USE constructions recognized for underground use shall be permitted to have a bare copper conductor cable with the assembly. Type USE single, parallel,

or cabled conductor assemblies recognized for underground use shall be permitted to have a bare copper concentric conductor applied. These constructions shall not an outer overall covering. Type SE or USE cable containing two or more conductors shall be permitted to have one conductor uninsulated.

11. Underground Feeder and Branch-Circuit Cable (Type UF)

The conductors shall be sizes 2.0 mm 2 (1.6 mm dia.) copper or 3.5 mm2 (2.0 mm dia.) aluminum or copper-clad aluminum through 100 mm2. The conductors of Type UF shall be moisture-resistant type that is suitable for branch-circuit wiring or one that is identified for such use. Where installed as a substitute wiring method for NM cable, the conductor insulation shall be rated 90°C. The overall covering shall be flame retardant; moisture, fungus, and corrosion resistant; and suitable for direct burial in the earth.

1101.2.2 Switches

All switches shall conform to the requirements of the PEC Part 1. Switches shall be marked with the current voltage, and, if horsepower rated, the maximum rating for which they are designed. They shall be of the externally type mounted in an enclosure listed for the intended use.

Metal faceplates for switches shall be of ferrous metal not less than 0.75 mm in thickness or of non-ferrous metal not less than 1.00 mm in thickness. Faceplates of insulating material shall be non-combustible and not less than 0.25 mm in thickness, but they shall not be permitted to be less than 0.25 mm in thickness if formed or reinforced to provide adequate mechanical strength.

1101.2.3 Receptacles

All receptacles shall conform to the requirements of the PEC Part 1. Receptacles shall be listed and marked with the manufacturer's name or identification and voltage and ampere ratings. The rating for receptacles shall not be less than 15 A, 125 V, or 15 A, 250 V. Table 1101.1 shows the receptacle ratings for various size circuits.

Table 1101.1 Receptacle Rating for Various Size Circuits

Circuit Rating (Amperes, A)	Receptacle Rating (Amperes, A)
15	15 Not over
20	15 or 20
30	30
40	40 or 50
50	50

Metal faceplates for receptacles shall be of ferrous metal not less than 0.75 mm in thickness or of non-ferrous metal not less than 1.00 mm in thickness. Faceplates of insulating material shall be non-combustible and not less than 0.25 mm in thickness if formed or reinforced to provide adequate mechanical strength.

1101.3 Construction Requirements

Installation of electric wiring and wiring devices shall comply with the governing laws and applicable codes and standards such as the PEC Part 1 and Safety Standards.

1101.3.1 Installation

1101.3.1.1 Conductors

1. Conductors of the Same Circuit

All conductors of the same circuit and, where used, the grounded conductor and all equipment grounding conductors and bonding conductors shall be contained within the same raceway, auxiliary gutter, cable tray, cable bus assembly, trench, cable, or cord, unless otherwise permitted in accordance with the PEC 1.

a. Paralleled Installations

Conductors shall be permitted to be run in parallel in accordance with the provisions of the PEC Part 1. The requirement to run all circuit conductors within the same raceway, auxiliary gutter, cable tray, trench, cable, or cord shall apply separately to each portion of the paralleled installation, and the equipment grounding conductors shall comply with the provisions of the PEC Part 1. Parallel runs in cable tray shall comply with the provisions of the PEC Part 1.

b. Grounding and Bonding Conductors

Equipment grounding conductors grounding conductors shall be permitted to be installed outside a raceway or cable assembly in accordance with the provisions of the PEC Part 1.

c. Non-ferrous Wiring Methods

Conductors in wiring methods with a nonmetallic or other nonmagnetic sheath, where run in different raceways, auxiliary gutters, cable trays, trenches, cables, or cords shall comply with the provisions of the PEC Part 1.

2. Conductors of Different Systems

Conductors of circuits rated 600 V, nominal or less, ac circuits, and dc circuits shall be permitted to occupy the same equipment wiring enclosure, cable, or raceway. All conductors shall have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway.

Conductors of circuits over 600 V, nominal, shall not occupy the same equipment wiring enclosure, cable, or raceway with conductors of circuits rated 600 V, nominal, or less unless otherwise permitted in the PEC Part 1.

1101.3.1.2 Switches

Installation of switches shall conform to the requirements of the PEC Part 1. All switches and circuit breakers used as switches shall be located in an accessible place to facilitate operation.

They shall be installed such that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is not more than 1980 mm above the floor or working platform.

Faceplates provided for snap switches mounted in boxes and other enclosures shall be installed so as to completely cover the opening and, where the switch is flush mounted, seat against the finished surface.

Metal enclosures for switches shall be grounded. Where nonmetallic enclosures are used with metal raceways or metal-armored cables, provision shall be made for grounding continuity. Snap switches, including dimmer and similar control switches, shall be effectively grounded and shall provide a means to ground metal faceplates, whether or not a metal faceplate is installed. Snap switches shall be considered effectively grounded if either of the following conditions is met:

1. The switch is mounted with metal screws to a metal box or to a nonmetallic box with integral means for grounding devices.

2. An equipment grounding conductor or equipment bonding jumper is connected to an equipment grounding termination of the snap switch.

1101.3.1.3 Receptacles

General installation requirements for receptacles shall be in accordance with the PEC Part 1. Receptacle outlets shall be located in branch circuits in accordance with the PEC Part 1.

Receptacles shall be mounted in boxes or assemblies designed for the purpose, and such boxes or assemblies shall be securely fastened in place unless otherwise permitted in the PEC Part 1.

Receptacles installed on 15- and 20-A branch circuits shall be of the grounding type. Grounding-type receptacles shall be installed only on circuits of the voltage class and current for which they are rated, except as provided in the PEC Part 1.

Receptacles and cord connectors that have grounding contacts shall have those contacts effectively grounded. They shall be grounded by connection to the equipment grounding conductor of the circuit supplying the receptacle or cord connector. The branch circuit wiring method shall include or provide an equipment-grounding conductor to which the grounding contacts of the receptacle or cord connector are connected.

1101.3.2 Personnel Qualification

The installation of electrical wiring and devices shall be done by a certified installer under the supervision of an Electrical Engineer based on the guidelines of Republic Act No. 7920, New Electrical Engineering Law.

1101.3.3 Locations

1101.3.3.1 Dry Locations

Insulated conductors and cables, receptacles, switches and other devices used in dry locations shall be any of the types identified in the PEC Part 1.

1101.3.3.2 Dry and Damp Locations

Insulated conductors and cables used in dry and damp locations shall be Types FEP, FEPB, MTW, PFA, RHH, RHW-2, SA, THHN, THW, THW-2, THHW, THHW- 2, THWN, THWN-2, TW, XHH, XHHW, XHHW-2, Z, or ZW.

Receptacles installed outdoors in a location protected from the weather or in other damp locations shall have an enclosure for the receptacle that is weatherproof when the receptacle is covered (attachment plug cap not inserted and receptacle covers closed).

1101.3.3.3 Wet Locations

Insulated conductors and cables used in wet locations shall be Moisture- impervious metal-sheathed, Types MTW, RHW, RHW-2, TW, THW, THW-2, THHW, THHW-2, THWN, THWN-2, Z, or ZW and Type for use in wet locations.

Receptacles installed in wet locations shall have an enclosure that is weatherproof. Switches in a wet location or outside of a building shall be enclosed in a weatherproof enclosure or cabinet.

1101.3.3.4 Locations Exposed to Direct Sunlight

Insulated conductors or cables used where exposed to direct rays of the sun shall comply with one of the following:

1. Cables listed, or listed and marked, as being sunlight resistant.
2. Conductors listed, or listed and marked, as being sunlight resistant.
3. Covered with insulating material, such as tape or sleeving.

1101.4 Method of Measurement

The work under this Item shall be measured either by meters, rolls, set and lump sum actually placed and installed as shown on the Plans.

1101.5 Basis of Payment

The quantity as determined in Section 1101.4, Method of Measurement shall be paid for at unit price stipulated in the Contract's Bill of Quantities. The payment shall constitute the full compensation for furnishing all the necessary materials, providing necessary equipment and tools in installing the wires and wiring devices labor cost and all the incidental expenses necessary to complete the work.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1101 (1)a1	Electric Wire, 1.6 mm dia. TW/THHN/THWN^2, Solid	Roll
1101 (1)a2	Electric Wire, 2.0 mm dia. TW/THHN/THWN2, Solid	Roll
1101 (1)a3	Electric Wire, 2.6 mm dia. TW/THHN/THWN2, Solid	Roll
1101 (1)a4	Electric Wire, 3.2 mm dia. TW/THHN/THWN2, Solid	Roll
1101 (1)b1	Electric Wire, 2.0 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b2	Electric Wire, 3.5 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b3	Electric Wire, 5.5 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b4	Electric Wire, 8.0 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b5	Electric Wire, 14 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b6	Electric Wire, 22 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b7	Electric Wire, 30 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b8	Electric Wire, 38 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b9	Electric Wire, 50 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b10	Electric Wire, 60 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b11	Electric Wire, 80 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b12	Electric Wire, 100 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b13	Electric Wire, 125 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b14	Electric Wire, 150 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1) b15	Electric Wire, 200 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b16	Electric Wire, 250 mm2 TW/THHN/THWN2, Stranded	Roll

1101 (1)b17	Electric Wire, 325 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b18	Electric Wire, 400 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)b19	Electric Wire, 500 mm2 TW/THHN/THWN2, Stranded	Roll
1101 (1)c1	Electric Wire, 14 mm2 , ASCR	Roll
1101 (1)c2	Electric Wire, 22 mm2 , ASCR	Roll
1101 (1)c3	Electric Wire, 30 mm2 , ASCR	Roll
1101 (1)c4	Electric Wire, 38 mm2 , ASCR	Roll
1101 (1)c5	Electric Wire, 50 mm2 , ASCR	Roll
1101 (1)c6	Electric Wire, 60 mm2 , ASCR	Roll
1101 (1)c7	Electric Wire, 80 mm2 , ASCR	Roll
1101 (1)c8	Electric Wire, 100 mm2 , ASCR	Roll
1101 (1)c9	Electric Wire, 125 mm2 , ASCR	Roll
1101 (1)c10	Electric Wire, 150 mm2 , ASCR	Roll
1101 (1)c11	Electric Wire, 200 mm2 , ASCR	Roll
1101 (1)c12	Electric Wire, 250 mm2 , ASCR	Roll
1101 (1)d1	Electric Wire, 1C X 4, XLPE	Roll
1101 (1)d2	Electric Wire, 1C X 6, XLPE	Roll
1101 (1)d3	Electric Wire, 1C X 10, XLPE	Roll
1101 (1)d4	Electric Wire, 1C X 25, XLPE	Roll
1101 (1)d5	Electric Wire, 1C X 35, XLPE	Roll
1101 (1)d6	Electric Wire, 1C X 50, XLPE	Roll
1101 (1)d7	Electric Wire, 1C X 70, XLPE	Roll
1101 (1)d8	Electric Wire, 1C X 95, XLPE	Roll
1101 (1)d9	Electric Wire, 1C X 120, XLPE	Roll
1101 (1)d10	Electric Wire, 1C X 185, XLPE	Roll
1101 (1)d11	Electric Wire, 1C X 240, XLPE	Roll
1101 (1)d12	Electric Wire, 1C X 300, XLPE	Roll

1101 (1)d13	Electric Wire, 1C X 400, XLPE	Roll
1101 (1)d14	Electric Wire, 1C X 500, XLPE	Roll
1101 (1)e1	Electric Wire, 2C X 4, XLPE	Roll
1101 (1)e2	Electric Wire, 2C X 6, XLPE	Roll
1101 (1)e3	Electric Wire, 2C X 10, XLPE	Roll
1101 (1)e4	Electric Wire, 2C X 25, XLPE	Roll
1101 (1)e5	Electric Wire, 2C X 35, XLPE	Roll
1101 (1)e6	Electric Wire, 2C X 50, XLPE	Roll
1101 (1)e7	Electric Wire, 2C X 70, XLPE	Roll
1101 (1)e8	Electric Wire, 2C X 95, XLPE	Roll
1101 (1)e9	Electric Wire, 2C X 120, XLPE	Roll
1101 (1)e10	Electric Wire, 2C X 185, XLPE	Roll
1101 (1)e11	Electric Wire, 2C X 240, XLPE	Roll
1101 (1)e12	Electric Wire, 2C X 300, XLPE	Roll
1101 (1)e13	Electric Wire, 2C X 400, XLPE	Roll
1101 (1)e14	Electric Wire, 2C X 500, XLPE	Roll
1101 (1)f1	Electric Wire, 3C X 4, XLPE	Roll
1101 (1)f2	Electric Wire, 3C X 6, XLPE	Roll
1101 (1)f3	Electric Wire, 3C X 10, XLPE	Roll
1101 (1)f4	Electric Wire, 3C X 25, XLPE	Roll
1101 (1)f5	Electric Wire, 3C X 35, XLPE	Roll
1101 (1)f6	Electric Wire, 3C X 50, XLPE	Roll
1101 (1)f7	Electric Wire, 3C X 70, XLPE	Roll
1101 (1)f8	Electric Wire, 3C X 95, XLPE	Roll
1101 (1)f9	Electric Wire, 3C X 120, XLPE	Roll
1101 (1)f10	Electric Wire, 3C X 185, XLPE	Roll
1101 (1)f11	Electric Wire, 3C X 240, XLPE	Roll
1101 (1)f12	Electric Wire, 3C X 300, XLPE	Roll

1101 (1)f13	Electric Wire, 3C X 400, XLPE	Roll
1101 (1)f14	Electric Wire, 3C X 500, XLPE	Roll
1101 (2)a1	Electric Wire, 1.6 mm dia. TW/THHN/THWN2, Solid	Meter
1101 (2)a2	Electric Wire, 2.0 mm dia. TW/THHN/THWN2, Solid	Meter
1101 (2)a3	Electric Wire, 2.6 mm dia. TW/THHN/THWN2, Solid	Meter
1101 (2)a4	Electric Wire, 3.2 mm dia. TW/THHN/THWN2, Solid	Meter
1101 (2)b1	Electric Wire, 2.0 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b2	Electric Wire, 3.5 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b3	Electric Wire, 5.5 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b4	Electric Wire, 8.0 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b5	Electric Wire, 14 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b6	Electric Wire, 22 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b7	Electric Wire, 30 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b8	Electric Wire, 38 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b9	Electric Wire, 50 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b10	Electric Wire, 60 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b11	Electric Wire, 80 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b12	Electric Wire, 100 mm2 TW/THHN/THWN2,Stranded	Meter
1101 (2)b13	Electric Wire, 125 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b14	Electric Wire, 150 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b15	Electric Wire, 200 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b16	Electric Wire, 250 mm2	Meter

	TW/THHN/THWN2, Stranded	
1101 (2)b17	Electric Wire, 325 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b18	Electric Wire, 400 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)b19	Electric Wire, 500 mm2 TW/THHN/THWN2, Stranded	Meter
1101 (2)c1	Electric Wire, 1C X 4, XLPE	Meter
1101 (2)c2	Electric Wire, 1C X 6, XLPE	Meter
1101 (2)c3	Electric Wire, 1C X 10, XLPE	Meter
1101 (2)c4	Electric Wire, 1C X 25, XLPE	Meter
1101 (2)c5	Electric Wire, 1C X 35, XLPE	Meter
1101 (2)c6	Electric Wire, 1C X 50, XLPE	Meter
1101 (2)c7	Electric Wire, 1C X 70, XLPE	Meter
1101 (2)c8	Electric Wire, 1C X 95, XLPE	Meter
1101 (2)c9	Electric Wire, 1C X 120, XLPE	Meter
1101 (2)c10	Electric Wire, 1C X 185, XLPE	Meter
1101 (2)c11	Electric Wire, 1C X 240, XLPE	Meter
1101 (2)c12	Electric Wire, 1C X 300, XLPE	Meter
1101 (2)c13	Electric Wire, 1C X 400, XLPE	Meter
1101 (2)c14	Electric Wire, 1C X 500, XLPE	Meter
1101 (2)d1	Electric Wire, 2C X 4, XLPE	Meter
1101 (2)d2	Electric Wire, 2C X 6, XLPE	Meter
1101 (2)d3	Electric Wire, 2C X 10, XLPE	Meter
1101 (2)d4	Electric Wire, 2C X 25, XLPE	Meter
1101 (2)d5	Electric Wire, 2C X 35, XLPE	Meter
1101 (2)d6	Electric Wire, 2C X 50, XLPE	Meter
1101 (2)d7	Electric Wire, 2C X 70, XLPE	Meter
1101 (2)d8	Electric Wire, 2C X 95, XLPE	Meter
1101 (2)d9	Electric Wire, 2C X 120, XLPE	Meter
1101 (2)d10	Electric Wire, 2C X 185, XLPE	Meter

1101 (2)d11	Electric Wire, 2C X 240, XLPE	Meter
1101 (2)d12	Electric Wire, 2C X 300, XLPE	Meter
1101 (2)d13	Electric Wire, 2C X 400, XLPE	Meter
1101 (2)d14	Electric Wire, 2C X 500, XLPE	Meter
1101 (2)e1	Electric Wire, 3C X 4, XLPE	Meter
1101 (2)e2	Electric Wire, 3C X 6, XLPE	Meter
1101 (2)e3	Electric Wire, 3C X 10, XLPE	Meter
1101 (2)e4	Electric Wire, 3C X 25, XLPE	Meter
1101 (2)e5	Electric Wire, 3C X 35, XLPE	Meter
1101 (2)e6	Electric Wire, 3C X 50, XLPE	Meter
1101 (2)e7	Electric Wire, 3C X 70, XLPE	Meter
1101 (2)e8	Electric Wire, 3C X 95, XLPE	Meter
1101 (2)e9	Electric Wire, 3C X 120, XLPE	Meter
1101 (2)e10	Electric Wire, 3C X 185, XLPE	Meter
1101 (2)e11	Electric Wire, 3C X 240, XLPE	Meter
1101 (2)e12	Electric Wire, 3C X 300, XLPE	Meter
1101 (2)e13	Electric Wire, 3C X 400, XLPE	Meter
1101 (2)e14	Electric Wire, 3C X 500, XLPE	Meter
1101 (2)f1	Electric Wire, 14 mm2 , ASCR	Meter
1101 (2)f2	Electric Wire, 22 mm2 , ASCR	Meter
1101 (2)f3	Electric Wire, 30 mm2 , ASCR	Meter
1101 (2)f4	Electric Wire, 38 mm2 , ASCR	Meter
1101 (2)f5	Electric Wire, 50 mm2 , ASCR	Meter
1101 (2)f6	Electric Wire, 60 mm2 , ASCR	Meter
1101 (2)f7	Electric Wire, 80 mm2 , ASCR	Meter
1101 (2)f8	Electric Wire, 100 mm2 , ASCR	Meter
1101 (2)f9	Electric Wire, 125 mm2 , ASCR	Meter
1101 (2)f10	Electric Wire, 150 mm2 , ASCR	Meter

1101 (2)f11	Electric Wire, 200 mm2 , ASCR	Meter
1101 (2)f12	Electric Wire, 250 mm2 , ASCR	Meter
1101 (3)	Single Pole Wall Switch on one switch plate	Set
1101 (4)	Duplex (2 Single Pole Wall Switches on one switch plate)	Set
1101 (5)	Triplex (3 Single Pole Wall Switches on one switch plate)	Set
1101 (6)	Three-way Switch	Set
1101 (7)	Four-way Switch	Set
1101 (8)	Double Pole Switch	Set
1101 (9)	Three Pole Switch	Set
1101 (10)	Dimmer Switch	Set
1101 (11)	Master Selector Switch	Set
1101 (12)	Automatic Door Switch	Set
1101 (13)	Switch Bank	Set
1101 (14)a	Passive Infra-Red (Presence) Detector/Switch, Surface Mounted	Set
1101 (14)b	Passive Infra-Red (Presence) Detector/Switch, Recessed	Set
1101 (15)	Single Convenience Outlet/Receptacle, Grounding Type (GT)	Set
1101 (16)	Duplex Convenience Outlets/Receptacles (GT)	Set
1101 (17)	Heavy Duty Convenience Outlet/Receptacles (GT)	Set
1101 (18)	Weatherproof Single Convenience Outlet/Receptacle (GT)	Set
1101 (19)	Weatherproof Duplex Convenience Outlet/Receptacle (GT)	Set
1101 (20)	Special Purpose Outlet/Receptacle, (GT) for ACU, WH, etc.	Set
1101 (21)	Pop-up type/Floor Single Convenience Outlet/Receptacle (GT)	Set
1101 (22)	Pop-up type/Floor Duplex Convenience Outlet/Receptacle (GT)	Set
1101 (23)	Pop-up type/Floor Triplex Convenience Outlet/Receptacle (GT)	Set

1101 (24)	Explosion Proof type Single Convenience Outlet/Receptacle (GT)	Set
1101 (25)	Explosion Proof type Duplex Convenience Outlet/Receptacle (GT)	Set
1101 (26)	Single Convenience Outlet with Ground Fault Circuit Interrupter (GFCI)	Set
1101 (27)	Duplex Convenience Outlet with GFCI	Set
1101 (28)	PVC Tape, 19 mm dia. x 18 mm	Roll
1101 (29)	Rubber Tape/ Friction Tape, 19 mm dia. x 227 g	Roll
1101 (30)a	Mica Tubing, 6.35mm	Meter
1101 (30)b	Mica Tubing, 12.7mm	Meter
1101 (30)c	Mica Tubing, 19.0mm	Meter
1101 (30)d	Mica Tubing, 25.40mm	Meter
1101 (31)	Messenger Wire	Meter
1101 (32)	Guy Wire	Meter
1101 (33)	Wires and Wiring Devices	Lump Sum
1101 (34)	Repair/Replacement of Wires and Wiring Devices	Lump Sum

XXIX. ITEM 1201 - WATER PUMPING SYSTEM

1201.1 Description

This Item shall consist of furnishing and installation of water pumping system, inclusive of all pipings and pipe fitting connections, valves, controls, capacitive flow meters, electrical wirings, tanks and all accessories ready for service in accordance with the Plans and this Specification.

1201.2 Material Requirements

1201.2.1 Water Pump

Pumps shall be end suction centrifugal type conforming to the requirements of American Water Works Association (AWWA) E 101, Standard for Vertical Turbine Pumps – Line Shaft and Submersible Type or AWWA E 103, Standard for Horizontal and Vertical Line-Shaft Pumps, whichever is applicable. Booster pumps and jet pumps shall only be required if deemed necessary.

Pumps shall be supplied with a pump nameplate easy to read and corrosion resistance containing complete pump information including: pump manufacturer's name, serial number, pump model number, number of stages, speed, total dynamic head in meter and discharge

capacity in gpm (m3/hr or liters per second), pump horsepower, year manufactured, and the like and shall conform with the Technical Specification given by the designer.

The type, size, capacity, location, quantity and electrical requirements of pumping units shall be as specified in the Plans.

1201.2.2 Water Tank

1201.2.2.1 Overhead/Elevated Water Tank

The materials used for water storage structures shall provide stability and durability, as well as protect the quality of the stored water. Steel structures shall follow the current American Water Works Association standards concerning steel tanks, standpipes, reservoirs, and elevated tanks wherever they are applicable. Other materials of construction may be acceptable when properly designed to meet the requirements of this specification.

The tank shall be provided with manhole, cover, drain pipes, distribution pipe outlet, overflow pipes and air vent, and float switch or electrode to automatically stop and start the operation of the pump.

1. Polyethylene Tanks

Polyethylene tanks shall be made of 100% approved food grade polyethylene material conforming to the requirements of ASTM D1998, Standard Specification for Polyethylene Upright Storage Tanks. The polyethylene tanks shall be seamless and be treated to protect it from harmful ultraviolet rays.

2. Steel Tanks

Steel tanks shall be AISI steel Grade 304 conforming to AWWA D 100, Standard for Welded Carbon Steel Tanks for Water Storage or AWWA D 103, Standard for Factory-Coated Bolted Steel Tanks for Water Storage. The steel tanks shall be groove designed with built-in drain valve and air vent.

3. Fiberglass Tanks

Fiberglass tanks shall conform to the applicable requirements of AWWA D120- 09, Thermosetting Fiberglass-Reinforced Plastic Tanks

4. Concrete Tanks

Materials for the construction of concrete tanks shall be in accordance with the requirements of Item 900, Structural Concrete and Item 902, Reinforcing Steel. Waterproofing of water tanks shall be in accordance with Item 1016, Waterproofing.

1201.2.2.2 Saddle for Water Tank

Saddle shall be provided and shall conform to the recommendation of the manufacturer of the equipment. Equipment shall be situated in a concrete and non-concrete saddle. All spaces between equipment bases and concrete foundation shall be filled with cement mortar.

1201.2.3 Pipes and Fittings

Pipes and fittings shall be made of brass, copper, cast iron, galvanized malleable, galvanized wrought iron, galvanized steel or other approved materials conforming to the applicable requirements of Item 1002, Plumbing. All pipes and fittings of the same material shall be supplied by a single manufacturer to ensure uniformity of standards and composition.

1201.2.4 Valves

All valves shall be of a rating suitable for the design working pressure of the system and shall conform to the applicable requirements of Item 1603, Valves.

1201.2.5 Electrical Equipment and Appurtenances

All electrical equipment and appurtenances to be used for the system shall be in conformity with the Philippine Electrical Code (PEC), Part 1 and with the recommendations of the manufacturer. Wherever practical, electrical equipment and components shall be designed for the ultimate conditions and loads. Electrical equipment shall include panels, bussing, short circuit protective devices, motor starters, motor control centers (MCC) buckets, transformers, lighting panels, conduit and conductors.

Power supply shall also be provided by the Contractor at the pull box installed inside the machine room and shall furnish and install the main circuit breaker and starter with suitable ratings and capacities, conduits, wirings, fittings, devices and all other equipment and electrical connections needed to complete the electrical installation of the system.

1201.3 Construction Requirements

1201.3.1 General

The installation of all water pumping system equipment shall be in accordance with the requirements of AWWA Standards, ASME Standards, Philippine Society of Mechanical Engineering (PSME) Code and the Philippine Electrical Code (PEC), Part 1.

1201.3.2 Storage of Equipment and Appurtenances

Equipment should be stored in a dry space when they are delivered on site. Special rust preventive measures to protect the internal parts of pumps shall be applied if the equipment must be stored for an extended period of time. Such provisions shall be removed completely before final installation and the bearings should then be re-lubricated.

1201.3.3 Installation

1201.3.3.1 Pumps

Each pump and electric motor shall be installed in accordance with the written instruction of the manufacturer and under the direct supervision of the manufacturer's representative and the Mechanical Engineer. Pump assemblies shall be adjusted such that driving units are properly aligned, plumbed, and leveled with driven units and interconnecting shafts and couplings. Misalignment shall not be compensated by use of flexible couplings. After pump

and driver have been set in position, aligned, and shimmed to proper elevation, the space between bottom of baseplate and concrete foundation shall be grouted with poured, non-shrink grout of proper category. All wedges shall be removed after grout is set and pack void with grout. Connect suction and discharge piping without imposing strain to pump flanges.

Foundations shall be constructed in conformity with the instructions of the manufacturer and with the Plans and drawings. Anchor bolts and expansion bolts shall be set accurately. Anchor bolts shall be sized and furnished by the pump Manufacturer.

1201.3.3.2 Water Tanks

The erection of overhead tanks shall be in accordance with AWWA D 100 or AWWA D 102, whichever is applicable.

All welds in the tank and structural attachments shall be made in a manner to ensure complete fusion with the base metal, within the limits specified for each joint, and in strict accordance with the qualified welding procedure specifications. For bolted steel tanks, all bolts shall be located and installed in accordance with the instructions provided by the manufacturer. Gasketing and sealants or both shall be supplied by the manufacturer and installed between all joints in compliance with the erection instructions.

Water storage tanks shall be disinfected in accordance with AWWA C 652, Disinfection of Water Storage Facilities.

1201.3.3.3 Pipes and Fittings

Installation and disinfection of pipes and fittings shall conform to the requirements of Item 1002, Plumbing.

1201.3.3.4 Valves

Installation of valves shall conform to the requirements of Item 1063, Valves.

1201.3.3.5 Electrical Equipment and Appurtenances

All electrical equipment and appurtenances shall be installed in accordance with the PEC Part 1 and with the instructions of the manufacturer.

1201.3.4 Testing

Appropriate test shall be done to demonstrate that the system complies with the requirements of the Plans and Specifications. All pumps and water storage tanks shall be tested in accordance with the applicable AWWA standards.

Testing of pipes, fittings and valves shall conform to Item 1002, Plumbing and Item 1603, Valves.

1201.3.5 Guarantee and Service

All equipment, materials and workmanship shall be guaranteed for a period of 1 year from date of completion. At any time within the period of guarantee and upon notification, the

Contractor shall repair and rectify the deficiencies, including replacement of parts or entire units.

1201.3.6 Miscellaneous

The Contractor shall submit three (3) bound copies "AS BUILT" diagrams to ensure compliance with the shop drawings, part lists, serial number and inventory of equipment including manufacturers operating and maintenance manuals.

All standard tools and equipment shall be furnished for proper and regular maintenance of installed equipment.

1201.4 Method of Measurement

The work under this Item shall be measured either by set and lump sum actually placed and installed water pumping system as indicated on the Plans.

1201.5 Basis of Payment

The quantity as determined in Section 1201.4, Method of Measurement shall be paid for at unit price stipulated in the Contract's Bill of Quantities. The payment shall constitute the full compensation for furnishing all the necessary materials, providing necessary equipment and tools in installing the water pumping system, labor cost and all the incidental expenses necessary to complete the work.
Payment shall be made under:

Pay Item	Description	Unit of Measurement
1201 (1)	Water Pumping System	Lump Sum
1201 (2)	Centrifugal Pump with control	Set
1201 (3)	Submersible Multi-Stage Deepwell Pump with control	Set
1201 (4)	Submersible Sump Pump with control	Set
1201 (5)	Booster Pump with control	Set
1201 (6)	Jet Pump with control	Set
1201 (7)	Water Tank	Set
1201 (7)a	Water Tank, Stainless	Set
1201 (7)b	Water Tank, Galvanized Iron	Set
1201 (7)c	Water Tank, Polyethylene	Set
1201 (7)d	Water Tank, Concrete	Set
1201 (8)	Valves and Pipe Fittings	Lump Sum
1201 (9)	Electrode	Set

XXX. ITEM 1600 – EXCAVATION FOR WATER SUPPLY SYSTEM

1600.1 Description

This Item shall consists of the necessary excavation for removal of all foundation of materials of whatever nature encountered including all obstructions of any nature that would interfere with the proper execution and completion of the work.

1600.2 Construction Requirements

1600.2.1 General

The removal of said materials shall conform to the lines and grades shown on the approved Plans and Specifications. Unless otherwise provided, the entire construction site shall be stripped of all vegetation and debris and such materials shall be removed from the site prior to performing any excavation. The Contractor shall furnish, place and maintain all supports and shoring that may be required for the sides of the excavation, and all pumping, ditching or other approved measures for the removal or exclusion of water, including taking care of storm water and waste water reaching the site of work from any source so as to prevent damage to the work and adjoining property.

In excavation which workers may be required to enter, excavated or other materials shall be stockpiled temporarily at least 600 mm from the edge of the trench and shall comply with the prevailing laws and issuances pertaining to safety requirements.

Excavations shall be dewatered and maintained dewatered so that the materials is excavated in its natural state and construction of the foundations is completed in the dry condition. The bottom of the excavation shall be kept free from excessive moisture and free-flowing water.

1600.2.2 Excavation beneath Proposed Structures

Excavation shall be carried to the grade of the bottom of the footing or slab. Unless otherwise specified in the Plans, the areas beneath proposed structures shall be over-excavated. After the required excavation or over-excavation has been completed, the exposed surface shall be scarified to the depth of 150 mm brought to optimum moisture content and shall be compacted to 100% of maximum dry density.

1600.2.3 Excavation beneath Areas to be Paved

Excavation under areas to be paved shall extend to the bottom of the aggregate base, if such base is called for; otherwise, it shall extend to the bottom of paving. After the required excavation has been completed, the exposed surface shall be scarified, brought to optimum moisture content and compacted to 100% of maximum dry density.

1600.2.4 Pipeline Trench Excavation/ Excavation for Foundation of Structure

Unless otherwise shown on the approved Plans and Specifications, excavation for pipeline shall be open-cut trenches.

The bottom of the trench, including any shoring, shall have a minimum width equal to the outside diameter of the pipe plus 300 mm and a maximum width equal to the outside diameter of the pipe plus 600 mm. The bottom of the trench shall be excavated uniformly to the grade of the bottom of the pipe.

The trench bottom shall be given a final trim using a string line for establishing grade, such that each pipe section when first laid will be wholly in contact with the ground or bedding along the extreme bottom of the pipe.

Rounding out the trench to form a cradle shall not be required. The maximum amount of open trench permitted at any one time and in one location shall be 100 m or the length necessary to accommodate the number of pipes installed in one day, whichever is greater.

Barricades and warning lights shall be provided and maintained for all trenches except at intersections and driveways in which case heavy steel plates, adequately braced bridging or other type of crossing capable of supporting vehicular traffic shall be furnished.

1600.2.5 Excavation in Lawn Areas

Where pipelines excavation occurs in lawn areas, the sod shall be carefully removed and stockpiled to preserve it for replanting. Excavated material shall be placed on the lawn provided a drop cloth or other suitable method is employed to protect the lawn from damage. The lawn shall not remain covered for more than 72 h. Immediately after the installation and completion of backfilling, the sod shall be replanted in a manner so as to restore the lawn as near as possible to its original condition.

1600.2.6 Rock Excavation

Rock excavation shall include removal and disposal of stones having a volume of 1 m^3 or more in existing ledges, bedding deposits and unsatisfied masses that cannot be excavated without blasting or the used rippers.

1600.2.7 Excavation beneath Proposed Concrete Reservoir

After the reservoir area has been stripped of all vegetation and debris, as specified in 1600.2.1, lawn and top soil from the top 600 mm of excavated soil shall be removed and stockpiled for possible later use as fill or around the reservoir and for miscellaneous top soil. Excavation under the reservoir shall extend to the bottom of the draindock layer. After such excavation had been completed, the exposed surface shall be rolled with heavy equipment to provide a reasonably smooth surface for placement of draindock.

1600.3 Method of Measurement

The quantity to be paid for shall be the volume of the materials excavated in cubic meter calculated by multiplying the horizontal area of the bottom of the structure or open-cut trench by the average depth. The average depth shall be calculated from the finished surface of the grade shown on the drawing or the original ground level, whichever is the lowest.

Dewatering shall be paid for on a lump sum basis, and no separate measurement shall be made for this work.

1600.4 Basis of Payment

Payment for all work under this Item shall be made at the Contract Unit Price per cubic meter for each earthwork which price and payment shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete all work.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1600 (1)	Excavation Beneath Proposed Structures	Cubic Meter
1600 (2)	Pipeline Trench Excavation	Cubic Meter

XXXI. ITEM 1726 – ELECTROMECHANICAL EQUIPMENT AND FACILITIES FOR PUMPING STATIONS

1726.1 Description

This Item shall consist of furnishing and installing electromechanical equipment and facilities for pumping stations in accordance with the Plans and this Specifications.

1726.2 Definition

1726.2.1 Motor Control Center (MCC)

A motor control center (MCC) is a metal floor-mounted assembly in NEMA 3R, powder- coated or NEMA 4x of one (1) or more metal enclosed vertical sections typically having a horizontal common power bus and principally containing combination of motor-control units, over current protection and overloading devices. These units are mounted one above the other in the vertical sections. The sections normally incorporate vertical copper bus bars connected to the common power bus, thus extending the common power supply to the individual units. Power may be supplied to the individual units by copper bus bar connections, bolt or bolted connection or suitable wiring. The motor control center shall be installed to control all main pumps and pumping station facilities.

1726.2.2 Local Control Panel Center (LCPC)

An enclosed metal assembly in NEMA 3R, powder-coated or NEMA 4x of a systematic and standard arrangement of two (2) or more components such as motor, magnetic controllers, overload relays, fused disconnect switches, and circuit breakers and related control devices such as pushbutton stations, selector switches, timers, switches, control relays, and the like with associated wiring, terminal lugs, pilot lights, and similar components. The local control panel shall be installed for the control of auxiliary and facility equipment such as cranes, rakes and flood gates.

1726.3 Material Requirements

1726.3.1 Motor Control Center (MCC)

1726.3.1.1 General

The motor control center shall be completely enclosed by metal stud/powder- coated or stainless dead-front type with operating handles, push buttons, name plates, mounted on the front and all arranged to present a neat appearance. It shall consist of vertical sections divided into isolated compartments for the individual motor starters and other major equipment.

The motor control center (enclosure and equipment) shall meet the requirements of Codes and Standards such as UL 845 (Standard for Motor Control Centers) and Philippine Electrical Code (PEC) Part 1, and as per recommendations of the manufacturer.

All MCC equipment shall be marked in accordance with the requirements of the PEC, Part 1.

1726.3.1.2 Enclosure

The enclosure of the MCC shall surround the equipment to protect personnel from contact with live buses or connections and to protect equipment from external conditions. The selection of type of enclosure to be used shall be based on the location of the MCC. The type of metal enclosure to be used shall conform to the requirements of the PEC, Part 1.

1726.3.1.3 Equipment and Appurtenances

A motor control center shall contain any of the combination of the following equipment such as:

1. Full-voltage reversing or non-reversing combination motor control units
2. Full-voltage multispeed combination motor-control units
3.Reduced-voltage part-winding, wye-delta or auto-transfer combination motor-control unit
4. Solid-state industrial controllers such as adjustable-speed drives, programmable controllers, protective relays
5. Lighting or distribution panelboards
6. Feeder-tap units
7. Incoming-line equipment, such as main lugs, fusible switch, isolation switch, or air circuit breaker
8. Control or lighting transformers
9. Special equipment assemblies
10. Over voltage and low voltage control unit device
11. Ground system component
12. Lightning Protection System

The foregoing equipment shall also contain such items as pushbuttons, selector switches, indicating lights, control transformers, control circuit fuses and auxiliary contacts incorporated as an integral part of the above units.

The specifications of all MCC equipment and appurtenances shall conform to the requirements of the UL 845, PEC, and recommendations of the manufacturer.

1726.3.1.4 Wires and Cables

All wires and cables for MCC equipment shall conform to the applicable requirements of Item 1101, Wires, Cables and Wiring Devices.

Grounding cables shall be provided and the size shall be in accordance with the PEC when not shown on the Plans or drawings.

1726.3.1.5 Raceways

Raceways shall conform to the applicable requirements of Item 1100, Conduits, Boxes and Fittings.

1726.3.1.6 Panelboard

NEMA Enclosure, Manual Transfer Switch & Automatic Transfer Switch shall conform to the applicable requirements of Codes and Standards such as PEC Part 1, and recommendations of the manufacturer.

1726.3.2 Generating Set

1726.3.2.1 General

Generator sets shall conform to the requirements of the Philippine Electrical Code (PEC) Part 1.

Generating sets shall be required to allow the pumping station to operate under normal conditions in case of a power failure when designated as stand-by. The generator set shall be sized to accommodate all loads at the pumping station and shall be of type suitable for locations in which they are installed. The rating of generators shall be in kilovolt amperes, kilowatts, full load current, voltages, cycles and number of phase.

Each generator shall be provided with a nameplate giving the manufacturer's name, engine (Gas or Diesel, capacity & specs), the rated frequency, power factor, number of phases if alternating current, the subtransient and transient impedances, the rating in kilovolt amperes & kilowatt, the normal volts and amperes corresponding to the rating, rated revolutions per minute, insulation system class and rated ambient temperature or rated temperature rise, time rating, separate elevated fuel tank and back-up heavy duty automatic battery charger.

Generating sets shall be provided with a floor mounted 4-sided soundproofing blanket enclosure. The enclosure shall be as large as possible to allow less heat buildup and also to be more effective at reducing the noise output from reaching other areas and acoustically isolating the pump to contain structure borne sound being transmitted from where it is mounted.

1726.3.2.2 Exhaust System

Each generating set shall be equipped with its own exhaust system. Exhaust piping shall not exert more than 37 kg of weight on the engine when the system is at operating temperature. Flexible connections shall also be provided to relieve exhaust system components of vibrational fatigue. They shall prevent vibration transmission throughout the structure and shall accommodate misalignment problems at installation. The appropriate exhaust system including piping shall be in accordance with the recommendations of the generating set manufacturer.

1726.3.2.3 Concrete Pad/Foundation

The generating set shall be mounted on a concrete pad/foundation. The foundation shall protect the unit from moisture that could occur from seepage. Materials for the construction

of concrete pad/foundation shall conform to the applicable requirements of Item 900, Structural Concrete.

1726.3.3 Local Control Panel Center (LCPC)

1726.3.3.1 General

The local control panel center (enclosure and devices) shall meet the requirements of Codes and Standards such as UL 508 (Industrial Control Equipment) and Philippine Electrical Code (PEC) Part 1, and recommendations of the manufacturer.

All LCPC units shall be marked in accordance with the requirements of the PEC Part 1.

1726.3.3.2 Enclosure

The requirement for the enclosure of LCPC shall be the same with Section 1726.3.1.2.

1726.3.3.3 Devices and Appurtenances

The specifications of all devices and appurtenances such as controllers, push buttons, crane limit switches, auxiliary contacts and master switches shall conform to the applicable requirements of UL 508 and the PEC Part 1 and with the recommendations of the manufacturer.

1726.3.3.4 Wires and Cables

All wires and cables for LCPC equipment shall conform to the applicable requirements of Item 1101, Wires, Cables and Wiring Devices.

The size of the control panel conductors shall have an ampacity of not less than 125% of the full-load current rating of all resistance heating loads plus 125% of the full-load current rating of the highest rated motor plus the sum of the full-load current ratings of all other connected motors and apparatus based on their duty cycle that may be in operation at the same time.

1726.3.3.5 Raceways

Raceways shall conform to the applicable requirements of Item 1100, Conduits, Boxes and Fittings.

1726.4 Construction Requirements

1726.4.1 General

All equipment and enclosures of motor control units, generators and local control panel center shall be installed so that it complies with the standards and codes such as UL 845, UL 508, the PEC and the recommendations of the Manufacturer.

1726.4.2 Motor Control Center (MCC)

1726.4.2.1 Unit Mounting

Construction of enclosure for MCC shall be in accordance with UL 845.

Provision shall be made so that each combination of motor-control unit and feeder-tap unit may be readily removed as a unit for rearrangement, replacement or repair. Exceptions shall be permitted where the size or weight of the unit makes its removal impracticable.

Unit doors shall be hinged and attached either to the vertical section or to the unit. Where the door is mounted on the unit, removal of the unit shall not leave the bus so exposed that accidental contact with it is likely.

A vertical section shall be provided to support the vertical and horizontal buses, the units, the doors and covers.

A vertical section shall be self-supporting and properly bolted to the floor or otherwise secured. These sections shall be assembled into a group to which additional sections may be readily added.

1726.4.2.2 Interlocking of Doors

Access to each combination motor-control unit or feeder tap unit shall be provided by a single separate hinged door, interlocked with its associated disconnecting device so that the door cannot be opened without first opening the disconnecting device.

Where two (2) sets of circuit disconnecting means are mounted in a single compartment to form a dual feeder tap unit, each disconnecting device shall be interlocked with its associated door. Provision shall be made for locking the disconnecting device in the open position when the door is closed.

Where required by the particular application, a deactivating means (defeater) shall be provided to permit entry into the enclosure when the disconnecting device is closed.

1727.4.2.3 Copper Busbars and Conductors

Bus bars shall be protected from physical damage and be held firmly in place. Other than for required interconnections and control wiring, only those conductors that are intended for termination in a vertical section shall be located in that section.

Conductors shall be permitted to travel horizontally through vertical sections where such conductors are isolated from the bus bars by a barrier. The conductor cable/wire shall be color coded.

The phase arrangement on three (3) - phase horizontal common power and vertical buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front, combination of wye-delta connection is used for starting system with large motors. Other bus bar arrangements shall be permitted in addition to the existing installations and shall be marked.

The minimum wire-bending space at the motor control center terminals and minimum gutter space shall be as required in the PEC.

Spacings between motor control center bus terminal and other bare metal parts shall be based on the approved specification, design and shop drawing of control center by the Professional Electrical and Mechanical Engineer.

Barriers shall be placed in all service-entrance motor control centers to isolate service bus bars and terminals from the remainder of the motor control center.

1726.4.2.4 Overcurrent Protection

The motor control center shall be provided with overcurrent protection in accordance with the PEC. The ampere rating or setting of the overcurrent protective device shall not exceed the rating of the common power bus. This protection shall be provided by an overcurrent protective device located ahead of the motor control center or a main overcurrent protective device located within the motor control center.

1726.4.3 Generating Set

The installation of generators shall meet the requirements of the PEC, Part 1. The ampacity of the conductors from the generator terminals to the first distribution device(s) containing over-current protection shall be based on the nameplate current rating of the generator and approved designed capacity by the Engineer.

Where wires pass through an opening in an enclosure, conduit box, or barrier, a bushing/locknut shall be used to protect the conductors from the edges of an opening having sharp edges. The bushing shall have smooth, well-rounded surfaces where it may be in contact with the conductors. The bushing and locknut shall be made of a material not deleteriously affected by oils, grease, or other contaminants.

The generator should be grounded and shall not be exposed to accidental contact where accessible to unqualified persons.

Generators shall be equipped with disconnect(s) by means of which the generator and all protective devices and control apparatus are able to be

disconnected entirely from the circuits supplied by the generator except where both of the following conditions apply:

1. The driving means for the generator can be readily shut down.

2. The generator is not arranged to operate in parallel with another generator or other source of voltage.

Generators shall be provided with overcurrent protection in accordance to the applicable requirements of the PEC, Part 1.

1726.4.4 Local Control Panel Center (LCPC)

1726.4.4.1 Unit Mounting

Construction of enclosure for LCPC shall be in accordance with UL 508.

Industrial control panel enclosures shall not be used as junction boxes, auxiliary gutters, or raceways for conductors feeding through or tapping off to other switches or overcurrent devices, unless adequate space for this purpose is provided.

1726.4.4.2 Busbars and Conductors

Busbars shall be protected from physical damage and be held firmly in place.

The phase arrangement on 3-phase horizontal common power and vertical buses shall be A, B, C from front to back, top to bottom, or left to right, as viewed from the front, combination of wye-delta connection is used for starting system with large motors of the industrial control panel. Other busbars arrangements shall be permitted for additions to existing installations and shall be marked.

The conductors shall not fill the wiring space at any cross section to more than 40% of the cross-sectional area of the space, and the conductors, splices, and taps shall not fill the wiring space at any cross section to more than 75% of the cross-sectional area of that space.

Wire bending space for the main supply terminals and for other terminals shall be in accordance with the requirements in the PEC, Part 1.

Multisection control panels shall be bonded together with an equipment grounding conductor or an equivalent grounding bus, sized in accordance with the PEC, Part 1. Equipment grounding conductors shall terminate on this grounding bus or to a grounding termination point provided in a single-section control panel.

1726.4.4.3 Overcurrent Protection

The control panel shall be provided with overcurrent protection in accordance with the PEC, Part 1.

The rating or setting of the overcurrent protective device for the circuit supplying the control panel shall not be greater than the sum of the largest rating or setting of the branch-circuit short-circuit and ground-fault protective device provided with the industrial control panel, plus 125 percent of the full- load current rating of all resistance heating loads, plus the sum of the full-load currents of all other motors and apparatus that could be in operation at the same time.

1726.5 Personnel Qualification

The installation of equipment and devices for motor control center, generators and local control panel center including wiring shall be done by a certified installer under the supervision based on the guidelines of Republic Act No. 8495, Philippine Mechanical Engineering Act of 1998 and Republic Act No. 7920, New Electrical Engineering Law.

The installer shall be certified and experienced in the proper installation of all equipment and devices and trained by a MCC/LCPC manufacturer.

1726.6 Testing

All mechanical and electrical equipment shall be tested to the satisfaction of the Engineer before any facility is put into operation. Test shall be made to determine whether the equipment has been properly assembled, aligned, adjusted and connected. Any changes, adjustments or replacements required to make the equipment operate as specified shall be carried out by the Contractor as part of the work. In addition to the mentioned testing conditions, the following field test requirements should be considered for electrical equipment, materials and components. The generator should be tested by no load and full load test at the plant from the time of delivery. Qualified personnel should operate the testing.

1. System test - Each panel board shall be tested with the power equipment connected, circuit breakers closed and all loads and fixtures permanently connected for their intended operation for a minimum of 24 h continuous operation in the presence of the Engineer, at the expense of the Contractor. The entire installation shall be free from any ground fault and from any short circuit. In no case shall the insulation resistance be less than that allowed by PEC regulations for Electrical Equipment of Buildings and/or manufacturer's recommendations. Failures shall be corrected in a manner satisfactory to the Engineer.

2. Performance Test and Equipment Setting - It shall be the responsibility of the Contractor to test the entire electrical system for the proper equipment operation. Setting of all protective relays, pilot devices and auxiliary systems shall conform with the operating requirements of the installations. The Contractor shall turn-over the entire electrical installation in a satisfactory working condition.

3. Generating sets shall be required to undergo emission testing to demonstrate compliance with emission standards before a permit is issued by the Environmental Management Bureau (EMB) of the Department of

Environment and Natural Resources (DENR). This is in compliance with Republic Act No. 8749, otherwise known as the "Philippine Clean Air Act".

4. Orientation to the qualified personnel for turn-over and submittal of book manual operation is a must.

1726.7 Method of Measurement

The work under this Item shall be measured by lump sum actually placed and installed motor control center and local control panel center, and generating set shall be measured by set as indicated on the Plans.

1726.8 Basis of Payment

The accepted quantities, measured as prescribed in Section 1726.7, Method of Measurement shall be paid for at the Contract Unit Price for Electromechanical for Pumping Station which price and payment shall be full compensation for furnishings and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1726 (1)	Motor Control Center (for main pumps and facilities)	Lump Sum
1726 (2)	Generating Set	Set
1726 (3)	Local Control Panel Center (for Auxiliary Equipment)	Lump Sum

XXXII. ITEM 1727 – AUXILIARY AND FACILITY EQUIPMENT

1727.1 Description

This Item of work shall consist of furnishing and installation of all materials, components, and equipment to complete the requirements for Auxiliary and Facility Equipment in accordance with the Plans and this Specification.

1727.2 Definition

Bridge. The part of a crane consisting of girders, trucks, end ties, footwalks, and drive mechanism which carries the trolley or trolleys.

Bumper (buffer). An energy absorbing device for reducing impact when a moving crane or trolley reaches the end of its permitted travel; or when two moving cranes or trolleys come in contact.

Cab. The operator's compartment on a crane.

Clearance. The distance from any part of the crane to a point of the nearest obstruction.

Drum. The cylindrical member around which the ropes are wound for raising or lowering the load.

Emergency Stop Switch. A manually or automatically operated electric switch to cut off electric power independently of the regular operating controls.

Equalizer. A device which compensates for unequal length or stretch of a rope.

Gantry Crane. A crane similar to an overhead crane except that the bridge for carrying the trolley or trolleys is rigidly supported on two or more legs running on fixed rails or other runway.

Hoist. An apparatus which may be a part of a crane, exerting a force for lifting or lowering.

Overhead Crane. A crane with a movable bridge carrying a movable or fixed hoisting mechanism and traveling on an overhead fixed runway structure.

Rated load. The maximum load for which a crane or individual hoist is designated and built by the manufacturer and shown on the equipment nameplate/s.

Rope. Refer to wire rope, unless otherwise specified.

Runway. An assembly of rails, beams, girders, brackets, and framework on which the crane or trolley travels.

Stop. A device to limit travel of a trolley or crane bridge. This device normally is attached to a fixed structure and normally does not have energy absorbing ability.

Trolley. The unit which travels on the bridge rails and carries the hoisting mechanism.

Standard References Acronyms:

ANSI. American National Standards Institute

ASME. American Society of Mechanical Engineers

ASTM. American Society for Testing and Materials

AWWA. American Water Works Association

CMAA. Crane Manufacturers Association of America, Inc.

OSHA. Occupational Safety and Health Standard (U.S. Department of Labor)

1727.3 Material Requirements

1727.3.1 Hoist Crane

Hoist crane shall have a minimum lifting capacity of 2 tons at all possible ranges.

1727.3.2 Overhead and Gantry Cranes

Overhead and Gantry Cranes shall meet any of the following applicable specifications:

1. ANSI/ASME B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)

2. ANSI/ASME B30.11, Monorails and Underhung Cranes

3. ANSI/ASME B30.17, Overhead and Gantry Cranes (Top Running Bridge, Single Girder, Underhung Hoist)

4. CMAA 70, Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Travelling Cranes

5. CMAA 74, Specifications for Top Running and Under Running Single Girder Electric Overhead Travelling Cranes Utilizing Under Running Trolley Hoist

6. OSHA 1910.179, Overhead and Gantry Cranes

1727.3.2.1 Rated Load Markings

The rated load of the overhead and gantry cranes shall be marked on each side of the crane and shall be legible from the ground or floor.

The rated load of the hoist shall be marked on the hoist or trolley unit or its load block and shall be legible from the ground or floor. If the crane has more than one hoisting unit, each hoist shall have its rated load marked on the hoist or trolley unit or its load block.

1727.3.2.2 Manufacturer's Identification Number

Overhead and gantry cranes shall be marked with manufacturer's identification information, on a plate or label attached to the crane, as follows:

1. Name and address of manufacturer
2. Manufacturer's model or serial number
3. Voltage of AC or DC power supply and phase and frequency of AC power supply
4. Date of Manufacture

1727.3.2.3 Stops and Bumpers

Overhead and gantry cranes shall be provided with trolley stops, bridge bumpers and trolley bumpers.

Stops

Stops shall be provided at the limits of travel of the trolley. It shall be fastened to resist forces applied when contacted.

Bridge Bumpers

A crane shall be provided with bumpers or other automatic means providing equivalent effect, unless the crane travels at a slow rate of speed and has a faster deceleration rate due to the use of sleeve bearings, or is not operated near the ends of bridge and trolley travel, or is restricted to a limited distance by the nature of the crane operation and there is no hazard of striking any object in this limited distance, or as used in similar operating conditions.

The bumpers shall have sufficient energy absorbing capacity to stop the crane when travelling at a speed of at least 40% of rated load speed.

The bumper shall be so mounted that there is no direct shear on bolts.

Bumpers shall be designed and installed as to minimize parts falling from the crane in case of breakage.

Trolley Bumpers

A trolley shall be provided with bumpers or other automatic means of equivalent effect, unless the trolley travels at a slow rate of speed, or is not operated near the ends of bridge and trolley travel, or is restricted to a limited distance of the runway and there is no hazard of striking any object in this limited distance, or is used in similar operating conditions.

When more than one (1) trolley is operated on the same bridge, each shall be equipped with bumpers or equivalent on their adjacent ends.

Bumpers or equivalent shall be designed and installed to minimize parts falling from the trolley in case of breakage.

1727.3.2.4. Guards for Hoisting Ropes

Guards shall be installed if hoisting ropes run near enough to other parts that will result to fouling or chafing.

A guard shall be provided to prevent contact between bridge conductors and hoisting ropes if they could come into contact.

1727.3.2.5 Sheaves

Sheave grooves shall be smooth and free from surface defects which could cause rope damage.

Sheaves carrying ropes which can be momentarily unloaded shall be provided with close-fitting guards or other suitable devices to guide the rope back into the groove when the load is applied again.

The sheaves in the bottom block shall be equipped with close-fitting guards that will prevent ropes from becoming fouled when the block is lying on the ground with ropes loose.

Pockets and flanges of sheaves used with hoist chains shall be of such dimensions that the chain does not catch or bind during operation.

All running sheaves shall be equipped with means for lubrication. Permanently lubricated, sealed and/or shielded bearings meet this requirement.

1727.3.2.6 Wire Ropes

The rated load divided by the number of parts of rope shall not exceed 20% of the nominal breaking strength of the rope.

Rope shall be secured to the drum as follows:

1. No less than two (2) wraps of rope shall remain on the drum when the hook is in its extreme low position.

2. Rope end shall be anchored by a clamp securely attached to the drum, or by a socket arrangement approved by the crane or rope manufacturer.

Rope clips attached with U-bolts shall have the U-bolts on the dead or short end of the rope. Spacing and number of all types of clips shall be in accordance with the clip manufacturer's recommendation. Clips shall be drop-forged steel in all sizes manufactured commercially. When a newly installed rope has been in operation for an hour, all nuts on the clip bolts shall be retightened.

Swaged or compressed fittings shall be applied as recommended by the rope or crane manufacturer.

Wherever exposed to temperatures, at which fiber cores would be damaged, rope having an independent wire rope or wire-strand core, or other temperature-damaged resistant core shall be used.

1727.3.2.7 Electric Chain Hoist

Industrial electric chain hoists shall be rated according to capacities as follows:

0.25, 0.5, 0.8, 1.0, 1.6, 2.0, 3.2 and 5.0 t.

1727.3.2.8 Equalizers

If a load is supported by more than one part of rope, the tension in the parts shall be equalized.

1727.3.2.9 Hooks

Hooks shall meet the manufacturer's recommendations and shall not be overloaded.

1727.3.2.10 Brakes

Brakes for Hoists

Each independent hoisting unit of a crane shall be equipped with at least one
(1) self-setting brake, hereafter referred to as a holding brake, applied directly to the motor shaft or some part of the gear train.

Each independent hoisting unit of a crane, except worm-geared hoists, the angle of whose worm is such as to prevent the load from accelerating in the lowering direction shall, in addition to a holding brake, be equipped with control braking means to prevent over speeding.

Holding Brakes

Holding brakes for hoist motors shall have not less than the following percentage of the full load hoisting torque at the point where the brake is applied.

1. 125% when used with a control braking means other than mechanical.
2.100% when used in conjunction with a mechanical control braking means.
3. 100% each if two (2) holding brakes are provided.

Holding brakes on hoists shall have ample thermal capacity for the frequency of operation required by the service.

Holding brakes on hoists shall be applied automatically when power is removed.

Where necessary holding brakes shall be provided with adjustment means to compensate for wear.

The wearing surface of all holding-brake drums or discs shall be smooth.

Each independent hoisting unit of a crane handling hot metal and having power control braking means shall be equipped with at least two (2) holding brakes.

Control Braking Means

A power control braking means such as regenerative, dynamic or counter torque braking, or a mechanically controlled braking means shall be capable of maintaining safe lowering speeds of rated loads.

The control braking means shall have ample thermal capacity for the frequency of operation required by service.

Brakes for Trolleys and Bridges

Foot-operated brakes shall not require an applied force of more than 32 kg to develop manufacturer's rated brake torque.

Brakes may be applied by mechanical, electrical, pneumatic, hydraulic, or gravity means.

Where necessary brakes shall be provided with adjustment means to compensate for wear. The wearing surface of all brakedrums or discs shall be smooth.

All foot-brake pedals shall be constructed so that the operator's foot will not easily slip off the pedal.

Foot-operated brakes shall be equipped with automatic means for positive release when pressure is released from the pedal.

If holding brakes are provided on the bridge or trolleys, they shall not prohibit the use of a drift point in the control circuit.

Brakes on trolleys and bridges shall have ample thermal capacity for the frequency of operation required by the service to prevent impairment of functions from overheating.

1727.3.2.11 Rail Sweeps

Bridge trucks shall be equipped with sweeps which extend below the top of the rail and project in front of the truck wheels.

1727.3.3 Automatic Trash Rake Complete with Accessories Ready for Service, Primary

It shall be a fully automated system and shall either be a stationary unit or as a traversing unit that serves more than one (1) bay. If possible, it is better if it has the capability to be operated manually at the site.

As much as possible, the rake shall fully penetrate the intake's bar/screen, so that even embedded and trapped debris is removed cleanly.

It shall have a safe working/lifting load capacity of 250 kg, or as required by the Engineer.

If possible, debris shall be loaded directly into a dump skip or trailer, eliminating the need for additional handling.

1727.3.4 Trash Screen Rake Complete with Accessories Ready for Service, Secondary

It shall be made of either aluminum, stainless steel, carbon steel or hot dipped galvanized steel. Some of its components can be made with non-metallic composites.

It shall capture floating and submerged debris within waterways.

Minimum and maximum bar/screen spacing shall be 12 mm and 200 mm, respectively.

1727.3.5 Hydraulic Gate Complete with Accessories Ready for Service

Hydraulic gate shall conform to any of the following applicable specifications:

1. Design of Hydraulic Steel Structures Manual, U.S. Army Corps of Engineers
2. AWWA C513, Standard for Open Channel, Fabricated Metal Slide Gates
3. AWWA C501, Standard for Cast-Iron Sluice Gates

1727.3.6 Horizontal Conveyor Complete with Accessories Ready for Service

Horizontal conveyors shall meet the applicable requirements for design, construction, inspection, testing, maintenance, and operation, as prescribed in the ANSI B20.1, Safety Code for Conveyors, Cableways, and Related Equipment.

Means for stopping the motor or engine shall be provided at the operator's station. Conveyor systems shall be equipped with an audible warning signal to be sounded immediately before starting up the conveyor.

If the operator's station is at a remote point, similar provisions for stopping the motor or engine shall be provided at the motor or engine location.

Emergency stop switches shall be arranged so that the conveyor cannot be started again until the actuating stop switch has been reset to running or "on" position.

1727.3.7 Inclined Conveyor Complete with Accessories Ready for Service

Inclined conveyor shall conform to ANSI B20.1, Safety Code for Conveyors, Cableways, and Related Equipment.

Inclined Conveyor shall be made either from stainless steel, anodized aluminum and/or galvanized material for high corrosion and abrasion resistance.

If possible, it shall have an easy disassembling and can be conveniently cleaned.

1727.3.8 Trash Hopper

If required, trash hopper shall be provided and shall conform to ANSI B20.1, Safety Code for Conveyors, Cableways, and Related Equipment.

1727.4 Construction Requirements

1727.4.1 Overhead and Gantry Cranes

1727.4.1.1 Crane Installation

Minimum clearance of 8 cm overhead and 6 cm laterally shall be provided and maintained between crane and obstructions.

Access to the cab and/or bridge walkway shall be by a conveniently placed fixed ladder, stairs, or platform requiring no step over any gap exceeding 31 cm.

1727.4.1.2 Foundation

Crane foundation shall conform to the manufacturer's requirements.

1727.4.1.3 Electrical Requirement

Electrical Wiring and Devices

Electrical wirings and devices shall comply with the following requirements or as per requirement by manufacturer.

1. The control circuit voltage shall not exceed 600 V for AC or DC current.

2. The voltage at pendant push-buttons shall not exceed 150 V for AC and 300 V for DC where pendant control boxes shall be constructed to prevent electrical shock and shall clearly marked for identification of functions.

3. Where multiple conductor cable with a suspended push-button station is used, it must be supported with acceptable condition that will protect the electrical conductors against strain.

Electrical Equipment

Electrical equipment shall be located or enclosed so that, under normal operating conditions, energized parts will not be exposed to inadvertent contact. Energized parts of electrical equipment shall be protected from direct exposure to grease, oil, and moisture, and they should be protected from dirt. If guards are provided for energized parts, the guards shall be constructed or located so that they cannot be deformed, under normal operating conditions, to make inadvertent contact with energized parts.

Controllers

1. Controller shall be located within convenient reach of the operator.

2. Crane not equipped with spring-return controllers or momentary contact push-buttons shall be provided with a device which will manually or automatically operated electric switch to cut off electric power independently of the regular operating controls.

1727.4.1.4 Testing Operational Tests

Prior to initial use, the crane shall be tested to insure compliance with this specification including the following functions:

1. Hoisting and lowering
2. Trolley travel
3. Bridge travel
4. Limit switches, locking and safety devices

The trip setting of hoist limit switches shall be determined by tests with an empty hook traveling in increasing speeds up to the maximum speed. The actuating mechanism of the limit switch shall be located so that it will trip the switch, under all conditions, in sufficient time to prevent contact of the hook or hook block with any part of the trolley.

Rated Load Test

Test loads shall not be more than 125% of the rated load unless otherwise recommended by the manufacturer.

1727.5 Method of Measurement

The quantity to be paid for will be measured as per individual item detailed in Subsection 1727.6, Basis of Payment as furnished on site and in accordance with these design standard, Specifications and as accepted by the Engineer.

1727.6 Basis of Payment

The accepted quantities measured shall be paid for at the Contract Unit Price per set for the type specified, complete in place, which price and payment shall be full compensation for furnishing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Item.

Payment shall be made under:

Pay Item	Description	Unit of Measurement
1727 (1)	Hoist Crane, tons	Set
1727 (2)a	Overhead Crane, 5 tons capacity chain hoist with trolley	Set
1727 (2)b	Overhead Crane, 7.5 tons capacity chain hoist with trolley	Set
1727 (2)c	Overhead Crane, 10 tons capacity chain hoist with trolley	Set
1727 (2)d	Overhead Crane, 15 tons capacity chain hoist with trolley	Set
1727 (2)e	Overhead Crane, 20 tons capacity chain hoist with trolley	Set
1727 (3)a	Gantry Crane, 5 tons capacity chain hoist with trolley	Set

1727 (3)b	Gantry Crane, 7.5 tons capacity chain hoist with trolley	Set
1727 (3)c	Gantry Crane, 10 tons capacity chain hoist with trolley	Set
1727 (3)d	Gantry Crane, 15 tons capacity chain hoist with trolley	Set
1727 (3)e	Gantry Crane, 20 tons capacity chain hoist with trolley	Set
1727 (4)a	Automatic trash rake complete with accessories ready for service, Primary	Set
1727 (4)b	Trash screen rake complete with accessories ready for service, Secondary	Set
1727 (5)	Hydraulic gate complete with accessories ready for service	Set
1727 (6)	Horizontal conveyor complete with accessories ready for service	Set
1727 (7)	Inclined conveyor complete with accessories ready for service	Set
1727 (8)	Trash Hopper	Set

Prepared by:

ENGR. RENE LENARD M. BUENAVENTURA
Sr. Project Planning and Development Officer

Checked by:

ARCH. ARTHUR O. AÑONUEVO
Officer-in-Charge, ~~PMD~~

Noted:

ENGR. JEOFFREY L. MACALALAD
Officer-in-Charge, PEPD