Section VI. Specifications

TABLE OF CONTENTS

SECTION 01010

GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION: The work specified herein is for the completion of PEZA-MEZ Master Drainage (Storm and Sewer Lines) System located in MEZ 1, Lapu-lapu City, Cebu..

a. The Drawings and the Specifications are complementary to each other. Drawings are graphic means of showing work to be done. They are particularly suited to show where materials are located. Thus, drawings exist essentially to show dimension, location and placement. Not all works however can be represented in the drawings. Generalized works are usually in statement form, and hence the Contractor is required to read the Specifications carefully.

b. Specifications, on the other hand, are used to describe the materials, construction techniques, samples, shop drawings, guarantees and other contract requirements. Together, the Drawings and Specifications are used to inform the Contractor.

1.2 THE LANGUAGE OF SPECIFICATIONS

a. The Specifications are of the abbreviated type and include incomplete sentences.

b. The selection of sentence structure depends on the underlying principles of Specifications:

1. That the Technical Specifications are only one part of the Contract Documents;
2. That the Contract is between Owner and the General Contractor; and
3. That the General Contractor is the only party responsible for completing the work in accordance with the Contract Documents.

Therefore:

(1) Only the General Contractor is referred to in the Specifications so as not to violate the intent of the Contract and so as not to undermine the proper chain of command.

(2) Any reference to Specialty Trade Contractor in the Technical Specifications is made only in so far as selection of Specialty Trade Contractors is made through bidding. Once the Specialty Trade Contractors are selected and assigned to the General Contractor, the General Contractor assumes responsibilities for the execution of the entire project in accordance with the Contract Documents, the word "Contractor" is meant the General Contractor.

(3) The omission of the phrase "The Contractor shall" is intentional because the whole Specifications is directed to the Contractor. Omitted words or phrases

shall be supplied by inference in the same manner as they are when a "note" occurs on the drawings.

(4) Where "as shown", "as indicated" or words of similar import are used, it shall be understood that reference to the drawings accompanying the specifications is made unless otherwise stated.

(5) Where "as indicated", "as required", "as permitted", "as authorized", "as approved", "as accepted" or words of similar import are used, it shall be understood that direction, requirement, permission, authorization, approval, or acceptance of the Engineer is intended unless otherwise stated.

(6) As used herein, “provided" shall be understood to mean "provided complete in place", that is "furnished and installed".

(7) Most sentences are in the imperative mood. This style is specially suited for instructions covering installation of products and equipment.

Example:

"spread adhesive using notched trowel"
"use a notched trowel"
"install flooring with textured side up"

The verb is the first word of the sentence clearly defining the action to be performed. This style is readily understandable and concise.

c. In cases where the specified brand carries with it the manufacturer's specifications shall hold precedence over these specifications.

1.3 PROJECT INFORMATION

a. The work shall conform to the contract drawings, details and maps, all of which form a part of these specifications.

b. Omissions from the drawings or specifications or the mis-description of details of work which are manifestly necessary to carry out the intent of the drawings and specifications, or which are customarily performed, shall not relieve the Contractor from performing such omitted or mis-described details of the work but they shall be performed as if fully and correctly set forth and described in the drawings and specifications.

c. The Contractor shall check all drawings furnished him immediately upon their receipt and shall promptly notify the Project Manager of any discrepancies. Figures marked on drawings shall be followed in preference to scale measurements. Large scale drawings shall govern small scale drawings. The Contractor shall compare all drawings and verify the figures before laying out the work and will be responsible for any errors which might have been avoided thereby.

d. Physical Data: The physical conditions indicated on the drawings and in the specifications are the result of site investigations by surveys and soil boring

conducted. However, it is expressly understood that the Engineer/Designers will not be responsible for any interpretation or conclusion drawn there from.

e. It shall be the duty of the Contractor to carefully examine, compare, and verify the data furnished by the Plans and Specifications. Any doubt as to the meaning of the plans (including notes thereon) and the Specifications, or any obscurity as to the wording of the Specifications will be explained. All directions and explanations necessary and proper to make more definite and certain any requirements of the plans (including notes thereon) or of the provisions of the Specifications to give them due effect, will be given by the Engineer.

f. In any case of discrepancy in the figures or drawings, the matter shall be submitted immediately to the Engineer, before any adjustments be made by the Contractor save only at the latter's own risk and expense. The decision of the Engineer on the adjustment of discrepancies so as to confirm the real intent of the plans and Specifications shall govern and shall be followed by the Contractor without extra charge.

PART 2 - SUBMITTALS

2.1 PROPOSED MATERIAL SUBMITTALS, CATALOG DATA AND SAMPLES

a. Proposed material submittals required of the Contractor shall be submitted within 30 calendar days after Notice to Proceed to allow sufficient time for processing, review, approval and procurement before the Contractor is ready to use prior to written approval.

b. The Contractor shall furnish the name and address of the manufacturer of each item of material and equipment. Each submittal shall be accompanied by a cover letter signed by the Contractor.

c. The Contractor shall furnish three copies for approval, giving full information, such as identifying description, catalog numbers, catalog cuts, and data sheets as maybe required for all material and equipment designated in the technical sections of this specification. Clearly mark each item proposed to be incorporated into the contract and identify in the submittals, with cross-references to the item number of the Contract drawings and specifications so as to identify clearly the use for which it is intended. Data submitted in a bound volume in the same numerical sequence as specification section paragraphs.

d. The Contractor shall certify on all submittals that the material being proposed conforms to contract requirements. In the event of any variance, the Contractor shall state specifically with portions vary, and request approval of a substitute. Incomplete submittals and submittal with inadequate data will be rejected.

2.2 SHOP DRAWINGS

a. Before starting the fabrication or installation of any of this work, the Contractor shall submit drawings as may be required and designated in the technical sections of these specifications.

b. In addition to the drawings designated in the technical sections, the Contractor shall furnish any and all sketches, drawings, and/or diagrams used in connection with the completion of the project, to the Engineer thru Project Manager. Drawings submitted for review or approval shall be clearly identified as their intended use in the project.

c. The Contractor shall prepare at his own expense and submit with such promptness as to cause no delay in his own work or in that of any other Contractor doing work on the same building, one (1) sepia (reproducible) print and two (2) blue print copies in 30" x 40" size of all shop drawings, as well as schedules, required corrections, including all necessary corrections relating to artistic effect. The Contractor shall make any corrections required by the Engineer, file with him two (2) corrected copies and furnish such other copies as may be needed.

2.3 The Contractor shall not relieve responsibility for any deviation from the requirements of the Contract Documents by the Engineer's approval of Shop Drawings, Product Data or Samples unless the Contractor has specifically informed the Engineer in writing of such deviation at the time of submission and the Engineer has given written approval to the specific deviation.

2.4 The Contractor shall not be relieved from responsibility for errors or omissions in the Shop Drawings, Product Data or Samples by the Engineer's approval thereof.

2.5 No portion of the work requiring submission of a Shop Drawings, Product Data or Sample shall commenced until the submittal has been approved by the Engineer. All such portions of the work shall be in accordance with approved submittals.

2.6 MANUFACTURER'S CERTIFICATES OF CONFORMANCE: Before delivery, manufacturer's certifications shall be furnished by the Contractor as required by the technical specifications. Pre-printed certifications will not be acceptable. All certifications shall be in the original copy. The original of all manufacturer's certifications shall name the appropriate items of equipment or material, specification, standard, or other document material, specification, standard or other document specified as controlling the quality of that item and shall have attached thereto certified copies of test data upon which the certifications are based. All certificates shall be signed by the manufacturer's official authorized to sign certificates of conformance.

2.7 LABORATORY REPORTS: Reports shall cite the contract requirements, the test or analysis procedures used, the actual test results, and state that the item tested or analyzed conforms or fails to conform to the specification requirements. All test reports shall be signed by representative of the testing laboratory authorized to sign certified test reports.

2.8 WARRANTY DOCUMENTS: In addition to the warrantees required, the Contractor shall submit together with the technical publications specified herein, a copy of all warranty documents on all items of equipment, including those obtained in writing from sub-contractors, manufacturers and suppliers.

2.9 TESTS AND INSPECTIONS

a. Tests, inspections and approvals of portions of the Work required by the Contract Documents or by laws, ordinances, rules, regulations shall be made at an appropriate time. Unless otherwise provided, the Contractor shall make arrangements for such tests, inspections and approvals with an independent testing laboratory or entity acceptable to the Owner, or with the appropriate public authority, and shall bear all

related costs of tests, inspections and approvals. The Contractor shall give the Engineer timely notice of when and where tests and inspections are to be made so the Engineer may observe such procedures. The Owner shall bear costs of tests, inspections or approvals which do not become requirements until after bids are received or negotiations concluded.

When requested, the Contractor shall furnish a complete written statement of the origin, composition and/or manufacture of any or all materials (manufactured, produced or grown) that are to be used in the work.

Unless otherwise provided, sampling and testing of materials shall be made by the Contractor, under the direct supervision of the Engineer.

The approval of preliminary samples shall not be considered as a guarantee of acceptance of all materials from the same source, nor the quality or quantity of such material, and it is understood, that all materials delivered on the work which do not meet the requirement of these Specifications shall be rejected by the Engineer. No materials shall be used in the work until sampled, tested and found satisfactory by the Engineer. The Contractor shall not be allowed any compensation for any delays or damages sustained pending the completion of testing and approval. Any material which has been sampled and passed as satisfactory may be resampled and re-tested at any time before use at the discretion of the Engineer.

When test of materials such as cement, concrete, asphalt, steel, timber, etc. are required by the Engineer or necessary, such tests shall be at the expense of the Contractor. The Contractor shall afford such facilities as the Engineer may require for collecting and forwarding samples to an approved Laboratory for testing. The materials represented by the samples shall not be allowed to be incorporated into the work until tests have been made, and the materials found to meet the requirements of the Specifications. The Contractor in all cases shall furnish the required samples without charge.

In the absence of any definite Specifications or reference to a Specification given in the body of the Standard Specification, such materials shall meet the Specifications and requirements of the American Society for Testing Materials (ASTM)

No pre-testing certificate of any materials to be incorporated into the work shall necessarily be acceptable.

2.10 MOBILIZATION AND DEMOBILIZATION

a. Description

Mobilization includes preparatory work and operations as follows: but not limited to the following:

1. Movement of personnel, equipment, construction plant and supplies to the project site from its regular place of business or another project to the site.
2. Establishment of offices, buildings and other facilities excluding field office and project site laboratories for the Engineer, necessary for work on the various items on the project; and

3. Costs incurred on operations that must be performed before starting work on the various items on the project site.

   Demobilization shall consist of the transportation of its plant, equipment and personnel from the site to its regular place of business on to another project.

b. Mobilization and Demobilization

1. Mobilization

   The Contractor shall mobilize and put to work all personnel and move into the Project Site (in accordance with his approved Construction Program and Equipment Moving-in and Utilization Schedule), the required construction equipment and plant needed for the successful completion of the Contract Work immediately after receipt of the approved Construction Program.

   The Engineer shall certify to the date of the actual mobilization of the programmed equipment to the site.

   The Engineer shall check and verify the number, type and actual condition of the equipment moved into the Project Site. The Engineer reserves the right to order the removal of each equipment that are not in good working condition from the Project Site at the Contractor's expense and said equipment are not to be accounted for.

   Construction equipment once moved into the Project Site, checked and accounted for by the Engineer shall not be permitted, prior to the completion of the Contract Work, to be moved out or transferred by the Contractor to another Project Site without the written approval of the Engineer.

   Periodic check-up of the Contractor's equipment moved-in for the Contract Work shall be conducted by the Engineer. The Contractor will pay to the Owner the amount equivalent to the ACEL Rental Rate of any equipment not accounted for during said check-up for the number of calendar day the equipment have been removed (without the written consent of the Engineer) from the Project Site until the said equipment have been returned. Such cases are grounds for disapproval of claims for time extensions by the Contractor.

   Breakdowns are to be repaired on site by the most expeditions method possible at no cost to the Owner. In the event of repairs being beyond the ability of personnel or tools at site to effect repairs in a reasonable time, such that the equipment and Construction Plan has to be removed from the site, then a replacement of machine or equipment or construction plant of a similar capacity shall be provided by the Contractor at no mobilization cost to the Owner nor extension of completion of Works.

c. Demobilization

   Demobilization shall include dismantlement and removal from the site of the Contractor's Construction Plant, materials and equipment and Temporary Facilities. Demobilization shall also include clean-up of the site after completion of the Contract Work as approved by the Owner and transportation from the site of Contractor's employees.

It shall include the legal removal and disposal of debris and materials not incorporated with the contract work prior to Contractor's moving out from the project.

PART 3- MEASUREMENT AND PAYMENT

3.1 MEASUREMENT

3.1.1 Lump sum items shall be provided for the provision of Testing of Materials.

3.1.2 No measurement shall be made for Mobilization and Demobilization which will be paid on a lump sum basis, which price shall include transportation to and from the site.

3.2 BASIS OF PAYMENT

3.2.1 The quantity for the provision of Testing of Materials determined as provided above shall be paid for all the appropriate contract unit price for the Pay Item listed below that is shown in the Bill of Quantities which prices and payment shall constitute full compensation for collecting, forwarding samples, and testing of materials to an approved Laboratory.

3.2.2 Seventy percent (70%) of the pay item shall be paid for Mobilization and thirty percent (30%) for Demobilization. The Contractor shall be entitled to receive payment in three (3) stages as listed below:

1. Thirty five percent (35%) on mobilization of sufficient equipment including loaders, graders, dump trucks, and backhoe required to begin construction. The Construction Plant shall also be erected on site and in operating condition.

   The Engineer shall be required to issue a certification in this respect before payment are released.

2. Thirty five percent (35%) on complete mobilization of all equipment as listed in the Equipment Utilization Schedule. In the event that there will be variance in the type and number of equipment supplied by the Contractor, the Engineer shall submit a certification that the equipment provided is sufficient to undertake the work. This certification shall be approved by the MEZ before additional payments for mobilization are released.

3. Thirty percent (30%) on demobilization for all pieces of equipment. Following completion of the works except those needed for routine maintenance during the Maintenance Period.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
01010 (1)	Testing of Materials	Lump Sum
01010 (2)	Mobilization and Demobilization	Lump Sum

SECTION 01575

TEMPORARY ENVIRONMENTAL CONTROLS

PART 1 - GENERAL

1.1 DEFINITIONS

1.1.1 Sediment: Soil and other debris that has eroded and has been transported by runoff water or wind.

1.1.2 Solid Waste: Garbage, refuse, debris, sludge, or other discharged material, including solid, liquid, semisolid, or contained gaseous materials resulting from domestic, industrial, commercial, construction, or agricultural operations.

a. Green waste: The vegetative matter from landscaping, land clearing and grubbing, including, but not limited to, grass, bushes, scrubs, small trees and saplings, tree stumps and plant roots. Marketable trees, grasses and plants that are indicated to remain, be re-located, or be re-used are not included.

b. Surplus soil: Existing soil that is in excess of what is required for this work, including aggregates intended, but not used, for on-site mixing of concrete, mortars and paving. Contaminated soil meeting the definition of hazardous material or hazardous waste is not included.

c. Inert construction and demolition debris: Broken or removed concrete, masonry, and rock asphalt paving; and shingles. Inert materials may be re-enforced with or contain ferrous wire, rods, accessories and weldments.

d. Wood: Dimension and non-dimension lumber, plywood, chipboard, hardboard. Treated and/or painted wood that meets the definition of lead contaminated or lead based contaminated paint is not included.

e. Scrap metal: Scrap and excess ferrous and non-ferrous metals such as re-enforcing steel, structural shapes, pipe and wire that are recovered or collected and disposed of as scrap. Scrap metal meeting the definition of hazardous material or hazardous waste is not included.

f. Paint cans: Metal cans that are empty of paints, solvents, thinners and adhesives. If permitted by the paint can label, a thin dry film may remain in the can.

1.1.3 Debris: Non-hazardous solid material generated during the construction, demolition, or renovation of a structure which exceeds 60 mm 2.5 inch particle size that is: a manufactured object; plant or animal matter; or natural geologic material (e.g. cobbles and boulders). A mixture of debris and other material such as soil or sludge is also subject to regulation as debris if the mixture is comprised primarily of debris by volume, based on visual inspection.

1.1.4 Garbage: Refuse and scraps resulting from preparation, cooking, dispensing, and consumption of food.

1.1.5 Oily Waste: Petroleum products and bituminous materials.

1.2 ENVIRONMENTAL PROTECTION REQUIREMENTS: Provide and maintain, during the life of the contract, environmental protection as defined. Plan for and provide environmental protective measures to control pollution that develops during normal construction practice. Plan for and provide environmental protective measures required to correct conditions that develop during the construction of permanent or temporary environmental features associated with the project. Comply with National and local regulations pertaining to the environment, including water, air, solid waste, hazardous waste and substances, oily substances, and noise pollution.

1.2.1 Contractor Liabilities for Environmental Protection: The Contractor shall be responsible for all damages to persons or property resulting from Contractor fault or negligence as well as for the payment of any civil fines or penalties as a result of the Contractor's or any subcontractor's violation of any applicable National or local environmental law or regulation.

1.3 UNFORESEEN HAZARDOUS MATERIAL: If a material is encountered that may be dangerous to human health upon disturbance during construction operations, stop that portion of work and notify the Owner's Representative immediately. If the material is not hazardous or poses no danger, the Government will direct the Contractor to proceed without change. If the material is dangerous and special handling of the material is necessary to accomplish the work, the Owner's Representative will arrange with the governing authority.

PART 2 - EXECUTION

2.1 PROTECTION OF NATURAL RESOURCES: Preserve the natural resources within the project boundaries and outside the limits of permanent work. Restore to an equivalent or improved condition upon completion of work. Confine construction activities to within the limits of the work indicated or specified.

2.1.1 Land Resources: Except in areas to be cleared, do not remove, cut, deface, injure, or destroy trees or shrubs without the Owner's Representative's permission. Do not fasten or attach ropes, cables, or guys to existing nearby trees for anchorages unless authorized by the Owner's Representative. Where such use of attached ropes, cables, or guys is authorized, the Contractor shall be responsible for any resultant damage.

2.1.1.1 Protection of Trees: Protect existing trees which are to remain and which may be injured, bruised, defaced, or otherwise damaged by construction operations. Remove displaced rocks from uncleared areas. By approved excavation, remove trees with 30 percent or more of their root systems destroyed.

2.1.1.2 Replacement: Remove trees and other landscape features scarred or damaged by equipment operations, and replace with equivalent, undamaged trees and landscape features. Obtain Owner's Representative's approval before replacement.

2.1.2 Water Resources

2.1.2.1 Stream Crossings: The Owner's Representative's approval is required before any equipment will be permitted to ford live streams. In areas where frequent crossings are required, install temporary culverts. Obtain approval prior to installation. Remove temporary culverts upon completion of work, and repair the area to its original.

2.1.2.2 Oily and Hazardous Substances: Prevent oil or hazardous substances from entering the ground, drainage areas, or navigable waters.

2.1.2.3 Stormwater Drainage: Construction site runoff shall be prevented from entering any storm drain or the river directly by the use of straw bales or other method suitable. Contractor shall provide erosion protection of the surrounding soils.

2.2 HISTORICAL AND ARCHAEOLOGICAL RESOURCES: Carefully protect in-place and report immediately to the Owner's Representative historical and archaeological items or human skeletal remains discovered in the course of work. Upon discovery, notify the Owner's Representative. Stop work in the immediate area of the discovery until directed by the Owner's Representative to resume work. The Government retains ownership and control over historical and archaeological resources.

2.3 EROSION AND SEDIMENT CONTROL MEASURES

2.3.1 Burnoff: Burnoff of the ground cover is not permitted.

2.3.2 Protection of Erodible Soils: Immediately finish the earthwork brought to a final grade, as indicated or specified. Immediately protect the side slopes and back slopes upon completion of rough grading. Plan and conduct earthwork to minimize the duration of exposure of unprotected soils.

2.3.3 Temporary Protection of Erodible Soils: Use the following methods to prevent erosion and control sedimentation:

2.3.3.1 Mechanical Retardation and Control of Runoff: Mechanically retard and control the rate of runoff from the construction site. This includes construction of diversion ditches, benches, berms, and use of silt fences and straw bales to retard and divert runoff to protected drainage courses.

2.4 CONTROL AND DISPOSAL OF SOLID WASTES: Pick up solid wastes, and place in covered containers which are regularly emptied. Prevent contamination of the site or other areas when handling and disposing of wastes. At project completion, leave the areas clean. Remove all solid waste (including non-hazardous debris) from property and dispose off-site at an approved landfill. Solid waste disposal off-site must comply local, requirements.

2.5 CONTROL AND DISPOSAL OF HAZARDOUS WASTES

2.5.1 Petroleum Products: Conduct the fueling and lubricating of equipment and motor vehicles in a manner that protects against spills and evaporation. The Contractor shall determine if any used oil generated while on-site exhibits a characteristic of hazardous waste.

2.6 DUST CONTROL: Keep dust down at all times, including during nonworking periods. Sprinkle or treat, with dust suppressants, the soil at the site, haul roads, and other areas disturbed by operations. Use vacuuming, wet mopping, wet sweeping, or wet power brooming. Air blowing will be permitted only for cleaning nonparticulate debris such as steel reinforcing bars. Only wet cutting will be permitted for cutting concrete blocks, concrete, and bituminous concrete. Do not unnecessarily shake bags of cement, concrete mortar, or plaster.

2.8 NOISE: Make the maximum use of low-noise emission products. Blasting or use of explosives will not be permitted without written permission.

PART 3 – MEASUREMENT AND PAYMENT

Temporary Environmental Controls shall not be measured and paid for separately but the cost thereof shall be considered as included in the contract unit price of the items called for.

SECTION 02226

SUBGRADE PREPARATION

PART 1 - GENERAL

1.1 DESCRIPTION: This Section shall consist of the preparation of the subgrade for the support of overlying structural layers. Unless authorized by the Engineer, subgrade preparation shall be done when the Contractor is able to start immediately the construction of the pavement structure.

PART 2 – PRODUCTS

2.1 MATERIAL REQUIREMENTS:

2.1.1 Unless otherwise stated in the Contract and except when the subgrade is in rock cut, all materials below subgrade level to a depth 150 mm or to such greater depth as may be specified shall meet the requirements of Selected Borrow for Topping.

Selected Borrow for topping are soils of such gradation that all particles will pass a sieve with 75 mm (3 inches) square opening and not more than 15% will pass the 0.075 mm (No. 200) sieve, as determined by AASHTO T11. The material shall have a plasticity index of not more than 6 as determined by AASHTO T90 and a liquid limit of not more than 30 as determined by AASHTO T89.

PART 3 – EXECUTION

3.1 PRIOR WORKS: Prior to commencing preparation of the subgrade, all culverts, cross drains, duct and the like (including their fully compacted backfill), ditches, drains and drainage outlets shall be completed. Any work on the preparation of the subgrade shall not be started unless prior work herein described is approved by the Engineer.

3.2 SUBGRADE LEVEL TOLERANCES: The finished compacted surface of the subgrade shall conform to the allowable tolerances as specified hereunder:

Permitted variation from	+ 20 mm
design LEVEL OF SURFACE	- 30 mm
Permitted SURFACE IRREGULARITY	
MEASURED BY 3-m STRAIGHT EDGE	30 mm
Permitted variation from	
design CROSSFALL OR CAMBER	$\pm$ 0.5%
Permitted variation from	
design LONGITUDINAL GRADE	
over 25 m length	$\pm$ 0.1%

3.3 SUBGRADE IN COMMON EXCAVATION

3.3.1 Unless otherwise specified, all materials below subgrade level in earth cuts to a depth 150 mm or other depth shown on the Plans or as directed by the Engineer shall be excavated. The material, if suitable, shall be set aside for future use or, if unsuitable, shall be disposed off in accordance with the following requirements:

3.3.1.1 Where the plans show the top portion of the roadbed to be selected topping, all unsuitable materials shall be excavated to the depth necessary for replacement of the selected topping to the required compacted thickness.

3.3.1.2 Where excavation to the finished graded section results in a subgrade or slopes of unsuitable soil, the engineer may require the contractor to remove the unsuitable material and backfill to the finished graded section with approved material. The Contractor shall conduct his operation in such a way that the Engineer can take the necessary cross-sectional measurements before the backfill is placed.

3.3.1.3 The excavation of muck shall be handled in a manner that will not permit the entrapment of muck within the backfill. The materials used for backfilling up to the ground line or water level, whichever is higher, shall be rock from other suitable granular material selected from the roadway excavation, if available. If not available, suitable material shall be obtained from other approved sources. Unsuitable material removed shall be disposed off to a designated areas shown on the Plans or approved by the Engineer.

3.3.2 Where material has been removed from below subgrade level, the resulting surface shall be compacted to a depth of 150 mm and in accordance with the following compaction requirements.

3.3.2.1 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, and 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. Compaction trials with the main types of fill material to be used in the Works shall be completed before work with the corresponding materials will be allowed to commence.

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

3.3.2.2 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 determined by AASHTO T99 Method C, is attained, at a moisture content determined by Engineer to be suitable for such density acceptance of compaction may be based on adherence to an approved roller pattern developed.

The Engineer shall make density tests of compacted material in accordance with AASHTO T 191, T 205, or other approved field density tests, including the use of properly calibrated nuclear testing devices during progress of the work. A correction for coarse particles may be made in accordance with AASHTO T224. 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 in-situ density tests shall be carried out for each 500 m of each layer of compacted fill.

3.3.2.3 Rock:

(1) Density requirements will not apply to portions of embankments constructed of materials which cannot be tested in accordance with approved methods.

(2) Embankment materials classified as rock 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 meeting the requirements set forth as enumerated below. Compaction Equipment, shall compact the embankment full width with a minimum of three complete passes for each layer of embankment.

Compaction equipment shall be capable of obtaining compaction requirements without detrimentally affected the compacted materials. The equipment shall be modern, efficient compacting units approved by the Engineer, the compacting units may be of any type, provided they are capable of compacting each lift of material as specified and meet the minimum requirements as contained herein. Minimum requirements for roller are as follows:

a. Sheepsfoot, tamping or grid rollers shall be capable of exerting a force of 45 Newton per millimeter (250 pounds per inch) of length of roller drum.

b. Steel-wheel rollers other than vibratory shall be capable of exerting a force of not less than 45 Newton per millimeter of width of the compression roll or rolls.

c. Vibratory steel-wheel rollers shall have a minimum mass of 6 tones. The compactor shall be equipped with amplitude and frequency controls and specifically designed to compact the material on which it is used.

d. Pneumatic-tire rollers shall have smooth tread tires of equal size that will provide a uniform compacting pressure for the full width of the roller and capable of exerting a ground pressure of at least 550 kpa (80 pounds per square inch).

e. Heavier compacting unit may be required to achieve the specified density of the embankment.

3.3.3 All materials immediately below subgrade level in earth cuts to a depth of 150 mm, or to such greater depth as may be specified, shall be compacted in accordance with the requirements for compaction of Subsection 3.3.2.

3.4 SUBGRADE IN ROCK EXCAVATION: Surface irregularities under the subgrade level remaining after trimming of the rock excavation shall be levelled by placing specified material and compacted to the requirements of Subsection 3.3.2.

3.5 SUBGRADE ON EMBANKMENT: After the embankment has been completed, the full width shall be conditioned by removing any soft or other unstable material that will not compacted properly. The resulting areas and all other low sections, holes or depressions shall be brought to grade with suitable material. The entire roadbed shall be shaped and compacted to the requirements of Subsection 3.3.2 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 cross-sections shown on the Plans.

3.6 SUBGRADE ON EXISTING PAVEMENT: Where the new pavement is to be constructed immediately over an existing Portland Cement concrete pavement and if so specified in the Contract the slab shall be broken into pieces with greatest dimension of not more than 500 mm and the existing pavement material compacted as specified in Subsection 3.3.2 as directed by the Engineer. The resulting subgrade level shall, as part pavement construction is shaped to conform to the allowable tolerances of Subsection 3.2 of this Specification by placing and compacting where necessary a leveling course comprising the material of the pavement course to be placed immediately above.

Where the new pavement is to be constructed immediately over an existing asphalt concrete pavement or gravel surface pavement and if so specified in the Contract the pavement shall be

scarified, thoroughly loosened, reshaped and re-compacted in accordance with Subsection 3.3.2 The resulting subgrade level shall conform to the allowable tolerances of Subsection 3.2 of this Specification.

3.7 PROTECTION OF COMPLETED WORK: The Contractor shall be required to protect and maintain at his own expense the entire work within the limits of his Contract in good condition satisfactory to the Engineer from the time he first started work until all work shall have been completed. Maintenance shall include repairing and recompacting ruts, ridges, soft spots and deteriorated sections of the subgrade caused by the traffic of the Contractor's vehicle/equipment or that of the public.

3.8 TEMPLATES AND STRAIGHT-EDGE: The Contractor shall provide for use of the Engineer, approved templates and straight-edges in sufficient number to check the accuracy of the work, as provided in this Specification.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

The area of Subgrade Preparation to be paid for will be the number of square meters including shaping to the required levels and tolerances .

4.2 BASIS OF PAYMENT

The accepted quantities, measured as prescribed in Part 4.1 shall be paid for at the appropriate contract unit price for Pay Item listed below that is included in the Bill of Quantities which price and payment shall be full compensation for the placing, or removal and disposal of all materials including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Payment will be made under:

Pay Item Number	Description	Levelof Measurement
02226	Subgrade Preparation	Square Meters

SECTION 02278

RUBBLE CONCRETE

Part 1 Description

This item shall consist of the construction of rubble concrete in accordance with this specification and in conformity with the lines, grades, slopes and dimensions shown in the Plans or established by the Engineer.

Part 2 Products

2.1 Stone

The stone shall be cleaned, hard, and durable and shall be subject to the Engineer's approval. Adobe stone shall not be used unless otherwise specified. Stones to be used shall be more than 0.015 cubic metre in volume and not less than 75 percent of the total volume of rock embankment and shall consist of stones 0.03 cubic metre in volume as described in Item 506.2. Stones obtained from excavation performed
under this contract may be used.

2.2 Concrete Class

Concrete shall be as indicated in the Drawings..

Part 3 Execution

3.1 Preparation of Foundation Bed

The foundation bed shall be excavated to the lines and grades as shown in the plans as directed by the Engineer, and shall be thoroughly compacted in accordance with Item 104.3.3.

3.2 Falsework and Formwork Construction

Falsework/formwork shall be constructed so as to withstand the stresses imposed.

Formwork used shall be constructed with sufficient strength, rigidity and shape as to leave the finished works true to the dimensions shown on the Plans and with the surface finished as specified.

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

3.3 Placing

One layer of concrete shall be placed at the prepared bed prior to placing of stones. Clearance between stones shall not be less than *2-1/2* inches or the maximum size of concrete aggregate for the class of concrete required.

Concrete shall be placed after each layer of stone and shall be thoroughly consolidated by means of a vibrator inserted in each layer of concrete. In no case shall the vibrator be operated longer than 10 seconds in any location.

After removal of forms, any cavities, voids and honeycomb spots shall be filled up with mortar 'composed of one part cement and two parts sand.

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

Part 4 Method of Measurement

The quantity to be paid for shall be the number of cubic meters of rubble concrete complete in place and accepted. In computing the quantity of payment the dimension used shall be those shown on the plans or ordered in writing by the Engineer.

Part 5 Basis of Payment

The quantity of rubble concrete determined as provided in the preceding section Method of Measurement, shall be paid for at the contract unit price per cubic meter for rubble concrete, which price and payment shall be full compensation for the preparation of the bed, furnishing, necessary excavations, falsework, and for all labor, equipment, tools and incidentals necessary to complete the Item.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
2278	Rubble Concrete	Cubic Meter

SECTION 02301

EARTHWORK FOR STRUCTURES AND PAVEMENTS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C33	Concrete Aggregates
ASTM C136	Sieve Analysis of Fine and Coarse Aggregates
ASTM D422	Particle-Size Analysis of Soils
ASTM D698	Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft (600 kN-m/m))
ASTM D1140	Amount of Material in Soils Finer Than the No. 200 (75-Micrometer) Sieve
ASTM D1556	Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft (2,700 kN-m/m))
ASTM D1586	Penetration Test and Split-Barrel Sampling of Soils
ASTM D1883	CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM D2434	Permeability of Granular Soils (Constant Head)
ASTM D2487	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D3017	Water Content of Soil and Rock in

	Place by Nuclear Methods (Shallow Depth)
ASTM D4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.2 DEFINITIONS

1.2.1 Backfill: Specified material used in refilling a cut, trench, or other excavation, placed at a specified degree of compaction.

1.2.2 Cohesive Materials: Cohesive materials include materials classified by ASTM D2487 as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when the fines have a plasticity index greater than zero.

1.2.3 Cohesionless Materials: Cohesionless materials include materials classified by ASTM D2487as GW, GP, SW, and SP. Materials classified as GM and SM will be identified as cohesionless only when the fines have a plasticity index of zero.

1.2.4 Compaction: The process of mechanically stabilizing a material by increasing its density at a controlled moisture condition. "Degree of Compaction" is expressed as a percentage of the maximum density obtained by the test procedure described in ASTM D698 or ASTM D1557 for general soil types.

1.2.5 Controlled Fill and Controlled Backfill: A specified soil mix or gradation of materials constructed to attain maximum bearing strength and minimize consolidation or differential settlement under a load. Controlled fill is sometimes called "structural fill."

1.2.6 Embankment: A "fill" having a top that is higher than adjoining ground.

1.2.7 Excavation: The removal of soil, rock, or hard material to obtain a specified depth or elevation.

1.2.8 Fill: Specified material placed at a specified degree of compaction to obtain an indicated grade or elevation.

1.2.9 Hard Material: Weathered rock, dense consolidated deposits or conglomerate materials, (excluding manmade materials such as concrete) which are not included in the definition of "rock" but which usually require the use of heavy excavation equipment with ripper teeth or the use of jack hammers for removal.

1.2.10 In Situ Soil: Existing in place soil.

1.2.11 Lift: A layer or course of soil placed on top of a previously prepared or placed soil.

1.2.12 Rock: Solid, homogeneous, interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of

which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement, exceeding 0.4 cubic meter (½ cubic yard) in volume. [Material indicated in the soil boring logs as having a standard penetration resistance as determined by ASTM D1586 greater than 600 blows per 300 mm foot is arbitrarily defined herein as "Rock."] Removal of "hard material" will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.2.13 Soil: The surface material of the earth's crust resulting from the chemical and mechanical weathering of rock and organic material.

1.2.14 Subgrade: The material in excavation (cuts) and fills (embankments) immediately below any subbase, base, pavement, or other improvement. Also, as a secondary definition, the level below which work above is referenced.

1.2.15 Topsoil: In natural or undisturbed soil formations, the fine-grained, weathered material on the surface or directly below any loose or partially decomposed organic matter. Topsoil may be a dark-colored, fine, silty, or sandy material with a high content of well-decomposed organic matter, often containing traces of the parent rock material. Gradation and material requirements specified herein apply to all topsoil references in this contract. The material shall be representative of productive soils in the vicinity.

1.2.16 Unsatisfactory Material: Existing, in situ soil or other material which can be identified as having insufficient strength characteristics or stability to carry intended loads in fill or embankment without excessive consolidation or loss of stability. Materials classified as PT, OH, or OL by ASTM D2487 are unsatisfactory. Unsatisfactory materials also include man-made fills, refuse, uncompacted backfills from previous construction, unsound rock or soil lenses, or other deleterious or objectionable material.

1.2.17 Working Platform: A layer of compacted crushed rock or natural stone that replaces the in situ soil to provide a stable, uniform bearing foundation for construction equipment to facilitate further site construction.

1.3 DELIVERY AND STORAGE: Deliver and store materials in a manner to prevent contamination or segregation.

PART 2 - PRODUCTS

2.1 MATERIALS

2.1.1 Soil Materials: Provide materials free from debris, roots, wood, scrap materials, vegetable matter, refuse or frozen material. Maximum particle size permitted is 75 mm (3 inches). Use excavated material from the site for the work indicated when material falls within the requirements specified herein.

2.1.1.1 Controlled Fill: Provide materials classified as GW, GP, SW, SP, by ASTM D2487 where indicated. [The liquid limit of such material shall not

exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index shall not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight shall be finer than 75 micrometers (No. 200) sieve when tested in accordance with ASTM D1140.

2.1.1.2 General Backfill Beside Structures: Soft, spongy, highly plastic, or otherwise unstable material is prohibited. Material shall be classified as GP, GM, GC, SP or by ASTM D2487. If more material is required than is available from on-site excavation, then provide that material from approved sources.

2.1.1.3 General Site Fill, Backfill and Embankment Material: Provide a soil material from the site or borrow that can be readily compacted to the specified densities. Materials shall be classified as GP, GM, GC, SP, SM, SC, or by ASTM D2487.

2.1.1.4 Working Platform: Material and thicknesses of working platform for support of construction equipment shall be at the discretion of the construction contractor. The gradation and placement of such material shall not create large void spaces upon which overlying work is indicated to be placed.

2.1.2.5 Topsoil: Provide material free of subsoil, stumps, rocks larger than 19 mm (3/4 inch) diameter brush, weeds, toxic substances, and other material or substance detrimental to plant growth. Topsoil shall be a natural, friable soil representative of productive soils in the vicinity. Modify topsoil provided if necessary conform with the requirements specified in Table I.

2.1.1.6 Borrow: Provide materials meeting requirements for general site fill, controlled fill. Obtain borrow materials in excess of those furnished from excavations described herein from other sources approved by the Owner's Representative.

PART 3 - EXECUTION

3.1 PROTECTION

3.1.1 Drainage and Dewatering: Plan for and provide the structures, equipment, and construction for the collection and disposal of surface and subsurface water encountered in the course of construction.

3.1.1.1 Drainage: Dispose of surface water which may accumulate in open excavations, unfinished fills, or other low areas. Remove water by trenching where approved, pumping, or other methods to prevent softening of exposed surfaces. Surface dewatering plan shall include rerouting of any storm water runoff or natural drainage if necessary and shall comply with requirements specified in Section 01575N, "Temporary Environmental Controls." Collect and dispose of surface and subsurface water encountered in the course of construction.

3.1.1.2 Dewatering: Groundwater flowing toward or into excavations shall be controlled to prevent sloughing or excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 0.91 m (3 feet) of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously.

Operate the dewatering system until construction work below existing water levels is complete. Have a back-up pump and system available for immediate use. See Section 01575, "Temporary Environmental Controls" for additional requirements.

3.1.2 Protection and Restoration of Surfaces: Protect newly graded areas from traffic, erosion, and settlements. Repair and reestablish damaged or eroded slopes, elevations or grades and restore surface construction prior to acceptance. Protect existing streams, ditches and storm drain inlets from water-borne soil. Conduct work in accordance with requirements specified in Section 01575, "Temporary Environmental Controls."

3.1.2.1 Disposal of Excavated Material: Dispose of excavated material in such a manner that it will not obstruct the flow of runoff, streams, endanger a partly finished structure, impair the efficiency or appearance of facilities, or be detrimental to the completed work.

3.1.2.2 Stockpile Rock: Stockpile rock from on site excavations and use to construct slopes or embankments adjacent to streams, or side and bottoms of channels and for protection against erosion. Remove excess stockpiled rock upon completion of construction.

3.2 SURFACE PREPARATION

3.2.1 Clearing and Grubbing: Perform as specified in Section 02231, "Clearing and Grubbing." Unless indicated otherwise, remove trees, logs, stumps, shrubs, and brush within the limits of construction. Grub out matted roots and roots over 50 mm (2 inches) in diameter to at least 450 mm (18 inches) below the existing surface. Conduct work in accordance with requirements specified in Section 01575, "Temporary Environmental Controls."

3.2.2 Stockpiling Topsoil: Strip approved topsoil to a depth of 100 mm (4 inches) from the site where excavation or grading is indicated and stockpile separately from other excavated material. Locate topsoil so that the material can be used readily for the finished grading. Protect and store in segregated piles until needed.

3.2.3 Unsatisfactory Material: Remove organic matter, sod, muck, rubbish, and unsuitable soils under embankments which are less than 0.90 m (3 feet) in thickness and under pavements or slabs on grade.

3.2.3.1 Subgrade Proof Rolling: After removal of topsoil or other overburden, proof roll the existing subgrade with six passes of a minimum 13.65 metric tons (15 ton) pneumatic-tired roller. Operate the roller in a systematic manner to assure the number of passes over all areas, and at speeds between 4 and 5.5 km per hour (2.5 and 3.5 miles per hour). When proof rolling under structures, one-half of the passes made with the roller shall be in a direction perpendicular to the other passes. Proof rolling shall be done in the presence of the Owner's Representative. Rutting or pumping shall indicate unsatisfactory material and that material shall be undercut, to a depth of 200 mm inches, and replaced with the appropriate fill material. Perform proof rolling only when weather conditions permit. Do not proof roll wet or saturated subgrades. Materials degraded by proof rolling a wet or saturated subgrade shall be replaced by the Contractor as directed by the Owner's Representative at no cost to the Government. Notify the Owner's Representative prior to proof rolling.

3.3 EXCAVATION: Excavate to contours and dimensions indicated. Keep excavations free from water while construction is in progress. Notify the Owner's Representative immediately in writing in the event that it becomes necessary to remove rock, hard material, or other material defined as unsatisfactory to a depth greater than indicated. Refill excavations cut below the depths indicated with controlled fill and compact as specified herein. Excavate soil disturbed or weakened by construction operations or soils soften from exposure to weather. Refill with controlled fill and compact as specified herein at no additional cost to the Owner.

3.4 BORROW MATERIALS: Select borrow materials to meet requirements and conditions of the particular fill or backfill materials to be used. [Perform necessary clearing, grubbing, disposal of debris, and satisfactory drainage of borrow pits as incidental operations to the borrow excavation.

3.4.1 Borrow Pits: Do not open borrow pits without approval of the Owner's Representative or before elevations and measurements are completed on the undisturbed surface. Excavate borrow pits to afford adequate drainage. Overburden and other soil material shall be used for refilling the borrow area.

3.5 FILLING AND BACKFILLING

3.5.1 Subgrade Preparation: Scarify the underlying subgrade surface to a depth of 150 mm (6 inches) before the fill is started. Step, bench, or break up sloped surfaces steeper than one vertical to 4 horizontal so that the fill material will bond with or be securely keyed to the existing material. Scarify existing surface to a minimum depth of 150 mm (6 inches) if subgrade density is less than the degree of compaction specified and recompact. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 300 mm (12 inches) and recompact as specified for the adjacent or overlying fill. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.5.2 Fill and Backfill Beside Structures: Place required backfill material adjacent to structures and compact in a manner that prevents wedging action or eccentric loading upon or against the structures. Step or serrate slopes bounding or within areas to be backfilled to prevent sliding of the fill. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Do not place material on surfaces that are muddy. Do not use equipment for backfilling operations or for the formation of embankments against structures that will overload the structure. Backfilling against concrete will be done only after the concrete has attained its 28-day compressive strength or only after approval has been obtained from the Owner's Representative.

3.5.3 Controlled Fill: Place controlled fill under pavements in loose lifts of 150 mm (6 inches). Do not place material on surfaces that are muddy. Compact with equipment well suited to the soil being compacted. Moisten or aerate material as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Compact each lift as specified herein before placing the overlaying lift. Compaction shall be accomplished continuously over the entire area. Sufficient passes shall be made to ensure that specified density is obtained.

3.5.4 Final Backfill for Utilities: Construct backfill (final backfill) for storm drains, manholes, utility lines, and other utility appurtenances using the material and compaction requirements specified herein for the adjacent or overlying work. Bedding and initial backfill requirements are specified in Section 02302, "Excavation, Backfilling, and Compacting for Utilities." Backfilling against concrete will be done only after the concrete has attained its 28-day compressive strength or only after approval has been obtained from the Owner's Representative.

3.5.5 Weather Limitations: Fill shall not be constructed when weather conditions detrimentally affect the quality of the finished course. Do not construct fill and backfill in the rain or on saturated subgrades. If weather conditions are windy, hot or arid, with high rate of evaporation, schedule the placement in cooler portions of the day and furnish equipment to add moisture to the fill or backfill during and after placement.

3.6 COMPACTION: Compact each layer or lift of material specified so that the in-place density tested is not less than the percentage of maximum density specified in Table III.

TABLE

	Percent ASTM D1557 Maximum Density	
	Cohesive Material	Cohesionless Material
Fill, Embankment and Backfill		
General Fill under steps and parking lots	90	95
General Fill under sidewalks and grassed areas	85	90
General Fill beside structures	90	95
Controlled fill and under footings, pavements and structures	95	100
Refill overblasts and undercut materials materials	N/A	100

Under Roadways, top 300 mm	95	100
Subgrade (Top of fill, backfill or cut)		
Under, steps	93	98
And parking lots, top 300 mm		
Under sidewalks, and grass areas, top 150 mm	85	90

3.7 FINISH OPERATIONS

3.7.1 Site Grading: Grade to finished grades indicated within 30 mm (0.10 foot). Grade areas to drain water away from structures [and to provide suitable surfaces for mowing machines. Existing grades which are to remain but are disturbed by the Contractor's operations shall be restored [as specified herein].

3.7.2 Finishing Subgrades Under Pavements: Finish surface of top lift of fill or top of subgrade to the elevation and cross section indicated. Finished surface shall be smooth and of uniform texture. Lightly scarify or blade the finished surface to bring the finished surface to within 15mm (0.05 foot) of the indicated grade and to eliminate imprints made by compaction and shaping equipment. Surface shall show no deviations in excess of 10 mm (3/8 inch) when tested with a 3 m. (10 foot) straightedge.

3.7.3 Spreading Topsoil: Clear areas indicated or specified to receive topsoil of materials interfering with planting and maintenance operations. Do not place topsoil when subgrade is extremely wet or dry, or in other conditions detrimental to seeding, planting, or grading. Spread topsoil to a uniform depth of 100 mm (4 inches) over the designated area.

3.7.4 Disposition of Surplus Material: Surplus or other soil material not required or suitable for filling, backfilling, or embankment shall be wasted by disposition in the area designated by the Owner’s Representative. Comply with the requirements of Section 01575, "Temporary Environmental Controls."

3.7.6 Protection of Surfaces: Protect newly graded areas from traffic, erosion, and settlements that may occur and as required in the Section 01575, "Temporary Environmental Controls" and as specified in the paragraph entitled "Protection and Restoration of Surfaces." Repair or reestablish damaged grades, elevations, or slopes prior to acceptance of work.

3.8 FIELD QUALITY CONTROL

3.8.1 Sampling: Furnish one 30 kg (50 pound) composite sample taken at random times daily of subgrade being compacted and fill material being placed. Submit samples, in the number directed, whenever the source or character of the fill, backfill, or embankment material changes. Contain each sample in a clean container and fasten to prevent loss of material. Tag each sample for identification. Tag shall contain the following information:

Contract No. _____
Sample No. _____
Date of Sample _____
Sampler _____
Source _____
Intended Use _____

3.8.2 Tests

Table III

Material Type ____	Location of Material ____	Test Frequency
Fills and Backfills	Structures (beside)	One test per side of structure per 185 square meters taken 300 mm below finished grade.
Controlled Fills	primary roadways structures (under)	One test per lift per 835 square meters.
Subgrades	Site	1672 square meters.
Embankments of Borrow	Any	One test per lift per 385 cubic meters placed.
Native soil subgrade	Any	One test or one test per other than structures 930 square meters and parking whichever is greater.
Borrow	Any	One test per lift per 385 cubic meters placed

Test fill backfill using ASTM C136for conformance to ASTM C33, and ASTM D2487 gradation limits. Test fill backfill for material finer than the 75 micrometers (No. 200) sieve using ASTM D1140. Test fill backfill for liquid limit and plasticity index using ASTM D4318. Test fill backfill and subgrade in cut materials for moisture density relations using ASTM D698, ASTM D1557 or ASTM D4253 and ASTM D4254. Test fill backfill for permeability in accordance with ASTM D2434. Perform one of each of the required tests for each material used when directed. Provide additional tests as specified above for each source change. Perform density tests in randomly selected locations using ASTM 1556, ASTM D2922 and ASTM D3017 as follows: one test per 1,670 square meters (18,000 square feet in each layer of lift 380 cubic meters (500 cubic yards) placed 840 square meters (1,000 square yards) subgrade in cut.

3.8.3 Acceptance: Acceptance of the compacted materials shall be determined in each unit by the results of a series of three consecutive field in-place density tests. Method of in-place tests shall be in accordance with paragraph "Tests." The average of three tests

shall equal or exceed the specified average density requirement. Fill shall be accepted or rejected by units with a complete unit being reworked in the event of rejection. A unit shall consist of 1530 cubic meters (2000 cubic yards) of fill or 20 percent of the total embankment fill quantity, whichever is less and have a minimum of 600 mm (2 feet) of fill.

PART 4 MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

4.1.1 Structure Excavation

The volume of excavation to be paid for will be the number of cubic meters measured in original position of material acceptably excavated in conformity with the plans or as directed by the Engineer.

4.1.2 Structural Backfill

The volume of structural backfill to be paid for will the number of cubic meter measured in final position of the free draining granular material actually provided and placed around structures as specified, complete in place and accepted.

4.1.3 Disposal of Excess Materials

Measurement of Disposal of Excess material shall be net volume in its original position.

4.2 BASIS OF PAYMENT

The accepted quantities, measured as prescribed Part 4.1 shall be paid for at the contract unit price for each of the Pay Item listed which price and payment shall be full compensation for the _____ and disposal of excavated material and furnishing and placing of structured backfill including labor, equipment, tools, and incidentals necessary to complete the work.

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Payment will be made under

Pay Item Number	Description	Unit of Measurement
02301 (1)	Structured Excavation	Cubic Meter
02301 (2)	Structural Backfill	Cubic Meter
02301 (3)	Disposal of Excess Materials	Cubic Meter
02301 (4)	Granular Bedding	Cubic Meter

SECTION 02302

EXCAVATION, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C33	Concrete Aggregates
ASTM D422	Particle-Size Analysis of Soils
ASTM D698 (12,400 ft-lbf/ft (600 kN-m/m))	Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D1140	Amount of Material in Soils Finer Than the No. 200 (75-Micrometer) Sieve
ASTM D1556	Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft (2,700 kN-m/m))
ASTM D1586	Penetration Test and Split-Barrel Sampling of Soils
ASTM D2487	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D3017	Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils

1.2 DEFINITIONS

1.2.1 Backfill: Material used in refilling a cut, trench or other excavation.

1.2.2 Cohesive Materials: Soils classified by ASTM D2487 as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesive only when fines have a plasticity index greater than zero.

1.2.3 Cohesionless Materials: Soils classified by ASTM D2487 as GW, GP, SW, and SP. Materials classified, as GM and SM will be identified as cohesionless only when the fines have a plasticity index of zero.

1.2.4 Compaction: The process of mechanically stabilizing a material by increasing its density at a controlled moisture condition. "Degree of Compaction" is expressed as a percentage of the maximum density obtained by the test procedure described in ASTM D698 or ASTM D155 for general soil types."

1.2.5 Granular Pipe Bedding: A dense, well-graded aggregate mixture of sand, gravel, or crushed stone (mixed individually, in combination with each other, or with suitable binder soil) placed on a subgrade to provide a suitable foundation for pipe. Granular bedding material may also consist of poorly graded sands or gravels where fast draining soil characteristics are desired.

1.2.6 In-Situ Soil: Existing in place soil.

1.2.7 Lift: A layer or course of soil placed on top of subgrade or a previously prepared or placed soil in a fill or backfill.

1.2.8 Refill: Material placed in excavation to correct overcut in depth.

1.2.9 Rock: Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling, drilling and the use of expansion jacks, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 0.76 cubic meter (1 cubic yard) in volume. Material identified in the soil boring logs as having a standard penetration resistance as determined by ASTM D1586 greater than 1968 blows per meter (600 blows per foot) is arbitrarily defined herein as "Rock."

1.2.10 Topsoil: In natural or undisturbed soil formations, the fine-grained, weathered material on the surface or directly below any loose or partially decomposed organic matter. Topsoil may be a dark-colored, fine, silty, or sandy material with a high content of well-decomposed organic matter, often containing traces of the parent rock material. Gradation and material requirements specified herein apply to all topsoil references in this contract. The material shall be representative of productive soils in the vicinity.

1.2.11 Unyielding Material: Rock rib, ridge, rock protrusion, or soil with cobbles in the trench bottom requiring a covering of finer grain material or special bedding to avoid bridging in the pipe or conduit.

1.2.12 Unsatisfactory Material: In-Situ soil or other material, which can be identified as having insufficient strength characteristics or stability to carry intended loads in the trench without excessive consolidation or loss of stability. Also backfill material, which contains refuse, large rocks, debris, soluble particles, and other material, which could damage the pipe or cause the backfill not to compact. Materials classified as PT, OH, or OL by ASTM D2487 are unsatisfactory.

1.2.13 Unstable Material: Material in the trench bottom which lacks firmness to maintain alignment and prevent joints from separating in the pipe, conduit, or appurtenance structure during backfilling. This may be material otherwise identified as satisfactory which has been disturbed or saturated.

1.3 SUBMITTALS:

Test Reports

Trench backfill material tests

Pipe bedding material tests

1.4 DELIVERY, STORAGE, AND HANDLING: Deliver and store materials in a manner to prevent contamination, segregation, and other damage.

1.5 PROTECTION

1.5.1 Utilities: Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Excavation made with power-driven equipment is not permitted within 600 mm (two feet) of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand or light equipment. Start hand light equipment excavation on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until the Engineer grants approval for backfill. Report damage to utility lines or subsurface construction immediately to the Engineer.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS: Provide soil materials as specified below free of debris, roots, wood, scrap material, vegetable matter, refuse, soft unsound particles, ice, or other deleterious and objectionable materials.

2.1.1 Backfill: Bring trenches to grade indicated on the drawings using material excavated on the site of this project. This material will be considered unclassified and no testing other than for compaction will be required before use as backfill, classified as GM, SM, SC by ASTM 2487 with a maximum particle size of 75 mm (3 inches).

2.1.2 Special Backfill for Roads and Paved Areas: Backfill trenches under roads, structures, and paved areas as specified in Section 02301, "Earthwork for Structures

and Pavements." With material conforming to the requirements stated above except that the liquid limit of the material cannot exceed 35 percent when tested in accordance with ASTM D4318, the plasticity index cannot exceed 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight can be finer than the 75 micrometers No. 200 sieve when tested in accordance with ASTM D1140.

2.1.3 Sand: Clean, coarse-grained sand classified as SW or SP by ASTM D2487 for bedding and backfill as indicated.

2.1.4 Gravel: Clean, coarsely graded natural gravel, crushed stone or a combination thereof having a classification of GW GP in accordance with ASTM D2487 for bedding and backfill as indicated. Maximum particle size shall not be more than 25mm per 300mm (one inch per foot) of pipe diameter or 75mm (3 inches) maximum.

2.1.5 Topsoil Material: Salvaged topsoil from stockpile. Topsoil should be free of subsoil, stumps, rocks larger than 19 mm (3/4 inch) in diameter with maximum 3 percent retained on 6 mm (1/4 inch) sieve, brush, weeds, toxic substances, and other material or substance detrimental to plant growth. Topsoil shall be a natural, friable soil representative of productive soils in the vicinity.

2.1.6 Borrow: Provide materials meeting requirement for general site fill, backfill, granular fill, and topsoil. Obtain borrow materials in excess of those furnished from excavations specified herein from sources off the project area.

2.1.9 Pipe Bedding: Provide material for pipe bedding consisting of GW GP GM GC SW SP SM SC sand gravel as classified in accordance with ASTM D2487.

2.2 CONCRETE PIPE CRADLES : Concrete pipe cradles where indicated conforming to lines and dimensions indicated. Construct cradles in accordance with Section 03307, "Concrete for Minor Structures." with concrete having a 28 day compressive strength of 20.7 MPa (3000 psi).

PART 3 - EXECUTION

3.1 PROTECTION

3.1.1 Drainage and Dewatering

3.1.1.1 Drainage: Surface water shall be directed away from excavation and construction sites so as to prevent erosion and undermining of foundations. Diversion ditches, and grading shall be provided and maintained as necessary during construction. Excavated slopes and backfill surfaces shall be protected to prevent erosion and sloughing. Excavation shall be performed so that the site and the area immediately surrounding the site and affecting operations at the site shall be continually and effectively drained.

3.1.2 Dewatering: Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the

excavation and to eliminate interference with orderly progress of construction. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. Operate the dewatering system until construction work below existing water levels is complete.

3.1.3 Underground Utilities: The Contractor shall physically verify the location and elevation of the existing utilities prior to starting construction. The Contractor shall mark the surface of the ground where existing underground utilities are discovered.

3.1.4 Structures and Surfaces: Protect newly backfilled areas slopes, or grades from traffic, erosion settlement, or any other damage. Repair and reestablish damaged or eroded grades and slopes and restore surface construction prior to acceptance. Protect existing streams, ditches, and storm drain inlets from water-borne soil. Perform work in accordance with requirements specified in Section 01575, "Temporary Environmental Controls."

3.2 SURFACE PREPARATION

3.2.1 Stockpiling Topsoil: Strip suitable soil from the site where excavation or grading is indicated and stockpile separately from other excavated material. Material unsuitable for use as topsoil shall be wasted. Locate topsoil so that the material can be used readily for the finished grading. Where sufficient existing topsoil conforming to the material requirements is not available on site, provide borrow materials suitable for use as topsoil. Protect topsoil and keep in segregated piles until needed.

3.2.2 Cutting Pavement, Curbs, and Gutters; Saw cut with neat, parallel, straight lines 300 mm (one foot) wider than trench width on each side of trenches and 300 mm (one foot) beyond each edge of pits. When the saw cut is within 300 mm (one feet) of an existing joint, remove pavement to the existing joint.

3.2.3 All 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.

3.3 GENERAL EXCAVATION AND TRENCHING: Keep excavations free from water while construction is in progress. Notify the Engineer immediately in writing if it becomes necessary to remove rock or hard, unstable, or otherwise unsatisfactory material to a depth greater than indicated. Make trench sides as nearly vertical as practicable except where sloping of sides is allowed. Sides of trenches shall not be sloped from the bottom of the trench up to the elevation of the top of the pipe. Excavate ledge rock, boulders, and other unyielding material to an overdepth at least 150 mm (6 inches) below the bottom of the pipe and appurtenances unless otherwise indicated or specified. Over excavate soft, weak, or wet excavations. Use bedding material placed in 150 mm (6 inch) maximum layers to refill over depths to the proper grade. At the Contractor's option, the excavations may be cut

to an overdepth of not less than 100 mm (4 inches) and refilled to required grade as specified. Grade bottom of trenches accurately to provide uniform bearing and support for each section of pipe or structure on undisturbed soil, or bedding material as indicated or specified at every point along its entire length except for portions where it is necessary to excavate for bell holes and for making proper joints. Dig bell holes and depressions for joints after trench has been graded. Dimension of bell holes shall be only 13 mm ½ inch greater than length, width, and depth of bell as required for properly making the particular type of joint to ensure that the bell does not bear on the bottom of the excavation. Trench dimensions shall be as indicated.

3.4 BEDDING: Bedding shall be Of materials and depths as indicated for utility lines and utility line structures. Place bedding in 150 mm (6 inch) maximum loose lifts. Provide uniform and continuous support for each section of structure except at bell holes or depressions necessary for making proper joints.

3.4.1 Concrete Cradles; Specified in lieu of other types of bedding for a particular type of pipe material, shall be as specified.

3.5 BACKFILLING; Construct backfill in two operations (initial and final) as indicated and specified in this section. Place initial backfill in 150 mm (6 inch) maximum loose lifts to 300 mm (one foot) above pipe unless otherwise specified. Ensure that initially placed material is tamped firmly under pipe haunches. Bring up evenly on each side and along the full length of the pipe, or structure. Ensure that no damage is done to the utility or its protective coating. Place the remainder of the backfill (final backfill) in 225 mm (9 inch) maximum loose lifts unless otherwise specified. Compact each loose lift as specified in the paragraph entitled "General Compaction" before placing the next lift. Do not backfill where the material in the trench is muddy, except as authorized. Provide a minimum cover from final grade of 600mm (2 feet) for storm drains and 1200 mm (3.9 feet) for sewer mains. Where settlements greater than the tolerance allowed herein for grading occur in trenches and pits due to improper compaction, excavate to the depth necessary to rectify the problem, then backfill and compact the excavation as specified herein and restore the surface to the required elevation. Coordinate backfilling with testing of utilities. Testing for the following shall be complete before final backfilling: water distribution, storm drainage and sanitary sewer

3.6 COMPACTION: Use hand-operated, plate-type, vibratory, or other suitable hand ampers in areas not accessible to larger rollers or compactors. Avoid damaging pipes and protective pipe coatings. Compact material in accordance with the following unless otherwise specified. If necessary, alter, change, or modify selected equipment or compaction methods to meet specified compaction requirements.

3.6.1 Compaction of Material in Subcuts or Overexcavations: In rock, compact to 95 percent of ASTM D1557 maximum density. In soft, weak, or wet soils, tamp refill material to consolidate to density of adjacent material in trench wall. In stable soils, compact to 90 percent of ASTM D1557maximum density.

3.6.2 Compaction of Pipe and Conduit Bedding: In rock, compact to 95 percent and in soil, compact to 90 percent of ASTM D1557 maximum density.

3.6.3 Compaction of Backfill: Compact initial backfill material surrounding pipes, or conduits, to 90 percent of ASTM D1557 maximum density except where bedding and backfill are the same material. Where bedding and backfill are the same material, compact initial backfill to the density of the bedding. Under areas to be

seeded or sodded, compact succeeding layers of final backfill to 85 percent of ASTM D1557 maximum density. For utilities under road or highway right-of-way, structures and pavements compact layers of final backfill as specified under paragraph entitled "Special Earthwork Installation Requirements."

3.7 SPECIAL EARTHWORK INSTALLATION REQUIREMENTS

3.7.1 Concrete Culvert Piping Under Embankment: Construct the embankment to 150 mm (6 inches) above elevation of top of pipe for 600 mm (24 inch) size pipe and to 750 mm (30 inches) above elevation of top of pipe where the pipe diameter is larger than 600mm (24 inches). After pipe installation, backfill and compact in accordance with requirements stated in paragraphs entitled "Backfilling and Compaction."

3.7.2 Manholes and Other Appurtenances: Provide at least 300 mm (12 inches) clear from outer surfaces to the embankment or shoring. Remove rock as specified herein. Remove unstable soil that is incapable of supporting the structure to an overdepth of 300 mm (one foot) and refill with gravel or sand to the proper elevation. Stabilize soft, weak, or wet excavations as indicated. Refill over depths with gravel or sand to the required grade and compact to 90 percent of ASTM D1557 maximum density.

3.7.3 Compaction under Roads, Streets, and other Areas to be Paved: Place final backfill in 150 mm (6 inch) maximum loose lifts. If a vibratory roller is used for compaction of final backfill, the lift thickness can be increased to 225 mm (9 inches). Compact all backfill surrounding pipes, conduits, and other structures to 90 percent of ASTM D1557 maximum density except compact the top 300 mm (12 inches) of subgrade to 95 percent of ASTM D1557 maximum density. Backfill to permit the rolling and compacting of the completed excavation with the adjoining material, providing the specified density necessary to enable paving of the area immediately after backfilling has been completed. Compaction requirements for materials in pavement sections above the subgrade level shall be as specified in Section 02301, "Earthwork for Structures and Pavement."

3.8 FINISH OPERATIONS

3.8.1 Grading: Finish to grades indicated within 30 mm (one-tenth of a foot). Grade areas to drain water away from structures. Grade existing grades that are to remain but have been disturbed by the Contractor's operations.

3.8.2 Spreading Topsoil: Clear areas to receive topsoil for the finished surface of materials that would interfere with planting and maintenance operations. Scarify subgrade to a depth of 50 mm (2 inches). Do not place topsoil when the subgrade is extremely wet or dry, or in other conditions detrimental to seeding, planting, or grading. Spread topsoil to a uniform depth of 100 mm (4 inches) over the designated areas.

3.8.3 Disposition of Surplus Material; Surplus or other soil material not required or suitable for filling, backfilling, or grading shall be wasted by disposition off the work site, Comply with requirements of Section 01575, "Temporary Environmental Controls."

3.8.4 Protection of Surfaces: Protect newly graded areas from traffic, erosion, and settlements that may occur and as required in Section 01575, "Temporary Environmental Controls." Repair or reestablish damaged grades, elevations, or slopes.

3.9 FIELD QUALITY CONTROL: Test sand, gravel, bedding, backfill and topsoil for conformance to specified requirements. Test backfill to be used under roads and paved areas for conformance to special requirements. Test bedding and backfill for moisture-density relations in accordance with ASTM D1557 and as specified herein. Perform at least one of each of the required tests for each material provided. Perform sufficiently in advance of construction so as not to delay work. Provide additional tests as specified above for each change of source. Perform final tests on topsoil to ensure adjustment of parameters into the ranges specified. Perform density and moisture tests in randomly selected locations and in accordance with ASTM D1556, ASTM D2922 and ASTM D3017 as follows:

a. Bedding and backfill in trenches: One test per 15 meters: (50 linear feet) in each lift.

b. Appurtenance structures: One test per 9 square meters (100 square feet) or fractions thereof in each lift.

Where ASTM D2922 and ASTM D3017 are used to test field compaction densities, verify test results by performing at least one test per day using ASTM D1556 at a location already tested in accordance with ASTM D2922. Perform at least one additional test using ASTM D1556 for every ten tests performed with a nuclear device, at locations checked in accordance with ASTM D2922.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

4.1.1 Pipe Culvert and Drain Excavation

The volume of excavation to be paid for will be the number of cubic meters measured in original position of materials acceptably excavated in conformity with the Plans or as directed by the Engineers.

4.1.2 Sewer Pipes Excavation

The volume of excavation to be paid for will be the number of cubic meters measured in original position of materials acceptably excavated in conformity with the Plans or as directed by the Engineers.

4.1.3 Backfilling

The volume of backfill to be paid for will be the number of cubic meter in final position actually provided and placed.

4.1.4 Foundation Fill

The volume of foundation fill to be paid for will be the number of cubic meters measures in final position of granular material actually provided and placed under pipes.

4.1.5 Disposal of Excess Materials

The volume of excess materials shall be the net volume in its original position.

4.2 BASIS OF PAYMENT

The accepted quantities, measured as prescribed in Part 4.1 shall be paid for at the contract unit price for each /and Pay Items listed below that is included in the Bill of Quantities which price and payment shall be full compensation including all labor, equipment, tool, and incidentals necessary to the work prescribed in this Section.

Payment will be made under:

Pay Item Number	Description	Level of Measurement
02302(1)a	Pipe Culvert and Drain Excavation	Cubic Meter
02302(1)b	Sewer Pipe Excavation	Cubic Meter
02302(2)	Backfill	Cubic Meter
02302(3)	Foundation Fill	Cubic Meter
02302(4)	Disposal of Excess Material	Cubic Meter
02302(5)	Removal of Existing Pavement	Square Meter
02302(6)	Removal of Existing RCP Lines	Linear Meter
02302(7)	Removal of Existing Manholes	Each
02302(8)	Disposal of Debris	Cubic Meter

SECTION 02530

SANITARY SEWERS

PART 1- GENERAL

1.1 REFERENCES**:** The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

1.1.1 AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(Errata 2002) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C153/A21.53	Ductile-Iron Compact Fittings for Water Service
AWWA C302	Reinforced Concrete Pressure Pipe, Noncylinder Type
AWWA C600	Installation of Ductile-Iron Water Mains and Their Appurtenances
AWWA C605	Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
AWWA C606	Grooved and Shouldered Joints
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 12 In. (100 mm Through 300 mm), for Water Distribution
AWWA M23	Manual: PVC Pipe - Design and Installation

1.1.2 ASME INTERNATIONAL (ASME)

ASME B1.20.1	(1983; R 2006) Pipe Threads, General Purpose (Inch)
ASME B16.1	Standard for Gray Iron Threaded Fittings; Classes 125 and 250
ASME B18.2.2	(1987; R 2005) Standard for Square and Hex Nuts
ASME B18.5.2.1M	Metric Round Head Short Square Neck Bolts
ASME B18.5.2.2M	(1982; R 2005) Metric Round Head Square Neck Bolts

1.1.3 ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 47/A 47M	(1999; R 2004) Standard Specification for Steel Sheet, Aluminum-Coated, by the Hot-Dip Process
ASTM A 48/A 48M	Standard Specification for Gray Iron Castings
ASTM A 536	(1984; R 2004) Standard Specification for Ductile Iron Castings
ASTM A 563	Standard Specification for Carbon and Alloy Steel Nuts
ASTM A 563M	Standard Specification for Carbon and Alloy Steel Nuts (Metric)
ASTM A 74	Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM A 746	Standard Specification for Ductile Iron Gravity Sewer Pipe
ASTM C 12	Standard Practice for Installing Vitrified Clay Pipe Lines
ASTM C 14	Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe
ASTM C 14M	Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)

ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 270	Standard Specifications for Mortar for Unit Masonry
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 361	Standard Specifications for Reinforced Concrete Low-Head Pressure Pipe
ASTM C 361M	Standard Specification for Reinforced Concrete Low-Head Pressure Pipe (Metric)
ASTM C 425	Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings
ASTM C 443	Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C 443M	Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C 478	Standard Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 478M	Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric)
ASTM C 564	Standard Specifications for Rubber Gaskets for Cast Iron Soil Pipe and Fittings
ASTM C 700	Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C 76	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C 76M	Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM C 923	Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals
ASTM C 923M	Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric)
ASTM C 924	Testing Concrete Pipe Sewer Lines by Low-Pressure Air

	Test Method
ASTM C 924M	Testing Concrete Pipe Sewer Liner by Low-Pressure Air Test Method (Metric)
ASTM C 94/C 94M	Standard Specification for Ready-Mixed Concrete
ASTM C 969	Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
ASTM C 969M	Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM C 972	(2000; R 2006) Compression-Recovery of Tape Sealant
ASTM C 990	Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants
ASTM C 990M	Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric)
ASTM D 1784	Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
ASTM D 1785	Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
ASTM D 2241	Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM D 2412	Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D 2464	Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2466	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
ASTM D 2467	Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
ASTM D 2996	(2001; R 2007e1) Filament-Wound "Fiberglass" (Glass-

	Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D 2997	(2001; R 2007e1) Centrifugally Cast "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D 3034	Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings
ASTM D 3139	(1998; R 2005) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
ASTM D 3212	Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D 3262	"Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D 3350	Polyethylene Plastics Pipe and Fittings Materials
ASTM D 3753	Glass-Fiber-Reinforced Polyester Manholes and Wet wells
ASTM D 3840	(2001; R 2005) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications
ASTM D 4101	Standard Specification for Polypropylene Injection and Extrusion Materials
ASTM D 412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension
ASTM D 4161	(2001; R 2005) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM D 624	(2000; R 2007) Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers
ASTM F 402	Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
ASTM F 405	Corrugated Polyethylene (PE) Tubing and Fittings
ASTM F 477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 714	(2008) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

ASTM F 758	(1995; R 2007e1) Smooth-Wall Poly(Vinyl Chloride) (PVC) Plastic Underdrain Systems for Highway, Airport, and Similar Drainage
ASTM F 794	Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM F 894	Polyethylene (PE) Large Diameter. Profile Wall Sewer and Drain Pipe
ASTM F 949	Poly (Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings

1.1.5 INTERNATIONAL STANDARDS AND SPECIFICATIONS (ISO)

ISO 3126	Plastic Piping Systems – Plastics Components – Determination of Dimensions
ISO 4427	Plastic Piping Systems – Polyethylene (PE) Pipes and Fittings for Water Supply

1.2 SYSTEM DESCRIPTION

1.2.1 Sanitary Sewer Gravity and Pressure Pipeline: Provide mains and laterals of Polyethylene Pipe (PE) plastic pipe. Provide building connections of Polyethylene Pipe (PE) plastic pipe. Provide new sanitary gravity sewer piping, sewer force main and appurtenances. Provide each system complete and ready for operation. The exterior sanitary gravity sewer and pressure piping system includes equipment, materials, installation, and workmanship as specified herein more than 1.5 m 5 feet outside of building walls.

1.3 SUBMITTALS: Submit the following:

SD-01 Preconstruction Submittals
Existing Conditions
Drawings of existing conditions, as specified.

SD-02 Shop Drawings
Drawings
Installation and As-Built drawings, as specified.
Precast concrete manhole
Metal items
Frames, covers, and gratings
Details, as specified.

SD-03 Product Data
Pipeline materials
Submit manufacturer's standard drawings or catalog cuts.

SD-06 Test Reports

Reports
Test and inspection reports, as specified.

SD-07 Certificates

Portland Cement
Certificates of compliance stating the type of cement used in manufacture of concrete pipe, fittings and precast manholes.
Gaskets
Certificates of compliance stating that the fittings or gaskets used for waste drains or lines designated on the plans are oil resistant.

1.4 QUALITY ASSURANCE

1.4.1 Installer Qualifications

Install specified materials by a licensed underground utility Contractor licensed for such work in the state where the work is to be performed. Installing Contractor's License shall be current and be state certified or state registered.

1.4.2 Drawings

a. Submit Installation Drawings showing complete detail, both plan and side view details with proper layout and elevations.

b. Submit As-Built Drawings for the complete sanitary sewer system showing complete detail with all dimensions, both above and below grade, including invert elevation.

c. Sign and seal As-Built Drawings by a Professional Surveyor and Mapper. Include the following statement: "All potable water lines crossed by sanitary hazard mains are in accordance with the permitted utility separation requirements."

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

1.5.1.1 Piping

Inspect materials delivered to site for damage; store with minimum of handling. Store materials on site in enclosures or under protective coverings. Store plastic piping and jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes and fittings free of dirt and debris.

1.5.1.2 Metal Items

Check upon arrival; identify and segregate as to types, functions, and sizes. Store off the ground in a manner affording easy accessibility and not causing excessive rusting or coating with grease or other objectionable materials.

1.5.1.3 Cement, Aggregate, and Reinforcement

As specified in Section 03300 CONCRETE.

1.5.2 Handling

Handle pipe, fittings, and other accessories in such manner as to ensure delivery to the trench in sound undamaged condition. Take special care not to damage linings of pipe and fittings; if lining is damaged, make satisfactory repairs. Carry, do not drag, pipe to trench.

1.6 PROJECT/SITE CONDITIONS

Submit drawings of existing conditions, after a thorough inspection of the area in the presence of the Contracting Officer. Details shall include the environmental conditions of the site and adjacent areas. Submit copies of the records for verification before starting work.

PART 2 - PRODUCTS

2.1 PIPELINE MATERIALS: Pipe shall conform to the respective specifications and other requirements specified below.

2.1.1 Gravity Sewer and Force Main Piping

2.1.1.1 Polyethylene (PE) Gravity and Pressure Pipe: Pipe shall be manufactured and tested in accordance with ISO 4427. Base compound material designation shall be PE 80 as listed in ISO 4427, with corresponding minimum required strength (MRS) at 50 years.

Dimensional requirements shall be as specified when tested in accordance with ISO 3126.

Pipes shall be manufactured from polyethylene containing only those antioxidants, UV stabilizers and pigments necessary for the manufacture of pipes conforming to this specification and for its end use, including weldability when it is possible.

For gravity sewer piping, pipes shall be classified as SDR 33 with nominal pressure rating, PN of 4.

For sewer force main piping, pipes shall be classified as SDR 13.6 with nominal pressure rating, PN of 10.

2.1.1.2 Polyethylene (PE) Fittings: Pipes may be joined by electro-fusion or by thermal butt fusion for sizes 150mm and larger. Joints shall be designed to a pressure rating of 1.6 MPa (16 bars).

2.2 CONCRETE MATERIALS

2.2.1 Cement Mortar

Cement mortar shall conform to ASTM C 270, Type M with Type II cement.

2.2.2 Portland Cement

Portland cement shall conform to ASTM C 150, Type [II] [V] for concrete used in concrete pipe, concrete pipe fittings, and manholes and type optional with the Contractor for cement used in concrete cradle, concrete encasement, and thrust blocking. [Air-entraining admixture conforming to ASTM C 260 shall be used with Type V cement.] [Where aggregates are alkali reactive, as determined by Appendix XI of ASTM C 33, a cement containing less than 0.60 percent alkali shall be used.]

2.2.3 Portland Cement Concrete

Portland cement concrete shall conform to ASTM C 94/C 94M, compressive strength of 28 MPa 4000 psi at 28 days, except for concrete cradle and encasement or concrete blocks for manholes. Concrete used for cradle and encasement shall have a compressive strength of 17 MPa 2500 psi minimum at 28 days. Concrete in place shall be protected from freezing and moisture loss for 7 days.

2.3 MISCELLANEOUS MATERIALS

2.3.1 Precast Concrete Manholes & Glass-Fiber-Reinforced Polyester Manholes

Precast concrete manhole risers, base sections, and tops shall conform to ASTM C 478M ASTM C 478 and be manufactured in accordance with Section 03 40 00.00 10 PLANT-PRECAST CONCRETE PRODUCTS FOR BELOW GRADE CONSTRUCTION; base and first riser shall be monolithic. Glass-Fiber-Reinforced Polyester Manholes shall conform to ASTM D 3753.

2.3.2 Gaskets and Connectors

Gaskets for joints between manhole sections shall conform to ASTM C 443M ASTM C 443. Resilient connectors for making joints between manhole and pipes entering manhole shall conform to ASTM C 923M ASTM C 923 or ASTM C 990M ASTM C 990.

2.3.3 External Preformed Rubber Joint Seals

An external preformed rubber joint seal shall be an accepted method of sealing cast iron covers to precast concrete sections to prevent ground water infiltration into sewer systems. All finished and sealed manholes constructed in accordance with paragraph entitled "Manhole Construction" shall be tested for leakage in the same manner as pipelines as described in paragraph entitled "Leakage Tests." The seal shall be multi-section with a neoprene rubber top section and all lower sections made of Ethylene Proplene Di Monomer (EPDM) rubber with a minimum thickness of 1.5 mm 60 mils. Each unit shall consist of a top and

bottom section and shall have mastic on the bottom of the bottom section and mastic on the top and bottom of the top section. The mastic shall be a non-hardening butyl rubber sealant and shall seal to the cone/top slab of the manhole/catch basin and over the lip of the casting. Extension sections shall cover up to two more adjusting rings. Properties and values are listed in the following tables:

Properties, Test Methods and Minimum Values for
Rubber used in Preformed Joint Seals

Physical Properties	Test	Methods	EPDM	Neoprene	Butyl mastic
Tensile, kPa	ASTM	D 412	12,684	15,132	-
Elogation percent	ASTM	D 412	553	295	350
Tear Resistance, N/mm	ASTM (Die	D 624 B)	49	28	-
Rebound, percent, 5 minutes	ASTM C 972 (mod.)		-	-	11
Rebound, percent, 2 hours	ASTM C 972		-	-	12]

Properties, Test Methods and Minimum Values for
Rubber used in Preformed Joint Seals

Physical Properties	Test Methods		EPDM	Neoprene	Butyl mastic
Tensile, psi	ASTM	D 412	1840	2195	-
Elogation percent	ASTM	D 412	553	295	350
Tear Resistance, ppi	ASTM (Die	D B) 624	280	160	-
Rebound, percent, 5 minutes	ASTM C 972 (mod.)		-	-	11
Rebound, percent, 2 hours	ASTM C 972		-	-	12]

2.3.4 Metal Items

2.3.4.1 Frames, Covers, and Gratings for Manholes

FS A-A-60005, cast iron; figure numbers shall be as follows:

a. Traffic manhole: Provide in paved areas.

Frame:	Figure 1, Size 22A
Cover:	Figure 8, Size 22A
Steps:	Figure 19

b. Non-traffic manhole:

Frame:	Figure 4, Size 22
Cover:	Figure 12, Size 22
Steps:	Figure 19

Frames and covers shall be cast iron, ductile iron or reinforced concrete. Cast iron frames and covers shall be as indicated or shall be of type suitable for the application, circular, without vent holes. The frames and covers shall have a combined weight of not less than 181.4 kg 400 pounds. Reinforced concrete frames and covers shall be as indicated or shall conform to ASTM C 478M ASTM C 478. The word "Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.3.4.2 Manhole Steps

Zinc-coated steel as indicated conforming to 29 CFR 1910.27. As an option, plastic or rubber coating pressure-molded to the steel may be used. Plastic coating shall conform to ASTM D 4101, copolymer polypropylene. Rubber shall conform to ASTM C 443M ASTM C 443, except shore A durometer hardness shall be 70 plus or minus 5. Aluminum steps or rungs will not be permitted. Steps are not required in manholes les 1.2 m 4 feet deep.

2.3.4.3 Manhole Ladders

A steel ladder shall be provided where the depth of a manhole exceeds 3.6 m 12 feet. The ladder shall not be less than 406 mm 16 inches in width, with 19 mm 3/4 inch diameter rungs spaced 305 mm 12 inches apart. The two stringers shall be a minimum 10 mm 3/8 inch thick and 51 mm 2 inches wide. Ladders and inserts shall be galvanized after fabrication in conformance with ASTM A 123/A 123M.

2.4 EQUIPMENT

2.4.1 Submersible Sewage Pump

2.4.1.1 Scope:

The Contractor shall furnish and install as shown on the plans and described in these specifications, submersible sewage pump. The Contractor shall also furnish all valving, piping, level and motor controls necessary to provide the owner with a fully operational system.

2.4.1.2 Specification for Pumps

Service	Sewage Lift Station 1	Sewage Lift Station 2	Sewage Lift Station 4	Sewage Lift Station 5
Quantity	3 (including 1 Stand-by)	3 (including 1 Stand-by)	3 (including 1 Stand-by)	3 (including 1 Stand-by)
Liquid Name	Sewage	Sewage	Sewage	Sewage
Maximum liquid temperature	104 ^{0}F	104 ^{0}F	104 ^{0}F	104 ^{0}F
Type	Non-clog Submersible	Non-clog Submersible	Non-clog Submersible	Non-clog Submersible
Design Capacity, (GPM)	230	750	195	230
Total Head, ft.	35	35	35	35
Motor Input, HP	7.5	10	5.0	7.5
Rpm	1770	1765	1760	1770
Material: Pump housing	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B
Impeller	ASTM A48 CLASS40B DIN W.-Nr. ASTM A48 Class 40B	ASTM A48 CLASS40B DIN W.-Nr. ASTM A48 Class 40B	ASTM A48 CLASS40B DIN W.-Nr. ASTM A48 Class 40B	ASTM A48 CLASS40B DIN W.-Nr. ASTM A48 Class 40B
Motor	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B	ASTM A48 CLASS25B DIN W.-Nr. ASTM A48 Class 25B
Product Name	SL1.40.A60. 75.4.61H	SL1.40.A60. 100.4.61H	SL1.30.A40. 40.A.4.61H	SL1.40.A60. 75.4.61H
Power Supply	440V x 3 phase x 60 Hz	440V x 3 phase x 60 Hz	440V x 3 phase x 60 Hz	440V x 3 phase x 60 Hz

2.4.1.3 Pumping System

Operating Conditions: Each pump shall be capable of delivering a design flow capacity against a total dynamic head as shown below. The pump shall be broadband efficiency design allowing the motor to operate throughout the entire calculated system curve range without utilizing the motor 1.10 service factor. Utility power at the site shall be 3 Phase, 60 hertz, 460 volt and 3 wire service.

2.4.1.4 Pump Construction:

Impeller: The impeller shall be of one-piece ASTM A48, Class 40B, close grain cast iron design. The impeller shall be or semi-open design, with smooth contours, without acute turns, free of blowholes and imperfections, with high efficiency throughout a broad-band operating range.

The impeller shall be capable of field trimming and balancing to meet actual site specific conditions. The hub shall be accurately slip fitted and key driven to the motor shaft. The impeller shall be securely attached to the shaft by means of a locking washer and impeller screw of AISI-304 stainless steel.

Volute: The pump volute casting shall be of high strength ASTM A48, Class 40B, close grain cast iron, single piece no-concrete design, with smooth contoured surfaces and fluid passages capable of passing any solid which passes through the impeller.

The foot mounted volute shall be designed to support the entire operating weight of the motor rotating assembly once lowered into place.

Enclosure: The motor enclosure shall be of ASTM A48, Class 40B, close grain cast
iron construction with smooth surfaces devoid of irregularities and blow holes. All adjoining sections of motor enclosure shall be joined and sealed with accurately machined rabbit joints with long overlaps and fitted with BUNA-N "O" rings. The combined metal to metal overlap contact and "O" ring seal compression shall insure watertight integrity to 65 feet of submergence.

Each motor shall be UL (Underwriter Laboratory) approved as Explosion-Proof for operation in a Class I, Division I, Group D hazardous location.

Electrical Cables: The motor and sensor cables length shall be as required of continuous unspliced cable. The cables shall be of heavy duty, submersible, hard service type, and shall have multi-conductor, stranded copper leads and type SOW neoprene jacketed portable rated at 600V, 60 ^{0}C.

Cable Entry: The cable entry water sealing design shall insure a watertight and submersible seal, comprised of BANU-N grommet, and epoxy sealed, butt connector spliced leads, keeping water from entering the top of the motor. The complete cable entry cap assembly shall be securely fastened to the motor junction chamber housing.

Junction Chamber: The cable entry junction chamber shall provide for sire nut connection of the power cable to the motor stator leads. The auxiliary signal cable shall also be connected by wire nut to the motor winding thermal and motor sealed moisture sensor leads.

Motor: The motor shall be dry, air, filled, squirrel cage induction shell type, Nema Design B. The stator windings shall be triple dipped and baked in class F varnish and insulatrd with moisture resistance class F insulation. The stator shall be heat-shrink fitted into the motor housing to provide accurate alignment and maximum heat transfer with the motor housing. U.L. approved as explosion-proof for operation in a Class I, Division I, Group D hazardous location.

The motor shall be rated for continuous duty service (submerged) and capable of sustaining 10 starts per hour with a minimum of 1.10 service factor.

At design point the motor winding temperature shall not exceed 105^0C. The motor shall be non-overloading across the entire anticipated operating range of the system curve without use of the service factor.

The pump and motor shall be of adequate design to provide proper heat transfer and cooling required by the motor at maximum rated power.

Motor Sensors: The motor stator temperature shall be continuously monitored by three (3) low resistant, bi-metallic, (N. C.) normally closed thermal switches embedded in the stator windings. These thermal sensor switches shall be as additional supplemental motor protection provided by the motor starter in the control panel.

The motor shall also be provided with a tandem probe sensing system. The two moisture sensing probes shall be mounted in the oil filled seal chamber and will detect the presence of conductive liquid which passes the primary lower seal.

Upon detection the sensors shall actuate a pane mounted relay which will provide the operator with a visual indication of impending seal failure.

Shaft: The pump and motor shaft shall be of one piece, extra heavy, high strength design, and of AISI-416 high chrome stainless steel shafting with tensile and mechanical properties. The shaft shall be of such design to provide for minimum overhang to reduce shaft deflection and prolong bearing life.

Bearing: The pump and motor shall rotate on two permanently lubricated ball. The upper bearing shall be of single row, deep grooved ball bearing type locked in place to withstand radial loading. The bearing shall be rated at a minimum B-10 bearing life of 17,500 hours of design loads. Upper and lower ball bearing shall be permanently lubricated with high temperature grease.

Mechanical Seals: Each pump shall be provided with a tandem mechanical shaft sealing system, operating independently.

The upper secondary mechanical seal shall have a ceramic stationary seal seat running against a positively driven rotating carbon ring which functions as an independent secondary barrier between the pumped fluid and the motor stator housing. Seal tension is preset by means of snap ring.

Mechanical seals of conventional double spring acting between the upper and lower seals, requiring pressure differentials to off-set external pressures shall not be considered acceptable.

2.4.1.5 Exposed Surfaces:

All exterior surfaces coming in contact with wastewater, other than brass or stainless steel, shall be protected by a suitable coating.

All exposed external metal surfaces shall first be cleaned by high pressure

water or team. Grease and oil shall be removed by a suitable solvent cleaner.

Immediately following surface preparation, the clean metal surface shall be given a standard finished coat of air-dried alkyd resin type enamel containing zinc chromate rust inhibitive pigment. The completed coating shall have a good adhesion and a high degree of resistance to moisture, alkalis and oils.

2.4.1.6 Controller:

Control Panel: The electrical controls shall be mounted inside a NEMA 3R enclosure fabricated of steel. The enclosure shall be provided with a through the door disconnect and bear a UL label of an enclosure manufacturer.

All components will bear a UL label. All wiring, workmanship and schematics will comply with standards set forth by the National Electrical Code (NEC) and underwriter Laboratory (UL).

Wiring/Conduit: All pilot duty volt control circuit wiring inside the control panel, shall be a minimum of MTH, 600 volt rated, 18 gauge with 90^0C temperature rating, in accordance with UL standards. All conduit connections are to be UL listed and installed in accordance with NEC standards.

Power Isolation: Power wiring and sensor/control wiring shall be isolated in separate conduit between the motor and the controller to avoid electrical field interference causing nuisance and false sensing.

Motor Protection: Each pump motor shall be protected by a properly sized motor starter.

The magnetic motor starter shall be equipped with under-voltage release and ambient compensated overload protection.

Mechanical Float Switch: The automatic pumping cycle shall controlled with a NEMA 4 mechanical ball and rod float switch, mounted onto the cover plate with vapor tight stand. The float switch shall be provided with DPST, level operated, snap action contacts. The mechanical float switch shall be field adjustable. The electrical contact shall maintain pump operation between the on and off level.

Moisture Sensing: A moisture sensing relay shall be provided for each submersible pump motor. The relay shall be electrically field connected to the tandem moisture probes mounted in the pumps oil field seal chamber, a relay coil will activate an indicating light on the panel door and annunciate an alarm signal.

Compression Alarm: An additional compression type sensor shall be provided to sense the static pressure of air trapped in the compression pipe as the liquid level rises. The compression alarm switch shall be provided with SPDT snap action contacts.

Mercury Sensor Alarm: An additional level sensor shall be provided to indicate high wet level conditions. The sensor shall activate a panel mounted

red alarm light.

In addition, the high water alarm sensor shall activate an audible-visible combination remote mounted NEMA 3R red light and bell. A "Push-to Silence" button shall be provided which will activate a relay silencing the audible alarm, the visual light will continue to indicate an alarm condition has been corrected.

2.4.1.7 Testing:

Each pump shall be given a commercial operation test to check for leakage, excessive vibration and to determine conformance with the performance specifications. All irregularities will be corrected prior to shipment from the factory.

2.4.1.8 Installation:

The installation of the pumping equipment shall be in accordance with the drawings and manufacturer's instructions. All equipment shall be supported and securely anchored, making sure all connection are plumb and tight. All construction debris shall be remove from the system and wet well prior to operation of the pumping equipment.

2.4.1.9 Start-Up and Field Testing:

Start-up and operational field tests shall be conducted by the pump manufacturer's factory trained start-up representative. The start-up and operational test shall be conducted in the presence of the Engineer, owner operator personnel and the contractor. Final site specific level control adjustment shall be made to ensure proper functioning of the system.

2.4.2.1 Warranty:

The pump unit or any part thereof shall be warranted against defects in material or workmanship within one year from the date of installation or 18 months from date of manufactures, whichever comes first, and shall be replaced at no charge with a new or manufactures part, F. O. B. Factory or authorized warranty service station. The warranty shall not assume responsibility for removal, reinstallation or freight, nor shall it assume responsibility of incidental damages resulting from the failure of the pump to perform. The warranty shall not apply to damage resulting from accident, alteration of design, misuse or abuse.

2.5 REPORTS

Submit Test Reports. Compaction and density test shall be in accordance with Section 31 00 00 EARTHWORK. Submit Inspection Reports for daily activities during the installation of the sanitary system. Information in the report shall be detailed enough to describe location of work and amount of pipe laid in place, measured in linear meters feet.

PART 3 - EXECUTION

3.1 INSTALLATION OF PIPELINES AND APPURTENANT CONSTRUCTION

3.1.1 Location

The work covered by this section shall terminate at a point approximately 1.5 m from the building, unless otherwise indicated. Where the location of the sewer is not clearly defined by dimensions on the drawings, do not lay sewer line closer horizontally than 3 m 10 feet to a water main or service line. Where sanitary sewer lines pass above water lines, encase sewer in concrete for a distance of 3 m 10 feet on each side of the crossing, or substitute rubber-gasketed pressure pipe for the pipe being used for the same distance. Where sanitary sewer lines pass below water lines, lay pipe so that no joint in the sewer line will be closer than 0.9 m 3 feet, horizontal distance, to the water line.

a. Sanitary piping installation parallel with water line:

1 Normal conditions: Sanitary piping or manholes shall be laid at least 3 m horizontally from a water line whenever possible. The distance shall be measured edge-to-edge.

2 Unusual conditions: When local conditions prevent a horizontal separation of 3 m, the sanitary piping or manhole may be laid closer to a water line provided that:

(aa) The top (crown) of the sanitary piping shall be at least 450 mm below the bottom (invert) of the water main.

(bb) Where this vertical separation cannot be obtained, the sanitary piping shall be constructed of AWWA-approved ductile iron water pipe pressure tested in place without leakage prior to backfilling.

(cc) The sewer manhole shall be of watertight construction and tested in place.

b. Installation of sanitary piping crossing a water line:

1 Normal conditions: Lay sanitary sewer piping by crossing under water lines to provide a separation of at least 450 mm between the top of the sanitary piping and the bottom of the water line whenever possible.

2 Unusual conditions: When local conditions prevent a vertical separation described above, use the following construction:

(aa) Sanitary piping passing over or under water lines shall be constructed of AWWA-approved ductile iron water pipe, pressure tested in place without leakage prior to backfilling.

(bb) Sanitary piping passing over water lines shall, in addition, be protected by providing:

(1). A vertical separation of at least 450 mm between the bottom of the sanitary piping and the top of the water line.

(2). Adequate structural support for the sanitary piping to prevent excessive deflection of the joints and the settling on and breaking of the water line.

(3). That the length, minimum 6.1 m, of the sanitary piping be centered at the point of the crossing so that joints shall be equidistant and as far as possible from the water line.

c. Sanitary sewer manholes: No water piping shall pass through or come in contact with any part of a sanitary sewer manhole.

3.1.1.2 Earthwork

Perform earthwork operations in accordance with Section 02302

3.1.1.3 Pipe Laying and Jointing

Inspect each pipe and fitting before and after installation; replace those found defective and remove from site. Provide proper facilities for lowering sections of pipe into trenches. Lay nonpressure pipe with the bell or groove ends in the upgrade direction. Adjust spigots in bells and tongues in grooves to give a uniform space all around. Blocking or wedging between bells and spigots [or tongues and grooves] will not be permitted. Replace by one of the proper dimensions, pipe or fittings that do not allow sufficient space for installation of joint material. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Provide batterboards not more than 7.50 m apart in trenches for checking and ensuring that pipe invert elevations are as indicated. Laser beam method may be used in lieu of batterboards for the same purpose. Branch connections shall be made by use of regular fittings or solvent cemented saddles as approved. Saddles for PVC composite pipe shall conform to Figure 2 of ASTM D 2680; saddles for ABS pipe shall comply with Table 3 of ASTM D 2751; and saddles for PVC pipe shall conform to Table 4 of ASTM D 3034.

3.1.1.4 Connections to Existing Lines

Obtain approval from the Contracting Officer before making connection to existing line. Conduct work so that there is minimum interruption of service on existing line.

3.1.2 Special Requirements

3.1.2.1 Installation of Polyethylene (PE) Plastic Pipe and Fittings

After a section of pipe has been lowered into the prepared trench and immediately before joining the pipe, the end of the pipe to be joined shall be cleaned, and the rubber gasket lubricated, with a vegetable compound soap all in accordance with the pipe manufacturer's instructions. Assembly of the pipe lengths shall be in accordance with the recommendations of the manufacturer of the type of joint used. All special tools and appliance required for joining the pipe shall be provided by the Contractor. When cutting or machining of the pipe is necessary, only tools and methods recommended by

the pipe manufacturer and approved by the Engineer shall be employed.

3.1.3 Concrete Work

Cast-in-place concrete is included in Section 03300 CAST-IN-PLACE CONCRETE. The pipe shall be supported on a concrete cradle, or encased in concrete where indicated or directed.

3.1.4 Manhole Construction

Construct base slab of cast-in-place concrete or use precast concrete base sections. Make inverts in cast-in-place concrete and precast concrete bases with a smooth-surfaced semi-circular bottom conforming to the inside contour of the adjacent sewer sections. For changes in direction of the sewer and entering branches into the manhole, make a circular curve in the manhole invert of as large a radius as manhole size will permit. For cast-in-place concrete construction, either pour bottom slabs and walls integrally or key and bond walls to bottom slab. No parging will be permitted on interior manhole walls. For precast concrete construction, make joints between manhole sections with the gaskets specified for this purpose; install in the manner specified for installing joints in concrete piping. Purging will not be required for precast concrete manholes. Cast-in-place concrete work shall be in accordance with the requirements specified under paragraph entitled "Concrete Work" of this section. Make joints between concrete manholes and pipes entering manholes with the resilient connectors specified for this purpose; install in accordance with the recommendations of the connector manufacturer. Where a new manhole is constructed on an existing line, remove existing pipe as necessary to construct the manhole. Cut existing pipe so that pipe ends are approximately flush with the interior face of manhole wall, but not protruding into the manhole. Use resilient connectors as previously specified for pipe connectors to concrete manholes.

3.1.5 Miscellaneous Construction and Installation

3.1.5.1 Connecting to Existing Manholes

Pipe connections to existing manholes shall be made so that finish work will conform as nearly as practicable to the applicable requirements specified for new manholes, including all necessary concrete work, cutting, and shaping. The connection shall be centered on the manhole. Holes for the new pipe shall be of sufficient diameter to allow packing cement mortar around the entire periphery of the pipe but no larger than 1.5 times the diameter of the pipe. Cutting the manhole shall be done in a manner that will cause the least damage to the walls.

3.1.5.2 Metal Work

a. Workmanship and finish: Perform metal work so that workmanship and finish will be equal to the best practice in modern structural shops and foundries. Form iron to shape and size with sharp lines and angles. Do shearing and punching so that clean true lines and surfaces are produced. Make castings sound and free from warp, cold shuts, and blow holes that may impair their strength or appearance. Give exposed surfaces a smooth finish with sharp well-defined lines and arises. Provide necessary rabbets, lugs, and brackets wherever necessary for fitting and support.

b. Field painting: After installation, clean cast-iron frames, covers, gratings, and steps not buried in concrete to bare metal of mortar, rust, grease, dirt, and other deleterious materials and apply a coat of bituminous paint. Do not paint surfaces subject to abrasion.

3.1.7 Installations of Wye Branches

Cutting into piping for connections shall not be done except in special approved cases. When the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, the pipe shall be encased in concrete backfill or supported on a concrete cradle as directed. Concrete required because of conditions resulting from faulty construction methods or negligence by the Contractor shall be installed at no additional cost to the Government. The installation of wye branches in an existing sewer shall be made by a method which does not damage the integrity of the existing sewer. One acceptable method consists of removing one pipe section, breaking off the upper half of the bell of the next lower section and half of the running bell of wye section. After placing the new section, it shall be rotated so that the broken half of the bell will be at the bottom. The two joints shall then be made with joint packing and cement mortar.

3.2 FIELD QUALITY CONTROL

3.2.1 Field Tests and Inspections

The Contracting Officer will conduct field inspections and witness field tests specified in this section. Perform field tests and provide labor, equipment, and incidentals required for testing. Be able to produce evidence, when required, that each item of work has been constructed in accordance with the drawings and specifications.

3.2.2 Tests for Nonpressure Lines

Check each straight run of pipeline for gross deficiencies by holding a light in a manhole; it shall show a practically full circle of light through the pipeline when viewed from the adjoining end of line. When pressure piping is used in a nonpressure line for nonpressure use, test this piping as specified for nonpressure pipe.

3.2.2.1 Leakage Tests

Test lines for leakage by either infiltration tests or exfiltration tests, or by low-pressure air tests. Prior to testing for leakage, backfill trench up to at least lower half of pipe. When necessary to prevent pipeline movement during testing, place additional backfill around pipe sufficient to prevent movement, but leaving joints uncovered to permit inspection. When leakage or pressure drop exceeds the allowable amount specified, make satisfactory correction and retest pipeline section in the same manner. Correct visible leaks regardless of leakage test results.

a. Infiltration tests and exfiltration tests: Perform these tests for sewer lines made of the specified materials, not only concrete, in accordance with ASTM C 969M ASTM C 969. Make calculations in accordance with the Appendix to ASTM C 969M ASTM C 969.

b. Low-pressure air tests: Perform tests as follows:

Test in accordance with UBPPA UNI-B-6. Allowable pressure drop shall be as given in UBPPA UNI-B-6. Make calculations in accordance with the Appendix to UBPPA UNI-B-6.

3.2.2.2 Deflection Testing

Perform a deflection test on entire length of installed plastic pipeline on completion of work adjacent to and over the pipeline, including leakage tests, backfilling, placement of fill, grading, paving, concreting, and any other superimposed loads determined in accordance with ASTM D 2412. Deflection of pipe in the installed pipeline under external loads shall not exceed 4.5 percent of the average inside diameter of pipe. Determine whether the allowable deflection has been exceeded by use of a pull-through device or a deflection measuring device.

a. Pull-through device: This device shall be a spherical, spheroidal, or elliptical ball, a cylinder, or circular sections fused to a common shaft. Circular sections shall be so spaced on the shaft that distance from external faces of front and back sections will equal or exceed diameter of the circular section. Pull-through device may also be of a design promulgated by the Uni-Bell Plastic Pipe Association, provided the device meets the applicable requirements specified in this paragraph, including those for diameter of the device, and that the mandrel has a minimum of 9 arms. Ball, cylinder, or circular sections shall conform to the following:

1 A diameter, or minor diameter as applicable, of 95 percent of the average inside diameter of the pipe; tolerance of plus 0.5 percent will be permitted.

2 Homogeneous material throughout, shall have a density greater than 1.0 as related to water at 4 degrees C 39.2 degrees F, and shall have a surface Brinell hardness of not less than 150.

3 Center bored and through-bolted with a 6 mm 1/4 inch minimum diameter steel shaft having a yield strength of not less than 483 MPa 70,000 psi, with eyes or loops at each end for attaching pulling cables.

4 Each eye or loop shall be suitably backed with a flange or heavy washer such that a pull exerted on opposite end of shaft will produce compression throughout remote end.

b. Deflection measuring device: Sensitive to 1.0 percent of the diameter of the pipe being tested and shall be accurate to 1.0 percent of the indicated dimension. Deflection measuring device shall be approved prior to use.

c. Pull-through device procedure: Pass the pull-through device through each run of pipe, either by pulling it through or flushing it through with water. If the device fails to pass freely through a pipe run, replace pipe which has the excessive deflection and completely retest in same manner and under same conditions.

d. Deflection measuring device procedure: Measure deflections through each run of installed pipe. If deflection readings in excess of 4.5 percent of average inside diameter of pipe are obtained, retest pipe by a run from the opposite direction. If retest continues

to show a deflection in excess of 4.5 percent of average inside diameter of pipe, replace pipe which has excessive deflection and completely retest in same manner and under same conditions.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Sewer Pipe of the different types and sizes will be measured by the linear meter in place. Conduit with sloped or skewed ends will be measured along the invert.

The quantities of Submersible Non-Clog Sewage – Pump shall be the by lot of submersible Non-Clog Sewage Pump specified, including controller and accessories.

4.2 BASIS OF PAYMENT

The quantities as provided in Part 4.1 shall be paid at the contract price per unit of measurement from each of the Pay Item here listed below which price and payment shall be full compensation including all labor, equipment, tools and incidentals necessary for the work prescribed in this Section.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
02530 (1)	Sewer Pipe	Linear Meter
02530 (2)	Sewer Force Main	Linear Meter
02530 (3)	Sewer Pipe Service Connection	Linear Meter
02530 (4)	Sewer Manhole Frames and Covers	Each
02530 (5)	Submersible Non-Clay Sewage Pump	Lot

SECTION 02630

STORM-DRAINAGE SYSTEM

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 123/A 123M	Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM C 14M	Concrete Sewer, Storm Drain, and Culvert Pipe (Metric)
ASTM C 76M	Reinforced Concrete Culverts, Storm Drain, and Sewer Pipe (Metric)
ASTM C 139	Concrete Masonry Units for Construction of Catch Basins and Manholes
ASTM C 231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 270	Mortar for Unit Masonry
ASTM C 924M	Concrete Pipe Sewer Lines by Low-Pressure Air Test Method (Metric)
ASTM C 1103M	Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric)
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 2167	Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

1.3 SUBMITTALS: The following shall be submitted

Product Data

Placing Pipe;

Printed copies of the manufacturer's recommendations for installation procedures of the material being placed, prior to installation.

Samples

Pipe for Culverts and Storm Drains;
Samples of the materials, before work is started.

Certificates

Pipeline Testing;
Determination of Density;
Frame and Cover for Gratings;

Certified copies of test reports demonstrating conformance to applicable pipe specifications, before pipe is installed. Certification on the ability of frame and cover or gratings to carry the imposed live load.

1.4 DELIVERIES, STORAGE, AND HANDLING

1.4.1 Delivery and Storage: Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Owner's Representative.

1.4.2 Handling: Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

PART 2 - PRODUCTS

2.1 PIPES FOR CULVERTS AND STORM DRAINS: Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

2.1.1 Concrete Pipe: ASTM C 76M ASTM C 76, Class II, IV, or ASTM C 655, D-Load.

2.1.1.1 Nonreinforced Pipe: ASTM C 14M ASTM C 14, Class [1] [2] [3].

2.1.1.2 Cast-In-Place Nonreinforced Conduit: ACI 346/346R, except that testing shall be the responsibility of and at the expense of the Contractor. In the case of other conflicts between ACI 346/346R and project specifications, requirements of ACI 346/346R shall govern.

2.1.2 PVC Pipe: The pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, shall be submitted prior to installation of the pipe.

2.1.2.1 Type PSM PVC Pipe: ASTM D 3034, Type PSM, maximum SDR 35, produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.

2.1.2.2 Profile PVC Pipe: ASTM F 794, Series 46, produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.

2.1.2.3 Smooth Wall PVC Pipe: ASTM F 679 produced from PVC certified by the compounder as meeting the requirements of ASTM D 1784, minimum cell class 12454-B.

2.2 MISCELLANEOUS MATERIALS

2.2.1 Concrete: Unless otherwise specified, concrete and reinforced concrete shall conform to the requirements for 20.70 MPa 3000 psi concrete under Section 03307A Concrete for Minor Structures. The concrete mixture shall have air content by volume of concrete, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 37.5 mm. (1-1/2 inches). Air content shall be determined in accordance with ASTM C 231. The concrete covering over steel reinforcing shall not be less than 25 mm (1 inch) thick for covers and not less than 40 mm (1-1/2 inches) thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 75 mm (3 inches) between steel and ground. Expansion-joint filler material shall conform to ASTM D 1751, or ASTM D 1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

2.2.2 Mortar: Mortar for pipe joints, connections to other drainage structures, and block construction shall conform to ASTM C 270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar.

Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.2.3 Precast Concrete Segmental Blocks: Precast concrete segmental block shall conform to ASTM C 139, not more than 200 mm (8 inches) thick, not less than 200 mm (8 inches) long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.2.4 Frame and Cover for Gratings: Frame and cover for gratings shall be cast gray iron, ASTM A 48M ASTM A 48, Class 35B; cast ductile iron, ASTM A 536, Grade 65-45-12; or cast aluminum, ASTM B 26/B 26M, Alloy 356.OT6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans.

2.3 STEEL LADDER: Steel ladder shall be provided where the depth of the manhole exceeds 3.66 m (12 feet). These ladders shall be not less than 406 mm (16 inches) 16 inches in width, with 19 mm 3/4 inch diameter rungs spaced 305 mm (12 inches) apart. The two stringers shall be a minimum 10 mm (3/8 inch) thick and 63 mm (2-1/2 inches) wide.

2.4 HYDROSTATIC TEST ON WATERTIGHT JOINTS

2.4.1 Concrete Pipe: A hydrostatic test shall be made on the watertight joint types as proposed. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested. During the test period, jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and Non-reinforced concrete pipe shall conform to AASHTO M 198 or ASTM C 443M ASTM C 443.

PART 3 - EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES: Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of SECTION 02302 "EXCAVATION, BACKFILLING AND COMPACTING OF UTILITIES " and SECTION.

3.1.1 Trenching: The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus 200 mm (8 inches minimum) to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified. Contractor shall not over excavate. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Owner.

3.1.2 Removal of Rock: Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe of at least 200 mm (8 inches) or 13 mm (1/2 inch) for each meter of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 02316 "Excavation, Trenching, and Backfilling for Utilities Systems".

3.1.3 Removal of Unstable Material: Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Owner’s Representative, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. When removal of unstable material is due to the fault or neglect of the Contractor in his performance of shoring and sheeting, water removal, or other specified requirements, such removal and replacement shall be performed at no additional cost to the Owner.

3.2 BEDDING: The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

3.2.1 Concrete Pipe Requirements: When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in a soil foundation accurately shaped and rounded to conform to the lowest one-fourth of the outside portion of circular pipe or to the lower curved portion of pipe arch for the entire length of the pipe or pipe arch. When necessary, the bedding shall be tamped. Bell holes and depressions for joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

3.2.2 Plastic Pipe: Bedding for PVC and PE pipe shall meet the requirements of ASTM D 2321. Bedding, haunching, and initial backfill shall be either Class IB or II material.

3.3 PLACING PIPE: Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated metal pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

TYPE OF PIPE	MAXIMUM ALLOWABLE DEFLECTION (%)
Plastic	7.5

Not less than 30 days after the completion of backfilling, the Owner's Representative may perform a deflection test on the entire length of installed flexible pipe using a mandrel or other suitable device. Installed flexible pipe showing deflections greater than those indicated above shall be retested by a run from the opposite direction. If the retest also fails, the suspect pipe shall be replaced at no cost to the Owner.

3.3.1 Concrete, PVC, and Ribbed PVC Pipe: Laying shall proceed upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.1 Multiple Culverts: Where multiple lines of pipe are installed, adjacent sides of pipe shall be at least half the nominal pipe diameter or 1 meter (3 feet apart), whichever is less.

3.4 JOINTING

3.4.1 Concrete Pipe

3.4.1.1 Cement-Mortar Bell-and-Spigot Joint: The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the

lower portion of the bell filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

3.4.1.2 Cement-Mortar Tongue-and-Groove Joint: The first pipe shall be bedded carefully to the established grade line with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

3.4.1.3 Flexible Watertight Joints: Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.5 DRAINAGE STRUCTURES

3.5.1 Manholes and Inlets: Construction shall be of reinforced concrete, plain concrete, complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated.

3.5.2 Walls and Headwalls: Construction shall be as indicated.

3.6 STEEL LADDER INSTALLATION: Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1.83 m (6 feet) 6 feet vertically, and shall be installed to provide at least 152 mm (6 inches) 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

3.7 BACKFILLING

3.7.1 Backfilling Pipe in Trenches: After the pipe has been properly bedded, selected material from excavation or borrow, at moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 150 mm (6 inches) in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation of at least 300 mm (12 inches) above the top of the pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding 220 millimeters. Inches. Tests for density shall be made as necessary to ensure conformance to the compaction requirements specified below. Where it is necessary, in the opinion of the Owner's Representative, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly. Untreated sheeting shall not be left in place beneath structures or pavements.

3.7.2 Backfilling Pipe in Fill Sections: For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 150 mm (6 inches) in compacted depth, and shall be compacted by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 300 mm (12 inches) above the top of the pipe shall extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 4 m, (12 feet), whichever is less. After the backfill has reached at least 300 mm (12 inches) above the top of the pipe, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding 220 mm. inches.

3.7.3 Movement of Construction Machinery: When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements: Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel- silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density: Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.7.5 Determination of Density: Testing shall be the responsibility of the Contractor and performed at no additional cost to the Owner. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D 1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified hand tamper. Field density tests shall be determined in accordance with ASTM D 2167 or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D 2922 results in a wet unit weight of soil and when using this method ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017 or ASTM D 2922. Test results shall be furnished to the Owner's Representative. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

3.8 PIPELINE TESTING: Lines shall be tested for leakage by low-pressure air or water testing or exfiltration tests, as appropriate. Low-pressure air testing for concrete pipes shall conform to ASTM C 924M ASTM C 924. Low-pressure air testing for plastic pipe shall conform to ASTM F 1417. Testing of individual joints for leakage by low-pressure air or water shall conform to ASTM C 1103M ASTM C 1103. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. When the water table is 600 mm (2 feet) or more above the top of the pipe at the upper end of the pipeline section to be tested, infiltration shall be measured using a suitable weir or other device acceptable to the Owner's Representative. An exfiltration test shall be made by filling the line to be tested with water so that a head of at least 600 mm (2 feet) is provided above both the water table and the top of the pipe at the upper end of the pipeline to be tested. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed 60 liters per mm in diameter per kilometer (250 gallons per inch in diameter per mile) of pipeline per day 9 mL per mm in diameter per 100 meters (0.2

gallons per inch in diameter per 100 feet) of pipeline per hour]. When leakage exceeds the maximum amount specified, satisfactory correction shall be made and retesting accomplished. Testing, correcting, and retesting shall be made at no additional cost to the Owner.

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

4.1.1 Pipe Culverts and Storm Drains: The length of pipe installed will be measured along the centerlines of the pipe from end to end of pipe without deductions for diameter of manholes. Pipe will be paid for at the contract unit price for the number of linear meters of culverts or storm drains placed in the accepted work.

4.1.2 Manholes and Inlets: The quantity of manholes and inlets will be measured as the total number of manholes and inlets of the various types of construction complete with frames and gratings or covers and, where indicated, with fixed side-rail ladders, feet, in the accepted work. The depth of manholes and inlets will be measured from the top of grating or cover to invert of outlet pipe.

4.1.3 Walls and Headwalls: Walls and headwalls will be measured by the number of cubic meters of reinforced concrete, used in the construction of the walls and headwalls. Wall and headwalls will be paid for at the contract unit price for the number of walls and headwalls constructed in the completed work.

4.1.3 Rock Excavation: Payment will be made for the number of cubic meters of material acceptably excavated, as specified and defined as rock excavation in Section 02302 EXCAVATION, BACKFILLING AND COMPACTING OF UTILITIES measured in the original position, and computed by allowing actual width of rock excavation with the following limitations: maximum rock excavation width, 750 mm for pipe of 300 mm or less nominal diameter; maximum rock excavation width, 400 mm greater than outside diameter of pipe of more than 300 mm nominal diameter. Measurement will include authorized over depth excavation. Payment will also include all necessary drilling, and all incidentals necessary for satisfactory excavation and disposal of authorized rock excavation. No separate payment will be made for backfill material required to replace rock excavation; this cost shall be included in the Contractor's unit price bid per cubic meter yard for rock excavation. In rock excavation for manholes and other appurtenances, 300 mm will be allowed outside the wall lines of the structures.

4.1.4 Backfill Replacing Unstable Material: Payment will be made for the number of cubic meters yards of select granular material required to replace unstable material for foundations under pipes or drainage structures, which will constitute full compensation for this backfill material, including removal and disposal of unstable material and all excavating, hauling, placing, compacting, and all incidentals necessary to complete the construction of the foundation satisfactorily

4.2 BASIS OF PAYMENT

The accepted quantity, measured as prescribed in Part 4.1 shall be paid for at the contract unit price for each of the Pay Item listed that is included in the Bill of quantities which price and payment shall constitute full compensation for the furnishing of materials, including all labor and equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
02630 (1)	Pipe Culvert	Linear Meter
02630 (2)	Curb Inlet Manhole	Each
02630 (3)	Surface Inlet Manhole	Each
02630 (4)	Surface Inlet Manhole Cast Iron Frames and Covers	Each
02630 (5)	Gutter Inlet Galvanized Grates and Frames	Each

SECTION 02721

SUBBASE COURSES

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	Bulk Density ("Unit Weight") and Voids in Aggregates
ASTM C 117	Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM D 75	Sampling Aggregates
ASTM D 1556	Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 2167	Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2487	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017	Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM E 11	Wire-Cloth Sieves for Testing Purposes

1.2 SUBMITTALS

Test Reports

Sampling and Testing;
Copies of initial and in-place test results.

1.3 DEGREE OF COMPACTION: Degree of compaction is a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557. In this specification, degree of compaction shall be a percentage of laboratory maximum density.

1.4 SAMPLING AND TESTING: Sampling and testing shall be the responsibility of the Contractor. An approved testing laboratory shall perform sampling and testing. Tests shall be performed at the specified frequency. No work requiring testing will be permitted until the testing laboratory has been inspected and approved. The materials shall be tested to establish compliance with the specified requirements.

1.4.1 Sampling: Samples for laboratory testing shall be taken in conformance with ASTM D 75. When deemed necessary, the Owner's Representatives will observe the sampling.

1.4.2 Tests

1.4.2.1 Sieve Analysis: Sieve analysis shall be made in conformance with ASTM C 117 and ASTM C 136. Sieves shall conform to ASTM E 11.

1.4.2.2 Liquid Limit and Plasticity Index: Liquid limit and plasticity index shall be determined in accordance with ASTM D 4318.

1.4.2.3 Moisture-Density Determinations: The maximum density and optimum moisture shall be determined in accordance with ASTM D 1557 or AASHTO T 180, Method D.

1.4.2.4 Density Tests: Density shall be field measured in accordance with ASTM D 1556. The calibration curves shall be checked and adjusted, if necessary, using only the sand cone method as described in paragraph Calibration, of the ASTM publication. Tests performed in accordance with ASTM D 2922 result in a wet unit weight of soil and, when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 3017. The calibration checks of both the density and moisture gauges shall be made by the prepared containers of material method, as described in paragraph Calibration, in ASTM D 2922, on each different type of material to be tested at the beginning of a job and at intervals as directed.

1.4.3 Testing Frequency

1.4.3.1 Initial Tests: One of each of the following tests shall be performed on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements prior to installation.

a. Sieve Analysis
b. Liquid limit and plasticity index moisture-density relationship

1.4.3.2 In-Place Tests: One of each of the following tests shall be performed on samples taken from the placed and compacted select-material subbase course. Samples shall be taken for each 1000 square meters of each layer of material placed in each area.

a. Sieve Analysis [including] [not including] 0.02 mm size material
b. Field Density
c. Moisture liquid limit and plasticity index

1.4.4 Approval of Material: The source of the material shall be selected prior to the time the material will be required in the work. Approval of the materials will be based on tests for gradation, liquid limit, and plasticity index performed on samples taken from the completed and compacted subbase course.

1.5 WEATHER LIMITATIONS: Construction shall be done when the atmospheric temperature is above 2 degrees C.35 degrees F. Completed areas damaged by rainfall, or other weather conditions shall be corrected to meet specified requirements.

1.6 EQUIPMENT: All plant, equipment, and tools used in the performance of the work shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 2 - PRODUCTS

2.1 MATERIALS

2.1.1 Subbase Course: Aggregates shall consist of crushed stone or slag, gravel, shell, sand, or other sound, durable, approved materials processed and blended or naturally combined. Aggregates shall be durable and sound, free from lumps and balls of clay, organic matter, objectionable coatings, and other foreign material. Material retained on the 4.75 mm No. 4 sieve shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested as specified in ASTM C 131. Aggregate shall be reasonably uniform in density and quality. Slag shall be an air-cooled, blast-furnace product having a dry weight of not less than 1050 kg/cubic meter (.65 pcf). Aggregates shall have a maximum size of 50 mm (2 inches) and shall be within the limits specified as follows:

Maximum Allowable Percentage by Weight
Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3	No.4
2 mm	50	80	--	85
0.075 mm	15	15	15	15

Maximum Allowable Percentage by Weight
Passing Square-Mesh Sieve

Sieve Designation	No. 1	No.2	No. 3	No.4
No. 10	50	80	--	85
No. 200	15	15	15	15

Particles having diameters less than 0.02 mm (0.0008 inch) shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D 422. The portion of any blended component and of the completed course passing the 0.425 mm (No. 40) sieve shall be either nonplastic or shall have a liquid limit not greater than 25 and a plasticity index not greater than 5.

2.1.2 Select-Material Subbase Course: Materials shall consist of selected soil or other materials from field excavation, stockpiles, or other sources. Material shall be free from lumps and balls of clay and from organic and other objectionable matter. Not more than 25 percent by weight shall pass the 0.075 mm (No. 200) sieve. The portion of material passing the 0.425 mm (No. 40) sieve shall have a liquid limit less than 35 and a plasticity index less than 12. The maximum particle size shall not exceed 75 mm. (3 inches). Particles having diameters less than 0.02 millimeters shall not be in excess of 3 percent by weight of the total sample tested as determined in accordance with ASTM D 422.

PART 3 - EXECUTION

3.1 STOCKPILING MATERIAL: Prior to stockpiling of material, storage sites shall be cleared and leveled by the Contractor. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Owner's Representative so as to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.2 PREPARATION OF UNDERLYING MATERIAL: Prior to constructing the subbase or select-material subbase course, the underlying course or subgrade shall be cleaned of all foreign substances. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. Ruts, or soft yielding spots, in the underlying courses, subgrade areas having inadequate compaction, and deviations of the surface from the specified requirements, shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D 2487, the surface shall be stabilized prior to placement of the subbase course. Mixing subbase-course material into the underlying course, and compacting by approved methods shall accomplish stabilization. The stabilized material shall be considered as part of the underlying course and shall meet all requirements for the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the subbase course is placed.

3.3 GRADE CONTROL: The finished and completed subbase course shall conform to the lines, grades, and cross sections shown. The lines, grades, and cross sections shown shall be maintained by means of line and grade stakes placed by the Contractor at the work site.

3.4 MIXING AND PLACING MATERIALS: The materials shall be mixed and placed to obtain uniformity of the Subbase or select-material subbase material at the water content specified. The Contractor shall make such adjustments in mixing or placing procedures or in equipment as may be directed to obtain the true grades, to minimize segregation and degradation, to reduce or accelerate loss or increase of water, and to insure a satisfactory subbase course.

3.6 LAYER THICKNESS: The compacted thickness of the completed course shall be as indicated. When a compacted layer of 150 mm (6 inches) is specified, the material may be placed in a single layer; when a compacted thickness of more than 150 mm (6 inches) is required, no layer shall exceed 150 mm (6 inches) nor be less than 75 mm (3 inches) when compacted.

3.7 COMPACTION: Each layer of the subbase course or select-material subbase shall be compacted as specified with approved compaction equipment. Water content shall be maintained during the compaction procedure to within plus or minus 3 percent of optimum water content, as determined from laboratory tests, as specified in paragraph SAMPLING AND TESTING. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Compaction shall continue until each layer is compacted through the full depth to at least 100 percent of laboratory maximum density. The Contractor shall make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory subbase course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.8 EDGES: Approved material shall be placed along the edges of the subbase or select-material subbase course in such quantity as will compact to the thickness of the course being constructed. When the course is being constructed in two or more layers, at least a 300 mm (1 foot) width of the shoulder shall be rolled and compacted simultaneously with the rolling and compacting of each layer of the subbase course, as directed.

3.9 SMOOTHNESS TEST: The surface of each layer shall not show deviations in excess of 10 mm (3/8 Inch) when tested with a 3.6 m (12 foot) 12 foot straightedge applied parallel with and at right angles to the centerline of the area to be paved. Removing material, replacing with new material, or reworking existing material and compacting, as directed, shall correct deviations exceeding this amount.

3.10 THICKNESS CONTROL: The completed thickness of the subbase or select-material subbase course shall be in accordance with the thickness and grade indicated on the drawings. The thickness of each course shall be measured at intervals providing at least one measurement for each 400 square meters (500 square yards) or part thereof of subbase course. The thickness measurement shall be made by test holes, at least 75 mm (3 inches) in diameter through the course. The completed subbase course shall not be more than 13 mm (1/2 inch) deficient in thickness nor more than 13 mm (1/2 inch) above or below the established grade. Where any of these tolerances are exceeded, the Contractor shall correct such areas by scarifying, adding new material of proper gradation or removing material, and compacting, as directed. Where the measured thickness is 13 mm (1/2) inch or more thicker than shown, the course will be considered as conforming to the specified thickness requirements plus 13 mm. (1/2 inch). The average job thickness shall be the average of the job measurements as specified above but within 6 mm (1/4 inch) of the thickness shown.

3.11 MAINTENANCE: The subbase or select-material subbase course shall be maintained in a satisfactory condition until accepted.

PART 4 – MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Aggreagate Subbase Course will be measured by the cubic meter. The quantities to be paid for shall be the design volume compacted in-place as shown on the Plans, and accepted in the completed course

4.2 BASIS OF PAYMENT

The accepted quantities, measured as prescribed in Part 4.1 shall be paid for at the contract unit price 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 Section.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
02721	Aggregate Subbase Course	Cubic Meter

SECTION 02722

AGGREGATE BASE COURSE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	Bulk Density ("Unit Weight") and Voids in Aggregates
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Specific Gravity and Absorption of Course Aggregate
ASTM C 128	Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM D 75	Sampling Aggregates
ASTM D 1556	Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 2487	Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM E 11	Wire-Cloth Sieves for Testing Purposes

1.2 DEFINITIONS

For the purposes of this specification, the following definitions apply.

1.2.1 Aggregate Base Course

Aggregate base course (ABC) is well graded, durable aggregate uniformly moistened and mechanically stabilized by compaction.

1.2.2 Degree of Compaction

Degree of compaction shall be expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D 1557.

1.3 SUBMITTALS

SD-06 Test Reports

Sampling and testing;

Field Density Tests;

Calibration curves and related test results prior to using the device or equipment being calibrated.

1.5 SAMPLING AND TESTING

Sampling and testing shall be the responsibility of the Contractor. Sampling and testing shall be performed by a testing laboratory approved in accordance with the Contract Document . Work requiring testing will not be permitted until the testing laboratory has been inspected and approved. The materials shall be tested to establish compliance with the specified requirements; testing shall be performed at the specified frequency. The Owner's Representative may specify the time and location of the tests. Copies of test results shall be furnished to the Owner's Representative after 24 hours completion of the tests.

1.5.1 Sampling

Samples for laboratory testing shall be taken in conformance with ASTM D 75. When deemed necessary, the Owner's Representative will observe the sampling

1.5.2 Tests

The following tests shall be performed in conformance with the applicable standards listed.

1.5.2.1 Sieve Analysis

Sieve analysis shall be made in conformance with ASTM C 117 and ASTM C 136. Sieves shall conform to ASTM E 11.

1.5.2.2 Liquid Limit and Plasticity Index

Liquid limit and plasticity index shall be determined in accordance with ASTM D 4318.

1.5.2.3 Moisture-Density Determinations

The maximum density and optimum moisture content shall be determined in accordance with ASTM D 1557, Method D and corrected with AASHTO T 224.

1.5.2.4 Field Density Tests

Density shall be field measured in accordance with ASTM D 1556. For the method presented in ASTM D 1556 the base plate as shown in the drawing shall be used.

1.5.2.5 Wear Test

Wear tests shall be made on Aggregate Base Course material in conformance with ASTM C 131.

1.5.3 Testing Frequency

1.5.3.1 Initial Tests

One of each of the following tests shall be performed on the proposed material prior to commencing construction to demonstrate that the proposed material meets all specified requirements when furnished. If materials from more than one source are going to be utilized, this testing shall be completed for each source.

a. Sieve Analysis

b. Liquid limit and plasticity index.

c. Moisture-density relationship.

d. Wear.

1.5.3.2 In Place Tests

Each of the following tests shall be performed on samples taken from the placed and compacted Aggregate Base Course. Samples shall be taken and tested at the rates indicated.

a. Density tests shall be performed on every lift of material placed and at a frequency of one set of tests for every (250 square meters 250 square yards), or portion thereof, of completed area.

b. Sieve Analysis shall be performed for every 500 metric tons (500 tons), or portion thereof, of material placed.

c. Liquid limit and plasticity index tests shall be performed at the same frequency as the sieve analysis.

1.5.4 Approval of Material

The source of the material shall be selected days prior to the time the material will be required in the work. Tentative approval of material will be based on initial test results. Final approval of the materials will be based on sieve analysis, liquid limit, and plasticity index tests performed on samples taken from the completed and fully compacted Aggregate Base Course.

1.6 WEATHER LIMITATIONS

Completed areas damaged by, rainfall, or other weather conditions shall be corrected to meet specified requirements.

1.7 PLANT, EQUIPMENT, AND TOOLS

All plant, equipment, and tools used in the performance of the work will be subject to approval before the work is started and shall be maintained in satisfactory working condition at all times. The equipment shall be adequate and shall have the capability of producing the required compaction, meeting grade controls, thickness control, and smoothness requirements as set forth herein.

PART 2 PRODUCTS

2.1 AGGREGATES

The Aggregate Base Course shall consist of clean, sound, durable particles of crushed stone, crushed gravel, crushed recycled concrete, angular sand, or other approved material. Aggregate Base Course shall be free of lumps of clay, organic matter, and other objectionable materials or coatings. The portion retained on the 4.75 mm (No. 4 sieve) shall be known as coarse aggregate; that portion passing the 4.75 mm (No. 4) sieve shall be known as fine aggregate.

2.1.1 Coarse Aggregate

Coarse aggregates shall be angular particles of uniform density. When the coarse aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements and shall be stockpiled separately.

a. Crushed Gravel: Crushed gravel shall be manufactured by crushing gravels, and shall meet all the requirements specified below.

b. Crushed Stone: Crushed stone shall consist of freshly mined quarry rock, and shall meet all the requirements specified below.

2.1.1.1 Aggregate Base Course

Aggregate Base Course coarse aggregate shall not show more than 50 percent loss when subjected to the Los Angeles abrasion test in accordance with ASTM C 131. The

amount of flat and elongated particles shall not exceed 30 percent. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3. In the portion retained on each sieve specified, the crushed aggregates shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces with the area of each face being at least equal to 75 percent of the smallest midsectional area of the piece. When two fractures are contiguous, the angle between planes of the fractures must be at least 30 degrees in order to count as two fractured faces. Crushed gravel shall be manufactured from gravel particles 50 percent of which, by weight, are retained on the maximum size sieve listed in TABLE 1.

2.1.2 Fine Aggregate

Fine aggregates shall be angular particles of uniform density. When the fine aggregate is supplied from more than one source, aggregate from each source shall meet the specified requirements.

2.1.2.1 Aggregate Base Course

Aggregate Base Course fine aggregate shall consist of screenings, angular sand, crushed recycled concrete fines, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

2.1.3 Gradation Requirements

The specified gradation requirements shall apply to the completed base course. The aggregates shall have a maximum size of 50 mm inches and shall be continuously well graded within the limits specified in TABLE 1. Sieves shall conform to ASTM E 11.

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3
50.0 mm(2-inch)	100	----	----
37.5 mm(1½-inch)	70-100	100	----
25.0 mm(1-inch)	45-80	60-100	100
12.5 mm(1/2-inch)	30-60	30-65	40-70

TABLE 1. GRADATION OF AGGREGATES

Percentage by Weight Passing Square-Mesh Sieve

Sieve Designation	No. 1	No. 2	No. 3
4.75 mm(No.4)	20-50	20-50	20-50

2.00 mm(No.10)	15-40	15-40	15-40
0.425 mm(No.40)	5-25	5-25	5-25
0.075 mm(No.200)	0-8	0-8	0-8

NOTE 1: Particles having diameters less than 0.02 mm (0.0008 inch) shall not be in excess of 3 percent by weight of the total sample tested.

NOTE 2: The values are based on aggregates of uniform specific gravity. If materials from different sources are used for the coarse and fine aggregates, they shall be tested in accordance with ASTM C 127 and ASTM C 128 to determine their specific gravities. If the specific gravities vary by more than 10 percent, the percentages passing the various sieves shall be corrected as directed by the Owner's Representative.

2.1.4 Liquid Limit and Plasticity Index

Liquid limit and plasticity index requirements shall apply to the completed course and shall also apply to any component that is blended to meet the required gradation. The portion of any component or of the completed course passing the 0.425 mm (No. 40) sieve shall be either nonplastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

PART 3- EXECUTION

3.1 GENERAL REQUIREMENTS

When the Aggregate Base Course is constructed in more than one layer, the previously constructed layer shall be cleaned of loose and foreign matter by sweeping with power sweepers or power brooms, except that hand brooms may be used in areas where power cleaning is not practicable. Adequate drainage shall be provided during the entire period of construction to prevent water from collecting or standing on the working area. Line and grade stakes shall be provided as necessary for control. Grade stakes shall be in lines parallel to the centerline of the area under construction and suitably spaced for string lining.

3.2 STOCKPILING MATERIAL

Prior to stockpiling of material, storage sites shall be cleared and leveled by the Contractor. All materials, including approved material available from excavation and grading, shall be stockpiled in the manner and at the locations designated. Aggregates shall be stockpiled on the cleared and leveled areas designated by the Owner's Representative to prevent segregation. Materials obtained from different sources shall be stockpiled separately.

3.3 PREPARATION OF UNDERLYING COURSE

Prior to constructing the Aggregate Base Course, the underlying course or subgrade shall be cleaned of all foreign substances. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. The underlying course shall conform to Section 02721 SUBBASE COURSES. Ruts or soft yielding spots in the underlying courses, areas having inadequate compaction, and deviations of the surface from the requirements set forth herein shall be corrected by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified

density requirements. For cohesionless underlying courses containing sands or gravels, as defined in ASTM D 2487, the surface shall be stabilized prior to placement of the Aggregate Base Course. Stabilization shall be accomplished by mixing Aggregate Base Course into the underlying course and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements of the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained by the Contractor in a satisfactory condition until the Aggregate Base Course is placed.

3.5 INSTALLATION

3.5.1 Mixing the Materials

The coarse and fine aggregates shall be mixed in a stationary plant, or in a traveling plant or bucket loader on an approved paved working area. The Contractor shall make adjustments in mixing procedures or in equipment as directed to obtain true grades, to minimize segregation or degradation, to obtain the required water content, and to insure a satisfactory Aggregate Base Course meeting all requirements of this specification.

3.5.2 Placing

The mixed material shall be placed on the prepared subgrade or subbase in layers of uniform thickness with an approved spreader. When a compacted layer 150 mm (6 inches) or less in thickness is required, the material shall be placed in a single layer. When a compacted layer in excess of 150 mm (6 inches) is required, the material shall be placed in layers of equal thickness. No layer shall exceed 150 mm (6 inches) or less than 75mm (3 inches) when compacted. The layers shall be so placed that when compacted they will be true to the grades or levels required with the least possible surface disturbance. Where the Aggregate Base Course is placed in more than one layer, the previously constructed layers shall be cleaned of loose and foreign matter by sweeping with power sweepers, power brooms, or hand brooms, as directed. Such adjustments in placing procedures or equipment shall be made as may be directed to obtain true grades, to minimize segregation and degradation, to adjust the water content, and to insure an acceptable Aggregate Base Course.

3.5.3 Grade Control

The finished and completed Aggregate Base Course shall conform to the lines, grades, and cross sections shown. Underlying material(s) shall be excavated and prepared at sufficient depth for the required thickness so that the finished Aggregate Base Course with the subsequent surface course will meet the designated grades.

3.5.4 Edges of Base Course

The Aggregate Base Course shall be placed so that the completed section will be a minimum of 1.5 m (5 feet) wider, on all sides, than the next layer that will be placed above it. Additionally, approved fill material shall be placed along the outer edges of Aggregate Base Course in sufficient quantities to compact to the thickness of the course being constructed, or to the thickness of each layer in a multiple layer course, allowing in each operation at least a 300 mm (1 foot) width of this material to be rolled and compacted simultaneously with rolling and compacting of each layer of Aggregate Base Course. If this base course material is to be placed adjacent to another pavement section, then the layers for both of these sections shall be placed and compacted along this edge at the same time.

3.5.5 Compaction

Each layer of the Aggregate Base Course shall be compacted as specified with approved compaction equipment. Water content shall be maintained during the compaction procedure to within the optimum water content determined from laboratory tests as specified in paragraph SAMPLING AND TESTING. Rolling shall begin at the outside edge of the surface and proceed to the center, overlapping on successive trips at least one-half the width of the roller. Alternate trips of the roller shall be slightly different lengths. Speed of the roller shall be such that displacement of the aggregate does not occur. In all places not accessible to the rollers, the mixture shall be compacted with hand-operated power tampers. Compaction shall continue until each layer has a degree of compaction that is at least 100 percent of laboratory maximum density through the full depth of the layer. The Contractor shall make such adjustments in compacting or finishing procedures as may be directed to obtain true grades, to minimize segregation and degradation, to reduce or increase water content, and to ensure a satisfactory Aggregate Base Course. Any materials that are found to be unsatisfactory shall be removed and replaced with satisfactory material or reworked, as directed, to meet the requirements of this specification.

3.5.6 Thickness

Compacted thickness of the aggregate course shall be as indicated. No individual layer shall exceed 150 mm (6 inches) nor be less than 75 mm (3 inches) in compacted thickness. The total compacted thickness of the Aggregate Base Course shall be within 13 mm (1/2) inch of the thickness indicated. Where the measured thickness is more than 13 mm (1/2) inch deficient, such areas shall be corrected by scarifying, adding new material of proper gradation, reblading, and recompacting as directed. Where the measured thickness is more than 13 mm (1/2) inch thicker than indicated, the course shall be considered as conforming to the specified thickness requirements. Average job thickness shall be the average of all thickness measurements taken for the job, but shall be within 6 mm (1/4 inch) of the thickness indicated. The total thickness of the Aggregate Base Course shall be measured at intervals in such a manner as to ensure one measurement for each 500 square meters yards of base course. Measurements shall be made in 75 mm (3 inch) diameter test holes penetrating the base course.

3.5.7 Proof Rolling

Proof rolling of the areas indicated shall be in addition to the compaction specified and shall consist of the application of 30 coverages with a heavy pneumatic-tired roller having four or more tires, each loaded to a minimum of 13,600 kg (30,000 pounds) and inflated to a minimum of 1035 kPa. (150 psi). In areas designated, proof rolling shall be applied to the top of the underlying material on which Aggregate Base Course is laid and to each layer of Aggregate Base Course. Water content of the underlying material shall be maintained at optimum or at the percentage directed from start of compaction to completion of proof rolling of that layer. Water content of each layer of the Aggregate Base Course shall be maintained at the optimum percentage directed from start of compaction to completion of proof rolling. Any materials or any underlying materials that produce unsatisfactory results by proof rolling shall be removed and replaced with satisfactory materials, recompacted and proof rolled to meet these specifications.

3.5.8 Finishing

The surface of the top layer of Aggregate Base Course shall be finished after final compaction and proof rolling by cutting any overbuilds to grade and rolling with a steel-wheeled roller. Thin layers of material shall not be added to the top layer of base course to meet grade. If the elevation of the top layer of Aggregate Base Course is 13 mm (1/2 inch) or more below grade, then the top layer should be scarified to a depth of at least 75 mm (3 inches) and new material shall be blended in, compacted and proof rolled to bring to grade. Adjustments to rolling and finishing procedures shall be made as directed to minimize segregation and degradation, obtain grades, maintain moisture content, and insure an acceptable base course. Should the surface become rough, corrugated, and uneven in texture or traffic marked prior to completion, the unsatisfactory portion shall be scarified, reworked and recompacted or it shall be replaced as directed.

3.5.9 Smoothness

The surface of the top layer shall show no deviations in excess of 10 mm (3/8 inch) when tested with a 3.05 meter (10 foot) straightedge. Measurements shall be taken in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 15 meter (50 foot) intervals. Deviations exceeding this amount shall be corrected by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

3.6 TRAFFIC

Completed portions of the Aggregate Base Course may be opened to limited traffic, provided there is no marring or distorting of the surface by the traffic. Heavy equipment shall not be permitted except when necessary to construction, and then the area shall be protected against marring or damage to the completed work.

3.7 MAINTENANCE

The Base Course shall be maintained in a satisfactory condition until the full pavement section is completed and accepted. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any area of that is damaged shall be reworked or replaced as necessary to comply with this specification.

3.8 DISPOSAL OF UNSATISFACTORY MATERIALS

Any unsuitable materials that must be removed shall be disposed of as Directed. No additional payments will be made for materials that must be replaced.

PART 4- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Aggreagate Base Course will be measured by the cubic meter. The quantity to be paid for shall be the design volume compacted in-place as shown on the Plans, and accepted in the completed course

4.2 BASIS OF PAYMENT

The accepted quantities, measured as prescribed in Part 4.1 shall be paid for at the contract unit price 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 Section.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
02722	Aggregate Base Course	Cubic Meter

SECTION 02742

HOT MIX BITUMINOUS PAVEMENT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASPHALT INSTITUTE (AI)

AI MS-2 Mix	Design Methods for Asphalt Concrete and Other Hot-Mix Types

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM C 29/C 29M	Unit Weight and Voids in Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 127	Specific Gravity and Absorption of Coarse Aggregate
ASTM C 128	Specific Gravity and Absorption of Fine Aggregate
ASTM C 131	Resistances to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	Sieve Analysis of Fine and Coarse Aggregates
ASTM C 188	Density of Hydraulic Cement
ASTM D 70	Specific Gravity of Semi-Solid Bituminous Materials
ASTM D 75	Sampling Aggregates
ASTM D 242	Mineral Filler for Bituminous Paving Mixtures
ASTM D 546	Sieve Analysis of Mineral Filler for Road and Paving Materials
ASTM D 692	Coarse Aggregate for Bituminous Paving Mixtures
ASTM D 854	Specific Gravity of Soils
ASTM D 946	Penetration-Graded Asphalt Cement for Use in Pavement Construction

ASTM D 979	Sampling Bituminous Paving Mixtures
ASTM D 995	Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
ASTM D 1073	Fine Aggregate for Bituminous Paving Mixtures
ASTM D 1075	Effect of Water on Cohesion of Compacted Bituminous Mixtures
ASTM D 1188	Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1559	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2726	Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 3381	Viscosity-Graded Asphalt Cement for Use in Pavement Construction

1.2 SUBMITTALS

Submit the following:

1.2.1 Samples

Bituminous pavement

1.2.2 Design Data

Job-mix formula

Submit a job-mix formula, for approval prior to preparing and placing the bituminous mixture. Design mix using procedures contained in Chapter V, Marshall Method of Mix Design, of AI MS-2. Formulas shall indicate physical properties of the mixes as shown by tests made by an approved commercial laboratory, using materials identical to those to be provided on this project. Submit formulas with material samples. Job-mix formula for each mixture shall be in effect until modified in writing by the Contractor and approved by the Owner's Representative. Provide a new job-mix formula for each source change.

1.2.3 Test Reports

Specific gravity test of asphalt

Coarse aggregate tests

Weight of slag test

Percent of crushed pieces in gravel

Fine aggregate tests

Specific gravity of mineral filler

Bituminous mixture tests

Aggregates tests

Bituminous mix tests

Pavement courses

1.3 QUALITY ASSURANCE

1.3.1 Required Data

Job-mix formula shall show the following:

a. Source and proportions, percent by weight, of each ingredient of the mixture;

b. Correct gradation, the percentages passing each size sieve listed in the specifications for the mixture to be used, for the aggregate and mineral filler from each separate source and from each different size to be used in the mixture and for the composite mixture;

c. Amount of material passing the 75 micrometers (No. 200) sieve determined by dry sieving;

d. Number of blows of hammer compaction per side of molded specimen;

e. Temperature viscosity relationship of the asphalt cement;

f. Stability, flow, percent voids in mineral aggregate, percent air voids, unit weight;

g. Asphalt absorption by the aggregate;

h. Effective asphalt content as percent by weight of total mix;

i. Temperature of the mixture immediately upon completion of mixing;

j. Asphalt viscosity grade [and/or penetration range]; and

k. Curves for the [leveling] [binder] [and] wearing course[s].

1.3.2 Charts

Plot and submit, on a grain size chart, the specified aggregate gradation band, the job-mix gradation and the job-mix tolerance band.

1.3.3 Selection of Optimum Asphalt Content

Base selection on percent of total mix and the average of values at the following points on the curves for each mix:

a. Stability: Peak

b. Unit Weight: Peak

c. Percent Air Voids: Median

1.4 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to the site for damage and store with a minimum of handling. Store aggregates in such a manner as to prevent segregation, contamination, or intermixing of the different aggregate sizes.

1.5 ENVIRONMENTAL CONDITIONS

Place bituminous mixture only during dry weather and on dry surfaces. Place courses only when the surface temperature of the underlying course is greater than 7 degrees C (45 degrees F) for course thickness greater than 25 mm (one inch) and 13 degrees C (55 degrees F) for course thickness 25 mm (one inch) or less.

1.6 CONSTRUCTION EQUIPMENT

A calibration laboratory shall have recalibrated calibrated equipment, such as scales, batching equipment, spreaders and similar equipment, within 12 months of commencing work.

1.6.1 Mixing Plant

Design, coordinate, and operate the mixing plant to produce a mixture within the job-mix formula tolerances and to meet the requirements of ASTM D 995, including additional plant requirements specified herein. The plant shall be a batch type, continuous mix type or drum-dryer mixer type, and shall have sufficient capacity to handle the new bituminous construction. The mixing plant and equipment shall remain accessible at all times for inspecting operation, verifying weights, proportions and character of materials, and checking mixture temperatures.

1.6.1.1 Cold Aggregate Feeder

Provide plant with a feeder or feeders capable of delivering the maximum number of aggregate sizes required in their proper proportion. Provide adjustment for total and proportional feed and feeders capable of being

locked in any position. When more than one cold elevator is used, feed each elevator as a separate unit and install individual controls integrated with a master control.

1.6.1.2 Dryer

Provide rotary drum-dryer, which continuously agitates the mineral aggregate during the heating and drying process. When one dryer does not dry the aggregate to specified moisture requirements, provide additional dryers.

1.6.1.3 Plant Screens and Bins for Batch and Continuous Mix Plants

Use screen to obtain accurate gradation and allow no bin to contain more than 10 percent oversize or undersize. Inspect screens each day prior to commencing work for plugged, worn, or broken screens. Clean plugged screens and replace worn or broken screens with new screens prior to beginning operations. Divide hot aggregate bins into at least three compartments arranged to ensure separate and adequate storage of appropriate fractions of the aggregate.

1.6.1.4 Testing Laboratory

Provide a testing laboratory for control and acceptance testing functions during periods of mix production, sampling and testing, and whenever materials subject to the provisions of these specifications are being supplied or tested. The laboratory shall provide adequate equipment, space, and utilities as required for the performance of the specified tests.

1.6.1.5 Surge and Storage Bins

Use for temporary storage of hot bituminous mixtures will be permitted under the following conditions:

a. When stored in surge bins for a period of time not to exceed 3 hours.

b. When stored in insulated and heated storage bins for a period of time not to exceed 12 hours. If it is determined by the Owner's Representative that there is an excessive amount of heat loss, segregation and oxidation of the mixture due to temporary storage, discontinue use of surge bins or storage bins.

1.6.1.6 Drum-Dryer Mixer

Do not use drum-dryer mixer if specified requirements of the bituminous mixture or of the completed bituminous pavement course cannot be met. If drum-dryer mixer is prohibited, use either batch or continuous mix plants meeting the specifications and producing a satisfactory mix.

1.6.2 Paving Equipment

1.6.2.1 Spreading Equipment

Self-propelled electronically controlled type, unless other equipment is authorized [by the Contracting Officer]. Equip spreading equipment of the self-propelled electronically controlled type with hoppers, tamping or vibrating devices, distributing screws, electronically adjustable screeds, and equalizing devices. Capable of spreading hot bituminous mixtures without tearing, shoving, or gouging and to produce a finished surface of specified grade and smoothness. Operate spreaders, when laying mixture, at variable speeds between 25 and 230 mm per second (5 and 45 feet per minute). Design spreader with a quick and efficient steering device; a forward and reverse traveling speed; and automatic devices to adjust to grade and confine the edges of the mixture to true lines. The use of a spreader that leaves indented areas or other objectionable irregularities in the fresh laid mix during operations is prohibited.

1.6.2.2 Rolling Equipment

Self-propelled pneumatic-tired rollers supplemented by three-wheel and tandem type steel wheel rollers. The number, type and weight of rollers shall be sufficient to compact the mixture to the required density without detrimentally affecting the compacted material. Rollers shall be suitable for rolling hot-mix bituminous pavements and capable of reversing without backlash. Pneumatic-tired rollers shall be capable of being operated both forward and backward without turning on the mat, and without loosening the surface being rolled. Equip rollers with suitable devices and apparatus to keep the rolling surfaces wet and prevent adherence of bituminous mixture. Vibratory rollers especially designed for bituminous concrete compaction may be used provided rollers do not impair stability of pavement structure and underlying layers. Repair depressions in pavement surfaces resulting from use of vibratory rollers. Rollers shall be self-propelled, single or dual vibrating drums, and steel drive wheels, as applicable; equipped with variable amplitude and separate controls for energy and propulsion.

1.6.2.3 Hand Tampers

Minimum weight of 11 kg (25 pounds) with a tamping face of not more than 0.032 square meter (50 square inches).

1.6.2.4 Mechanical Hand Tampers

Commercial type, operated by pneumatic pressure or by internal combustion.

PART 2 PRODUCTS

2.1 AGGREGATES

Grade and proportion aggregates and filler so that combined mineral aggregate conforms to specified grading.

2.1.1 Coarse Aggregates

ASTM D 692, except as modified herein. At least 75 percent by weight of aggregate retained on the 4.75 mm (No. 4) sieve shall have two or more fractured faces. Percentage of wear, Los Angeles test, except for slag, shall not exceed 40 in accordance with ASTM C 131. Weight of slag shall not be less than 1120 kg per cubic meter (70 pounds per cubic foot). Soundness test is required in accordance with ASTM C 88; after 5 cycles, loss shall not be more than 12 percent when tested with sodium sulfate or 18 percent when tested with magnesium sulfate.

2.1.2 Fine Aggregate

ASTM D 1073, except as modified herein. Fine aggregate shall be produced by crushing stone, slag or gravel that meets requirements for wear and soundness specified for coarse aggregate. Where necessary to obtain the gradation of aggregate blend or workability, natural sand may be used. Quantity of natural sand to be added shall be approved by the Owner's Representative and shall not exceed 15 percent of weight of coarse and fine aggregate and material passing the 75 micrometers No. 200sieve.

2.1.3 Mineral Filler

Nonplastic material meeting the requirements of ASTM D 242.

2.2 ASPHALT CEMENT

ASTM D 946, penetration Grade 85-100 or ASTM D 3381, viscosity Grade AC-10.

2.3 GRADATION OF AGGREGATES

ASTM C 136. Aggregate shall have a gradation within the limits designated in Table I and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa, but grade uniformly from coarse to fine. Table I is based on aggregates of uniform specific gravity and the percentages passing the various sieves are subject to appropriate correction when aggregates of varying specific gravities are provided. When materials of different specific gravities are provided, make satisfactory arrangements for separate stockpiles, controlled distribution, and other operations necessary to maintain the specific gravity of the mixture constant and uniform. The final lift of the overlay surface shall conform to the wearing course as specified herein.

TABLE I

GRADATION OF AGGREGATES
TOTAL PERCENT PASSING (BY WEIGHT)

MIX NO. SIEVE SIZE	Wearing Course
19.0 mm (3/4 inch)	100
12.5 mm (1/2 inch)	80-100
9.5 mm (3/8 inch)	70-90
4.75 mm (No. 4)	50-70
2.36 mm (No. 8)	35-50
1.18 mm (No. 30)	18-29
600 micrometers (No. 50)	13-23
300 micrometers (No. 100)	8-16
75 micrometers (No. 200)	4-10

2.4 Quantity of Bituminous Material

Mix asphalt cement with aggregates of corresponding mixes in the following proportions:

ASPHALT CEMENT PERCENT BY WEIGHT OF TOTAL MIX

Wearing Course

4-10

2.5 COMPOSITION OF MIXTURE

Gradation of mineral aggregate shall be as specified herein. The percentage of bituminous material provided in the bituminous mixtures shall be within the limits specified. Mixtures shall have the following physical properties:

Test Property	**Values**
Stability Flow (0.25 mm)	Not less than 454 kg Not more than 20 nor less than 8]
Percent Air Voids	not less than 3 nor more than 5 for wearing course
Percent Voids in Mineral Aggregates	See Table II

TABLE II

MINIMUM PERCENT VOIDS IN MINERAL AGGREGATE (VMA)

U.S.A. Standard Sieve Designation	Nominal Maximum Particle Size, mm.	Minimum VMA Percent
4.75 mm (No. 4)	4.75	18
9.5 mm (3/8 inch)	9.50	16
12.5 mm (1/2 inch)	12.50	15
19.0 mm (3/4 inch)	19.0	14
25.0 mm (1 inch)	25.0	13

2.5.1 Index of Retained Strength

ASTM D 1075, 75 or greater.

2.6 VARIATIONS FROM FORMULA

Variations from the approved job-mix formula shall not exceed the following, and in no case shall the job-mix formula, with tolerances applied, fall outside the general limits for aggregate gradation and bituminous material specified herein:

Aggregate	Tolerance (Plus or Minus)
12.5 mm and larger	8 percent
9.5 and 4.75 mm	7 percent
2.36 and 1.18 mm	6 percent
600 and 300 micrometers	5 percent
150 micrometers	4 percent
75 micrometers	3 percent
Asphalt Cement	0.5 percent
Temperature of Mixture as discharged	11 degrees C

2.7 SOURCE QUALITY CONTROL

Use materials for testing that are identical to materials to be provided in this project. Employ a commercial laboratory approved by the Owner's Representative to perform testing.

2.7.1 Tests

Perform testing in accordance with the following:

a. Specific Gravity Test of Asphalt: ASTM D 70

b. Coarse Aggregate Tests:

(1) Bulk Specific Gravity: ASTM C 127

(2) Abrasion Loss: ASTM C 131

(3) Soundness Loss: ASTM C 88

c. Weight of Slag Test: ASTM C 29/C 29M

d. Percent of Crushed Pieces in Gravel: Count by observation and weight

e. Fine Aggregate Tests:

(1) Bulk Specific Gravity: ASTM C 128

(2) Soundness Loss: ASTM C 88

f. Specific Gravity of Mineral Filler: ASTM C 188 or ASTM D 854

g. Bituminous Mixture Tests:

(1) Bulk Specific Gravity: ASTM D 1188 or ASTM D 2726

(2) Theoretical Maximum Specific Gravity: ASTM D 2041

(3) Index of Retained Strength: ASTM D 1075

1. Specimens

ASTM D 1559 for the making and testing of bituminous specimens with the following exceptions:

a. Compaction: Apply 75 blows of the hammer to each flat face of the specimens for primary roads; and 50 blows for secondary roads, streets, and parking areas.

b. Curves: Plot curves for the wearing course to show the effect on the test properties of at least four different percentages of asphalt on the unit weight, stability, flow, air voids, and voids in mineral aggregate; each point on the curves shall represent the average of at least four specimens.

c. Cooling of Specimen: After compaction is completed, allow the specimen to cool in air to the same temperature approximately as that of the water, 25 degrees C (77 degrees F), to be used in the specific gravity determination.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Mixing

Produce bituminous mixture in a plant as specified herein.

3.1.2 Preparation of Mineral Aggregates

Store different size aggregate in separate stockpiles so that different sizes will not mix. Stockpile different-sized aggregates in uniform layers by use of a clamshell or other approved method so as to prevent segregation. The use of bulldozers in stockpiling of aggregate or in feeding aggregate to the dryer is prohibited. Feed aggregates into the cold elevator by means of separate mechanical feeders so that aggregates are graded within requirements of the job-mix formulas and tolerances specified. Regulate rates of feed of the aggregates so that moisture content and temperature of aggregates are within tolerances specified herein. Dry and heat aggregates to the temperature necessary to achieve the mixture determined by the job mix formula within the job tolerance specified. Provide adequate dry storage for mineral filler.

3.1.3 Preparation of Bituminous Mixture

Accurately weigh aggregates and dry mineral filler and convey into the mixer in the proportionate amounts of each aggregate size required to meet the job-mix formula. Introduce required amount of asphalt into the mixer at a temperature not to exceed 163 degrees C (325 degrees F) so that the asphalt can mix uniformly with the aggregate. In batch mixing, after aggregates and mineral filler have been introduced into the mixer and mixed for not less than 15 seconds, add asphalt by spraying or other approved methods and continue mixing for a period of not less than 20 seconds, or as long as required to obtain a homogeneous mixture. The time required to add or spray asphalt into the mixer will not be added to the total wet-mixing time provided the operation does not exceed 10 seconds and a homogeneous mixture is obtained. When a continuous mixer is employed, mixing time shall be more than 35 seconds to obtain a homogeneous mixture. Additional mixing time, when required, will be as directed. Temperature of the mixture at the time of discharge shall not exceed 163 degrees C (325 degrees F). Temperature of the aggregate and mineral filler in the mixer shall not exceed 177 degrees C (350 degrees F) when asphalt is added. When mixture is prepared in a twin-pug mill mixer, volume of the aggregates, mineral filler, and asphalt shall not extend above tips of mixer blades when blades are in a vertical position. Overheated and carbonized mixtures, or mixtures that foam or show indication of free moisture, will be rejected. When free moisture is detected in batch or continuous mix plant produced mixtures, waste the mix and withdraw the aggregates in the hot bins immediately and return to the respective stockpiles; for drum-dryer mixer plants, waste the mix, including that in surge or storage bins that is affected by free moisture.

3.1.4 Transportation of Bituminous Mixtures

Transport bituminous material from the mixing plant to the paving site in trucks having tight, clean, smooth beds that have been coated with a minimum amount of concentrated solution of hydrated lime and water or other approved coating to prevent adhesion of the mixture to the truck. Petroleum products will not be permitted for coating truck. If air temperature is less than 16 degrees C (60 degrees F) or if haul time is greater than 30 minutes, cover each load with canvas or other approved material of ample size to protect the mixture from the loss of heat. Make deliveries so that the spreading and rolling of all the mixture prepared for one day's run can be completed during daylight, unless adequate approved

artificial lighting is provided. Deliver mixture to area to be paved so that the temperature at the time of dumping into the spreader is within the range specified herein. Reject loads that are below minimum temperature, that have crusts of cold unworkable material, or that have been wet excessively by rain. Hauling over freshly laid material is prohibited.

3.1.5 Surface Preparation of Underlying Course

Prior to the laying of the asphalt concrete, clean underlying course of foreign or objectionable matter with power blowers or power brooms, supplemented by hand brooms and other cleaning methods where necessary. During the placement of multiple lifts of bituminous concrete, each succeeding lift of bituminous concrete shall have its underlying lift cleaned and provided with a bituminous tack coat if the time period between the placement of each lift of bituminous concrete exceeds 14 days, or the underlying bituminous concrete has become dirty.

3.1.6 Spraying of Contact Surfaces

Spray contact surfaces of previously constructed pavement with a thin coat of bituminous materials to act as an anti-stripping agent, conforming to Section 02744, "Bituminous Tack Coat." Paint contact surfaces of structures with a thin coat of emulsion or other approved bituminous material prior to placing the bituminous mixture. Tack coat the previously placed primed coats on base courses when surface has become excessively dirty and cannot be cleaned or when primed surface has cured to the extent that it has lost all bonding effect.

3.2 PLACEMENT

3.2.1 Machine Spreading

The range of temperatures of the mixtures at the time of spreading shall be between 121 degrees C (250 degrees C) and 149 degrees C (300 degrees F). Bituminous concrete having temperatures less than minimum spreading temperature when dumped into the spreader will be rejected. Adjust spreader and regulate speed so that the surface of the course is smooth and continuous without tears and pulling, and of such depth that, when compacted, the surface conforms with the cross section, grade, and contour indicated. Unless otherwise directed, begin the placing along the centerline of areas to be paved on a crowned section or on the high side of areas with a one-way slope. Place mixture in consecutive adjacent strips having a minimum width of 3 m (10 feet), except where the edge lanes require strips less than 3 m (10 feet) to complete the area. Construct longitudinal joints and edges to true line markings. Establish lines parallel to the centerline of the area to be paved, and place string lines coinciding with the established lines for the spreading machine to follow. Provide the number and location of the lines needed to accomplish proper grade control. When specified grade and smoothness requirements can be met for initial lane construction by use of an approved long ski-type device of not less than 9 m (30 feet) in length and for subsequent lane construction by use of a short ski or shoe, in-place string lines for grade control may be omitted. Place mixture as nearly continuous as possible and adjust the speed of placing as needed to permit proper rolling. Normally, hot mix paving is not allowed on base temperature below 7 degrees (45 degrees F).

3.2.2 Shoveling, Raking, and Tamping After Machine-Spreading

Shovelers and rakers shall follow the spreading machine. Add or remove hot mixture and rake the mixture as required to obtain a course that when completed will conform to requirements specified herein. Broadcasting or fanning of mixture over areas being compacted is prohibited. When segregation occurs in the mixture during placing, suspend spreading operation until the cause is determined and corrected. Correct irregularities in alignment left by the spreader by trimming directly behind the machine. Immediately after trimming, compact edges of the course by tamping laterally with a metal lute or by other approved methods. Distortion of the course during tamping is prohibited.

3.2.3 Hand-Spreading in Lieu of Machine-Spreading

In areas where the use of machine spreading is impractical, spread mixture by hand. The range of temperatures of the mixtures when dumped onto the area to be paved shall be between 121 degrees C (250 degrees F) and 149 degrees C (300 degrees F). Mixtures having temperatures less than minimum spreading temperature when dumped onto the area to be paved will be rejected. Spread hot mixture with rakes in a uniformly loose layer of a thickness that, when compacted, will conform to the required grade, thickness, and smoothness. During hand spreading, place each shovelful of mixture by turning the shovel over in a manner that will prevent segregation. Do not place mixture by throwing or broadcasting from a hovel. Do not dump loads any faster than can be properly handled by the shovelers and rakers.

3.3 COMPACTION OF MIXTURE

Compact mixture by rolling. Begin rolling as soon as placement of mixture will bear rollers. Delays in rolling freshly spread mixture shall not be permitted. Start rolling longitudinally at the extreme sides of the lanes and proceed toward center of pavement, or toward high side of pavement with a one-way slope. Operate rollers so that each trip overlaps the previous adjacent strip by at least 300 mm (one foot. Alternate trips of the roller shall be of slightly different lengths). Conduct tests for conformity with the specified crown, grade and smoothness immediately after initial rolling. Before continuing rolling, correct variations by removing or adding materials as necessary. If required, subject course to diagonal rolling with the steel wheeled roller crossing the lines of the previous rolling while mixture is hot and in a compactable condition. Speed of the rollers shall be slow enough to avoid displacement of hot mixture. Correct displacement of mixture immediately by use of rakes and fresh mixture, or remove and replace mixture as directed. Continue rolling until roller marks are eliminated and course has a density of at least 96 percent but not more than 100 percent of that attained in a laboratory specimen of the same mixture prepared in accordance with ASTM D 1559. During rolling, moisten wheels of the rollers enough to prevent adhesion of mixture to wheels, but excessive water is prohibited. Operation of rollers shall be by competent and experienced operators. Provide sufficient rollers for each spreading machine in operation on the job and to handle plant output. In places not accessible to the rollers, compact mixture thoroughly with hot hand tampers. Skin patching of an area after compaction is prohibited. Remove mixture that becomes mixed with foreign materials or is defective and replace with fresh mixture compacted to the density specified herein. Roller shall pass over unprotected edge of the course only when laying of course is to be discontinued for such length of time as to permit mixture to become cold.

3.4 JOINTS

Joints shall present the same texture and smoothness as other portions of the course, except permissible density at the joint may be up to 2 percent less than the specified course density. Carefully make joints between old and new pavement or within new pavements in a manner to ensure a thorough and continuous bond between old and new sections of the course. Vertical contact surfaces of previously constructed sections that are coated with dust, sand, or other objectionable material shall be painted with a thin uniform coat of emulsion or other approved bituminous material just before placing fresh mixture.

3.4.1 Transverse

Roller shall pass over unprotected end of freshly laid mixture only when laying of course is to be discontinued. Except when an approved bulkhead is used, cut back the edge of previously laid course to expose an even, vertical surface for the full thickness of the course. When required, rake fresh mixture against joints, thoroughly tamp with hot tampers, smooth with hot smoothers, and roll. Transverse joints in adjacent lanes shall be offset a minimum of 600 mm (2 feet).

3.4.2 Longitudinal Joints

Space 150 mm (6 inches) apart. Do not allow joints to coincide with joints of existing pavement or previously placed courses. Spreader screed shall overlap previously placed lanes 50 to 75 mm (2 to 3 inches) and be of such height to permit compaction to produce a smooth dense joint. With a lute, push back mixture placed on the surface of previous lanes to the joint edge. Do not scatter mix. Remove and waste excess material. When edges of longitudinal joints are irregular, honeycombed, or poorly compacted, cut back unsatisfactory sections of joint and expose an even vertical surface for the full thickness of the course. When required, rake fresh mixture against joint, thoroughly tamp with hot tampers, smooth with hot smoothers, and roll while hot.

3.5 FIELD QUALITY CONTROL

3.5.1 Sampling

3.5.1.1 Aggregates At Source

Prior to production and delivery of aggregates, take at least one initial sample in accordance with ASTM D 75 [from each stockpile]. Collect each sample by taking three incremental samples at random from the source material to make a composite sample of not less than 22 kg (50 pounds). Repeat the sampling when the material source changes or when testing reveals unacceptable deficiencies or variations from the specified grading of materials.

3.5.1.2 Cold Feed Aggregate Sampling

Take two samples daily from the belt conveying materials from the cold feed. Collect materials in three increments at random to make a representative composite sample of not less than 22 kg (50 pounds). Take samples in accordance with ASTM D 75.

3.5.1.3 Coarse and Fine Aggregates

Take a 22 kg (50 pound) sample from the cold feed at least once daily for sieve analyses and specific gravity tests. Additional samples may be required to perform more frequent tests when analyses show deficiencies, or unacceptable variances or deviations. The method of sampling is as specified herein for aggregates.

3.5.1.4 Mineral Filler

ASTM D 546. Take samples large enough to provide ample material for testing.

3.5.1.5 Pavement and Mixture

Take plant samples for the determination of mix properties and field samples for thickness and density of the completed pavements. Furnish tools, labor and material for samples, and satisfactory replacement of pavement. Take samples and tests at not less than frequency specified hereinafter and at the beginning of plant operations; for each day's work as a minimum; each change in the mix or equipment; and as often as directed. Accomplish sampling in accordance with ASTM D 979.

3.5.2 Testing

3.5.2.1 Aggregates Tests

a. Gradation: ASTM C 136.

b. Mineral Filler Content: ASTM D 546.

c. Abrasion: ASTM C 131 for wear (Los Angeles test). Perform one test initially prior to incorporation into the work and each time the source is changed.

3.5.2.2 Bituminous Mix Tests

Test one sample for each 455 metric tons (500 tons), or fraction thereof, of the uncompacted mix for extraction in accordance with ASTM D 2172; perform a sieve analysis on each extraction sample in accordance with ASTM C 136 and ASTM C 117. Test one sample for each 455 metric tons (500 tons) or fraction thereof for stability and flow in accordance with ASTM D 1559. Test one sample for each material blend for index of retained strength in accordance with ASTM D 1075.

3.5.2.3 Pavement Courses

Perform the following tests:

a. Density: For each 910 metric tons (1000 tons) of bituminous mixture placed, determine the representative laboratory density by averaging the density of four laboratory specimens prepared in accordance with ASTM D 1559. Samples for laboratory specimens shall be taken

from trucks delivering mixture to the site; record in a manner approved by the Owner's Representative the project areas represented by the laboratory densities. From each representative area recorded, determine field density of pavement by averaging densities of 100 mm 4 inch diameter cores obtained from wearing course; take one core for each 1672 square meters (2000 square yards) or fraction thereof of course placed. Determine density of laboratory prepared specimens and cored samples in accordance with ASTM D 1188 or ASTM D 2726, as applicable. Separate pavement layers by sawing or other approved means. Maximum allowable deficiency at any point, excluding joints, shall not be more than 2 percent less than the specified density for any course. The average density of each course, excluding joints, shall be not less than the specified density. Joint densities shall not be more than 2 percent less than specified course densities and are not included when calculating average course densities. When the deficiency exceeds the specified tolerances, correct each such representative area or areas by removing the deficient pavement and replacing with new pavement.

b. Thickness: Determine thickness of binder and wearing courses from samples taken for the field density test. The maximum allowable deficiency at any point shall not be more than 6 mm (1/4 inch) less than the thickness for the indicated course. Average thickness of course or of combined courses shall be not less than the indicated thickness. Where a deficiency exceeds the specified tolerances, correct each such representative area or areas by removing the deficient pavement and replacing with new pavement.

c. Smoothness: Straightedge test the compacted surface of, and wearing course as work progresses. Apply straightedge parallel with and at right angles to the centerline after final rolling. Unevenness of course shall not vary more than 6 mm in 3 m (1/4 inch in 10 feet); variations in the wearing course shall not vary more than 3 mm in 3 m (1/8 inch in 10 feet). Correct each portion of the pavement showing irregularities greater than that specified.

d. Finished Grades: Finish grades of each course placed shall not vary from the finish elevations, profiles, and cross sections indicated by more than 13 mm (1/2 inch). Finished surface of the final wearing course will be tested by running lines of levels at intervals of 8 m (25 feet) longitudinally and transversely to determine elevations of completed pavement. Correct deficient paved areas by removing existing work and replacing with new materials that meet the specifications. Skin patching for correcting low areas is prohibited.

e. Finish Surface Texture of Wearing Course: Visually check final surface texture for uniformity and reasonable compactness and tightness. Final wearing course with a surface texture having undesirable irregularities such as segregation, cavities, pulls or tears, checking, excessive exposure of coarse aggregates, sand

streaks, indentations, ripples, or lack of uniformity shall be removed and replaced with new materials.

3.6 PROTECTION

Do not permit vehicular traffic, including heavy equipment; on pavement until surface temperature has cooled to at least 50 degrees C (120 degrees F). Measure surface temperature by approved surface thermometers or other satisfactory methods.

PART 4- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

The area to be paid for under this item shall be the number of square meters of asphalt pavement placed, compacted and accepted

4.2 BASIS OF PAYMENT

The accepted quantities, measured as prescribed in Part 4.1 shall be paid for at the contract unit price which price and payment shall be full compensation for furnishing all materials handling, mixing hauling, placing, rolling, compacting, labor and equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
02742	Asphalt Pavement	Square Meter

SECTION 02743

BITUMINOUS PRIME COAT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 140	Sampling Bituminous Materials
ASTM D 977	Emulsified Asphalt
ASTM D 2397	Cationic Emulsified Asphalt

1.2 SUBMITTALS

Submit the following:

Test Reports

Bituminous materials

1.3 DELIVERY, STORAGE, AND HANDLING

Inspect the materials for contamination and damage. Unload and store the materials with a minimum of handling.

1.4 ENVIRONMENTAL REQUIREMENTS

Apply the prime coat only when the surface is dry or contains moisture not in excess of the amount that will permit uniform distribution and the desired penetration. Apply the prime coat only when the ambient temperature is 10 degrees C (50 degrees F) or above and when the temperature has not been below 1.7 degrees C (35 degrees F) for 12 hours immediately prior to application, unless otherwise directed.

1.5 CONSTRUCTION EQUIPMENT

Provide equipment dependable and adequate for the purpose intended and properly maintained in satisfactory and safe operating condition at all times. Calibrated equipment such as asphalt distributors scales, batching equipment, and an approved calibration laboratory prior to commencing work shall have recalibrated spreaders and similar equipment.

1.5.1 Bituminous Distributor

Bituminous distributor shall have pneumatic tires of such width and number that the load produced on the base surface shall not exceed 295 kg per 25 mm (650 pounds per inch) of tire width. The bituminous distributor shall be designed and equipped to distribute the bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rates from 0.23 to 9.05 liters per square meter (0.05 to 2.0 gallons per square yard), with a pressure range of 172.4 to 517.1 kPa (25 to 75 pounds per square inch) and an allowable variation not to exceed 5 percent from any specified rate. Distributor equipment shall include a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating the materials to the proper application temperature, a thermometer for reading the temperature of the tank contents, and a hose and spray nozzle attachment for applying bituminous material to spots unavoidably missed by the distributor and to areas inaccessible to the distributor. The distributor shall be equipped to circulate and agitate the bituminous material during the heating process.

1.5.2 Heating Equipment for Storage Tanks

The equipment for heating the bituminous material shall be steam, electric or hot oil heaters. Steam heaters shall consist of steam coils and equipment for producing steam, so designed that the steam cannot get into the material. An armored thermometer with a temperature range from 4.4 to 204.4 degrees C (40 to 400 degrees F) shall be fixed to the tank so that the temperature of the bituminous material may be determined at all times.

1..3 Brooms and Blowers

Brooms and blowers shall be of the power type and suitable for cleaning prepared subgrades or bases.

PART 2- PRODUCTS

2.1 BITUMINOUS MATERIAL

2.1.1 Emulsified Asphalt

ASTM D 977, Type SS-1

PART 3 EXECUTION

3.1 SURFACE PREPARATION

Immediately before applying the prime coat, remove loose material, dirt, clay, and other objectionable material from the surface to be primed. After the cleaning operation and prior to the application of the prime coat, examine the area to be primed. Ensure that the area is fit to receive the bituminous priming material.

3.2 APPLICATION

Immediately following the surface preparation, apply the bituminous material by means of the bituminous distributor. Apply the bituminous material at a pressure range of 172.4 to

517.1 kPa (25 to 75 pounds per square inch) within the temperature limits specified herein, and at the rate of not less than not less than 0.91 liter nor more than 1.36 liters of bituminous material per square meter (0.20 gallon nor more than 0.30 gallon of bituminous material per square yard). Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Unless the distributor is equipped to obtain satisfactory results at the junction of previous and subsequent applications, spread building paper on the surface of the applied material for a sufficient distance back from the ends of each application, so that flow from the sprays may be started and stopped on the paper, and so that all sprayers will operate at full force on the surface to be treated. Immediately after the application, remove the building paper and apply bituminous material to spots missed by the distributor.

3.2.1 Curing

Following the application of bituminous material, allow the surface to cure without being disturbed for a period of not less than 48 hours or longer, as may be necessary to attain penetration into the foundation course and evaporation of the volatiles from the bituminous material. Furnish and spread enough sand to effectively blot up and cure excess bituminous material. Maintain the primed surface until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and repriming deficient areas.

3.2.2 Application Temperature for Emulsified Asphalt

Between 23.9 and 54.4 degrees C 75 and 130 degrees F.

3.3 FIELD QUALITY CONTROL

Furnish samples of bituminous materials for testing. Sample bituminous materials in accordance with ASTM D 140.

3.4 PROTECTION

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades to prevent traffic over freshly treated surfaces.

PART 4 MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Bituminous Prime Coat shall be measured by the tonne. The quantity to be paid for shall be the number of tonnes of bituminous material applied and accepted in the completed work.

4.2 BASIS OF PAYMENT

The accepted quantity measured as prescribed in Part 4.1 shall be paid for at the contract unit price which price and payment shall be full compensation for furnishing and placing all materials, including labor, equipment, tools and incidentals necessary to complete this Section.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
02743	Prime Coat	Tonne

SECTION 02744

BITUMINOUS TACK COAT

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T102 Spot Test of Asphaltic Materials

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM D 140 Sampling Bituminous Materials

ASTM D 977 Emulsified Asphalt

ASTM D 2397 Cationic Emulsified Asphalt

1.2 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

1.2.1 Certified test reports: For emulsified asphalt

1.3 DELIVERY AND STORAGE

Inspect the materials delivered to the site for contamination and damage. Unload and store the materials with a minimum of handling.

1.4 WEATHER LIMITATIONS

Apply the tack coat only when the surface is dry. Apply the tack coat only when the ambient temperature is 10 degrees C (50 degrees F) or above and when the temperature has not been below 1.7 degrees C (35 degrees F) for 12 hours immediately prior to application, unless otherwise directed.

PART 2 PRODUCTS

2.1 MATERIALS

Bituminous material for the tack coat shall be emulsified asphalt.

2.1.1 Emulsified Asphalt

ASTM D 977, Type SS-1 or SS-1h ASTM D 2397, Type CSS-1 or CSS-1h. Dilute the emulsified asphalt with equal parts of water. The base asphalt used to manufacture the emulsion shall show a negative spot when tested in accordance with AASHTO T102 using standard naphtha.

2.2 CONSTRUCTION EQUIPMENT

Provide equipment dependable and adequate for the purpose intended and properly maintained in satisfactory and safe operating condition. Calibrated equipment such as asphalt distributors, scales, batching equipment, a calibration laboratory prior to commencing work shall have recalibrated spreaders and similar equipment.

2.2.1 Bituminous Distributor

The bituminous distributor shall be designed and equipped to distribute the bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rates from 0.23 to 9.05 liters per square meter (0.05 to 2.0 gallons per square yard), with a pressure range of 172.4 to 517.1 kPa (25 to 75 pounds per square inch) and with an allowable variation not to exceed 5 percent from any specified rate. Distributor equipment shall include a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gages, volume-measuring devices, adequate heaters for heating the materials to the proper application temperature, a thermometer for reading the temperature of the tank contents, and a hose and spray nozzle attachment suitable for applying bituminous material to spots unavoidably missed by the distributor and to areas inaccessible to the distributor. The distributor shall be equipped to circulate and agitate the bituminous material during the heating process.

2.2.2 Heating Equipment for Storage Tanks

The equipment for heating the bituminous material shall be steam, electric, or hot oil heaters. Steam heaters shall consist of steam coils and equipment for producing steam, so designed that the steam cannot get into the material. An armored thermometer with a temperature range from 4.4 to 204.4 degrees C (40 to 400 degrees F) shall be fixed to the tank so that the temperature of the bituminous material may be determined at all times.

2.2.3 Brooms and Blowers

Brooms and blowers shall be of the power type suitable for cleaning the surfaces for application of the bituminous material.

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Immediately before applying the tack coat, remove loose material, dirt, clay, and other objectionable material from the surface to be treated by a power broom or blower supplemented with hand brooms. After the cleaning operation and prior to the application

of the tack coat, inspect the area to be paved to determine the fitness of the area to receive the bituminous material.

3.2 APPLICATION OF BITUMINOUS MATERIAL

Apply the tack coat when the surface to be treated is dry. Immediately following the preparation of the surface for treatment, apply the bituminous material by means of the bituminous distributor, within the limits of temperature specified herein and at a rate of not less than 0.23 liter nor more than 0.68 liter of diluted emulsion per square meter (not less than 0.05 gallon nor more than 0.15 gallon of diluted emulsion per square yard). Apply the bituminous material so that uniform distribution is obtained over the entire surface to be treated. Treat lightly coated areas and spots missed by the distributor with the bituminous material. Following the application of bituminous material, allow the surface to cure without being disturbed for period of time necessary to permit setting of the tack coat. Apply the bituminous tack coat only as far in advance of the placing of the overlying layer as required for that day's operation. Maintain and protect the treated surface from damage until the succeeding course of pavement is placed.

3.2.1 Application Temperature for Emulsified Asphalt

Between 23.9 and 54.4 degrees C (75 and 130 degrees F).

3.3 FIELD SAMPLING AND TESTING

3.3.1 Sampling Bituminous Materials

Furnish samples of bituminous materials for testing. Test in accordance with ASTM D 140.

3.3.2 Bituminous Material Tests

Perform spot test for asphalt in accordance with AASHTO T102 on each shipment.

3.4 TRAFFIC CONTROLS

Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

PART 4 MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

The quantity to be paid for shall be the number of tonne of bituminous material applied and accepted in the completed work.

4.2 BASIS OF PAYMENT

The accepted quantity measured as prescribed in Part 4.1 shall be paid for at the contract unit price which price and payment shall be full compensation for furnishing and placing

all materials, including labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
02744	Tack Coat	Tonne

SECTION 02770

CONCRETE SIDEWALKS AND CURBS AND GUTTERS

PART 1 - GENERAL

1.1 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

Making and Curing Concrete Test Specimens in the Field

ASTM C 143	Slump of Hydraulic Cement Concrete
ASTM C 171	Sheet Materials for Curing Concrete
ASTM C 172	Sampling Freshly Mixed Concrete

Air Content of Freshly Mixed Concrete by the Volumetric Method

Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements

1.2 SUBMITTALS

Product Data
Concrete;

SD-06 Test Reports
Field Quality Control;
Copies of all test reports.

1.3 WEATHER LIMITATIONS

1.3.1 Placing During Cold Weather: Concrete placement shall not take place when the air temperature reaches 5 degrees C (40 degrees F) and is falling, or is already below that point. Placement may begin when the air temperature reaches 2 degrees C (35 degrees F) and is rising, or is already above 5 degrees C (40 degrees F). Provisions shall be made to protect the concrete from freezing during the specified curing period. If necessary to place concrete when the temperature of the air, aggregates, or water is below 2 degrees C, 35 degrees F, placement and protection shall be approved in writing.

1.3.2 Placing During Warm Weather: The temperature of the concrete as placed shall not exceed 30 degrees C (85 degrees F) except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature. The placing temperature shall not exceed 35 degrees C (95 degrees F) at any time.

1.4 PLANT, EQUIPMENT, MACHINES, AND TOOLS

1.4.1 General Requirements: Plant, equipment, machines, and tools used in the work shall be subject to approval and shall be maintained in a satisfactory working condition at all times. The equipment shall have the capability of producing the required product, meeting grade controls, thickness control and smoothness requirements as specified. Use of the equipment shall be discontinued if it produces unsatisfactory results. The Owner's Representative shall have access at all times to the plant and equipment to ensure proper operation and compliance with specifications.

1.4.2 Slip Form Equipment: Slip form paver or curb forming machine, will be approved based on trial use on the job and shall be self-propelled, automatically controlled, crawler mounted, and capable of spreading, consolidating, and shaping the plastic concrete to the desired cross section in 1 pass.

PART 2 - PRODUCTS

2.1 CONCRETE: Concrete shall conform to the applicable requirements of Section 03307 CONCRETE FOR MINOR STRUCTURES except as otherwise specified. Concrete shall have a minimum compressive strength of 17 MPa 2500 psi at 28 days. Maximum size of aggregate shall be 25 mm. (1 inches).

2.1.1 Air Content: Mixtures shall have air content by volume of concrete of 5 to 7 percent, based on measurements made immediately after discharge from the mixer.

2.1.2 Slump: The concrete slump shall be 50 mm plus or minus 25 mm (2 inches plus or minus 1 inch) where determined in accordance with ASTM C 143.

2.2 CONCRETE CURING MATERIALS

2.2.1 Impervious Sheet Materials: Impervious sheet materials shall conform to ASTM C 171, type optional, except that polyethylene film, if used, shall be white opaque.

2.2.2 Burlap: Burlap shall conform to AASHTO M 182.

2.3 CONCRETE PROTECTION MATERIALS: Concrete protection materials shall be a linseed oil mixture of equal parts, by volume, of linseed oil and either mineral spirits, naphtha, or turpentine. At the option of the contractor, commercially prepared linseed oil mixtures, formulated specifically for application to concrete to provide protection against the action of deicing chemicals may be used, except that emulsified mixtures are not acceptable.

2.4 JOINT FILLER STRIPS

2.4.1 Contraction Joint Filler for Curb and Gutter: Contraction joint filler for curb and gutter shall consist of hard-pressed fiberboard.

2.4.2 Expansion Joint Filler, Premolded: Expansion joint filler, premolded, shall conform to ASTM D 1751 or ASTM D 1752, 10 mm (3/8 inch thick), unless otherwise indicated.

2.5 JOINT SEALANTS

2.5.1 Joint Sealant, Hot-Poured: Joint sealant, hot-poured shall conform to ASTM D 3405.

2.6 FORM WORK: Formwork shall be designed and constructed to ensure that the finished concrete will conform accurately to the indicated dimensions, lines, and elevations, and within the tolerances specified. Forms shall be of wood or steel, straight, of sufficient strength to resist springing during depositing and consolidating concrete. Wood forms shall be surfaced plank, 50 mm (2 inches) nominal thickness, straight and free from warp, twist, loose knots, splits or other defects. Wood forms shall have a nominal length of 3 m. (10 feet). Radius bends may be formed with 19 mm ¾ inch boards, laminated to the required thickness. Steel forms shall be channel-formed sections with a flat top surface and with welded braces at each end and at not less than two intermediate points. Ends of steel forms shall be interlocking and self-aligning. Steel forms shall include flexible forms for radius forming, corner forms, form spreaders, and fillers. Steel forms shall have a nominal length of 3 m (10 feet) with a minimum of 3 welded stake pockets per form. Stake pins shall be solid steel rods with chamfered heads and pointed tips designed for use with steel forms.

2.6.1 Sidewalk Forms: Sidewalk forms shall be of a height equal to the full depth of the finished sidewalk.

2.6.2 Curb and Gutter Forms: Curb and gutter outside forms shall have a height equal to the full depth of the curb or gutter. The inside form of curb shall have batter as indicated and shall be securely fastened to and supported by the outside form. Rigid forms shall be provided for curb returns, except that benders or thin plank forms may be used for curb or curb returns with a radius of 3 m (10 feet) or more, where grade changes occur in the return, or where the central angle is such that a rigid form with a central angle of 90 degrees cannot be used. Back forms for curb returns may be made of 38 mm (1-1/2 inch) benders, for the full height of the curb, cleated together. In lieu of inside forms for curbs, a curb "mule" may be used for forming and finishing this surface, provided the results are approved.

PART 3 - EXECUTION

3.1 SUBGRADE PREPARATION: The subgrade shall be constructed to the specified grade and cross section prior to concrete placement. Subgrade shall be placed and compacted as directed.

3.1.1 Sidewalk Subgrade: The subgrade shall be tested for grade and cross section with a template extending the full width of the sidewalk and supported between side forms.

3.1.2 Curb and Gutter Subgrade: The subgrade shall be tested for grade and cross section by means of a template extending the full width of the curb and gutter. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement.

3.1.3 Maintenance of Subgrade: The subgrade shall be maintained in a smooth, compacted condition in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed.

3.2 FORM SETTING: Forms shall be set to the indicated alignment, grade and dimensions. Forms shall be held rigidly in place by a minimum of 3 stakes per form placed at intervals not to exceed 1.2 meters (4 feet). Corners, deep sections, and radius bends shall have additional stakes and braces, as required. Clamps, spreaders, and braces shall be used where required to ensure rigidity in the forms. Forms shall be removed without injuring the concrete. Bars or heavy tools shall not be used against the concrete in removing the forms. Any concrete found defective after form removal shall be promptly and satisfactorily repaired. Forms shall be cleaned and coated with form oil each time before concrete is placed.

3.2.1 Sidewalks: Forms for sidewalks shall be set with the upper edge true to line and grade with an allowable tolerance of 3 mm (1/8 inch) in any 3 m (10 foot) long section. After forms are set, grade and alignment shall be checked with a 3 m (10 foot) straightedge. Side forms shall not be removed for 12 hours after finishing has been completed.

3.2.2 Curbs and Gutters: The forms of the front of the curb shall be removed not less than 2 hours nor more than 6 hours after the concrete has been placed. Forms back of curb shall remain in place until the face and top of the curb have been finished, as specified for concrete finishing. Gutter forms shall not be removed while the concrete is sufficiently plastic to slump in any direction.

3.3 SIDEWALK CONCRETE PLACEMENT AND FINISHING

3.3.1 Formed Sidewalks: Concrete shall be placed in the forms in one layer. When consolidated and finished, the sidewalks shall be of the thickness indicated. After concrete has been placed in the forms, a strike-off guided by side forms shall be used to bring the surface to proper section to be compacted. The concrete shall be consolidated with an approved vibrator, and the surface shall be finished to grade with a strike off.

3.3.2 Concrete Finishing: After straight edging, when most of the water sheen has disappeared, and just before the concrete hardens, the surface shall be finished with a wood float or darby to a smooth and uniformly fine granular or sandy texture free of waves, irregularities, or tool marks. A scored surface shall be produced by brooming with a fiber-bristle brush in a direction transverse to that of the traffic, followed by edging.

3.3.3 Edge and Joint Finishing: All slab edges, including those at formed joints, shall be finished with an edger having a radius of 3 mm. (1/8 inch). Transverse joint shall be edged before brooming, and the brooming shall eliminate the flat surface left by the surface face of the edger. Corners and edges which have crumbled and areas which lack sufficient mortar for proper finishing shall be cleaned and filled solidly with a properly proportioned mortar mixture and then finished.

3.3.4 Surface and Thickness Tolerances: Finished surfaces shall not vary more than 8 mm (5/16 inch) from the testing edge of a 3 m 10-foot straightedge. Permissible deficiency in section thickness will be up to 6 mm (1/4 inch).

3.4 CURB AND GUTTER CONCRETE PLACEMENT AND FINISHING

3.4.1 Formed Curb and Gutter: Concrete shall be placed to the section required in a single lift. Consolidation shall be achieved by using approved mechanical vibrators. Curve shaped gutters shall be finished with a standard curb "mule".

3.4.2 Curb and Gutter Finishing: Approved slipformed curb and gutter machines may be used in lieu of hand placement.

3.4.3 Concrete Finishing: Exposed surfaces shall be floated and finished with a smooth wood float until true to grade and section and uniform in texture. Floated surfaces shall then be brushed with a fine-hair brush with longitudinal strokes. The edges of the gutter and top of the curb shall be rounded with an edging tool to a radius of 13 mm. (1/2 inch). Immediately after removing the front curb form, the face of the curb shall be rubbed with a wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed. The front curb surface, while still wet, shall be brushed in the same manner as the gutter and curb top. The top surface of gutter and entrance shall be finished to grade with a wood float.

3.4.4 Joint Finishing: Curb edges at formed joints shall be finished as indicated.

3.4.5 Surface and Thickness Tolerances: Finished surfaces shall not vary more than 6 mm (1/4 inch) from the testing edge of a 3 m (10-foot) straightedge. Permissible deficiency in section thickness will be up to 6 mm. (1/4 inch).

3.5 SIDEWALK JOINTS: Sidewalk joints shall be constructed to divide the surface into rectangular areas. Transverse contraction joints shall be spaced at a distance equal to the sidewalk width or 1.5 m 5 feet on centers, whichever is less, and shall be continuous across the slab. Longitudinal contraction joints shall be constructed along the centerline of all sidewalks 3 m 10 feet or more in width. Transverse expansion joints shall be installed at sidewalk returns and opposite expansion joints in adjoining curbs. Where the sidewalk is not in contact with the curb, transverse expansion joints shall be installed as indicated. Expansion joints shall be formed about structures and features which project through or into the sidewalk pavement, using joint filler of the type, thickness, and width indicated.

3.5.1 Sidewalk Contraction Joints: The contraction joints shall be formed in the fresh concrete by cutting a groove in the top portion of the slab to a depth of at least one-fourth of the sidewalk slab thickness, using a jointer to cut the groove, or by sawing a groove in the hardened concrete with a power-driven saw, unless otherwise approved. Sawed joints shall be constructed by sawing a groove in the concrete with a 3 mm 1/8 inch blade to the depth indicated. An ample supply of saw blades shall be available on the job before concrete placement is started, and at least one standby sawing unit in good working order shall be available at the jobsite at all times during the sawing operations.

3.5.2 Sidewalk Expansion Joints: Expansion joints shall be formed with 12 mm ½ Inch) joint filler strips. Joint filler shall be placed with top edge 6 mm 1/4 inch below the surface and shall be held in place with steel pins or other devices to prevent warping of the filler during floating and finishing. Immediately after finishing operations are completed, joint edges shall be rounded with an edging tool having a radius of 3 mm, (1/8 inch), and concrete over the joint filler shall be removed. At the end of the

curing period, expansion joints shall be cleaned and filled with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C (50 degrees F) at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.6 CURB AND GUTTER JOINTS: Curb and gutter joints shall be constructed at right angles to the line of curb and gutter.

3.6.1 Contraction Joints: Contraction joints shall be constructed directly opposite contraction joints in abutting portland cement concrete pavements and spaced so that monolithic sections between curb returns will not be less than 1.5 m (5 feet) nor greater than 4.5 m (15 feet) in length. Contraction joints shall be constructed by means of 3 mm 1/8 inch thick separators and of a section conforming to the cross section of the curb and gutter. Separators shall be removed as soon as practicable after concrete has set sufficiently to preserve the width and shape of the joint and prior to finishing.

3.6.2 Expansion Joints: Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb and gutter. Expansion joints shall be provided in curb and gutter directly opposite expansion joints of abutting portland cement concrete pavement, and shall be of the same type and thickness as joints in the pavement. Where curb and gutter do not abut portland cement concrete pavement, expansion joints at least 12 mm ½ inch in width shall be provided at intervals not exceeding 9 meters. feet. Expansion joints shall be provided in nonreinforced concrete gutter at locations indicated. Expansion joints shall be sealed immediately following curing of the concrete or as soon thereafter as weather conditions permit. Expansion joints and the top 25 mm 1 inch depth of curb and gutter contraction-joints shall be sealed with joint sealant. The joint opening shall be thoroughly cleaned before the sealing material is placed. Sealing material shall not be spilled on exposed surfaces of the concrete. Concrete at the joint shall be surface dry and atmospheric and concrete temperatures shall be above 10 degrees C (50 degrees F) at the time of application of joint sealing material. Excess material on exposed surfaces of the concrete shall be removed immediately and concrete surfaces cleaned.

3.7 CURING AND PROTECTION

3.7.1 General Requirements: Concrete shall be protected against loss of moisture and rapid temperature changes for at least 7 days from the beginning of the curing operation. Unhardened concrete shall be protected from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand and ready for use before actual concrete placement begins. Protection shall be provided as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

3.7.1.1 Mat Method: The entire exposed surface shall be covered with 2 or more layers of burlap. Mats shall overlap each other at least 150 mm. (6 inches). The mat shall be thoroughly wetted with water prior to placing on

concrete surface and shall be kept continuously in a saturated condition and in intimate contact with concrete for not less than 7 days.

3.7.1.2 Impervious Sheeting Method: The entire exposed surface shall be wetted with a fine spray of water and then covered with impervious sheeting material. Sheets shall be laid directly on the concrete surface with the light-colored side up and overlapped 300 mm (12 inches) when a continuous sheet is not used. The curing medium shall not be less than 450 mm (18-inches) wider than the concrete surface to be cured, and shall be securely weighted down by heavy wood planks, or a bank of moist earth placed along edges and laps in the sheets. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

3.7.2 Backfilling: After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted to conform to the surrounding area in accordance with lines and grades indicated.

3.7.3 Protection: Completed concrete shall be protected from damage until accepted. The Contractor shall repair damaged concrete and clean concrete discolored during construction. Concrete that is damaged shall be removed and reconstructed for the entire length between regularly scheduled joints. Refinishing the damaged portion will not be acceptable. Removed damaged portions shall be disposed of as directed.

3.8 FIELD QUALITY CONTROL

3.8.1 General Requirements: The Contractor shall perform the inspection and tests described and meet the specified requirements for inspection details and frequency of testing. Based upon the results of these inspections and tests, the Contractor shall take the action and submit reports as required below, and any additional tests to insure that the requirements of these specifications are met.

3.8.2 Concrete Testing

3.8.2.1 Strength Testing: The Contractor shall provide molded concrete specimens for strength tests. Samples of concrete placed each day shall be taken not less than once a day nor less than once for every 190 cubic meters (250 cubic yards) of concrete. The samples for strength tests shall be taken in accordance with ASTM C 172. Cylinders for acceptance shall be molded in conformance with ASTM C 31/C 31M by an approved testing laboratory. Each strength test result shall be the average of 2 test cylinders from the same concrete sample tested at 28 days, unless otherwise specified or approved. Concrete specified on the basis of compressive strength will be considered satisfactory if the averages of all sets of three consecutive strength test results equal or exceed the specified strength, and no individual strength test result falls below the specified strength by more than 4 MPa. (500 psi).

3.8.2.2 Air Content: Air content shall be determined in accordance with ASTM C 173 or ASTM C 231. ASTM C 231 shall be used with concretes and mortars made with relatively dense natural aggregates. Two tests for air content shall be made on randomly selected batches of each class of concrete placed during each shift. Additional tests shall be made when excessive variation in concrete workability is reported by the placing foreman or the Government inspector. If results are out of tolerance, the placing foreman shall be notified and he shall take appropriate action to have the air content corrected at the plant. Additional tests for air content will be performed on each truckload of material until such time as the air content is within the tolerance specified.

3.8.2.3 Slump Test: Two slump tests shall be made on randomly selected batches of each class of concrete for every 190 cubic meters, (250 cubic yards), or fraction thereof, of concrete placed during each shift. Additional tests shall be performed when excessive variation in the workability of the concrete is noted or when excessive crumbling or slumping is noted along the edges of slip-formed concrete.

3.8.3 Thickness Evaluation: The anticipated thickness of the concrete shall be determined prior to placement by passing a template through the formed section or by measuring the depth of opening of the extrusion template of the curb forming machine. If a slip form paver is used for sidewalk placement, the subgrade shall be true to grade prior to concrete placement and the thickness will be determined by measuring each edge of the completed slab.

3.8.4 Surface Evaluation: The finished surface of each category of the completed work shall be uniform in color and free of blemishes and form or tool marks.

3.9 SURFACE DEFICIENCIES AND CORRECTIONS

3.9.1 Thickness Deficiency: When measurements indicate that the completed concrete section is deficient in thickness by more than 6 mm (1/4 inch) the deficient section will be removed, between regularly scheduled joints, and replaced.

3.9.2 High Areas: In areas not meeting surface smoothness and plan grade requirements, high areas shall be reduced either by rubbing the freshly finished concrete with carborundum brick and water when the concrete is less than 36 hours old or by grinding the hardened concrete with an approved surface grinding machine after the concrete is 36 hours old or more. The area corrected by grinding the surface of the hardened concrete shall not exceed 5 percent of the area of any integral slab, and the depth of grinding shall not exceed 6 mm. (¼ inch). Pavement areas requiring grade or surface smoothness corrections in excess of the limits specified above shall be removed and replaced.

3.9.3 Appearance: Exposed surfaces of the finished work will be inspected and any deficiencies in appearance will be identified. Areas which exhibit excessive cracking, discoloration, form marks, or tool marks or which are otherwise inconsistent with the overall appearances of the work shall be removed and replaced.

PART 4- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

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

4.2 BASIS OF PAYMENT

The quantity as determined in Part 4.1, shall be paid for at the contract unit price per square meter which prices and payment shall constitute full compensation for placing and furnishing materials and for all labor, equipment, tools and incidental necessary to complete the work.

Payment will be under

Pay Item Number	Description	Unit of Measurement
02770	Sidewalk Pavement	Square Meter

SECTION 03300

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only. Unless specified, all publications below shall be of the latest edition.

1.1.1 American Concrete Institute (ACI) Publications:

ACI 224 R	Control of Cracking in Concrete Structures
ACI 301	Specifications for Structural Concrete for Buildings
ACI 302.1 R	Guide for Concrete Floor and Slab Construction
ACI 304	Recommended Practice for Measuring, Mixing, Transporting and Placing Concrete
ACI-305R	Hot-Weather Concreting
ACI 315	Details and Detailing of Concrete Reinforcement
ACI 318R	Building Code Requirements for Reinforced Concrete
ACI 347-R	Recommended Practice for Concrete Formwork
ACI 350R	Environmental Engineering Concrete Structures

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

C 39	Compressive Strength of Cylindrical Concrete Specimens
C 94	Ready-Mixed Concrete
C920	Elastomeric Joint Sealants
C 138	Test Methods for Unit Weight, Yield and Air Content (Gravimetric) or Concrete
C 231	Standard Test Method for Air Content of Freshly-Mixed Concrete by the Pressure Method
C 173	Standard Test Method for Air Content of Freshly-Mixed Concrete by the Volumetric Method
D 1751	Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)

1.1.3 American Welding Society (AWS) Publication:

D1.4 Structural Welding Code-Reinforcing Steel

1.1.4 Product Standards Agency (PSA) Publications:

a. Philippine National Standards:

PNS 07	Specifications for Portland Cement
PNS 18	Specifications for Concrete Aggregates
PNS 49	Specifications for Steel Bars for Concrete Reinforcement

b. Standards Administrative Order (SAO)

SAO-6 Philippine Plywood

1.2 DESCRIPTION OF WORK: The work includes the provision of cast-in-place concrete.

1.3 SUBMITTALS:

1.3.1 Shop Drawings: Reproductions of contract drawings are unacceptable.

1.3.1.1 Shop Drawings for Reinforcing Steel: ACI 315. Indicate bending diagrams, assembly diagrams, splicing and laps of bars, shapes, dimensions, and details of bar reinforcing, accessories, and concrete cover. Do not scale dimensions from structural drawings to determine lengths of reinforcing rods.

1.3.1.2 Shop Drawings for Formwork: ACI 347. Include design calculations indicating arrangement of forms, sizes and grade of supports (lumber), panels, and related components. Indicate placement schedule, construction, and location and method of forming control joints. Include locations of inserts, pipework, conduit, sleeves, and other embedded items. Furnish drawings and descriptions of shoring and reshoring methods, proposed for suspended slab, spandrel beams, and other horizontal concrete members. Furnish schedule of form removal of structures not included in paragraph entitled "Removal of Forms".

1.3.1.3 Shop Drawings for Construction Joints: ACI 318. Drawings shall clearly indicate sequence of pouring for all footings, columns, beams and slabs.

1.3.2 Contractor Mix Design: Thirty days minimum prior to concrete placement, submit a mix design for each strength and type of concrete. Furnish a complete list of materials including type; brand; source and amount of cement and admixtures; applicable reference specifications; and copies of test reports showing that the mix has been successfully tested to produce concrete with the properties specified and will be suitable for the job conditions. Submit additional data regarding concrete aggregates if the source of aggregate changes.

1.3.3 Certified Laboratory Test Reports: Before delivery of materials, certified copies in 5 copies of the reports of all tests required in referenced publications or otherwise specified herein shall be submitted to and approved by the Owner's Representative. The testing shall have been performed within one year of submittal of the test reports for approval by an independent laboratory approved by the Owner's Representative. Test reports on a previously tested materials shall be accompanied by notarized certificates from the manufacturer certifying that the previously tested material is of the same type, quality, manufacture, and make as that proposed for use in this project. Certified test reports are required for the following:

a. Aggregates
b. Reinforcement
c. Cement

1.3.4 Certificates of Compliance:

a. Materials for Curing Concrete
b. Joint sealant
c. Joint filler
d. Vapor barrier
e. Admixtures

1.3.5 Catalog Data:

a. Materials for curing concrete
b. Joint sealant
c. Joint filler
d. Vapor barrier
e. Admixtures

1.4 DELIVERY AND STORAGE:

1.4.1 Cement: Cement in bags shall be stored in a suitable weatherproof structure which shall be as air-tight as practicable; floors shall be elevated above the ground a distance sufficient to prevent the absorption of moisture. Bags shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls; the manner of storage shall permit easy access for inspection and identification of each shipment. Bulk cement shall be transferred to elevated airtight and weatherproof bins. At the time of use all cement shall be free-flowing and free of lumps. Cement that has been in storage longer than 6 months will be tested by standard mortar tests or other tests as deemed necessary by the Owner's Representative to determine its suitability for use and such cement shall not be used without approval of the Owner's Representative.

1.4.2 Aggregates: Aggregates shall be stored on areas covered with tightly laid wood planks, sheet metal, or other hard and clean surface, and in a manner that will preclude the inclusion of foreign material. Aggregates of different sizes shall be stored in separate piles. Stock piles of coarse aggregate shall be built in horizontal layers not exceeding 1.20 meters in depth to minimize segregation. Should the coarse aggregate become aggregated it shall be remixed to conform to the grading requirements.

1.4.3 Reinforcement: Store reinforcement of different sizes in racks raised above the ground with accurate identification. Protect reinforcing steel from contaminants such as grease, oil, and dirt.

1.4.4 Admixtures: Admixtures shall be stored in a manner that will not damage the containers.

PART 2 - PRODUCTS

2.1 CONCRETE

2.1.1 Contractor-Furnished Mix Design: ACI 211.1 and ACI 301. Unless indicated otherwise in the drawings, the following shall apply:

Location	28-Day Compressive Strength (Mpa)	(kg/sq.cm.)	Maximum Agg. Size (mm)	Slump (mm)
All Structural Elements	21.0	211	25	27-75

2.2 MATERIALS:

2.2.1 Cement: PNS 07, Type I

2.2.2 Water: Water shall be fresh, clean, and potable.

2.2.3 Aggregates: PNS 18, except as modified herein. Obtain aggregates for exposed concrete surfaces from one source. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the cement.

2.2.4 Nonshrink Grout: ASTM C 827 non-metallic.

2.2.5 Admixtures:

2.2.5.1 Accelerating: ASTM C 494, Type C.

2.2.5.2 Retarding: ASTM C 494, Type B or D.

2.2.5.3 Water Reducing: ASTM C 494, Type A or E.

2.2.5.3 Air entraining, AM C 260

Percentage of air content shall be as required in ACI 318, ACI 201.2R and ASTM C 1116, as applicable.

2.2.6 Materials for Forms: Provide wood, plywood, or steel. Use plywood or steel forms where a smooth form finish is required. Lumber shall be square edged or tongue-and-groove boards, free of raised grain, knotholes, or other surface defects. Plywood shall conform with SAO 6, Type I, Grade A or better surfaces. Steel form surfaces shall not contain irregularities, dents, or sags.

2.2.7 Reinforcement:

2.2.7.1 Reinforcing Bars: ASTM A615. All reinforcing steel shall be deformed. Reinforcing steel shall have a minimum yield strength of 414 MPa (Grade

60) for 16mm diameter and above, 276 MPa (Grade 40) for 12mm diameter and below.

2.2.8 Vapor Barrier: ASTM C 171 polyethylene sheeting, minimum 6 mil thickness.

2.2.9 Materials for Curing Concrete:

2.2.9.1 Impervious Sheeting: ASTM C 171; waterproof paper, clear or white polyethylene sheeting, or polyethylene-coated burlap.

2.2.9.2 Pervious Sheeting: AASHTO M 182.

2.2.9.3 Liquid Membrane-Forming Compound: ASTM C 309, white-pigmented, Type 2, Class B, free of paraffin or petroleum.

2.2.9.4 Liquid Chemical Sealer-Hardener Compound: Compound shall not contain petroleum resins or waxes. Compound shall not reduce the adhesion of resilient flooring, tile, paint, waterproofing, or other material applied to concrete.

2.2.10 Expansion/Contraction Joint Filler: ASTM D 1751 or ASTM D1752.

2.2.11 Joint Sealants:

2.2.11.1 Horizontal Surfaces (3 percent slope, maximum):

a. Outside Buildings: ASTM D 1190.
b. Inside Buildings: ASTM D 1190 or ASTM D 1850.

2.2.11.2 Vertical Surfaces (greater than 3 percent slope): ASTM C 920, Type M, Grade NS, Class 25, Use T.

2.2.12 FORMS: ACI 301.

2.2.12.1 General Requirements: Forms shall be provided for all concrete not indicated or specified otherwise. Forms shall be set true to line and grade and maintained so as to insure completed work within the allowable tolerance specified, and shall be mortar-tight. The Contractor shall be responsible for the adequacy of forms and form supports. Bolts and rods used for internal ties shall be arranged so that when the forms are removed, all metals will have concrete cover not less than that indicated in the drawings. Bolts or rod type form ties that must be removed when forms are removed shall not be used for watertight forms. Wire tire shall not be used where the concrete surface will be exposed to weathering and where discoloration will be exposed. All form work shall be provided with adequate clean-out openings to permit inspection and easy cleaning after all reinforcement has been placed. Where forms for continuous surfaces are placed in successive units, the forms shall be fitted over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Panel forms shall be constructed to provide tight joints between panels. All forms shall be constructed so that they can be removed without damaging the concrete. All exposed joints, edges, and external corners shall be chamfered a minimum of 20 mm

unless specified otherwise herein. Forms for heavy girders and similar members shall be constructed with a proper camber as indicated.

2.2.12.2 Materials for Forms: Forms shall be of wood, plywood, or steel. Wood forms for surfaces exposed to view in the finished structure and requiring a smooth form finish, shall be plywood. For unexposed surfaces, undressed square-edge lumber may be used. Forms for surfaces requiring special finishes shall be plywood, or shall be lined with plywood, a non-absorptive, hard-pressed fiberboard, absorptive-type lining or other suitable material. Plywood, other than for lining, shall be concrete-form plywood not less than 16 mm thick free of raised grain, torn surfaces, worn edges, patches, or other surface defects which would impair the texture of the concrete surface. Surfaces of steel forms shall be free from irregularities, dents, and sags.

2.2.12.3 Coating: Before placing the concrete, the contact surfaces of forms shall be coated with a non-staining mineral oil or suitable non-staining form coating compound or shall be given two coats of nitrocellulose lacquer, except as specified otherwise. Mineral oil shall not be used on forms for surfaces which are to be painted. For surfaces not exposed to view in the finished structure, sheathing may be wetted thoroughly with clean water. All excess coating shall be removed by wiping with cloths. Reused forms shall have the contact surfaces cleaned thoroughly; those which have been coated shall be given an additional application of the coating. Plaster waste molds shall be sized with two coats of thin shellac or lacquer and coated with soft or thinned non-staining grease.

2.2.12.4 Tolerance and Variations: The Contractor shall set and maintain concrete forms to ensure that, after removal of the forms and prior to patching and finishing, no portion of the concrete work will exceed any of the tolerances specified. Variations in floor levels shall be measured before removal of supporting shores. The Contractor shall be responsible for variations due to deflection, when the latter results from concrete quality or curing other than that which has been specified. The tolerances specified shall not be exceeded by any portion of any concrete surfaces; the specified variation for one element of the structure will not be applicable when it will permit another element of the structure to exceed its allowable variations except as otherwise specified herein, tolerances shall conform to ACI 347.

PART 3 - EXECUTION

3.1 PROPORTIONING, MEASUREMENT AND MIXING: ASTM, C94, ACI 301, ACI 302.1R, and ACI 304, except as modified herein.

3.1.1 Proportioning of Materials: Proportioning of materials shall be accomplished by weighing, except as otherwise provided herein. In urgent situations, volumetric proportioning may be used temporarily, if permitted by the Owner's Representative, who will stipulate the length of the period during which volumetric proportioning may be used. The Contractor shall furnish the necessary equipment and shall establish accurate procedures for determining the quantities of free moisture in the aggregates, the true volume of the fine aggregate if volumetric proportioning is

used, and the air content of the freshly mixed concrete if air-entrained concrete is used. Moisture, volumetric, and air determinations shall be made at intervals as directed by the Owner's Representative as specified herein under Sampling and Testing requirements. Allowable tolerances for measuring cement and water shall be one percent; for aggregates 2 percent and for admixtures 3 percent.

3.1.1.1 Weight Measurement: The fine aggregate and each size of coarse aggregate shall be weighed separately. Cement in standard packages shall be weighed on a scale separate from that used for weighing the other materials.

3.1.1.2 Volumetric Measurement: The weight proportions shall be transposed into equivalent volumetric proportions by weighing representative samples of the aggregates in the condition in which they will be measured and in accordance with ASTM C 29. In determining the true volume of the fine aggregate, allowance shall be made for the bulking effect from the moisture contained therein. Suitable allowances shall also be made for variations in the moisture conditions of the aggregates.

3.1.2 Mixing: All concrete shall be machine mixed. In emergencies, the mixing may be done by hand if so authorized by the Owner's Representative. Mixing shall begin within 30 minutes after the cement has been added to the aggregates. The time of mixing after all cement and aggregates are in the mixer drum shall be not less than one minute for mixers having a capacity of one cubic yard or less; for mixers of larger capacities, the minimum time shall be increased 15 seconds for each additional cubic yard or fraction thereof of additional capacity. A reduction in the aforementioned mixing time shall be permitted in accordance with ASTM C 94 if mixer performance tests made at the Contractor's option and at his expense, indicate adequate mixing with the reduced time. All mixing water shall be introduced in the drum before one-fourth of the mixing time has elapsed. The entire contents of the mixer drum shall be discharged before recharging. The time elapsing between the introduction of the mixing water to the cement and aggregates or the cement to the aggregates and placing of the concrete in final position in the forms shall not exceed 60 minutes if the air temperature is less than 30 degrees C and 45 minutes if the air temperature is equal or greater than 30 degrees C. The retempering of concrete, i.e., remixing with or without additional cement, aggregate, or water, is not permitted.

3.1.3 Ready Mixed Concrete: Ready-mixed concrete shall conform to ASTM C 94 as modified herein. Ready-mixed concrete is defined in this specification as concrete produced regularly by a commercial establishment and delivered to the purchaser in the plastic state. Ready-mixed concrete may be used provided that (a) the plant has sufficient capacity and transportation equipment to deliver the concrete at the rate desired, and (b) the plant meets the requirements specified herein for equipment, measurement of materials, and mixing, except as modified herein. The cement, aggregates, water and admixtures shall conform to all applicable requirements of this specification. Ready-mixed concrete not specified otherwise herein shall be mixed and delivered by one of the following methods.

3.1.3.1 Truck Mixing: Concrete shall be mixed and delivered in a truck mixer. Mixers shall be charged with a ribbon fed mixture of aggregates and cement, or in the absence of facilities for ribbon feeding, the aggregates shall be charged before the cement. When mixing is begun during or immediately after charging a portion of the mixing water not in excess of

that required to produce the minimum acceptable slump, shall be added ahead of or with, the other ingredients. Total mixing shall be for not less than 50 nor more than 100 revolutions of the drum at the manufacturer's rated mixing speed after all ingredients including water are in the drum except as follows: After 30 to 75 revolutions of the drum the slump shall be tested and additional water shall be added if necessary to produce the required slump; if additional water is necessary, mixing shall be continued for at least 20 revolutions after the water is added. Mixing speed shall be not less than 16 rpm for open-top mixers, and not less than 4 rpm nor more than 16 rpm for open-top mixers. Any turning of the drum during transportation shall be at the speed designated by the manufacturer of the equipment, as agitating speed. Each batch of concrete delivered at the job site shall be accompanied by a time slip issued at the batching plant, bearing the time of departure therefrom and the signature of the inspector. Discharge of concrete from the drum shall be completed within one hour or before the drum completes 250 revolutions after the introduction of water to the cement and the aggregates.

3.1.3.2 Combination Central Plant and Truck Mixing (Shrink Mixing): Concrete shall be partially mixed in a central plant mixer and the mixing completed in a truck mixer. The mixing time in a central-plant mixer shall be the minimum required to intermingle the ingredients and shall not exceed 30 minutes. The mixing shall be completed in a truck mixer as specified herein under truck mixing.

3.1.3.3 Central-Plant Mixing: Concrete shall be mixed completely in a stationary mixer at a plant and transported to the site of the work in a truck agitator or a truck mixer operating at a speed of rotation designated by the manufacturer as agitating speed. Mixing shall begin within 30 minutes after cement has been added to aggregates. When authorized in writing by the Owner's Representative, non-agitation equipment approved by him may be used for transporting concrete. The time lapse between the introduction of the mixing water to the cement and aggregates and the placing of concrete in final position in the forms, shall not exceed: (a) for agitating equipment - 60 minutes, air temperature less than 30 degrees C; (b) for non-agitating equipment - 30 minutes.

3.1.4 Consistency of Concrete: Slump shall be determined in accordance with ASTM C 143. Samples for slump determination shall be taken from the concrete during placing in the forms.

3.2 PLACING REINFORCEMENT AND MISCELLANEOUS MATERIALS: ACI 301.

3.2.1 General Requirements: All reinforcement bars, stirrups, hanger bars, wire fabric, spirals and other reinforcing materials shall be provided as indicated in the drawing or required by this specification, together with all necessary wire ties, chairs, spacers, supports and other devices necessary to install and secure the reinforcement properly. All reinforcement, when placed, shall be free from rust, scale, oil, grease, clay, and other coatings, and foreign substances that would reduce or destroy the bond. Rusting of reinforcement shall not reduce the effective cross sectional area of the reinforcement to the extent that the strength is reduced beyond specified values. Heavy, thick rust or loose, flaky rust shall be removed by rubbing with burlap or other approved method, prior to placing. Reinforcement which has bends not shown

on the project drawings or on approved shop drawings, or is reduced in section by rusting such that its weight is not within permissible ASTM tolerances, shall not be used. All reinforcement shall be supported and wired together to prevent displacement by construction loads or by the placing of concrete. Unless directed otherwise by the Engineer, reinforcement shall not be bent after being partially embedded in hardened concrete. Detailing of reinforcing shall conform to ACI 315. Where cover over reinforcing steel is not specified or indicated it shall be in accordance with ACI 318.

3.2.2 Placing: Reinforcement shall be placed accurately and secured. It shall be supported by suitable chairs and spacers or by metal hangers. On the ground, and where otherwise subject to corrosion, concrete or other suitable non-corrodible material shall be used for supporting reinforcement. Where the concrete surface will be exposed to the weather in the finished structure or where rust would impair the appearance or finish of the structure, all reinforcement supports, within specified concrete cover, shall be galvanized or made of a suitable non-corrodible material.

3.2.3 Splicing of Reinforcement: Splicing of reinforcement shall be in accordance with ACI 318, except as indicated otherwise or modified herein. Where splices in addition to those indicated on the drawings are necessary, they shall be approved by the Owner's Representative prior to their use. Splices shall not be made in beams, girders, and slabs at points of maximum stress. Butt splicing shall preferably be used over lapping for bar sizes larger than 32 mm ϕ. Splices to be welded shall conform to AWS D 1.4; certification of weldability of the reinforcement by the manufacturer, shall be submitted to the Owner's Representative. If the Contractor elects to use butt splicing of reinforcing, he shall submit complete details of the process to be used to the Owner's Representative. If butt splices are used the Contractor shall ensure that the splice meets the requirements specified herein by performing at least three splices which shall be submitted for tests to a testing laboratory that has been approved for such testing by the Owner's Representative. The cost of these shall be borne by the Contractor.

3.2.4 Moving Reinforcing Steel: All placement or movement of reinforcing steel after placement, to positions other than indicated or specified, shall be subject to the approval of the Owner's Representative.

3.2.5 Concrete Protection for Reinforcement: Concrete protection for reinforcement shall be as indicated; or if not indicated, in accordance with ACI 318.

3.2.6 Tolerances and Variations: The minimum concrete cover for reinforcement specified in the contract documents takes precedence over all permissible reinforcement-placement variations; nothing in the variations listed below is to be construed as permitting violation or compromise thereof:

a. Height of bottom bars	plus or minus 6 mm. above form
b. Lengthwise positioning	plus or minus 50 mm. of bars
c. Spacing bars in walls	plus or minus 25 mm. and solid slabs
d. Spacing bars in beams and footings	minus 0 mm plus 6 mm.

e. Height of top bars — minus 0 mm plus 6 mm.

f. Stirrup spacing

(1) For any one stirrup — plus or minus 25 mm.

(2) For over-all group of stirrups — plus or minus 25 mm.

3.2.7 Vapor Barrier: Provide beneath the on-grade concrete floor slab. Use the greatest widths and lengths practicable to eliminate joints wherever possible. Lap joints a minimum of 300 mm. Remove torn, punctured, or damaged vapor barrier material and provide with new vapor barrier prior to placing concrete. Concrete placement shall not damage vapor barrier material.

3.2.8 Setting Miscellaneous Material: Anchors and bolts, including but not limited to those for machine and equipment bases; frames or edgings, hangers and inserts, door bucks, pipe supports, pipe sleeves, pipes passing through walls, metal ties, conduits, flashing reglets, drains and all other materials in connection with concrete construction shall, where practicable be placed and secured in position when the concrete is placed. Anchor bolts for machines shall be set to templates, shall be plumbed carefully and checked for location and elevation with an instrument, and shall be held in position rigidly to prevent displacement while concrete is being placed.

3.3 CONVEYING AND PLACING CONCRETE: ACI 301 and ACI 304, except as modified herein.

3.3.1 Conveying: Concrete shall be conveyed from the mixer to the forms as rapidly as practicable by proper methods which will not cause segregation or loss of ingredients. It shall be deposited as nearly as practicable in its final position in the forms. At any point in the conveying, the free vertical drop of the concrete shall not exceed 1 m. Conveying equipment shall be cleaned thoroughly before each run. All concrete shall be deposited as soon as practicable after the forms and the reinforcement have been inspected and approved by the Owner's Representative. Concrete which has segregated in conveying shall be removed and disposed of as directed by the Owner's Representative.

3.3.2 Placing Concrete: No concrete shall be placed after there is evidence of initial set. Concrete placement will not be permitted when weather conditions prevent proper placement and consolidation. The placement of concrete in uncovered areas during periods of precipitation will not be allowed except for covered areas. Subgrades of earth or other material shall be properly prepared and, if necessary, covered with heavy building paper or other suitable material to prevent the concrete from becoming contaminated. Before placing concrete on porous subgrades, they shall be dampened. Forms shall be clean of dirt, construction debris and water. Fresh concrete shall not be placed on vertical supporting members such as columns and walls without approval of the Owner's Representative. Concrete shall be deposited in approximately horizontal layers, 300 mm to 500 mm deep in a manner to preclude the formation of cold joints between successive layers.

3.3.3 Vibration: All concrete shall be compacted with high frequency, internal mechanical vibrating equipment supplemented by hand spading and tamping. Concrete slabs 100

mm or less in depth shall be consolidated by wood tampers, spading and settling with a heavy leveling straight edge. Vibrators shall be designed to operate with vibratory element submerged in the concrete, and shall have a frequency of not less than 6,000 impulses per minute when submerged. The vibrating equipment shall be adequate at all times in number of units and power of each unit to consolidate the concrete properly. Vibration of forms and reinforcement shall not be employed except when authorized specifically by the Owner's Representative. Vibrators shall not be used to transport the concrete in the forms. Vibration shall be discontinued when the concrete has been compacted thoroughly and ceases to decrease in volume.

3.3.4 Construction Joints: Joints not shown on the drawings shall be made and located so as to least impair the strength of the structure and shall be subject to approval of the Owner's Representative. In general, they shall be located near the middle of the spans of slabs, beams, and girders unless a beam intersects a girder at this point, in which case the joints in the girders shall be offset a distance equal to twice the width of the beam. Horizontal joints in walls and columns shall be at the underside of floors, slabs, beams, or girders and at the top of footings or grade slabs. Beams, girders, brackets, column capitals, haunches and drop panels shall be placed at the same time as slabs. Joints shall be perpendicular to the main reinforcement.

3.3.4.1 Reinforcement in Construction Joints: All reinforcing steel shall be continued across joints. Keys and inclined dowels shall be provided as indicated. Longitudinal keys at least 38 mm deep shall be provided in all joints in walls.

3.3.4.2 Preparation of Surface: The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed.

3.3.4.3 Bonding: When a bonded construction joint is required, bond shall be obtained by one of the following methods:

a. The use of suitable chemical retardant which delays but does not prevent setting of the surface mortar. Retarded mortar shall be removed within 24 hours after placing to produce a clean exposed aggregate bonding surface.

b. By roughening the surface of the concrete in proper manner, which will expose the aggregate uniformly and will not leave laitance, loosened particles of aggregate, or damaged concrete at the surface.

3.3.5 Embedded Items:

3.3.5.1 Other Embedded Items: All sleeves, inserts, anchors and embedded items required for adjoining work or for its support shall be placed prior to concreting. All sub-contractors, whose work is related to the concrete or must be supported by it, shall be given ample notice and opportunity to introduce or furnish embedded items before the concrete is placed. All ferrous metal sleeves, inserts, anchors and other embedded ferrous items exposed to the weather or where rust would impair the appearance or finish of the structure shall be galvanized.

3.3.5.2 Placing Embedded Items: Expansion joint material, and embedded items shall be positioned accurately and supported against displacement. Voids in sleeves, inserts and anchor slots shall be filled temporarily with readily

removable material to prevent the entry of concrete into the voids. Aluminum shall not be embedded in concrete except where aluminum is protected from direct contact with the concrete.

3.3.5.3 Reinforcing Bars: Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items, but not so as to impair design strengths of the members. If bars are moved more than one bar diameter, the resulting arrangement of bars shall be subject to the approval of the Owner's Representative.

3.3.6 Placing Concrete in Hot Weather: Placing concrete in hot weather shall be in accordance with ACI 305 except as modified herein. In hot weather, extra care should be made to prevent rapid drying of newly placed concrete. When the outdoor ambient temperature is more than 32 degrees C; the temperature of the concrete as placed shall not exceed 32 degrees C; the fresh concrete shall be shaded as soon as possible after placing; and curing shall be started as soon as the surface of the fresh concrete is sufficiently hard to permit it without damage.

3.4 SURFACE FINISHES (EXCEPT FLOOR AND SLAB ON GRADE):

3.4.1 Repair of Surface Defects: All surface defects including tie holes, minor honeycombing, and other defective concrete shall be repaired with cement mortar with the approval of the Owner's Representative. Cement mortar for patching shall be the same composition as that used in the concrete, except that for exposed surfaces part of the cement shall be white portland cement to provide a finish color matching the surrounding concrete. Patching shall be done as soon as the forms are removed; areas of surfaces, which are to be cured with a curing compound, shall be covered during the application of the compound. All areas to be patched shall be cleaned thoroughly. Minor honeycombed or otherwise defective areas shall be cut out to solid concrete to a depth of not less than 25 mm. The edges of the cut shall be perpendicular to the surface of the concrete. The area to be patched and at least 150 mm adjacent thereto shall be saturated with water before placing the mortar. The mortar shall be mixed approximately one hour before placing and shall be remixed occasionally during this period with a trowel without the addition of water. A grout of cement and water mixed to the consistency of paint shall then be brushed onto the surfaces to which the mortar is to be bonded. The mortar shall be compacted into place and screened slightly higher than the surrounding surface. Patches shall be cured as specified for the concrete. Holes extending through the concrete shall be filled by means of a plunger type gun or other suitable device from the unexposed face. The excess mortar shall be wiped off the exposed face with a cloth. Finished surfaces shall be protected from stains and abrasions as cast finish against steel, plywood, forms, and rubbed finish shall be equal in workmanship, texture, and general appearance to that of sample panels specified herein. Concrete with excessive honeycombing, which exposes the reinforcing steel or other defects which affect the structural strength of the member, shall be rejected or the defects corrected as directed by the Owner's Representative, and at the expense of the Contractor.

3.4.2 Finishing of Formed Surfaces: Finishing of formed surfaces shall be accomplished as soon as practicable after form removal and repair of surface defects. Finishing shall be accomplished and specified herein where indicated.

3.4.2.1 As Cast Finishes:

a. Smooth Form Finish: The form facing material shall produce a smooth, hard, uniform texture on the concrete. Tie holes and defects shall be patched. All fins shall be completely removed.

b. Rough Form Finish: No selected form facing materials are required for rough form finish surfaces. Tie holes and defects shall be patched. Fins exceeding 6 mm in height shall be chipped off or rubbed off. Otherwise, surfaces shall be left with the texture imparted by the forms.

3.4.3 Unindicated Finish: Finishes not indicated on the drawings shall be as follows.

3.4.3.1 Smooth Form Finish: For all concrete surfaces exposed to public view.

3.4.3.2 Rough Form Finish: For all concrete surfaces not exposed to public view.

3.4.4 Unformed Surfaces:

3.4.4.1 Related Unformed Surfaces: Tops of walls or buttresses, horizontal offsets, and similar unformed surfaces occurring adjacent to formed surfaces shall be struck smooth after concrete is placed and shall be floated to a texture reasonably consistent with that of the adjacent formed surfaces. Final treatment on formed surfaces shall continue uniformly across the unformed surfaces.

3.5 CURING AND PROTECTION (Except Floors): ACI 301 unless otherwise specified.

3.5.1 General Requirements: Concrete shall be protected adequately from injurious action by sun, rain, flowing water, and mechanical injury, and shall not be allowed to dry out from the time it is placed until the expiration of the minimum curing periods specified herein. Curing shall be accomplished by moist curing, or by application of liquid chemical or liquid membrane forming compound, except as specified otherwise herein. Membrane forming compound shall not be used on surfaces for which special finish is specified, on any surface to be painted, waterproofed, tiled, roofed, or where coverings are to be bonded. Completion of curing shall be initiated immediately following the removal of forms.

3.5.2 Moist Curing:

3.5.2.1 Mats: The entire surface of the concrete shall be covered with two thicknesses of wet burlap weighing not less than 250 gram per square meter, dry weight, mats, or other suitable material having high absorptive quality. The material shall be thoroughly wet when applied and shall be kept continuously wet during the time it remains on the slab. Mats shall be made of clean material which is free from any substance which will have a deleterious effect on the concrete; they shall be at least as long as the width of the concrete under construction. During application, the mats shall not be dragged over the finished concrete nor over mats already placed; they shall be placed to provide complete coverage of surface and edges of the pavement with a slight overlap over adjacent mats. These mats shall be left in place not less than 7 days during which time they shall be kept wet continuously.

3.5.2.2 Impervious-Sheeting Curing: The entire exposed surface shall be wetted thoroughly with a fine spray of water and then covered with (a) waterproofed paper, (b) polyethylene-bonded water-proof paper sheeting, (c) polyethylene-coated burlap sheeting, or (d) polyethylene sheeting, as specified elsewhere herein. Sheets shall be laid directly on the concrete surface and overlapped 300 mm when a continuous sheet is not used. The curing medium shall be not less than 450 mm wider than the concrete surface to be cured, and shall be weighed down by placing a bank of moist earth on the edges just outside the forms and over the transverse laps to form closed joints. Sheets shall be satisfactorily repaired or replaced if torn or otherwise damaged during curing. The curing medium shall remain on the concrete surface to be cured for not less than 7 days.

3.5.3 Liquid Membrane-Forming Compound Curing: Liquid membrane-forming compound curing shall be accomplished by applying a white-pigmented liquid compound, free of paraffin or petroleum, over the concrete surface to restrict evaporation of the mixing water. All joint openings except sawed joints shall be sealed at the top by inserting moistened paper or fiber rope, or covering with strips of waterproof material, prior to application of the curing compound, in a manner to prevent the curing compound from entering the joint. Seven days following the placing of the liquid membrane-forming compound shall be considered as the end of the curing period and the basis for determining when joint sealing material will be placed in joints.

3.5.3.1 Application of Curing Compound: The compound shall be applied immediately after the surface losses its water sheen and has a dull appearance and before joints are sawed. Curing compound shall be agitated thoroughly by mechanical means during use and shall be applied uniformly in a 2-coat continuous operation by suitable power-spraying equipment. The total coverage for the two coats shall be between 4 to 5 square meter per liter of undiluted compound. The compound shall form a uniform, continuous, coherent film that will not check, crack or peel and shall be free from pinholes or other imperfections. An additional coat of the compound shall be applied immediately to areas where the film is defective. Suitable covering other than liquid curing compound, shall be kept readily available for use to protect the freshly placed concrete in the event conditions occur which prevent correct application of the compound at the proper time. Concrete surfaces that are subject to heavy rainfall within 3 hours after the curing compound has been applied shall be resprayed with two coats of curing compound by the method and at the foregoing coverage rate specified, at no additional cost to the Owner.

3.5.3.2 Protection of Treated Surfaces: Concrete surfaces to which liquid membrane-forming compounds have been applied shall be kept free from all foot and vehicular traffic and all other sources of abrasion for not less than 72 hours. Continuity of the coating shall be maintained for the entire curing period and any damage to the coating during this period shall be repaired immediately.

3.5.3.3 Liquid Chemical Sealer-Hardener Curing: Apply sealer-hardener to interior floors not receiving floor covering and floors located under access flooring. Apply the sealer-hardener in accordance with manufacturer's

recommendations. Seal or cover joints and opening in which joint sealant is to be applied as required by the joint sealant manufacturer. The sealer-hardener shall not be applied until the concrete has cured for a minimum of 30 days. Apply a minimum of 2 coats of sealer-hardener.

3.5.4 Curing Periods: When the 7-day compression-test-cylinders, representative of parts of a structure already placed, indicate that the 28-day strengths may be less than 90 percent of the design strengths, those parts of the structure shall be given additional curing, as directed by the Owner's Representative. Cast-in-place parts of a structure which will be permanently submerged in fresh water may be cured for not less than 12 hours, provided they are submerged immediately thereafter. Curing, except steam curing, shall be as follows:

Time (minimum)	Concrete Element
7 days	All concrete not specified otherwise

3.5.5 Removal of Forms and Protection: Forms shall be removed in a manner, which will prevent damage to the concrete. Forms shall not be removed without approval of the Engineer, or before the expiration of the minimum periods specified herein:

	Days After Placing
Side forms on columns, walls, pedestals	1
Forms for columns	2

3.5.6 Special Requirements for High-Early-Strength Portland Cement Concrete: The curing periods, minimum periods during which supporting forms and shores shall be left in place, and minimum periods for maintaining curing temperatures shall be not less than one-quarter of those specified herein for portland-cement concrete, but in no case less than 48 hours.

3.6 SAMPLING AND TESTING:

3.6.1 Sampling:

3.6.1.1 Aggregates: Prior to production and delivery of aggregates, at least one initial sample shall be taken at the source. Each sample shall be collected by taking three incremental samples at random from the source material to make a composite sample of not less than 20 kilograms. Three random samples shall then be taken from each 270 metric tons of material, or a day's run, whichever is the least amount, during the course of the project. Three increments shall be taken from the same vehicle at the central plant during unloading. The above sampling shall be repeated when the source of material is changed or when unacceptable deficiencies or variations from the specified grading of materials are found in testing.

a. Coarse Aggregates: A 20 kilograms or larger sample for analysis as specified herein shall be taken 2 times daily with a sampling device approved by the Owner's Representative. The samples shall be taken from the conveyor belt. The plant shall be brought up to full operation

before samples are taken. The samples shall be taken so that a uniform cross-section, accurately representing the materials on the belt or in the bins, is obtained. Random checks of the sampling may be made by the Owner's Representative. Additional sampling is required when analyses show deficiencies or unacceptable variances or deviation from the specified requirements.

b. Fine Aggregates: A 20 kilogram-sample shall be taken as specified herein for sampling of fine aggregate. The sample shall be taken at least 2 times daily for sieve analysis of fine aggregate sand and specific gravity tests. Additional samples may be required when analyses show deficiencies, unacceptable variances, or deviations. Sampling can be reduced to 1 time daily when test results show that the fine aggregates consistency meet specified requirements. Samples of sand shall be taken when the sand is moist.

c. Sample Identification: Each sample shall be contained in a clean container which shall be securely fastened to prevent loss of material. It shall be tagged for identification. The tag shall contain the following information:

Contract No. _____
Sample No. _____ Quantity _____
Date of Sample _____
Sampler _____
Source _____
Intended Use _____
For Testing _____

3.6.1.2 Concrete: ASTM C 172. Samples for strength tests of concrete placed each day shall be taken not less than once a day, nor less than once for each 50 cubic meters of concrete, nor less than once for each 400 sq.m. of surface area for slabs or walls. Nine (9) cylinders shall be molded from each day sample.

3.6.2 Testing:

3.6.2.1 Aggregate Testing: Gradation tests shall be made on each sample without delay. All other aggregate tests required by this specification shall be made on the initial source samples, and shall be repeated whenever there is a change of source. The tests shall include an analysis of each grade of material and an analysis of the combined material representing the aggregate part of the mix.

3.6.2.2 Cement:

a. The Contractor's inspection shall be performed in accordance with PNS 07. The Contractor's certification shall include:

1) A report of the mill test results signed by the laboratory chemist;

2) At the time of shipment from the mill or other storage point, a manufacturer's certificate that the cement was tested in accordance with the specified requirements;

3) A statement that the concrete for the project will contain cement conforming to the specified requirements.

The Contractor shall make all necessary arrangement with the cement supplier and carrier for the identification and transportation of the certified cement from the manufacturer to the concrete batch plant.

b. At any time the cement stored at the concrete plant or other storage area is not certified by the cement manufacturer for use in the project, or if the Contractor desires to use cement of a different brand or type which is not certified by the cement mill, the Contractor shall, before using the cement, secure three random samples of the cement in storage, and arrange for complete chemical and physical tests by an owner approved cement testing laboratory to provide information as to the properties of the cement. Test results of each individual sample shall be reported; acceptance will be determined on the average test result of the three samples for the selected lot size. Cement not meeting the specified requirements shall not be used in the concrete. Each shipment of acceptable cement as determined by field tests shall be sampled, the samples identified and stored for not less than 42 days. A random sample shall be tested for conformance at least once each month. The sampling and testing shall continue until subsequent shipments of cement are certified by the cement producer.

c. The Owner reserves the right to inspect and sample at the source or at the site of work all cement to be used on the project.

3.6.2.3 Concrete Testing:

a. Testing consistency of concrete slumps shall be determined in accordance with ASTM C 143. Consistency may be determined in the field by means of the ball-penetration method in accordance with ASTM C 360 after a correlation between slump and ball-penetration is determined. Tests to verify the ratio will be made at least once each working day. Samples for slump determination will be taken from the concrete during placing in the forms; samples for ball-penetration shall be taken as specified in ASTM C 360. Tests shall be made as follows:

1) At the beginning of a concrete placement operation and at subsequent intervals to insure that the specification requirements are met.

2) Whenever test cylinders are made.

b. Compressive Tests: Testing of specimen for compressive strength shall be in accordance with ASTM C 39. Test two (2) cylinders at seven (7) days, six (6) cylinders at twenty eight (28) days and hold one (1) cylinder in reserve. When a satisfactory relationship between 7-day and 28-day strength has been established, the 7-day test results may be used as an indicator of the 28-day strength. Each strength test result shall be the average of two cylinders from the same concrete sample tested at 28 days. If the average of the three strength test result is less than f'c or if any strength test result falls below f'c by more than 3.5 MPa (500 psi), take a minimum of three ASTM C42 core samples from the in-place work represented by the low test cylinder results and test. Concrete represented by core tests shall be considered structurally adequate if the average of three cores is equal to at least 85 percent of f'c and if no single core is less than 75 percent of f'c locations represented by erratic core strength shall be retested. Demolition and concrete replacement if recommended by the Engineer shall be borne by the Contractor.

c. Air Content Tests: Test methods for air content of concrete shall comply with ASTM C-138, C 173 and C 231 as applicable.

PART 4- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

4.1.1 Reinforcing Steel

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

4.1.2 Structural Cement

The quantity of structural concrete to be paid for will be the final quantity placed and accepted in the completed structures

4.2 BASIS OF PAYMENT

The accepted quantities measured as prescribed in Part 4.1 shall be paid for at the contract price for each of the pay item listed below. Payment shall constitute full compensation for furnishing, placing of all materials including all labor, equipment, tools and incidentals necessary to complete the work prescribed in the Section.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
03300 (1)	Reinforcing Steel	Kilogram
03300 (2)	Reinforcing Cement	Cubic Meter

SECTION 03307

CONCRETE FOR MINOR STRUCTURES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

ACI INTERNATIONAL (ACI)

ACI 308	Standard Practice for Curing Concrete
ACI 318/318R	Building Code Requirements for Structural Concrete and Commentary
ACI 318M	Metric Building Code Requirements for Structural Concrete and Commentary
ACI 347R	Guide to Formwork for Concrete

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 185	Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
ASTM A 615/A 615M	Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM C 31/C 31M	Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Concrete Aggregates
ASTM C 39/C 39M	Compressive Strength of Cylindrical Concrete Specimens
ASTM C 94/C 94M	Ready-Mixed Concrete
ASTM C 150	Portland Cement
ASTM C 171	Sheet Materials for Curing Concrete
ASTM C 172	Sampling Freshly Mixed Concrete
ASTM C 231	Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	Air-Entraining Admixtures for Concrete

ASTM C 309	Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 494/C 494M	Chemical Admixtures for Concrete
ASTM C 595	Blended Hydraulic Cements
ASTM C 685	Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 920	Elastomeric Joint Sealants
ASTM D 75	Sampling Aggregates
ASTM D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

1.2 SUBMITTALS

1.2.1 Product Data

Air-Entraining Admixture;
Water Reducing or Retarding Admixture;
Curing Materials;
Reinforcing Steel;
Joint Sealants - Field Molded Sealants;

Manufacturer's literature is available from suppliers which demonstrates compliance with applicable specifications for the above materials.

1.2.2 Test Reports

Aggregates;

Aggregates will be accepted on the basis of certificates of compliance and test reports that show the material(s) meets the quality and grading requirements of the specifications under which it is furnished.

Concrete Mixture Proportions;

Ten days prior to placement of concrete, the contractor shall submit the mixture proportions that will produce concrete of the quality required. Applicable test reports shall be submitted to verify that the concrete mixture proportions selected will produce concrete of the quality specified.

1.2.3 Certificates

Cementitious Materials;

Certificates of compliance attesting that the concrete materials meet the requirements of the specifications shall be submitted in accordance with the Special Clause "CERTIFICATES OF COMPLIANCE". Cementitious material will be accepted on the

basis of a manufacturer's certificate of compliance, accompanied by mill test reports that the material(s) meet the requirements of the specification under which it is furnished.

Aggregates;

Aggregates will be accepted on the basis of certificates of compliance and tests reports that show the material(s) meet the quality and grading requirements of the specifications under which it is furnished.

1.3 DESIGN AND PERFORMANCE REQUIREMENTS

The Owner thru his authorized representative will maintain the option to sample and test aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary to assist the owner in procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Concrete will be sampled in accordance with ASTM C 172. Slump and air content will be determined in accordance with ASTM C 143/C 143M and ASTM C 231, respectively, when cylinders are molded. Compression test specimens will be made, cured, and transported in accordance with ASTM C 31/C 31M. Compression test specimens will be tested in accordance with ASTM C 39/C 39M. Samples for strength tests will be taken not less than once each shift in which concrete is produced. A minimum of three specimens will be made from each sample; two will be tested at 28 days for acceptance, and one will be tested at 7 days for information.

1.3.1 Strength

Acceptance test results will be the average strengths of two specimens tested at 28 days. The strength of the concrete will be considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength, f'c, and no individual acceptance test result falls below f'c by more than 3.4 MPa. (500 psi).

1.3.2 Construction Tolerances

A Class "C" finish shall apply to all surfaces except those specified to receive a Class "D" finish. A Class "D" finish shall apply to all surfaces, which will be permanently concealed after construction. The surface requirements for the classes of finish required shall be as specified in ACI 347R.

1.3.3 Concrete Mixture Proportions

Concrete mixture proportions shall be the responsibility of the Contractor. Mixture proportions shall include the dry weights of Cementitious material(s); the nominal maximum size of the coarse aggregate; the specific gravities, absorptions, and saturated surface-dry weights of fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per cubic meter of concrete. All materials included in the mixture proportions shall be of the same type and from the same source as will be used on the project. Specified compressive strength f'c shall be 20.7 MPa (3,000) psi at 28 days. The maximum nominal size coarse aggregate shall be 19 mm (3/4 inch.), in accordance with ACI 318M. ACI 318/318R. The air content shall

be between 4.5 and 7.5 percent. The slump shall be between 50 and 125 mm. (2 and 5 inches). The maximum water cement ratio shall be 0.50.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Cementitious Materials

Cementitious materials shall conform to the appropriate specifications listed:

2.1.1.1 Portland Cement

ASTM C 150, Type I, IA, II, IIA, III, IIIA or V

2.1.2 Aggregates

Aggregates shall meet the quality and grading requirements of ASTM C 33 Class Designations 4M or better

2.1.3 Admixtures

Admixtures to be used, when required or approved, shall comply with the appropriate specification listed. Chemical admixtures that have been in storage at the project site for longer than 6 months or that have been subjected to freezing shall be retested at the expense of the contractor at the request of the Contracting Officer and shall be rejected if test results are not satisfactory.

2.1.3.1 Air-Entraining Admixture

Air-entraining admixture shall meet the requirements of ASTM C 260.

2.1.3.2 Accelerating Admixture

Calcium chloride shall meet the requirements of ASTM D 98. Other accelerators shall meet the requirements of ASTM C 494/C 494M, Type C or E.

2.1.3.3 Water-Reducing or Retarding Admixture

Water-reducing or retarding admixture shall meet the requirements of ASTM C 494/C 494M, Type A, B, or D.

2.1.4 Water

Water for mixing and curing shall be fresh, clean, potable, and free from injurious amounts of oil, acid, salt, or alkali, except that unpotable water may be used if it meets the requirements of COE CRD-C 400.

2.1.5 Reinforcing Steel

Reinforcing steel bar shall conform to the requirements of ASTM A 615/A 615M, Grade 40. Welded steel wire fabric shall conform to the requirements of ASTM A 185. Details of reinforcement not shown shall be in accordance with ACI 318M, ACI 318/318R, Chapters 7 and 12.

2.1.6 Expansion Joint Filler Strips, Premolded

Expansion joint filler strips, premolded shall be sponge rubber conforming to ASTM D 1752, Type I.

2.1.7 Joint Sealants - Field Molded Sealants

Joint sealants - field molded sealants shall conform to ASTM C 920, Type M, Grade NS, Class 25, use NT for vertical joints and Type M, Grade P, Class 25, use T for horizontal joints. Bond-breaker material shall be polyethylene tape, coated paper, metal foil, or similar type materials. The backup material shall be compressible, nonshrink, nonreactive with the sealant, and a nonabsorptive material such as extruded butyl or polychloroprene foam rubber. Immediately prior to installation of field-molded sealants, the joint shall be cleaned of all debris and further cleaned using water, chemical solvents, or other means as recommended by the sealant manufacturer or directed.

2.1.8 Formwork

The design and engineering of the formwork as well as its construction shall be the responsibility of the Contractor.

2.1.9 Form Coatings

Forms for exposed surfaces shall be coated with nonstaining form oil, which shall be applied shortly before concrete is placed.

2.1.10 Vapor Barrier

Vapor barrier shall be polyethylene sheeting with a minimum thickness of 0.15 mm 6 mils or other equivalent material having a vapor permeance rating not exceeding 30 nanograms per pascal second square meter 0.5 perms as determined in accordance with ASTM E 96.

2.1.11 Curing Materials

Curing materials shall conform to the following requirements.

2.1.11.1 Impervious Sheet Materials

Impervious sheet materials, ASTM C 171, type optional, except polyethylene Film, if used, shall be white opaque.

2.1.11.2 Membrane-Forming Curing Compound

ASTM C 309, Type 1-D or 2, Class [A] [B].

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 General

Construction joints shall be prepared to expose coarse aggregate, and the surface shall be clean, damp, and free of laitance. Ramps and walkways, as necessary, shall be constructed to allow safe and expeditious access for concrete and workmen. Standing or flowing water, loose particles, debris, and foreign matter shall have been removed. Earth foundations shall be satisfactorily compacted. Spare vibrators shall be available. The Owner's representative shall accept the entire preparation. Prior to placing.

3.1.2 Embedded Items

Reinforcement shall be secured in place; joints, anchors, and other Embedded items shall have been positioned. Internal ties shall be arranged so that when the forms are removed all metal will be not less than 50 mm from concrete surfaces permanently exposed to view or exposed to water on the finished structures. Embedded items shall be free of oil and other foreign matters such as loose coatings or rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. All equipment needed to place, consolidate, protect, and cure the concrete shall be at the placement site and in good operating condition.

3.1.3 Formwork Installation

Forms shall be properly aligned, adequately supported, and mortar tight. The form surfaces shall be smooth and free from irregularities, dents, sags, or holes when used for permanently exposed faces. All exposed joints and edges shall be chamfered, unless otherwise indicated.

3.1.4 Production of Concrete

3.1.4.1 Ready-Mixed Concrete

Ready-mixed concrete shall conform to ASTM C 94/C 94M except as otherwise specified.

3.1.4.2 Concrete Made by Volumetric Batching and Continuous Mixing

Concrete made by volumetric batching and continuous mixing shall conform to ASTM C 685.

3.1.4.3 Batching and Mixing Equipment

The contractor shall have the option of using an on-site batching and mixing facility. The facility shall provide sufficient batching and mixing equipment capacity to prevent cold joints. The method of measuring materials, batching operation, and mixer shall be submitted for review.

3.2 CONVEYING AND PLACING CONCRETE

Conveying and placing concrete shall conform to the following requirements.

3.2.1 General

Concrete placement shall not be permitted when weather conditions prevent proper placement and consolidation without approval. When concrete is mixed and/or transported by a truck mixer, the concrete shall be delivered to the site of the work and discharge shall be completed within 1-1/2 hours or 45 minutes when the placing temperature is 30 degrees C (85 degrees F) or greater unless a retarding admixture is used. Concrete shall be conveyed from the mixer to the forms as rapidly as practicable by methods which prevent segregation or loss of ingredients. Concrete shall be in place and consolidated within 15 minutes after discharge from the mixer. Concrete shall be deposited as close as possible to its final position in the forms and be so regulated that it may be effectively consolidated in horizontal layers 450 mm (18 inches) or less in thickness with a minimum of lateral movement. The placement shall be carried on at such a rate that the formation of cold joints will be prevented.

3.2.2 Consolidation

Each layer of concrete shall be consolidated by rodding, spading, or internal vibrating equipment. Internal vibration shall be systematically accomplished by inserting the vibrator through the fresh concrete in the layer below at a uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator and overlay the adjacent, just-vibrated area by approximately 100 mm. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm (6 inches) into the layer below, if such a layer exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly at the rate of about 75 mm (3 inches) per second.

3.2.3 Hot-Weather Requirements

When the rate of evaporation of surface moisture, as determined by use of Figure 1 of ACI 308, is expected to exceed 1 kilogram per square meter (0.2 pound per square foot) per hour, provisions for windbreaks, shading, fog spraying, or covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow.

3.3 FORM REMOVAL

Forms shall not be removed before the expiration of 24 hours after concrete placement except where otherwise specifically authorized. Supporting forms and shoring shall not be removed

until the concrete has cured for at least 5 days. When conditions on the work are such as to justify the requirement, forms will be required to remain in place for longer periods.

3.4 FINISHING

3.4.1 General

No finishing or repair will be done when either the concrete or the ambient temperature is below 10 degrees C. (50 degrees F).

3.4.2 Finishing Formed Surfaces

All fins and loose materials shall be removed, and surface defects including tie holes shall be filled. All honeycomb areas and other defects shall be repaired. All unsound concrete shall be removed from areas to be repaired. Surface defects greater than 13 mm (1/2 inch) in diameter and holes left by removal of tie rods in all surfaces not to receive additional concrete shall be reamed or chipped and filled with dry-pack mortar. The prepared area shall be brush-coated with an approved epoxy resin or latex bonding compound or with a neat cement grout after dampening and filled with mortar or concrete. The cement used in mortar or concrete for repairs to all surfaces permanently exposed to view shall be a blend of Portland cement and white cement so that the final color when cured will be the same as adjacent concrete.

3.4.3 Finishing Unformed Surfaces

All unformed surfaces that are not to be covered by additional concrete or backfill shall be float finished to elevations shown, unless otherwise specified. Surfaces to receive additional concrete or backfill shall be brought to the elevations shown and left as a true and regular surface. Exterior surfaces shall be sloped for drainage unless otherwise shown. Joints shall be carefully made with a jointing tool. Unformed surfaces shall be finished to a tolerance of 10 mm (3/8 inch) for a float finish and 8 mm (5/16 inch) for a trowel finish as determined by a 3 m (10 foot) straightedge placed on surfaces shown on the plans to be level or having a constant slope. Finishing shall not be performed while there is excess moisture or bleeding water on the surface. No water or cement shall be added to the surface during finishing.

3.4.3.11 Trowel Finish

Trowelling shall be done immediately following floating to provide a smooth, even, dense finish free from blemishes including trowel marks. Finished surfaces shall be protected from damage during the construction period.

3.4.3.12 Broom Finish

The concrete shall be screeded and floated to required finish plane with no coarse aggregate visible. After surface moisture disappears, the surface shall be broomed or brushed with a broom or fiber bristle brush in a direction transverse to that of the main traffic or as directed.

3.4.3.13 Expansion and Contraction Joints

Expansion and contraction joints shall be made in accordance with the details shown or as otherwise specified. Provide 12 mm (1/2 inch) thick transverse expansion joints where new work abuts an existing concrete. Expansion joints shall be provided at a maximum spacing of 10 m (30 feet) on center in sidewalks, unless otherwise indicated. Contraction joints shall be provided at a maximum spacing of 2 linear meters (6 linear feet in sidewalks, unless otherwise indicated. Contraction joints shall be cut at a minimum of 25 mm (1 inch) deep with a jointing tool after the surface has been finished.

3.5 CURING AND PROTECTION

Beginning immediately after placement and continuing for at least 7 days, [except for concrete made with Type III cement, at least 3 days,] all concrete shall be cured and protected from premature drying, extremes in temperature, rapid temperature change, mechanical damage, and exposure to rain or flowing water. All materials and equipment needed for adequate curing and protection shall be available and at the site of the placement prior to the start of concrete placement. Preservation of moisture for concrete surfaces not in contact with forms shall be accomplished by one of the following methods:

a. Continuous sprinkling or ponding.

b. Application of absorptive mats or fabrics kept continuously wet.

c. Application of sand kept continuously wet.

d. Application of impervious sheet material conforming to ASTM C 171.

e. Application of membrane-forming curing compound conforming to ASTM C 309, Type 1-D, on surfaces permanently exposed to view and Type 2 on other surfaces shall be accomplished in accordance with manufacturer's instructions.

The preservation of moisture for concrete surfaces placed against wooden forms shall be accomplished by keeping the forms continuously wet for 7 days , except for concrete made with Type III cement, 3 days. If forms are removed prior to end of the required curing period, other curing methods shall be used for the balance of the curing period. During the period of protection removal, the temperature of the air in contact with the concrete shall not be allowed to drop more than 15 degrees C 25 degrees F within a 24 hour period.

3.6 TESTS AND INSPECTIONS

3.6.1 General

The individuals who sample and test concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I.

3.6.2 Inspection Details and Frequency of Testing

3.6.2.1 Preparations for Placing

Foundation or construction joints, forms, and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor to certify that it is ready to receive concrete.

3.6.2.2 Air Content

Air content shall be checked at least once during each shift that concrete is placed for each class of concrete required. Samples shall be obtained in accordance with ASTM C 172 and tested in accordance with ASTM C 231.

3.6.2.3 Slump

Slump shall be checked once during each shift that concrete is produced for each class of concrete required. Samples shall be obtained in accordance with ASTM C 172 and tested in accordance with ASTM C 143/C 143M.

3.6.2.4 Consolidation and Protection

The Contractor shall ensure that the concrete is properly consolidated, finished, protected, and cured.

3.6.3 Action Required

3.6.3.1 Placing

The placing foreman shall not permit placing to begin until he has verified that an adequate number of acceptable vibrators, which are in working order and have competent operators, are available.

3.6.3.2 Air Content

Whenever a test result is outside the specification limits, the concrete shall not be delivered to the forms and an adjustment shall be made to the dosage of the air-entrainment admixture.

3.6.3.3 Slump

Whenever a test result is outside the specification limits, the concrete shall not be delivered to the forms and an adjustment should be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the water-cement ratio does not exceed that specified in the submitted concrete mixture proportion.

3.6.4 Reports

The results of all tests and inspections conducted at the project site shall be reported informally at the end of each shift and in writing weekly and shall be delivered within 3 days after the end of each weekly reporting period

PART 4 - MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

The quantity of Reinforced Concrete Lined Ditch to be paid will be the linear meter erected in place and accepted.

4.2 BASIS OF PAYMENT

The accepted quantities measured as provided in Part 4.1 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 include for full compensation for furnishing and placing and finishing concrete, placing of reinforcing steel, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
03307(1)	Reinforced Concrete lined ditch	Linear Meter
03307(2)	Concrete	Cubic Meter
03307(3)	Reinforcement	Kilogram
03307(4)	Lean Concrete	Cubic Meter

SECTION 04200

STONE MASONRY

PART 1 - GENERAL

1.1 SCOPE:

This work shall consist of stone masonry in slope protection and drainage canal in accordance with the specification and in conformity with the lines, grades, sections, and dimensions shown on the plans or as ordered in writing by the Engineer.

PART 2 - PRODUCTS

2.1 STONE:

The stone be cleaned, hard, durable and shall be subject to the Engineer's approval. Adobe stone shall not be used unless otherwise specified.

Sizes and Shapes - Unless other sizes are shown on the plans, stones shall have thickness of not less than 150 mm and widths of not less than one and one-half times their respective thickness and lengths of not less than one and one half times their respective widths. Each stone shall be of good shape and be free of depressions and projections that might weaken or prevent it from being properly bedded.

Dressing – The stone shall be dressed to remove any thin or weak portions. Face stones shall be dressed to provide bed and joint lines that do not vary more than 20 mm from the true lines and to ensure the meeting of bed and joint lines without the rounding corners of the stones in excess of 30 mm in radius. Bed surfaces of the face stones shall be approximately normal to the face of the stones for about 80 mm and from this point may depart from a normal plane not to exceed 50 mm in 300 mm.

Finished for exposed Faces – Face stones shall be pitched to line along the beds and joints. The maximum projection of rock faces beyond the pitch lines shall not be more than 50 mm.

2.2 MORTAR:

Cement, fine aggregate and water shall conform to the respective requirements for those materials as specified under Section 03300 Cast-In-Place Concrete except as to the grading of fine aggregate which shall all pass the 2.36 mm (No.8) sieve not less than 15 or more than 40 percent shall pass the 0.3 mm (No.50) sieve, and not more than 10 percent shall pass the 0.15 mm (No.100) sieve.

The mortar for the masonry shall be composed of one part of Portland cement and two parts of fine aggregate by volume and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel. Mortar shall be mixed only in those quantities required for immediate use. Unless an approved mortar mixing machine is used,

the fine aggregate and cement shall be mixed dry in a tight box until the mixture assumes a uniform color, after which, water shall be added as the mixing continues until the mortar attains the proper consistency. Mortar that is not used within 90 minutes after water has been added shall be discarded. Retempering of mortar will not be permitted.

PART 3 – CONSTRUCTION REQUIREMENT

3.1 SELECTION AND PLACING:

When the masonry is to be placed on a prepared foundation bed, the bed shall be firm and normal to or in steps normal to the face of the wall and shall have been approved by the Engineer before any stone is placed.

Care shall be taken to prevent the bunching of small stone or stones of the same size. Large stones shall be used in the corners.

All stones shall be cleaned thoroughly and wetted immediately before being set and the bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid in full beds of mortar and the joints shall be flushed with mortar.

The exposed faces of individual stones shall be parallel to the faces of the walls in which the stone are set.

The stones shall be so handled as not to jar or displace the stone already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. The rolling or turning of stones on the walls will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off and the stone relaid with fresh mortar.

3.2 BED AND JOINTS:

Beds for face stones may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than 5 stones. Joints may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than stone stones. They may be at angles with the vertical from 0° to 45°. Face stone shall bond at least 150 mm longitudinally and 50 mm vertically. At no place shall corners of four stones be adjacent to each other.

Cross beds for vertical faced walls shall be level and for battered walls may vary from level to normal to the batter line of the face of the wall.

3.3 HEADERS:

Headers shall be distributed uniformly throughout the walls of structures so as to form at least one-fifth of the exposed faces. They shall be of such lengths as to extend from the front face of the wall into the backing of at least 300 mm. When a wall is 450 mm or less in thickness, the headers shall extend entirely from front to back face.

3.4 BACKING:

Backing shall be built chiefly of large stones and in a workman like manner. The individual stones composing the backing and hearting shall be well bonded with the stones in the face of wall and with each other. All openings and interstices in the backing shall be filled completely with mortar or with spalls surrounded completely by mortar.

3.5 POINTING:

Both bed and vertical joints shall be finished as shown on the plans or as directed by the Engineer. The mortar in joints on top of surface of masonry shall be crowned slightly at the center of the masonry to provide drainage

3.6 COPING:

Copings if called for shall be as shown on the plans. Where copings are not called for the top of the wall shall be finished with stones wide enough to cover the top of the wall from 450 mm to 1000 mm in length and of random heights with a minimum height of 150 mm. Stone shall be laid in such a manner that the top course is an integral part of the wall. The tops of top course of stone shall be pitched to line in both vertical and horizontal planes.

3.6 WEEP HOLES:

All walls and abutments shall be provided with weep holes. Unless otherwise shown on the plans or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets for water can be obtained and shall be placed not more than 2 m center to center.

3.7 GRANULAR BACKFILL FILTER MATERIAL:

Granular backfill filter material shall be permeable and shall meet the requirements of AASHTO M6 except that soundness tests will not be required and minor variation in grading and content of deleterious substances may be approved by the Engineer.

3.8 CLEANING EXPOSED FACES:

Immediately after being laid and while the mortar is fresh, all face stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

3.9 CURING:

In hot or dry weather, the masonry shall be satisfactorily protected from the sun and shall be kept wet for a period of at least three days after completion.

PART 4 –MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

The quantity to be paid for shall be the number of cubic meters of stone masonry complete in place and accepted. Projections extending beyond the faces of the walls shall not be

included. In computing the quantity for payment, the dimensions used shall be those shown on the plans or ordered in writing by the Engineer. No deductions shall be made for weep holes, drain pipes or other openings of less than one square meter in area.

4.2 BASIS OF PAYMENT

The quantity of Stone Masonry determined as provided in Part 4.1, shall be paid for at the contract price per cubic meter, which price and payment shall be full compensation for furnishing and placing all materials, including mortar for masonry, and for all labor, equipment tools and incidentals necessary to complete the work.

Payment will be made under

Pay Item Number	Description	Unit of Measurement
04200	Stone Masonry	Cubic Meter

SECTION 04230

REINFORCED MASONRY (CONCRETE HOLLOW BLOCK)

PART 1 - GENERAL

1.1 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1.1.1 American Concrete Institute (ACI) Publication:

315 Manual of Standard Practice for Detailing Reinforced Concrete Structures

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

C 39	Compressive Strength of Cylindrical Concrete Specimens
C 91	Masonry Cement
C 144	Aggregate for Masonry Mortar
C 270	Mortar for Unit Masonry
C 404	Aggregates for Masonry Grout
C 426	Drying Shrinkage of Concrete Block
D 1056	Flexible Cellular Materials-Sponge or Expanded Rubber
D 1667	Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Sponge)
E 447	Compressive Strength of Masonry Prisms

1.1.3 Product Standards Agency (PSA) Publications (Philippines):

PNS 07	Specifications for Portland Cement
PNS 16	Specifications for Concrete Hollow Blocks
PNS 18	Specifications for Concrete Aggregate
PNS 49	Specifications for Steel Bars for Concrete Reinforcement
SAO 181	Industrial Quicklime and Hydrated Lime

1.2 DEFINITIONS:

1.2.1 Concealed Masonry Surfaces:

a. Surfaces of foundation walls against which backfill is placed.

b. Surfaces covered by furring and wallboard plaster, stucco, or masonry facings.

c. Surfaces above suspended ceilings.

d. Surfaces within attic spaces, crawl spaces, pipe or duct chases and elevator shafts.

1.2.2 Exposed Masonry Surfaces: Masonry surfaces other than those listed above including those to be painted.

1.2.3 Grout Lift and Grout Pour: A grout lift is the layer of grout placed in a single continuous operation. A grout pour is the entire height of grout fill placed in one day and is composed of a number of successively placed grout lifts.

1.2.4 Reinforced Hollow Unit Masonry: Hollow concrete masonry units reinforced vertically and horizontally with steel bars located within cells or kerfs in the units and with cells containing reinforcing bars filled solidly with grout.

1.2.5 Additional Definitions:

1.2.5.1 Back-Up: That part of masonry walls which is behind the exterior facing.

1.2.5.2 Bed Joint: The horizontal layer of mortar on which a masonry unit is laid.

1.2.5.3 Head Joint: The vertical mortar joint between ends of masonry units. Sometimes called a cross-joint.

1.2.5.4 Kerf: A cut or notch made with a saw, or with a cutter, part way through a portion of a unit.

1.2.5.5 Low Lift Grouting: The technique of grouting masonry in 0.20 to 1.8 meters lifts as the wall is being laid.

1.2.5.6 Reinforced Masonry: Masonry in which reinforcement is embedded in such a manner that the component act together to resist lateral forces.

1.3 SUBMITTALS: (Not Applicable)

1.4 DELIVERY, STORAGE AND HANDLING: Handle, store and protect masonry units to avoid chipping, breakage or contact with the soil. Keep steel reinforcing bars free of rust and loose scale. Reject rusted steel reinforcing bars. Deliver cement and lime in unbroken bags, barrels, or other sealed containers. Keep cementitious materials dry. Store and handle cement to prevent the inclusion of foreign materials. Store aggregates in a manner to avoid contamination or segregation. Plainly mark and label containers with the manufacturer's names and brands.

PART 2 - PRODUCTS

2.1 MASONRY UNITS:

2.1.1 Concrete Masonry Units:

2.1.1.1 Aggregates: PNS 18

2.1.1.2 Linear Drying Shrinkage: Not to exceed 0.065 percent when tested in accordance with ASTM 426.

2.1.2.3 Kinds and Shapes: In addition to the requirements specified, concrete masonry units of the various kinds shall conform to PNS 16, Type II for 200 mm thick, 150 mm thick and for 100 mm thick. Include closer, jamb, lintel and bond beam units and special shapes and sizes to complete the work as indicated.

2.2 CENTERING DEVICE: Provide centering clips that prevent displacement of reinforcing bars during the course of construction.

2.3 DEFORMED REINFORCING BARS: PNS 49, Grade 275 (40,000 psi).

2.4 MATERIALS FOR MORTAR AND GROUT:

2.4.1 Admixtures:

2.4.1.1 Admixtures: May be used in mortar or grout provided that the admixture does not adversely affect bond or compressive strength of mortar or grout.

2.4.1.2 Prohibited Ingredients: Do not use air entraining compounds, calcium chloride salts or other chemicals that will adversely affect metals or the coatings of metals embedded in the mortar or grout.

2.4.2 Aggregate for Mortar: ASTM C 144, except that not less than 3 percent nor more than 15 percent shall pass the No. 100 sieve. Aggregate used in mortar for joint 6 mm or less shall have 100 percent passing the No. 8 sieve with 10 percent being retained on the No. 16 sieve.

2.4.3 Aggregate for Grout:

2.4.3.1 Fine Aggregate: ASTM C 404, Size No. 2 or ASTM C 144.

2.4.3.2 Pea Gravel: ASTM C 404, except that 100 percent shall pass the 9 mm screen and not more than 5 percent shall pass the No. 8 sieve.

2.4.3.3 Coarse Aggregate: ASTM C 404, size No. 8.

2.4.4 Portland Cement: PNS 07, Type I.

2.4.5 Lime Putty: Slaked according to manufacturer's instructions.

2.4.5.1 Hydrated Lime: SAO 181.

2.4.5.2 Pulverized Quicklime: SAO 181 except 100 percent shall pass the No. 20 sieve and 90 percent shall pass the No. 50 sieve.

2.4.5.3 Lime Paste: Lime paste shall be made with pulverized quicklime or hydrated lime. Hydrated lime processed by the steam method shall be allowed to soak not less than 24 hours. Quicklime and other hydrated lime shall be allowed to soak not less than 72 hours. In lieu of hydrated lime paste for use in mortar, the hydrated lime may be added in the dry form.

2.4.6 Water: Potable.

2.5 MORTAR MIXES:

2.5.1 Proportions: Type M in accordance with the proportion specifications of ASTM C 270. The mortar shall have a flow, after 11 minutes, of 75 percent or more when tested for water retention in accordance with ASTM C 91 except mortar shall be mixed to an initial flow of 105 to 115 percent.

2.6 GROUT MIXTURES:

2.6.1 Proportions: Mix in laboratory established proportions to in a compressive strength at 28 days of not less than 14.0 MPa (2000 psi) when tested in accordance with ASTM C 91 for fine aggregate and ASTM C 39 for grout containing coarse aggregate. Grout shall be classified as fine and low lift types as specified below and shall be used subject to the limitations of Table I herein.

2.6.1.1 Fine Grout: Portland cement, fine aggregate, and sufficient water to obtain a pouring consistency without segregation of the constituents. Slump shall be approximately 125 mm.

2.6.1.2 Low Lift Grout: Portland cement, lime paste or hydrated lime, fine aggregate and coarse aggregate, and sufficient water to obtain a pouring consistency without segregation of the constituents. Slump between 200 and 250 mm. Maximum sizes of coarse aggregate for grout in accordance with Table I herein.

2.7 SOURCE QUALITY CONTROL: Prior to delivery of masonry units to the site, select by random sampling nine individual whole units from the units proposed for use. Select units free from cracks or other structural defects. Test in accordance with PNS 16.

PART 3 - EXECUTION

3.1 PREPARATION:

3.1.1 Protection:

a. Forms And Shores: Where required, construct forms to the shapes, lines, and dimensions of the members indicated. Construct forms sufficiently rigid to prevent deflections which may result in cracking or other damage to supported masonry and sufficiently tight to prevent leakage of mortar and grout. Do not remove supporting forms or shores until the supported masonry has acquired sufficient strength to support its weight and construction loads to which it may be subjected. In no case shall supporting forms or shores be removed in less than 10 days. Wait at least 16 hours after grouting masonry walls after applying uniform loads and wait an additional 48 hours before applying concentrated loads.

b. Wall Bracing: Brace walls against wind and other forces during construction. Allow sufficient time between lifts to prevent cracking of face shells of hollow masonry units. If blowouts, misalignment, or cracking of face-shells should occur during construction, tear down and rebuild the wall at no additional cost to the Owner.

3.1.2 Surface Preparation: Clean laitance, dust, dirt, oil, organic matter or foreign materials from concrete surface upon which reinforced masonry is to be placed. Use sandblasting, if necessary, to remove laitance from pores and expose to the aggregate.

3.2 LAYING MASONRY UNITS:

3.2.1 Wet Masonry Units: Do not wet concrete masonry units. Do not lay units having a film of water on the surface.

3.2.2 Embedded Items: Build in wall plugs, accessories, flashings pipe sleeves and other items required being built-in as the masonry works progresses. Fill cells receiving anchor bolts and cells of the first course below bearing plates with mortar or grout. Fill spaces around metal doorframes and other built-in items with mortar. Point openings around flush-mounted electrical outlet boxes in wet locations, including the flush joint above the box with mortar. Do not embed aluminum items.

3.2.3 Bond Beams and Lintels: Install bond units, reinforced as indicated, filled with grout. Install open bottom type bond beam units over cells to be filled. Place wire mesh or small mesh metal lath under open bond beam units if used over cells not to be filled.

3.2.4 Unfinished Work: Step back-unfinished work for joining with new work. Do not use toothing without the written approval of the Owner's Representative. Remove loose mortar and thoroughly clean the exposed joints before laying new work.

3.2.5 Placing Units: Lay hollow masonry units so as to preserve the vertical continuity of cells filled with grout. The minimum clear horizontal dimensions of vertical cores shall be 50 mm by 75 mm. Masonry bond units at corners. Anchor intersections by reinforcing bars as indicated. Adjust each unit to its final position while mortar is still soft and plastic. If any unit is disturbed after mortar has stiffened, remove and relay in fresh mortar. Keep chases, raked out joints, and spaces to be grouted, free from mortar and other debris.

3.2.6 Bond Pattern: Lay masonry units in running bond.

3.2.7 Cutting and Fitting: Wherever possible, use full units of the proper size in lieu of cut units. Use power masonry saws for cutting and fitting. Concrete -masonry units shall be wet cut. Make cut edges clean, true and sharp. Make openings carefully so that wall plates, cover plates or escutcheons required by the installation will completely conceal the openings and will be aligned at the bottom with the masonry joints. Cut webs of hollow masonry units to the minimum required for proper installation. Provide reinforced masonry lintels, above openings over 300 mm wide for pipes, ducts and cables trays unless steel sleeves are used.

3.2.8 Mortar Joints: Spread bed joints with mortar for the full thickness of the face shells. Where only cells containing reinforcement are to be grouted, spread cross webs around such cell with mortar to prevent leakage of grout. Butter head joints for full thickness of the face shell and place the units. Avoid fins of mortar that protrude into cells to be grouted.

3.2.9 Jointing: Tool joints when the mortar is thumbprint hard. Tool horizontal joints first. Brush joints to remove loose and excess mortar. Mortar joints shall be finished as follows:

3.2.9.1 Flush Joints: Flush cut joints in concealed masonry surfaces and joints above electrical outlet boxes in wet areas. Make flush cut joints by cutting off the mortar flush with the face of the wall.

3.2.9.2 Tooled Joints: Tool joints in exposed exterior and interior masonry surfaces slightly concave. Use a jointer of sufficient length to obtain a straight and true mortar joints.

3.2.10 Joint Width: 9 mm wide.

3.3 PLACING REINFORCING STEEL: Prior to placing grout, clean, reinforcement of loose, flaky rust, scale, grease, mortar, grout, or other coating which might destroy or reduce its bond with the grout. Details of reinforcement shall be in conformance with ACI 315. Do not bend or straighten reinforcing in a manner injurious to the steel. Do not use bars with kinks or bends not shown on the drawings. Placement of reinforcement shall be inspected and approved prior to placing grout.

3.3.1 Positioning Bars: Position vertical bars accurately at the centerline of the wall. Maintain a minimum clearance between the bars and masonry units of 12 mm and between parallel bars of one diameter of the reinforcement. Hold vertical reinforcing in place using metal support, centering clips, spacers, ties or caging devices located near the ends of each bar and at intermediate intervals of not more than 192 diameters of the reinforcement.

3.3.2 Splices: Locate splices only as indicated. Stagger splices in adjacent bars at least 600 mm. Lap bars a minimum of 40 diameters of the reinforcement or 600 mm, whichever is greater. Welded or mechanical connections shall develop the full strength of the reinforcement.

3.4 PLACING GROUT: Use a hand bucket, concrete hopper or grout pump. Place grout in final position within 1-½ hours after mixing. Where grouting is discontinued for more than one hour, stop the grout 25-mm below the top of a course to form a key at pour points. Place grout to completely fill the grout spaces without segregation of the aggregates.

3.4.1 Low Lift Grout Method: Place grout as masonry is erected at a rate that will not cause displacement of the masonry due to hydrostatic pressure of the grout. If mortar has been allowed to set prior to grouting, remove fins protruding more than 12 mm into the grout space. Rod or puddle grout during placement using a long 25-mm by 50-mm wood stick or a mechanical vibrator.

3.5 TOLERANCE: Lay masonry plumb, true to line, with course level. Keep bond patterns plumb throughout.

3.6 FIELD QUANTITY CONTROL:

3.6.1 Grout: Employ a qualified testing laboratory to proportion and test grout. Do not change laboratory established proportions or use materials with different physical or chemical characteristics in grout for the work unless additional evidence is furnished that the grout meets the specified requirements.

3.7 CLEANING: After mortar joints have attained their initial set but prior to hardening, completely remove mortar and grout daubs or splashing from exposed masonry surfaces. Before completion of the work, make out defects in joints in exposed masonry surfaces fill with mortar and tool to match existing joints. Immediately after grout work is completed remove scum and stairs which have percolated through the masonry using a high pressure steam of water and a stiff fiber bristled brush. Do not use metal tools or metal brushes for cleaning. Dry brush exposed concrete masonry unit surfaces at the end of work each day.

PART 4- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

Measurement will be made by the linear meter of CHB Lined Ditch laid in position and accepted.

4.2 BASIS OF PAYMENT

The quantities measured as provided under part 4.1 shall be paid at the contract price which price and payment shall be full compensation for furnishing and laying concrete hollow blocks, laying of reinforcing, steels, formworks, installation and plastering and all labor, equipment, tools and incidentals necessary to complete the work.

Payment will be made under

Pay Item Number	Description	Unit of Measurement	
04230	CHB Lined Ditch	Linear	Meter

SECTION 03410

PRECAST CONCRETE

PART 1 – GENERAL

1.1 SCOPE

This Section shall consist of furnishing materials, labor and work required to complete precast cover for reinforced concrete canal.

1.2 SUBMITTAL

a. Sample

Submit sample of each type for the approval of the Architect/Engineer

b. Shop Drawing

Submit shop drawings showing mounting details for the approval of Architect/Engineer

1.3 DELIVERY,HANDLING ANS TORAGE

Handle, store and protect precast items both in transit and on jobsite to avoid chipping, breaking or contact with soil. Materials shall not be delivered unduly long before it is required for the proper conduct of work.

1.4 QUALAITY CONTROL

a. Ensure that the preceeding work is clean and ready to be receive units.

b. Reject damaged materials and ensure good quality of materials to be installed.

PART 2 – PRODUCTS

2.1 CONTRACTO-FURNISHED MIX DESIGN: ACI 318. The minimum compressive strength of concrete at 28 days shall be 3000 psi, unless otherwise indicated.

2.2 MATERIALS

2.2.1 Cement: ASTM C 150, Type 1

2.2.2 Water: Water shall be fresh, clean and potable

2.2.3 Aggregates: ASTM C 33. Obtain aggregates for exposed concrete surfaces from one source. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the content.

2.2.4 Reinforcement: Reinforcing Bars. ASTM A 706, Grade 60.

2.3 FABRICATION: PCI MNL-116, unless specified otherwise.

2.3.1 Forms: Brace forms to prevent deformation. Forms hall produce a smooth, dense surface.

2.3.2 Reinforcement Placement: ACI 318 for placement and splicing. Reinforcement may be preassembled before placement in forms.

2.3.3 Concrete

1. Concrete Mixing: ASTM C 94. Mixing operations shall produce batch-to-batch uniformity o strength, consistency, and appearance.

2. Concrete Placing: ACI 304, ACI 305 for hot hot water concreting.

3. Concrete Curing: Commence curing immediately following the initial set and completion of surface finishing. Provide curing procedure to keep the temperature of the concrete between 50 and 190 degrees F. When accelerated curing is used, apply heat at controlled rate and uniformity along the casting beds. Monitor temperatures at various points in a product line in different casts.

4. Surface Finish: Precast members containing hairline cracks which are visible and are less than 0.02 inches in width, may be accepted, except that cracks larger than 0.005 inches in width for surfaces exposed to the weather shall be repaired. Precast members which contain cracks greater that 0.2 inch in width shall be approved by the Engineer, prior to being repaired. Any precast member that is structurally impaired or contains honeycombed section deep enough to expose reinforcing shall be rejected.

2.3.4 Acceptance Sampling and Testing

1. Type of Specimen

Compression tests for determining concrete compressive strength may be on either concrete cylinders or on cores drilled from the manhole section.

1. Compression Testing Cores:

a) Obtaining Cores – cores shall be obtained and prepared in accordance with the Core Strength Test Method of T 280.

b) Number of Cores - One core shall be taken from each manhole section.

c) Acceptability on the Basis of Core Test Results:

1) When the compressive strengths of cores tested for a manhole sections is equal to or greater than the design concrete strength, the compressive strength of the concrete for the manhole is acceptable.

2) If the compressive strength of the core tested is less than the design concrete strength, the manhole section from which the core was taken may be recored. If the compressive strength of the recore is equal to or greater than the design concrete compressive strength, the compressive strength of the concrete for the manhole is acceptable.

3) If the compressive strength of the recore is less than the design concrete strength, the manhole section from which the core was taken shall be rejected.

2. Plugging Core Holes – The core holes shall be plugged and sealed by the manufacturer in a manner such that the manhole section will meet all of the test requirement of this specification. Manhole sections so sealed shall be considered satisfactory for use.

3. Test Equipment – Every manufacturer furnishing manholes sections under this specification shall furnish all facilities and personnel necessary

PART 3 – EXECUTION

3.1 SURFACE REPAIR: Prior to erection, and again after installation, precast members shall be checked for damage, such as cracking, spalling, and honeycombing. As directed by the Engineer precast members that do not meet the surface finish requirements specified in Pat 2 in paragraph titled, "Surface Finish" shall be repaired, or removed and replaced with new precast members.

3.2 ERECTION: Precast members shall be erected after the concrete has attained the specified compressive strength, unless otherwise approved by the precast manufacturer. Erect in accordance with the approved shop drawings. Follow the manufacturer's recommendations for maximum tolerances. Align member ends.

3.3 OPENING: When a pipe enters the manhole through a wall of a precast unit, the contractor with the approval of the precast manufacturer shall perform the cutting or drilling of hole of the concrete and steel reinforcement in a manner that will not loosen the reinforcement in the wall. The steel reinforcement shall be cut flush with the wall face. All joints and opening cut in the wall shall be grouted.

Drill holes less than 300mm in diameter with a diamond tipped core drill.

PART 4- MEASUREMENT AND PAYMENT

4.1 MEASUREMENT

The quantity to be measured for payment will be the actual number of precast concrete manhole of the several types and sizes installed in place, completed and accepted. Each member will include the concrete, reinforcement or other such material contained within or attached to the unit.

Core drilling for pipe opening of several sizes will be measured on an each basis.

4.2 BASIS OF PAYMENT

The accepted quantities measured as prescribed in Part 4.1 shall be paid for the contract unit price which per unit of measurement respectively for each of the particular pay item listed below that are shown in the Bill of quantities shall be full compensation for all works prescribed in this Section.

Payment will be made under:

Pay Item Number	Description	Unit of Measurement
03410(1)	Sewer Manholes	Each
03410(2)	Core Drilling	Each

SECTION 16520

EXTERIOR LIGHTING SYSTEM

PART 1 - GENERAL

1.1 REFERENCE: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

a. American Association of State Highway and Transportation Officials (AASHTO);
b. American National Standards Association (ANSI);
c. ASTM International (ASTM);
d. Institute of Electrical and Electronics Engineers (IEEE);
e. National Electrical Manufacturers Association (NEMA);
f. National Fire Protection Association (NFPA);
g. Underwriter's Laboratories (UL);
h. Philippine Electrical Code (PEC).

1.2 DEFINITIONS:

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100;
b. Average life is the time after which 50 percent will have failed and 50 percent will have survived under normal conditions;
c. Groundline section is that portion between 305 mm (one foot) above and 610 mm (2 feet) below the groundline.

1.3 SUBMITTALS: All lighting fixtures to be used shall be manufactured by Cooper. The following shall be submitted:

1.3.1 Shop Drawings:

a. Luminaire Drawings;
b. Poles

1.3.2 Product Data:

a. Fluorescent lighting fixtures;
b. Fluorescent electronic ballasts;
c. Fluorescent lamps; and
d. Steel poles.

1.3.3 Samples:

a. Luminaires. Submit one sample of each luminaire type. Sample will be returned to the Contractor for installation in the project work.

1.3.4 Design Data:

a. Design data for Luminaires

1.3.5 Test Reports:

a. Operating test

Submit operating test results as stated in paragraph entitled “Field Quality Control”.

1.3.6 Manufacturer’s Instructions:

a. Concrete Poles: Submit instructions prior to installation;

1.3.7 Operation and Maintenance Data:

a. Operational Service. Submit documentation that includes contact information, summary of procedures, and the limitations and conditions applicable to the project. Indicate manufacturer's commitment to reclaim materials for recycling and/or reuse.

1.4 QUALITY ASSURANCE

1.4.1 Drawing Requirements

a. Luminaire Drawings: Include dimensions, effective projected area (EPA), accessories, and installation and construction details. Photometric data, including zonal lumen data, average and minimum ratio, aiming diagram, and candlepower distribution data shall accompany shop drawings.

b. Poles: Include dimensions, wind load determined in accordance with AASHTO LTS-5, pole deflection, pole class, and other applicable information.

1.4.2 Design Data for Luminaires:

a. Distribution data according to IESNA classification type as defined in IESNA HB-9;

b. Computerized horizontal illumination levels in lux at ground level, taken every 3 m. Include average maintained lux level and maximum and minimum ratio;

c. Amount of shielding on luminaires.

1.4.3 Regulatory Requirements: In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Owner. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of the latest edition of the Philippine Electrical Code (PEC 2009) and NFPA 70 unless more stringent requirements are specified or indicated.

1.4.4 Standard Products: Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall

include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.5 Alternative Qualifications: Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.6 Material and Equipment Manufacturing Date: Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Steel Poles: Do not store poles on ground. Support poles so they are at least 305 mm (one foot) above ground level and growing vegetation. Do not remove factory-applied pole wrappings until just before installing pole.

1.6 WARRANTY

The equipment items shall be supported by service organizations which are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

1.7 OPERATIONAL SERVICE

Coordinate with manufacturer for maintenance agreement or take-back program. Collect information from the manufacturer about maintenance agreement or green lease options, and submit to Owner. Services shall reclaim materials for recycling and/or reuse. Services shall not landfill or burn reclaimed materials. Indicate procedures for compliance with regulations governing disposal of mercury. When such a service is not available, local recyclers shall be sought after to reclaim the materials.

PART 2 - PRODUCTS

2.1 PRODUCT COORDINATION

Products and materials not considered to be lighting equipment or lighting fixture accessories are specified in Section 33 71 02 Underground Electrical Distribution.

2.2 ENCLOSED AND GASKETED VAPOR-TIGHT FIXTURES: Provide enclosed and gasketed vapor-tight fixtures suitable for wet and dry locations consisting of a cast-aluminum body, cap or matching outlet box, porcelain lampholder, glass enclosing globe, cork gaskets, and cast-aluminum guards for outdoor pole mounting in accordance with UL 1598 and NFPA 70. Provide body with mounting screws and gasket to ensure a vapor-tight joint between the body and outlet box.

2.2.1 Fluorescent Lighting Fixtures: Fixtures shall be UL 1598 listed. Fluorescent lighting fixture shall have electronic ballast, unless specifically indicated otherwise.

Fluorescent lighting fixtures shall be manufactured by “GE”, “Cooper”, “Philips” or “Maxitech”.

2.2.2 Fluorescent Lamp Electronic Ballast: The electronic ballast shall as a minimum meet the following characteristics. Fluorescent lamp electronic ballast shall be “GE” or “Philips”.

a. Ballast shall comply with UL 935, ANSI C82.11, and NFPA 70, unless specified otherwise. Ballast shall be 100% electronic high frequency type with no magnetic core and coil components. Ballast shall provide transient immunity as recommended by IEEE C62.41.1 and IEEE C62.41.2. Ballast shall be designed for the wattage of the lamps used in the indicated application. Ballasts shall be designed to operate on the voltage system to which they are connected;
b. Power factor shall be 0.95 (minimum);
c. Ballast shall operate at a frequency of 20,000 Hertz (minimum); Ballast shall be compatible with and not cause interference with the operation of occupancy sensors or other infrared control systems. Provide ballasts operating at or above 40,000 Hertz where available;
d. Ballast shall have light regulation of plus or minus 10 percent lumen output with a plus or minus 10 percent input voltage regulation. Ballast shall have 10 percent flicker (maximum) using any compatible lamp;
e. Ballast factor shall be between 0.85 (minimum) and 1.00 (maximum). Current crest factor shall be 1.7 (maximum);
f. Ballast shall be UL listed Class P with a sound rating of "A.";
g. Ballast shall have circuit diagrams and lamp connections displayed on the ballast;
h. Ballasts shall be instant start unless otherwise indicated. Instant start ballasts shall operate lamps in a parallel circuit configuration that permits the operation of remaining lamps if one or more lamps fail or are removed. Provide series/parallel wiring for programmed start ballasts where available;
i. Ballasts for compact fluorescent fixtures shall be programmed start;
j. Ballasts for T-5 and smaller lamps shall have end-of-life protection circuits as required by ANSI/IEC C78.81 and ANSI/IEC C78.901 as applicable;
k. Ballast shall be capable of starting and maintaining operation at a minimum of -17 degrees C (0 degrees F) unless otherwise indicated;
l. Electronic ballast shall have a full replacement warranty of 5 years from date of manufacture as specified in paragraph entitled "Electronic Ballast Warranty" herein.

2.2.3. Fluorescent Lamps: Fluorescent lamps shall be UL listed and shall be “GE”, “PHILIPS”, or approved equal. Average rated life is based on 3 hours operating per start.

2.2.3.1 T-8 Lamp Ballast:

a. Total harmonic distortion (THD): Shall be 20 percent (maximum);
b. Input wattage:
   1. 37watts (maximum) when operating one F36T8 lamp;
   2. 72 watts (maximum) when operating two F36T8 lamp;
c. Ballast efficacy factor:
   1. 2.54 (minimum) when operating one F36T8 lamp;

2. 1.44 (minimum) when operating two F36T8 lamp;

2.2.4 Lamp Holder: Lamp holder shall be UL listed and shall be rated 600 volts. Housing shall be polycarbonate and shall have a temperature index of 115 degree C. Lamp Holder shall be "BJB" or approved equal.

2.3 DEVICE PLATES: Provide a one-piece device plates for outlets to suit the devices installed. For metal outlet boxes, plates on unfinished walls shall be of zinc-coated sheet steel or cast metal having round or beveled edges. For nonmetallic boxes and fittings, other suitable plates may be provided. Plates shall be nylon or lexan, minimum 0.792 mm wall thickness. Plates shall be same color as the switch with which they are mounted. Screws shall be machine-type with countersunk heads in color to match finish of plate. Sectional type device plates will not be permitted. Plates installed in wet locations designed for use with underground conductors. Poles shall have a pull box having a minimum clear opening of 65 by 130 mm (2.5 by 5 inches). Handhole cover shall be secured by stainless steel captive screws. Metal poles shall have an internal grounding connection accessible from the handhole near the bottom of each pole. Scratched, stained, chipped, or dented poles shall not be installed.

2.3.1 Steel Poles: Steel Poles shall conform to AASHTO LTS-5. Provide steel poles having minimum 11-gage steel with minimum yield/strength of 331 MPa (48,000 psi) and hot-dipped galvanized in accordance with ASTM A 123/A 123M factory finish. Provide a pole grounding connection designed to prevent electrolysis when used with copper ground wire. Pole shall be anchor bolt mounted type. Poles shall have tapered tubular members, either round in cross section or polygonal. Pole shafts shall be one piece. Poles shall be welded construction with no bolts, rivets, or other means of fastening except as specifically approved. Pole markings shall be approximately 900 to 1270 mm (3 to 4 feet) above grade and shall include manufacturer, year of manufacture, top and bottom diameters, and length. Base covers for steel poles shall be structural quality hot-rolled carbon steel plate having a minimum yield of 248 MPa (36,000 psi).

2.3.2 Pole Foundations: Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa (50,000 psi); the top 305 mm (12 inches) of the rod shall be galvanized in accordance with ASTM A 153/A 153M. Concrete shall be as specified in Section 033100, Structural Concrete.

2.4 EQUIPMENT IDENTIFICATION

2.4.1 Manufacturer's Nameplate: Each item of equipment shall have a nameplate bearing the manufacturer's name, address, model number, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.

2.4.2 Labels: Provide labeled luminaires in accordance with UL 1598 requirements. Luminaires shall be clearly marked for operation of specific lamps and ballasts according to proper lamp type. The following lamp characteristics shall be noted in the format "Use Only _____":

a. Lamp code: T8 and nominal wattage.
b. Correlated color temperature (CCT) and color rendering index (CRI) for all luminaires.

Markings related to lamp type shall be clear and located to be readily visible to service personnel, but unseen from normal viewing angles when lamps are in place.

Ballasts shall have clear markings indicating multi-level outputs and indicate proper terminals for the various outputs.

2.4.3 Factory Applied Finish: Electrical equipment shall have factory-applied painting systems which shall, as a minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 - EXECUTION

3.1 INSTALLATION

Electrical installations shall conform to the latest edition of Philippine Electrical Code (PEC 2009) IEEE C2, NFPA 70, and to the requirements specified herein.

3.1.1 Steel Poles: Provide pole foundations with galvanized steel anchor bolts, threaded at the top end and bent 1.57 rad (90 degrees) at the bottom end. Provide ornamental covers to match pole and galvanized nuts and washers for anchor bolts. Concrete for anchor bases, polyvinyl chloride (PVC) conduit ells, and ground rods shall be as specified in Section 337102 Underground Electrical Distribution. Thoroughly compact backfill with compacting arranged to prevent pressure between conductor, jacket, or sheath and the end of conduit ell. Adjust poles as necessary to provide a permanent vertical position with the bracket arm in proper position for luminaire location. After installation, paint exposed surfaces of steel poles with two finish coats of exterior oil paint of a color as indicated or aluminum paint.

3.1.2 Pole Setting: Depth shall be as indicated. Poles in straight runs shall be in a line. Dig holes large enough to permit the proper use of tampers to the full depth of the hole. Place backfill in the hole in 150 mm (6 inch) maximum layers and thoroughly tamp. Place surplus earth around the pole in a conical shape and pack tightly to drain water away.

3.2 GROUNDING

Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 33 71 02 Underground Electrical Distribution. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.3 FIELD APPLIED PAINTING

Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria.

3.4 FIELD QUALITY CONTROL

Upon completion of installation, verify that equipment is properly installed, connected, and adjusted. Conduct an operating test to show that the equipment operates in accordance with the requirements of this section.

SECTION 16302

UNDERGROUND ELECTRICAL DISTRIBUTION

PART 1 - GENERAL

1.1 REFERENCE: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

a. ASTM International (ASTM);
b. Institute of Electrical and Electronics Engineers (IEEE);
c. Insulated Cable Engineers Association (ICEA);
d. National Electrical Manufacturers Association (NEMA);
e. National Fire Protection Association (NFPA);
f. Underwriter's Laboratories (UL);
g. Philippine Electrical Code (PEC);
h. Philippine National Standards (PNS).

1.2 DEFINITIONS:

a. Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE 100;
b. In the text of this section, the words conduit and duct are used interchangeably and have the same meaning;
c. In the text of this section, "medium voltage cable splices," and "medium voltage cable joints" are used interchangeably and have the same meaning.

1.3 SUBMITTALS: The following shall be submitted in accordance with submittal procedures:

1.3.1 Shop Drawings:

a. Pre-cast Underground Structures.

1.3.2 Product Data:

a. Pre-cast Concrete Structures;
b. Sealing Material;
c. Pulling-In Irons;
d. Handhole Frames and Covers;
e. Cable supports (racks, arms and insulators).

1.4 QUALITY ASSURANCE:

1.4.1 Precast Underground Structures: Submittal required for each type used. Provide calculations and drawings for precast manholes and handholes bearing the seal of a registered professional engineer including:

a. Material description (i.e., f'c and Fy);
b. Manufacturer's printed assembly and installation instructions;
c. Design calculations;
d. Reinforcing shop drawings in accordance with ACI SP-66;
e. Plans and elevations showing opening and pulling-in iron locations and details.

1.4.2 Regulatory Requirements: In each of the publications referred to herein, consider the advisory provisions to be mandatory, as though the word, "shall" had been substituted for "should" wherever it appears. Interpret references in these publications to the "authority having jurisdiction," or words of similar meaning, to mean the Owner. Equipment, materials, installation, and workmanship shall be in accordance with the mandatory and advisory provisions of the latest edition of the Philippine Electrical Code (PEC 2009) and NFPA 70 unless more stringent requirements are specified or indicated.

1.4.3 Standard Products: Provide materials and equipment that are products of manufacturers regularly engaged in the production of such products which are of equal material, design and workmanship. Products shall have been in satisfactory commercial or industrial use for 2 years prior to bid opening. The 2-year period shall include applications of equipment and materials under similar circumstances and of similar size. The product shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer; however, the component parts of the item need not be the products of the same manufacturer unless stated in this section.

1.4.3.1 Alternative Qualifications: Products having less than a 2-year field service record will be acceptable if a certified record of satisfactory field operation for not less than 6,000 hours, exclusive of the manufacturers' factory or laboratory tests, is furnished.

1.4.3.2 Material and Equipment Manufacturing Date Products manufactured more than 3 years prior to date of delivery to site shall not be used, unless specified otherwise.

PART 2 - PRODUCTS

2.1 CONDUIT, DUCTS AND FITTINGS:

2.1.1 Rigid Metal Conduit: Rigid metal conduit shall be UL 6 listed. Rigid metal conduit shall be “PANASONIC” or approved equal.

2.1.1.1 Rigid Metallic Conduit, PVC Coated: Rigid metallic conduit shall conform to NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 15.75 kV per mm (400 volts per mil) at 60 Hz, and tensile strength shall be minimum 25 MPa (3,500 psi).

2.1.2 Intermediate Metallic Conduit (IMC): IMC shall be UL 1242 listed. IMC shall be “PANASONIC” or approved equal.

2.1.2.1 Intermediate Metallic Conduit, PVC Coated: IMC with PVC coating shall conform to NEMA RN 1, Type A40, except that hardness shall be nominal 85 Shore A durometer, dielectric strength shall be minimum 15.75 kV per mm (400 volts per mil) at 60 Hz, and tensile strength shall be minimum 25 MPa (3,500 psi).

2.1.3 Plastic Conduit for Direct Burial – Polyvinyl Chloride (PVC) Conduit: PVC conduit shall be thick wall of not less than Schedule 40. PVC conduit shall be PNS 14 compliant. PVC conduit shall be "NELTEX Powerguard 8055" or approved equal.

2.1.4 Plastic Conduit for Concrete Encasement – Polyvinyl Chloride (PVC) Conduit: PVC conduit shall be thick wall of not less than Schedule 40. PVC conduit shall be PNS 14 compliant. PVC conduit shall be "NELTEX Powerguard 8055" or approved equal.

2.1.5 Interduct: Provide corrugated or solid wall polyethylene (PE) or PVC innerducts with pullwire. Size as indicated.

2.1.6 Conduit Sealing Material: Compounds for sealing ducts and conduit shall have a putty-like consistency workable with the hands at temperatures as low as 2 degrees C (35 degrees F), shall neither slump at a temperature of 150 degrees C (300 degrees F), nor harden materially when exposed to the air. Compounds shall adhere to clean surfaces of fiber or plastic ducts; metallic conduits or conduit coatings; concrete, masonry, or lead; any cable sheaths, jackets, covers, or insulation materials; and the common metals. Compounds shall form a seal without dissolving, noticeably changing characteristics, or removing any of the ingredients. Compounds shall have no injurious effect upon the hands of workmen or upon materials. Inflatable bladders may be used as an option.

2.1.7 Fittings:

2.1.7.1 Metal Fittings: Fittings shall be UL 514B listed.

2.1.7.2 PVC Conduit Fittings: Fittings shall conform to PNS 14 or NEMA TC3.

2.1.7.3 PVC Duct Fittings: Duct fittings shall conform to PNS 14 or NEMA TC 9.

2.1.7.4 Outlet Boxes for Steel Conduit: Outlet boxes for use with rigid or flexible steel conduit shall be cast-metal cadmium or zinc-coated if of ferrous metal with gasketed closures and shall conform to UL 514A.

2.2 INSULATED CONDUCTORS RATED 600 VOLTS OR LESS: Conductor sizes indicated are for copper conductors unless otherwise noted. Insulated conductors manufactured more than 12 months before deliver to the job site shall not be used. Wires and cables shall be "Phelps Dodge" or "Philflex".

2.2.1 Conductors: Conductors 8.0 mm2 (8 AWG) and larger diameter shall be stranded. Conductors 5.5 mm2 (10 AWG) and smaller diameter shall be solid, except that conductors for remote, control, alarm and signal circuits, classes 1, 2, and 3, shall be stranded unless specifically indicated otherwise. Conductor sizes and capacities shown are based on copper, unless indicated otherwise.

2.2.1.1 Equipment Manufacturer Requirements: When manufacturer's equipment requires copper conductor at the terminations or requires copper conductors to be provided between components of equipment, provide copper conductors or splices, splice boxes, and other work required to satisfy manufacturer's requirements.

2.2.1.2 Minimum Conductor Sizes: Minimum size for branch circuits shall be 3.5 mm² (12 AWG); for Class 1 remote-control and signal circuits, 2.0 mm² (14 AWG); for Class 2 low-energy remote-control and signal circuits, 1.25 mm² (16 AWG); and for Class 3 low-energy remote-control, alarm and signal circuits, 0.65 mm² (22 AWG).

2.2.2 Color Coding: Provide for all service, feeder, branch, control, and signaling circuit conductors. Color shall be green for grounding conductors, and white for neutrals, except where neutrals of more than one system are installed in same raceway or box, the other neutral shall be white with a colored (not green) stripe. The color of the ungrounded conductors in different voltage system shall be as follows:

a.	480 volt, 3-phase, 3-wire	Phase A – Black Phase B – Red Phase C – Blue
b.	230 volt, 1-phase	Black and Red

2.2.3 Insulation: Unless otherwise indicated or specified, power and lighting wires and cables shall be 600 volts, Type THW conforming to UL 83. Type THW wires and cables shall be suitable for the type of service where the conductor temperature does not exceed 75 degree C in dry and wet location only. Grounding wires and cable shall also be Type TW conforming to UL 83. Conductor sizes indicated by Square Millimeter (mm2) are for copper conductors.

2.3 LOW VOLTAGE WIRE CONNECTORS AND TERMINALS: Provide a uniform compression over the entire conductor contact surface. Use solderless terminal lugs on stranded conductors.

a. For use with copper conductors: UL 486A-486B;
b. For use with aluminum conductors: UL 486A-486B. For connecting aluminum to copper, connectors shall be the circumferentially compressed, metallurgically bonded type.

2.4 LOW VOLTAGE SPLICES: Provide splices in conductors with a compression connector on the conductor and by insulating and waterproofing using one of the following methods which are suitable for continuous submersion in water and shall conform to ANSI C119.1. Low voltage splices shall be “3M” or approved equal.

2.4.1 Heat Shrinkable Splice: Provide heat shrinkable splice insulation by means of a thermoplastic adhesive sealant material which shall be applied in accordance with the manufacturer's written instructions.

2.4.2 Cold Shrinkable Rubber Splice: Provide a cold-shrink rubber splice which consists of EPDM rubber tube which has been factory stretched onto a spiraled core which is removed during splice installation. The installation shall not require heat or flame, or any additional materials such as covering or adhesive. It shall be designed for use with inline compression type connectors, or indoor, outdoor, direct-burial or submerged locations.

2.5 PANELBOARDS: Panelboards for use as service disconnecting means shall conform with UL 869A. Panelboards shall be bolt-on type circuit breaker-equipped. Design shall be such that any individual breakers can be removed without disturbing adjacent units or without loosening or removing supplemental insulation supplied as means of obtaining clearances as required by UL."Specific breaker placement" is required in panelboards to match the breaker placement indicated in the panelboard schedule on the drawings. Main breaker shall be "separately" mounted above or below the branch breakers. Where "space only" is indicated, make provisions for future installation of breakers. Directories shall indicate load served by each circuit in panelboard. Directories shall also indicate source of service of the panelboard. Type directories and mount in holder behind transparent protective covering. Panelboards shall be locally fabricated by "LJ Industrial Fabrication", "Asiaphil", "KC Industrial" or "Fuji-Haya Electric".

2.5.1 Enclosure: Enclosures shall meet the requirements of UL 50. All cabinets shall be fabricated from stainless steel sheet of not less than 2.0 mm (14 gauge), with full seam-welded box ends. Front edges of cabinets shall be form-flanged or fitted with structural shapes welded or riveted to the sheet steel, for supporting the panelboard front. All cabinets shall be so fabricated that no part of any surface on the finished cabinet shall deviate from a true plane by more than 3 mm (1/8 inch). Flush doors shall be mounted on hinges that expose only the hinge roll to view when the door is closed. Each door shall be fitted with a combined catch and lock, except that door over 600 mm (24 inches) long shall be provided with a three-point latch having a knob with a T-handle, and a cylinder lock. Two keys shall be provided for each lock, and all locks shall be keyed alike. Finished-head cap screws shall be provided for mounting the panelboard fronts on the cabinets.

2.5.2 Bus Bars: Bus bars shall be copper with silver-plated contact surfaces. Plating shall be a minimum of 0.005 mm (0.0002 inch) thick. Make bus connections and joints with hardened steel bolts. The through-bus shall be rated at the full ampacity of the main throughout the board. Phase bus bars shall be insulated with an epoxy finish coating powder providing a minimum breakage voltage of 16,000 volts per ASTM D 149.

2.5.3 Buses: Support bus bars on bases independent of the circuit breakers. Main buses and back pans shall be designed so that breakers may be changed without machining, drilling, or tapping. Provide an isolated neutral bus in each panel for connection of circuit neutral conductors. Provide a separate ground bus identified as equipment grounding bus per UL 67 for connecting grounding conductors; bond to steel cabinet.

2.5.4 Circuit Breakers: Circuit breakers shall be UL 489 listed, bolt-on, thermal magnetic-type having a minimum short-circuit current rating equal to the short-circuit current rating of the panelboard in which the circuit breaker is mounted. Equipped the breakers with dual-rated terminal lugs and connectors. Plug-in circuit breakers are unacceptable. Circuit breakers shall be "Square D", "Seimens", "GE", or "ABB".

2.5.5 Multipole Breakers: Provide common trip-type with single operating handle. Breaker design shall be such that overload in one pole automatically causes all poles to open. Maintain phase sequence throughout each panel so that any three adjacent breaker poles are connected to Phases A, B, and C, respectively.

2.5.6 Transformers: Transformer shall be NEMA ST 20 approved, general purpose, dry-type, self-cooled ventilated or unventilated. The transformer shall form as integral prt of the

panelboard. Transformers shall have 180 degrees C insulationwith temperature rise not exceeding 115 degrees C under full-rated load in maximum ambient of 40 degrees C. Transformer of 115 degrees C temperature rise shall be capable of carrying continuously 115 percent of nameplate kVA without exceeding insulation rating. Transformer shall be quiet type with maximum sound level at least 3 decibels less than the NEMA standard level for transformer ratings indicated. Provide four 2-1/2 percent full capacity taps, 2 above and 2 below rated primary voltage. Transformer windings shall be copper. Transformers shall be "Federal Pacific", "GE", "Square D" or approved equal.

2.6 TAPE:

2.6.1 Insulating Tape: UL 510 listed, plastic insulating tape, capable of performing in a continuous temperature environment of 80 degrees C.

2.6.2 Buried Warning and Identification Tape: Provide detectable tape

2.6.3 Fireproofing Tape: Provide tape composed of a flexible conformable unsupported intumescent elastomer. Tape shall be not less than 0.762 mm (0.030 inch thick), noncorrosive to cable sheath, self-extinguishing, noncombustible, and shall not deteriorate when subjected to oil, water, gases, salt water, sewage, and fungus.

2.7 PULL ROPE: Pull rope shall be plastic or flat pull line (bull line) having a minimum tensile strength of 890 N (200 pounds).

2.8 GROUNDING AND BONDING:

2.8.1 Driven Ground Rods: Provide UL listed copper-clad steel ground rods conforming to UL 467 not less than 19 mm (3/4 inch) in diameter by 3.1 m (10 feet) in length. Sectional type rods may be used for rods 20 feet or longer.

2.8.2 Grounding Conductors Stranded-bare copper conductors shall conform to ASTM B 8, Class B, soft-drawn unless otherwise indicated. Solid-bare copper conductors shall conform to ASTM B 1 for sizes 8.0 mm2 (8 AWG) and smaller. Insulated conductors shall be of the same material as phase conductors and green color-coded, except that conductors shall be rated no more than 600 volts. Aluminum is not acceptable.

2.9 CAST-IN-PLACE CONCRETE: Provide concrete for encasement of underground ducts with 20 MPa (3,000 psi) minimum 28-day compressive strength. Concrete associated with electrical work for other than encasement of underground ducts shall be 30 MPa (4,000 psi) minimum 28-day compressive strength unless specified otherwise.

2.10 UNDERGROUND STRUCTURES: Provide precast concrete underground structures or standard type cast-in-place manhole types as indicated, conforming to ASTM C 857 and ASTM C 478M ASTM C 478. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Locate duct entrances and windows near the corners of structures to facilitate cable racking. Covers shall fit the frames without undue play. Form steel and iron to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place

before depositing concrete. Install a pulling-in iron in the wall opposite each duct line entrance. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable.

2.10.1 Cast-In-Place Structures: Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Concrete block shall conform to ASTM C 139.

2.10.2 Precast Concrete Structures, Risers and Tops: In lieu of cast-in-place, Contractors, at their option, may provide precast concrete underground structures subject to the requirements specified below. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete products, including precast manholes.

2.10.2.1 General: Precast concrete structures shall have the same accessories and facilities as required for cast-in-place structures. Likewise, precast structures shall have plan area and clear heights not less than those of cast-in-place structures. Concrete materials and methods of construction shall be the same as for cast-in-place concrete construction, as modified herein. Slope in floor may be omitted provided precast sections are poured in reinforced steel forms. Concrete for precast work shall have a 28-day compressive strength of not less than 30 MPa (4,000 psi). Structures may be precast to the design and details indicated for cast-in-place construction, precast monolithically and placed as a unit, or structures may be assembled sections, designed and produced by the manufacturer in accordance with the requirements specified. Structures shall be identified with the manufacturer's name embedded in or otherwise permanently attached to an interior wall face.

2.10.2.2 Design for Precast Structures: Design shall conform to ACI 318M. In the absence of detailed on-site soil information, design for the following soil parameters/site conditions:

a. Angle of Internal Friction (phi) = 0.523 rad (30 degrees);
b. Unit Weight of Soil (Dry) = 1760 kg/m^3 (110 pcf), (Saturated) = 2080 kg/m^3 (130 pcf);
c. Coefficient of Lateral Earth Pressure (Ka) = 0.33;
d. Ground Water Level = 915 mm (3 feet) below ground elevation;
e. Vertical design loads shall include full dead, superimposed dead, and live loads including a 30 percent magnification factor for impact. Live loads shall consider all types and magnitudes of vehicular (automotive, industrial, or aircraft) traffic to be encountered. The minimum design vertical load shall be for H20 highway loading per AASHTO HB-17;
f. Horizontal design loads shall include full geostatic and hydrostatic pressures for the soil parameters, water table, and depth of installation to be encountered. Also, horizontal loads imposed by adjacent structure foundations, and horizontal load components of vertical design loads, including impact, shall be considered, along with a pulling-in iron design load of 26,700 N (6,000 pounds);
g. Each structural component shall be designed for the load combination and positioning resulting in the maximum shear and moment for that particular component;

h. Design shall also consider the live loads induced in the handling, installation, and backfilling of the manholes. Provide lifting devices to ensure structural integrity during handling and installation.

2.10.2.3 Construction: Structure top, bottom, and wall shall be of a uniform thickness of not less than 150 mm (6 inches). Thin-walled knock-out panels for designed or future duct bank entrances shall not be permitted. Quantity, size, and location of duct bank entrance windows shall be as directed, and cast completely open by the precaster. Size of windows shall exceed the nominal duct bank envelope dimensions by at least 305 mm (12 inches) vertically and horizontally to preclude in-field window modifications made necessary by duct bank misalignment. However, the sides of precast windows shall be a minimum of 150 mm (6 inches) from the inside surface of adjacent walls, floors, or ceilings. Form the perimeter of precast window openings to have a keyed or inward flared surface to provide a positive interlock with the mating duct bank envelope. Provide welded wire fabric reinforcing through window openings for in-field cutting and flaring into duct bank envelopes. Provide additional reinforcing steel comprised of at least two No. 4 bars around window openings. Provide drain sumps a minimum of 305 mm (12 inches) in diameter and 100 mm (4 inches) deep for precast structures.

2.10.2.4 Joints: Provide tongue-and-groove joints on mating edges of precast components. Shiplap joints are not allowed. Design joints to firmly interlock adjoining components and to provide waterproof junctions and adequate shear transfer. Seal joints watertight using preformed plastic strip conforming to AASHTO M 198, Type B. Install sealing material in strict accordance with the sealant manufacturer's printed instructions. Provide waterproofing at conduit/duct entrances into structures, and where access frame meets the top slab, provide continuous grout seal.

2.10.3 Handhole Frames and Covers: Frames and covers of steel shall be welded by qualified welders in accordance with standard commercial practice. Steel covers shall be rolled-steel floor plate having an approved anti-slip surface. Hinges shall be of wrought steel, 125 by 125 mm (5 by 5 inches by) approximately 4.75 mm (3/16 inch) thick, without screw holes, and shall be for full surface application by fillet welding. Hinges shall have non-removable pins and five knuckles. The surfaces of plates under hinges shall be true after the removal of raised anti-slip surface, by grinding or other approved method.

2.11 CABLE SUPPORTS (RACKS, ARMS, AND INSULATORS): The metal portion of racks and arms shall be zinc-coated after fabrication.

2.11.1 Cable Racks: The wall bracket shall be 100 mm (4 inches) by approximately 38 mm by 4.76 mm (1-1/2 inch by 3/16 inch) channel steel, 1,220 mm (48 inches) long (minimum) in manholes. Slots for mounting cable rack arms shall be spaced at 200 mm (8 inch) intervals.

2.11.2 Rack Arms: Cable rack arms shall be steel or malleable iron or glass reinforced nylon and shall be of the removable type. Rack arm length shall be a minimum of 200 mm (8 inches) and a maximum of 305 mm (12 inches).

2.11.3 Insulators: Insulators for metal rack arms shall be dry-process glazed porcelain. Insulators are not required for nylon arms.

PART 3 - EXECUTION

3.1 INSTALLATION: Install equipment and devices in accordance with the manufacturer's published instructions and with the requirements and recommendations of the latest edition of the Philippine Electrical Code (PEC 2009), NFPA 70 and IEEE C2 as applicable. In addition to these requirements, install telecommunications in accordance with TIA-758-A and RUS Bull 1751F-644.

3.2 CABLE INSPECTION: Prior to installation, each cable reel shall be inspected for correct storage positions, signs of physical damage, and broken end seals. If end seal is broken, moisture shall be removed from cable prior to installation in accordance with the cable manufacturer's recommendations.

3.3 CABLE INSTALLATION PLAN AND PROCEDURE: The Contractor shall obtain from the manufacturer an installation manual or set of instructions which address such aspects as cable construction, insulation type, cable diameter, bending radius, cable temperature limits for installation, lubricants, coefficient of friction, conduit cleaning, storage procedures, moisture seals, testing for and purging moisture, maximum allowable pulling tension, and maximum allowable sidewall bearing pressure. The Contractor shall then perform pulling calculations and prepare a pulling plan which shall be submitted along with the manufacturer’s instructions. Cable shall be installed strictly in accordance with the cable manufacturer's recommendations and the approved installation plan. Calculations and pulling plan shall include:

a. Site layout drawing with cable pulls identified in numeric order of expected pulling sequence and direction of cable pull;
b. List of cable installation equipment;
c. Lubricant manufacturer's application instructions;
d. Procedure for resealing cable ends to prevent moisture from entering cable;
e. Cable pulling tension calculations of all cable pulls;
f. Cable percentage conduit fill;
g. Cable sidewall bearing pressure;
h. Cable minimum bend radius and minimum diameter of pulling wheels used;
i. Cable jam ratio;
j. Maximum allowable pulling tension on each different type and size of conductor;
k. Maximum allowable pulling tension on pulling device.

3.4 UNDERGROUND STRUCTURE CONSTRUCTION: Provide standard type cast-in-place construction as specified herein and as indicated, or precast construction as specified herein. Horizontal concrete surfaces of floors shall have a smooth trowel finish. Cure concrete by applying two coats of white pigmented membrane forming-curing compound in strict accordance with the manufacturer's printed instructions, except that precast concrete may be steam cured. Curing compound shall conform to ASTM C 309. Locate duct entrances and windows in the center of end walls (shorter) and near the corners of sidewalls (longer) to facilitate cable racking and splicing. Covers for underground structures shall fit the frames without undue play. Steel and iron shall be formed to shape and size with sharp lines and angles. Castings shall be free from warp and blow holes that may impair strength or appearance. Exposed metal shall have a smooth finish and sharp lines and arises. Provide

necessary lugs, rabbets, and brackets. Set pulling-in irons and other built-in items in place before depositing concrete.

3.4.1 Cast-In-Place Concrete Structures: Construct walls on a footing of cast-in-place concrete except that precast concrete base sections may be used for precast concrete manhole risers. Provide concrete block conforming to ASTM C.

3.4.2 Precast Concrete Construction: Set commercial precast structures on 150 mm (6 inches) of level, 90 percent compacted granular fill, 19 mm to 25 mm (3/4 inch to 1 inch) size, extending 305 mm (12 inches) beyond the structure on each side. Compact granular fill by a minimum of four passes with a plate type vibrator. Installation shall additionally conform to the manufacturer's instructions.

3.4.3 Pulling-In Irons: Provide steel bars bent as indicated, and cast in the walls and floors. Alternatively, pipe sleeves may be precast into the walls and floors where required to accept U-bolts or other types of pulling-in devices possessing the strengths and clearances stated herein. The final installation of pulling-in devices shall be made permanent. Cover and seal exterior projections of thru-wall type pulling-in devices with an appropriate protective coating. In the floor the irons shall be a minimum of 150 mm (6 inches) from the edge of the sump, and in the walls the irons shall be located within 150 mm (6 inches) of the projected center of the duct bank pattern or precast window in the opposite wall. However, the pulling-in iron shall not be located within 150 mm (6 inches) of an adjacent interior surface, or duct or precast window located within the same wall as the iron. If a pulling-in iron cannot be located directly opposite the corresponding duct bank or precast window due to this clearance limitation, locate the iron directly above or below the projected center of the duct bank pattern or precast window the minimum distance required to preserve the 150 mm (6 inch) clearance previously stated. In the case of directly opposing precast windows, pulling-in irons consisting of a 915 mm (3 foot) length of No. 5 reinforcing bar, formed into a hairpin, may be cast-in-place within the precast windows simultaneously with the end of the corresponding duct bank envelope. Irons installed in this manner shall be positioned directly in line with, or when not possible, directly above or below the projected center of the duct bank pattern entering the opposite wall, while maintaining a minimum clear distance of 75 mm (3 inches) from any edge of the cast-in-place duct bank envelope or any individual duct. Pulling-in irons shall have a clear projection into the structure of approximately 100 mm (4 inches) and shall be designed to withstand a minimum pulling-in load of 26,700 N (6,000 pounds). Irons shall be hot-dipped galvanized after fabrication.

3.4.4 Cable Racks, Arms and Insulators: Cable racks, arms and insulators shall be sufficient to accommodate the cables. Racks in power manholes shall be spaced not more than 915 mm (3 feet) apart, and each manhole wall shall be provided with a minimum of two racks. Racks in signal manholes shall be spaced not more than 420 mm (16 1/2 inches) apart with the end rack being no further than 305 mm (12 inches) from the adjacent wall. Methods of anchoring cable racks shall be as follows:

a. Provide a 15 mm diameter by 125 mm (5/8 inch diameter by 5 inch) long anchor bolt with 75 mm (3 inch) foot cast in structure wall with 50 mm (2 inch) protrusion of threaded portion of bolt into structure. Provide 15 mm (5/8 inch) steel square head nut on each anchor bolt. Coat threads of anchor bolts with suitable coating immediately prior to installing nuts;
b. Provide concrete channel insert with a minimum load rating of 1,192 kg per meter (800 pounds per foot). Insert channel shall be steel of the same length as "vertical rack channel;" channel insert shall be cast flush in structure wall. Provide 15 mm (5/8 inch)

steel nuts in channel insert to receive 15 mm diameter by 75 mm (5/8 inch diameter by 3 inch) long steel, square head anchor bolts;

c. Provide concrete "spot insert" at each anchor bolt location, cast flush in structure wall. Each insert shall have minimum 365 kg (800 pound) load rating. Provide 15 mm diameter by 75 mm (5/8 inch diameter by 3 inch) long steel, square head anchor bolt at each anchor point. Coat threads of anchor bolts with suitable coating immediately prior to installing bolts.

3.4.5 Field Painting: Cast-iron frames and covers not buried in concrete or masonry shall be cleaned of mortar, rust, grease, dirt and other deleterious materials, and given a coat of bituminous paint.

3.5 UNDERGROUND CONDUIT AND DUCT SYSTEMS:

3.5.1 Requirements: Depths to top of the conduit shall be in accordance with PEC 2009 and NFPA 70. Run conduit in straight lines except where a change of direction is necessary. Numbers and sizes of ducts shall be as indicated. Ducts shall have a continuous slope downward toward underground structures and away from buildings, laid with a minimum slope of 100 mm per 30 m (4 inches per 100 feet). Depending on the contour of the finished grade, the high-point may be at a terminal, a manhole, a handhole, or between manholes or handholes. Short-radius manufactured 90-degree duct bends may be used only for pole or equipment risers, unless specifically indicated as acceptable. The minimum manufactured bend radius shall be 450 mm (18 inches) for ducts of less than 80 mm (3 inch) diameter, and 900 mm (36 inches) for ducts 80 mm (3 inches) or greater in diameter. Otherwise, long sweep bends having a minimum radius of 7.6 m (25 feet) shall be used for a change of direction of more than 5 degrees, either horizontally or vertically. Both curved and straight sections may be used to form long sweep bends, but the maximum curve used shall be 30 degrees and manufactured bends shall be used. Ducts shall be provided with end bells whenever duct lines terminate in structures.

3.5.2 Treatment: Ducts shall be kept clean of concrete, dirt, or foreign substances during construction. Field cuts requiring tapers shall be made with proper tools and match factory tapers. A coupling recommended by the duct manufacturer shall be used whenever an existing duct is connected to a duct of different material or shape. Ducts shall be stored to avoid warping and deterioration with ends sufficiently plugged to prevent entry of any water or solid substances. Ducts shall be thoroughly cleaned before being laid. Plastic ducts shall be stored on a flat surface and protected from the direct rays of the sun.

3.5.3 Conduit Cleaning: As each conduit run is completed, for conduit sizes 75 mm (3 inches) and larger, draw a flexible testing mandrel approximately 305 mm (12 inches) long with a diameter less than the inside diameter of the conduit through the conduit. After which, draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs. For conduit sizes less than 75 mm (3 inches), draw a stiff bristle brush through until conduit is clear of particles of earth, sand and gravel; then immediately install conduit plugs.

3.5.4 Jacking and Drilling Under Roads and Structures: Conduits to be installed under existing paved areas which are not to be disturbed, and under roads and railroad tracks, shall be zinc-coated, rigid steel, jacked into place. Where ducts are jacked under existing pavement, rigid steel conduit will be installed because of its strength. To protect the corrosion-resistant conduit coating, pre-drilling or installing conduit inside a larger iron pipe sleeve (jack-and-sleeve) is required. For crossings of existing railroads and airfield pavements greater than 15 m (50 feet) in length, the pre-drilling method or the jack-and-sleeve method will be used.

Separators or spacing blocks shall be made of steel, concrete, plastic, or a combination of these materials placed not farther apart than 1.2 m (4 feet) on centers. Hydraulic jet method shall not be used.

3.5.5 Galvanized Conduit Concrete Penetrations: Galvanized conduits which penetrate concrete (slabs, pavement, and walls) in wet locations shall be PVC coated and shall extend from at least 50 mm (2 inches) within the concrete to the first coupling or fitting outside the concrete (minimum of 150 mm (6 inches) from penetration).

3.5.6 Multiple Conduits: Separate multiple conduits by a minimum distance of 65 mm (2 1/2 inches), except that light and power conduits shall be separated from control, signal, and telephone conduits by a minimum distance of 300 (12 inches). Stagger the joints of the conduits by rows (horizontally) and layers (vertically) to strengthen the conduit assembly. Provide plastic duct spacers that interlock vertically and horizontally. Spacer assembly shall consist of base spacers, intermediate spacers, ties, and locking device on top to provide a completely enclosed and locked-in conduit assembly. Install spacers per manufacturer's instructions, but provide a minimum of two spacer assemblies per 3,050 mm (10 feet) of conduit assembly.

3.5.7 Conduit Plugs and Pull Rope: New conduit indicated as being unused or empty shall be provided with plugs on each end. Plugs shall contain a weephole or screen to allow water drainage. Provide a plastic pull rope having 915 mm (3 feet) of slack at each end of unused or empty conduits.

3.5.8 Conduit and Duct Without Concrete Encasement: Provide not less than 75 mm (3 inches) clearance from the conduit to each side of the trench. Grade bottom of trench smooth; where rock, soft spots, or sharp-edged materials are encountered, excavate the bottom for an additional 75 mm (3 inches), fill and tamp level with original bottom with sand or earth free from particles, that would be retained on a 6.25 mm (1/4 inch) sieve. The first 150 mm (6 inch) layer of backfill cover shall be sand compacted as previously specified. The rest of the excavation shall be backfilled and compacted in 75 to 150 mm (3 to 6 inch) layers.

3.5.8.1 Encasement Under Roads and Structures: Under roads and paved areas, install conduits in concrete encasement of rectangular cross-section providing a minimum of 75 mm (3 inch) concrete cover around ducts. Concrete encasement shall extend at least 1,525 mm (5 feet) beyond the edges of paved areas and roads, and 3,660 mm (12 feet) beyond the rails on each side of railroad tracks.

3.5.9 Duct Encased in Concrete: Construct underground duct lines of individual conduits encased in concrete. Do not mix different kinds of conduit in any one duct bank. Concrete encasement surrounding the bank shall be rectangular in cross-section and shall provide at least 75 mm (3 inches) of concrete cover for ducts. Separate conduits by a minimum concrete thickness of 65 mm (2 1/2 inches), except separate light and power conduits from control, signal, and telecommunications conduits by a minimum concrete thickness of 75 mm (3 inches). Before pouring concrete, anchor duct bank assemblies to prevent the assemblies from floating during concrete pouring. Anchoring shall be done by driving reinforcing rods adjacent to duct spacer assemblies and attaching the rods to the spacer assembly.

3.6 CABLE PULLING: Test existing duct lines with a mandrel and thoroughly swab out to remove foreign material before pulling cables. Pull cables down grade with the feed-in point at the manhole or buildings of the highest elevation. Use flexible cable feeds to convey cables through manhole opening and into duct runs. Do not exceed the specified cable

bending radii when installing cable under any conditions, including turn-ups into switches, transformers, switchgear, switchboards, and other enclosures. Cable with tape or wire shield shall have a bending radius not less than 12 times the overall diameter of the completed cable. If basket-grip type cable-pulling devices are used to pull cable in place, cut off the section of cable under the grip before splicing and terminating.

3.6.1 Cable Lubricants: Use lubricants that are specifically recommended by the cable manufacturer for assisting in pulling jacketed cables.

3.7 CONDUCTORS INSTALLED IN PARALLEL: Conductors shall be grouped such that each conduit of a parallel run contains 1 Phase A conductor, 1 Phase B conductor, 1 Phase C conductor, and 1 neutral conductor.

3.8 LOW VOLTAGE CABLE SPLICING AND TERMINATING: Make terminations and splices with materials and methods as indicated or specified herein and as designated by the written instructions of the manufacturer. Do not allow the cables to be moved until after the splicing material has completely set. Make splices in underground distribution systems only in accessible locations such as manholes, handholes, or aboveground termination cabinets.

3.8.1 Terminating Aluminum Conductors:

a. Use particular care in making up joints and terminations. Remove surface oxides by cleaning with a wire brush or emery cloth. Apply joint compound to conductors, and use UL-listed solid aluminum connectors for connecting aluminum conductors. When connecting aluminum to copper conductors, use connectors specifically designed for this purpose;

b. Terminate aluminum conductors to copper bus either by: (1) in line splicing a copper pigtail to the aluminum conductor (copper pigtail shall have a ampacity at least that of the aluminum conductor); or (2) using a circumferential compression type, aluminum bodied terminal lug UL listed for AL/CU and steel Belleville spring washers, flat washers, bolts, and nuts. Belleville spring washers shall be cadmium-plated hardened steel. Install the Belleville spring washers with the crown up toward the nut or bolt head, with the concave side of the Belleville bearing on a heavy-duty, wide series flat washer of larger diameter than the Belleville. Tighten nuts sufficient to flatten Belleville and leave in that position. Lubricate hardware with joint compound prior to making connection. Wire brush and apply joint compound to conductor prior to inserting in lug;

c. Terminate aluminum conductors to aluminum bus by using all-aluminum nuts, bolts, washers, and lugs. Wire brush and apply inhibiting compound to conductor prior to inserting in lug. Lubricate hardware with joint compound prior to making connection; if bus contact surface is unplated, scratch-brush and coat with joint compound (without grit).

3.9 GROUNDING SYSTEMS: Provide grounding system as indicated, in accordance with PEC 2009 and NFPA 70 and IEEE C2, and as specified herein. Noncurrent-carrying metallic parts associated with electrical equipment shall have a maximum resistance to solid earth ground not exceeding the following values:

a. Pad-mounted transformers without protective fences = 5 ohms;
b. Ground in manholes = 5 ohms;
c. Grounding other metal enclosures of primary voltage electrical and electrically-operated equipment = 5 ohms.

3.9.1 Grounding Electrodes Provide UL listed cone pointed driven ground rods driven full depth plus 300 mm (12 inches), installed to provide an earth ground of the appropriate value for the particular equipment being grounded. If the specified ground resistance is not met, an additional ground rod shall be provided in accordance with the requirements of NFPA 70 (placed not less than 6 feet from the first rod). Should the resultant (combined) resistance exceed the specified resistance, measured not less than 48 hours after rainfall, the Owner shall be notified immediately.

3.9.2 Grounding Connections: Make grounding connections which are buried or otherwise normally inaccessible, by exothermic weld or compression connector.

a. Make exothermic welds strictly in accordance with the weld manufacturer's written recommendations. Welds which are "puffed up" or which show convex surfaces indicating improper cleaning are not acceptable. Mechanical connectors are not required at exothermic welds;
b. Make compression connections using a hydraulic compression tool to provide the correct circumferential pressure. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

3.9.3 Grounding Conductors: Provide bare grounding conductors, except where installed in conduit with associated phase conductors. Ground cable sheaths, cable shields, conduit, and equipment with 14 mm^2 (6 AWG) conductor. Ground other noncurrent-carrying metal parts and equipment frames of metal-enclosed equipment. Ground metallic frames and covers of handholes and pull boxes with a braided, copper ground strap with equivalent ampacity of 14 mm^2 (6 AWG). Provide direct connections to the grounding conductor with 600 V insulated, full-size conductor for each grounded neutral of each feeder circuit, which is spliced within the manhole.

3.9.4 Ground Cable Crossing Expansion Joints: Protect ground cables crossing expansion joints or similar separations in structures and pavements by use of approved devices or methods of installation which provide the necessary slack in the cable across the joint to permit movement. Use stranded or other approved flexible copper cable across such separations.

3.10 EXCAVATING, BACKFILLING, AND COMPACTING: Provide in accordance with PEC 2009 and NFPA 70 .

3.10.1 Reconditioning of Surfaces:

3.10.1.1 Unpaved Surfaces: Restore to their original elevation and condition unpaved surfaces disturbed during installation of duct or direct burial cable. Preserve sod and topsoil removed during excavation and reinstall after backfilling is completed. Replace sod that is damaged by sod of quality equal to that removed. When the surface is disturbed in a newly seeded area, re-seed the restored surface with the same quantity and formula of seed as that used in the original seeding, and provide topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

3.10.1.2 Paving Repairs Where trenches, pits, or other excavations are made in existing roadways and other areas of pavement where surface treatment of any kind exists, restore such surface treatment or pavement the same thickness and in the same kind as previously existed, except as otherwise specified, and to match and tie into the adjacent and surrounding existing surfaces.

3.11 CAST-IN-PLACE CONCRETE: Provide concrete in accordance with Section CAST-IN-PLACE .

3.11.1 Concrete Slabs for Equipment: Unless otherwise indicated, the slab shall be at least 200 mm 8 inches thick, reinforced with a 152 mm x 152 mm - MW19 by MW19 (6 by 6 - W2.9 by W2.9) mesh, placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inch) thick, well-compacted gravel base. Top of concrete slab shall be approximately 100 mm (4 inches) above finished grade with gradual slope for drainage. Edges above grade shall have 15 mm (1/2 inch) chamfer. Slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Stub up conduits, with bushings, 50 mm (2 inches) into cable wells in the concrete pad. Coordinate dimensions of cable wells with transformer cable training areas.

3.11.2 Sealing: When the installation is complete, the Contractor shall seal all conduit and other entries into the equipment enclosure with an approved sealing compound. Seals shall be of sufficient strength and durability to protect all energized live parts of the equipment from rodents, insects, or other foreign matter.