SPECIFICATION 601 – STRUCTURAL CONCRETE

601-1 DESCRIPTION

601-1.01 Scope

a. This work shall consist of furnishing, placing, finishing and curing portland cement concrete in bridges, culverts, retaining walls and other structures in accordance with these specifications and in conformity with the lines, grades and dimensions shown on the plans or established by the Engineer. Concrete in bridge approach slabs is included in this work.

b. Portland cement concrete shall consist of a homogeneous mixture of portland cement, fine aggregate, coarse aggregate, water and admixtures, if required, proportioned and mixed according to these specifications.

601-2 MATERIALS

601-2.01 The following materials shall meet the applicable requirements specified in the following specifications:

Material	Specification
Portland Cement……..	701-1
Joint Fillers……..	705-1
Copper Water Stops or Flashing…….	705-5
Rubber and Neoprene Water Stops…….	705-6
Curing Materials…….	711-1
Air-entraining Admixtures……..	711-2
Chemical Admixtures…….	711-3
Water……...	712-1
Bearings and Expansion Plates, Bronze and Copper Alloy……	715-7
Other Metallic Materials…….	715
Elastomeric Bearing……	717
Rubble Stone……...	718-2

601-2.02 Fine Aggregate - Shall meet the requirements of Article 703-1 of Specification 703 - Aggregates, except that manufactured sand shall not be used as fine aggregate for concrete which will serve as the travel surface for vehicular traffic such as bridge decks and bridge approach slabs. The same source of sand shall be used for all faces of a concrete structure exposed to view.

601-2.03 Coarse Aggregate - shall meet the requirements specified in Article 703-2 of Specification 703 - Aggregates, except that the gradings given in Table 703-2 are only suggested and not mandatory, provided the size limitations included in Table 601-1 of this specification are complied with. In addition, for concrete that is to serve as the travel way for vehicular traffic, such as bridge decks and bridge approach slabs, the coarse aggregate shall have a minimum polishing value of 48% as determined by ASTM D 3319.

601-2.04 Cement Requirements

a. The Contractor shall furnish mill certificates of compliance of the cement with the requirements of these specifications. Cement may also be accepted from pretested and approved bins. However, the Authority may sample and test the cement at any time, at its discretion.

b. Cement shall be protected from rain and moisture by storing in suitable weatherproof bins or buildings. Any cement damaged by moisture or which fails to meet any of the specified requirements will be rejected and shall be removed from the work site.

c. Cement stored by the Contractor for a period longer than 60 days shall require the Engineer's approval before being used in the work. Stored cement shall meet the specification requirements at any time after storage when retesting is ordered by the Engineer.

d. Cement of different brands, types, or from different mills shall be stored separately.

SPECIFICATION 601 – STRUCTURAL CONCRETE

601-2.05 Classes of Concrete - Five classes of concrete are provided for in these specifications, based on their specified compressive strength at 28 days. The various classes and their basic requirements are indicated in Table 601-1. Each class of concrete shall be used in that part of the structure as called for in the plans and other contract documents, or ordered by the Engineer.

TABLE 601-1

PORTLAND CEMENT CONCRETE MIXTURES

Class of Concrete	Specified Compressive Strength at 28 days (psi)	Max. Coarse Aggregate Size (sq. opening)	Design Slump Range* (inches)
A	3,000	1" with 5% max. passing No. 8	2 - 4
B	2,200	2" with 5% max. passing No. 4	1 - 4
D	5,000	1" with 5% max. passing No. 8	1 - 3
A-4	4,000	1" with 5% max. passing No. 8	2 - 4
A-6	6,000	1" with 5% max. passing No. 8	2 - 4
A-7	7,000	1" with 5% max. passing No. 8	2 - 4

Class of Concrete	Specified Compressive Strength at 28 days (psi)	Max. Coarse Aggregate Size (sq. opening)	Design Slump Range* (inches)
A-8	8,000	1" with 5% max. passing No. 8	2 - 4
A-9	9,000	1" with 5% max. passing No. 8	2 - 4

* These slump ranges may be modified for air-entrained concrete, slipform concrete, and for flowing concrete, subject to approval by the Engineer.

601-2.06 Proportioning of Concrete

a. The Contractor shall design the concrete mixes determining the proportions of portland cement, coarse and fine aggregate, and water necessary to conform to these specifications and to obtain concrete having not less than the strength specified for each class in Table 601-1. The volumetric proportioning methods such as outlined in the American Concrete Institute (ACI) Standard 211.1, "Recommended Practice for Selecting Proportions for Normal Weight Concrete", or other approved volumetric proportioning methods, shall be employed in the design of mixes. Separate mix designs shall be submitted for each mix to be used such as for travel way and otherwise, and whenever a change in fine or coarse aggregates is necessary.

b. The Contractor shall submit for the record, prior to the start of concreting operations, the proposed mix, including the aggregate gradings to be used, with certified laboratory reports on the tests performed on trial mixes. In the event that the proportions of concrete mixture designed by the Contractor do not produce concrete of the specified strength, the Contractor shall adjust the mix accordingly in order to

obtain the required strength, at no additional cost to the Authority, and shall submit new certified test results.

c. Whenever the Contractor modifies the concrete mix, other than minor adjustment in the relative quantities of fine and coarse aggregates, he shall submit copy of the new mix design to the Engineer together with copies of test results of the new mix.

d. In the event ready-mixed concrete from a commercial plant is used by the Contractor, such concrete and plant shall meet the requirements of AASHTO M-157 except as modified by these specifications and shall have been inspected and approved by the Authority for use on its projects within the last six months.

601-2.07 Air-entrained Concrete

a. Air-entrained concrete shall be used in structures or parts of structures wherever indicated on the plans. Air-entrained concrete, at the option of the Contractor, may be concrete containing an air-entraining admixture or an air-entraining portland cement.

b. In the event the Contractor elects to use an air-entraining admixture, he shall determine by trial the amount of the particular admixture that will produce concrete having the specified air content and this amount shall not be varied except as approved by the Engineer. The admixture shall be added during batching at the plant.

c. The contractor shall determine the proportions and batch weights for air-entrained concrete in the manner prescribed for regular concrete provided, however, that in making such adjustments as may be necessary by reason of air-entrainment, the minimum quantity of fine aggregate and the minimum quantity of water shall be used which will produce concrete of the required workability.

d. Air entrained concrete, in addition to conforming to the master limits shown in Table 601-1 for the class or classes specified, shall contain not less than 4 nor more than 6 percent entrained air determined by means of the test for air content, AASHTO T 152 (Pressure Method), AASHTO T 196 (Volumetric Method) or AASHTO T 199 (Chace meter). The Contractor shall provide the necessary testing equipment, as a subsidiary obligation under the concrete pay items, for testing by the Authority during placement.

601-2.08 Chemical Admixtures

a. Water reducing, set retarding, or superplasticizers chemical admixtures may be used at the option of the Contractor but subject to approval by the Engineer. The Contractor shall designate in advance the particular types, trade names and manufacturers of admixtures that he proposes to use and only such admixtures as are approved by the Engineer shall be incorporated into the concrete. Admixtures selected for use shall be compatible with all other components of the concrete.

b. Retarding admixtures may be used when the setting time of concrete must be retarded for proper placement. The quantity of admixture added to the mix shall be the minimum required for minimum retardation consistent with placing conditions. Retarding admixtures, when used, shall be added at the plant.

c. The use of calcium chloride as an admixture will not be permitted.

601-2.09 Sampling and Testing

a. Compliance with the applicable requirements included in the above articles will be determined in accordance with the following AASHTO standards:

Sampling Fresh Concrete……..	T 141
Size of Aggregates…….	T 27
Consistency (Slump)…….….	T 119
Weight per Cu. Ft. and Air Content…...	T 121 (Pressure Method) T 196 (Volumetric Method) Making and Curing Concrete Test
Specimens in the Field…….……	T 23
Compressive Strength of Cylindrical Concrete Specimens…….....	T 22
Sampling and Testing for Total Chloride Ion in Concrete and Concrete Raw Materials…….	T 260

b. Sampling frequency for compressive strength tests of concrete will be as follows:

1. One set of six cylinders shall be obtained for each 25 cubic meters of concrete or fraction thereof placed each day for testing at 7 and 28 days. The control unit for sampling, testing and acceptance purposes will be a lot which is defined as 25 cubic meters of concrete or fraction thereof placed each day.

2. For Class D concrete, additional sets of 3 cylinders each will be obtained as required to determine when the load transfer can be made on prestressed units or the tensioning of the steel initiated on post-tensioned units.

3. Additional sets of specimens will be made as needed to determine when forms may be removed or when a structure may be put into service, or if the Engineer deems it necessary to determine the acceptability of concrete.

4. The Contractor shall furnish at his expense all metal or single use plastic molds with lids, conforming to AASHTO M 205 and T 23, that are necessary to comply with the required frequency of sampling. As a subsidiary obligation, when using single use plastic molds, the Contractor shall furnish stripping tools for removing the sample from the mold. Cardboard molds will not be accepted.

5. The concrete for the test specimens will not be measured for payment but shall be furnished by the Contractor without additional compensation.

c. Slump tests, and air content tests when applicable, shall be made of the concrete from each batch from which test cylinders are taken. Additional slump tests will be made as determined by the Engineer to check the consistency of the concrete.

d. For concrete intended for use on the travel way for vehicular travel, samples will be taken of the fresh mix, the mortar will be washed out and the remaining aggregates will be tested for compliance with the requirements of Articles 601-2.02 and 601-2.03 of this specification as to manufactured sands and polishing value of the coarse aggregate.

601-2.10 Basis of Acceptance

a. In general, the acceptability of the quality of the concrete delivered to or made at the jobsite will be based on slump tests, air content test, aggregate tests and on the results of standard compressive strength tests of representative samples at 28 days as covered by these specifications. However, this does not relieve the responsibility of the Contractor for the concrete during placement, consolidation, finishing, curing and protection prior to final acceptance by the Highway Authority.

b. Failure of the fine and coarse aggregate to meet the polishing value requirements may be cause for the rejection and removal of concrete for use on vehicular travel ways.

c. Concrete shall be placed at a slump as nearly consistent with the design mix value as is practical. Any batches with slumps varying from the design mix specified values by more than the tolerances shown below will be rejected for use in the work.

Specified Slump	Tolerance
3 in. or less	+ ½ in.
More than 2 in. to 4 in.	+ 1 in.
Greater than 4 in.	+ 1 1/2 in.

d. Air content, when specified, shall be within ±2% of the design value. Any batches with air content exceeding this tolerance will be rejected for use in the work.

e. The compressive strength of the quantity of concrete placed and represented by one set of cylinders shall be determined as the average of the three cylinders comprising the set. If any cylinder shows evidence of improper sampling, molding, handling, curing or testing, the test result of such defective cylinder shall be discarded and the compressive strength of the concrete represented shall be determined from the test results of the remaining cylinders. Low strength shall not be a basis for discarding a cylinder test result.

f. The compressive strength level of an individual class of concrete will be considered satisfactory if both of the following requirements are met:

1. The moving average of all sets of three consecutive strength tests equals or exceeds the specified compressive strength. The following applies to the computation of the moving average:

(a) The first moving average value shall be computed by averaging the test results of the first three sets of cylinders. Subsequent moving average values shall be computed by dropping the test result of the first cylinder set in the previous average, adding the test results of the next cylinder set and computing a new average.

(b) The cylinder strength test values shall be entered into the moving average computations in the same chronological order that the concrete is delivered and sampled.

(c) Test values of cylinder sets representative of concrete that fails to meet the acceptance criteria and is rejected and removed will be eliminated from the moving average computation.

2. No individual strength test (average of cylinders set) falls below the specified compressive strength by more than 500 psi.

g. Should concrete used in the work fail to conform to the requirements in paragraph "f" above, the Contractor shall, at his expense, make corrective changes, subject to the approval of the Engineer, in the material mix proportions or in the concrete fabrication procedures, before placing additional concrete. In addition, such corrective changes shall be made when the compressive strength of concrete tested at 7 days consistently indicates that the concrete will not attain the specified compressive strength at 28 days.

h. When the moving average fails to meet the compressive strength requirement, the in-place concrete will be considered deficient but will be accepted, if the deficiency in the moving average does not exceed 300 psi and if no individual cylinders set is deficient by more than 500 psi, but

payment for the concrete represented by the failing averages will be at a reduced unit price as specified in Article 601-5.05. When the moving average is deficient by more than 300 but not over 500 psi and no individual cylinder set is deficient by more than 500 psi, the deficient concrete may be accepted, at the discretion of the Authority, subject to a satisfactory structural analysis at the Contractor's expense and to applicable unit price reduction as per Article 601-5.05

i. All concrete represented by a cylinder set which shows a strength falling below the specified value by more than 500 psi will be considered deficient and will be rejected.

j. The Contractor may elect to drill core samples of the hardened concrete classified as deficient under paragraphs "h" and "i" above, at his expense but under the direction and supervision of the Engineer, to be tested at the Authority's laboratory. The following criteria shall govern the coring program:

1. The obtaining and testing of drilled cores shall be in accordance with AASHTO T 24 and T 22. Moisture conditioning shall be in accordance with paragraph 6.3 of T 24.

2. The cores shall be drilled no earlier than 28 days and no later than 56 days after the pouring of the concrete in question.

3. A minimum of three cores shall be taken for each 25 cubic meters, or fraction thereof, of concrete classified as deficient as a result of the cylinder tests, at random locations selected by the Engineer within each deficient lot.

4. The core strength for each 25 cubic meters, or fraction thereof shall be the average of all cores tested from each concrete lot. The concrete represented by the core tests will be considered acceptable if the average of

the cores is equal to at least 85 percent of the specified compressive strength and if no single core test is less than 75 percent of the specified compressive strength.

5. Should the first set of cores show deficient strength, the Contractor will have the option, at his expense, of obtaining one additional set of cores for further testing. This additional cores shall be drilled no later that 84 days after the pouring of the concrete in question, shall not exceed the number drilled for the first set and shall be subject to the criteria in paragraphs (1), (3) and (4) above. However, the results of all cores tested will be used in determining the average strength of the questioned concrete.

6. The Contractor shall repair at his expense the core holes.

k. Concrete that fails both the cylinder and core strength tests acceptance criteria will be rejected and shall be removed and disposed of at the Contractor's expense. In some cases, the location of rejected concrete may be such as to require the removal, at the Contractor's expense, of otherwise satisfactory concrete. The removal shall be performed in such a manner as will not cause damage to the remaining concrete or to other units of the structure.

l. When the cylinder tests results indicate that the concrete mix meets the specified strength but the Authority has reasonable doubts as to the actual strength of the in-place concrete due to deficiencies in the placing, consolidation, curing or protection of the concrete, the Authority may order the Contractor to have cores drilled following the procedures specified in paragraph "j" above. If these cores meet the acceptance criteria specified in "j" above, the Authority will bear the cost of the drilling, testing and repair. However, if the cores fail, the Contractor shall bear the cost and the concrete represented by the failing cores will be subject to rejection and removal as determined by the Authority.

SPECIFICATION 601 – STRUCTURAL CONCRETE

601-3 CONSTRUCTION REQUIREMENTS

601-3.01 General - Portland cement concrete may be produced at the project site or may be supplied by a commercial plant as ready-mixed concrete.

601-3.02 Measuring and Batching - Measuring and batching of materials shall be done at a batching plant. The measuring equipment and batching plant, and the measuring and batching procedures followed shall be in accordance with the requirements of AASHTO M 157.

601-3.03 Mixing and Delivery - Concrete may be mixed at a central plant, in truck mixers or at the site as described in these specifications. The mixing and delivery of concrete shall be in accordance with the requirements of AASHTO M 157 as modified and supplemented by the following paragraphs of this article.

a. The Contractor shall supply concrete at a rate consistent with placement operations as determined by the Engineer. The intervals between deliveries of batches shall not be so great as to allow the concrete in place to harden partially.

b. The Engineer may order discontinuing the use of any type of concrete mixing or transporting units that fail to meet the specification requirements.

c. Volumetric batching and continuous mixing mobile equipment may be used if approved by the Engineer. In such case, the batching and mixing shall be in accordance with AASHTO M 241.

d. When an approved retardant admixture is authorized, the 1-hour limitation between the introduction of the cement to the aggregates and discharge at the site may be increased by 30 minutes.

e. Concrete for bridge decks or for pavement which is to be delivered at an ambient temperature above 85°F shall be designed to include an approved retardant admixture.

f. The entire contents of the mixer shall be removed from the drum before materials for another batch are placed therein. Upon cessation of mixing for a period exceeding one hour the mixer shall be thoroughly cleaned. The delivery unit shall also be completely emptied, cleaned and free from concrete and wash water before receiving the next load of concrete.

g. When a truck mixer or agitator is approved for mixing or delivery of concrete, no water from the truck water system or elsewhere shall be added after the initial introduction of mixing water for the batch.

h. Certification of Batches - Before unloading at the site of delivery, the concrete supplier shall furnish to the Engineer delivery tickets containing the following information concerning the concrete in the truck. The tickets shall be issued to the truck operator at the proportioning plant for each load.

1. Name and number of batch plant.
2. Serial number of ticket.
3. Date and truck number.
4. Name of Contractor.
5. Specific designation of job (name and location).
6. Specific class of concrete in conformance with job specifications.
7. Volume of concrete (cubic yards).
8. For central mixed concrete, time when first mixing was completed at the central mix plant.
9. For transit mixed concrete and truck-mixed concrete, time when the cement was introduced to the aggregates.

10. Name of admixture, if any.

11. Spaces to indicate time when discharge commenced and when completed.

i. Small Construction Mixers - In miscellaneous work involving small quantities of concrete, the Engineer may permit the use of small construction mixers. Any concrete produced under such conditions shall be mixed not less than 90 seconds after all the materials are in the mixer drum and until a satisfactory consistency of the concrete is obtained.

j. Hand Mixing - Hand mixing may be authorized by the Engineer for miscellaneous work involving a very small quantity of concrete. In such case, the mixing shall be done on a clean and watertight platform and in such manner as to insure a uniform mixture of satisfactory consistency.

k. Delivery - The organization supplying concrete shall have sufficient plant capacity and transporting equipment to insure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of rehandling and without damage to the structure or the concrete.

l. Retempering - The concrete shall be mixed only in such quantities as are required for immediate use and any concrete which has developed initial set shall not be used. Retempering concrete by adding water or by other means will not be permitted.

601-3.04 Consistency

a. All concrete delivered or made at the job site shall show a slump within the tolerance limits specified in paragraph 601-2.10b.

b. Concrete shall be of such consistency and plasticity, and show the necessary cohesiveness that it will flow around reinforcing steel and that individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportional amount of sand.

601-3.05 Falsework

a. The Contractor shall be responsible for designing and constructing safe and adequate falsework which provides the necessary rigidity, supports the loads imposed, and produces in the finished structure the lines and grades indicated on the plans.

b. The Contractor shall furnish, upon request of the Engineer, detailed working drawings and design calculations of the falsework for bridges. The acceptance of such drawings and the falsework inspection by the Engineer will in no way relieve the Contractor of full responsibility for the adequacy and safety of the falsework.

c. Falsework which cannot be founded upon a solid footing shall be supported by falsework piling which shall be spaced, driven and removed in a manner approved by the Engineer. No additional compensation will be paid for the use and removal of falsework piling.

d. Falsework shall be set to give the finished structure the specified camber plus an allowance for shrinkage and settlement. The weight of the finishing screed for bridge decks and other construction loads and their effect on the required camber shall be considered by the Contractor in the design of the falsework.

e. Suitable screw jacks or hardwood wedges shall be incorporated into the falsework and adjusted to take up any settlement in the formwork either before or during the placing of concrete.

SPECIFICATION 601 – STRUCTURAL CONCRETE

601-3.06 Forms

a. Forms for all exposed concrete surfaces shall be made from one or more of the following materials:

1. Faced with exterior type plywood.

2. Lumber dressed at least on one side and two edges.

3. Metal

4. Plastic

5. Fiberglass

b. All forms shall be well constructed, carefully aligned, substantial and firm, securely based and fastened together in final position. They shall be strong enough to prevent the plastic concrete from bulging the forms between supports and to withstand the action of mechanical vibrators. They shall be so constructed as to produce mortar tight joints and smooth, even concrete surfaces.

c. Forms shall be designed to resist the pressure resulting from plastic concrete weighing 150 pounds per cubic foot, a live load allowance of 50 pound per square foot on horizontal surfaces, and other live loads incidental to the construction operations. Concrete misshapen by bulges or deformations caused by inadequate forms shall be removed or corrected as ordered by the Engineer at the Contractor's expense.

d. Forms shall be filleted and chamfered as shown on plans, and shall be given a bevel or draft in the case of all projections, such as girders and copings, to assure easy removal.

e. Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 2.5 centimeters from the face without injury to concrete. In case wire ties are permitted, suitable cones shall be provided. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in color.

f. Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that extraneous material may be removed from the forms immediately before placing the concrete.

g. All forms shall be treated with an approved form coating prior to placing reinforcement and wood forms shall be saturated with water immediately before placing the concrete. The form coating to be used can be of any acceptable commercial quality, which permit the ready release of the forms and will not discolor or stain the concrete.

h. The specifications for forms, as regards design, mortar tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and coating, also apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease or other foreign matter.

i. Stay-in-place metal forms will not be permitted unless specifically shown on the plans. In such case, the Contractor shall submit detailed shop drawings, samples, specifications and any other information complying with Specification 715.

j. All forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for periods which shall be determined as specified in Article 601-3.13. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.

k. Forms to be re-used shall be maintained in good conditions as to tightness and surface smoothness at all times. Any warped or bulged lumber shall be resized before being used. Unsatisfactory forms shall not be used and shall be removed immediately from the site of the work.

601-3.07 Handling and Placing Concrete

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

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

2. Concrete shall be placed so as to avoid segregation of material and the displacement of reinforcement. All equipment used for conveying the concrete mix shall be capable of meeting this requirement and is subject to approval by the Engineer. In case any conveyance equipment results in an inferior quality of concrete, the Engineer may

order discontinuance of its use and its substitution by a satisfactory method of placing. Concrete shall not come in contact with aluminum during conveyance and placing operations.

3. Open troughs and chutes shall be of metal or metal lined, except aluminum. Where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. All chutes throughs and pipes shall be kept clean and free from coating or hardened concrete by thoroughly flushing with water after each run.

4. Dropping concrete a distance of more than 1.5 meters or depositing a large quantity at any point and running or working it along the form shall not be permitted.

5. Special care shall be taken to fill each part of the form by depositing concrete directly into the forms at or as near to its final position as possible, to work the coarser aggregates back from the face of the concrete and to force the concrete under and around the reinforcement without displacing the reinforcement. After the concrete has taken its initial set, care shall be exercised to avoid jarring the forms or placing strain near the ends of reinforcement projecting out of the concrete.

6. Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provisions:

(a) The vibration shall be internal unless special authorization of other method is given by the Engineer.

(b) Vibrators shall be of a type and design approved by the Engineer. They shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4,500 impulses per minute. The Contractor shall have available at the job site a copy of the manufacturer's literature on the vibrators, showing that they comply with the above requirements.

(c) Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

(d) The Contractor shall provide a sufficient number of vibrators to properly compact each batch immediately after it is placed in the forms. Extra vibrators shall be on hand for emergency use and for use when other vibrators are being serviced. All vibrators shall be in satisfactory working conditions.

(e) Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and imbedded fixtures and into corners and angles of the forms but with care not to cause segregation.

(f) Vibration shall be applied at the point of deposit and in the areas of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete but shall not be continued at any one point to the extent that localized areas of grout or segregation of aggregates are created.

(g) Vibration shall not be applied directly or through the reinforcement to the sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation and vibrators shall not be used to push or distribute concrete laterally in the forms. The vibrating element shall be inserted in the concrete mass a sufficient depth to vibrate the bottom of each layer effectively, in as nearly a vertical position as practicable. It shall be withdrawn completely from the concrete before being advanced to the next point of application.

(h) To secure even and dense surfaces free from aggregate pockets or honeycombing, vibration shall be supplemented by such spading as is necessary to insure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with vibrators while the concrete is plastic.

(i) External vibration methods will be permitted by the Engineer when satisfactory results are demonstrated.

(j) The provisions of this paragraph shall apply to precast piling, concrete cribbing and other precast members except that if approved by the Engineer, the manufacturers' methods of vibration may be used.

7. When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth

to expose sound concrete. To avoid visible joints as far as possible on exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed and levelled whenever concreting is discontinued. Where a "feather edge" might be produced at a construction joint, as in the sloped top surface of a wing wall, an inset form shall be used to produce a blocked out portion in the preceding layer which shall produce an edge thickness of not less than 15 centimeters in the succeeding layer. Work shall not be discontinued within 45 centimeters of the top of any face, unless provision has been made for a coping less than 45 centimeters thick, in which case, if permitted by the Engineer, the construction joint may be made at the under side of the coping.

8. Immediately following the discontinuance of placing concrete, all accumulation of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcing steel.

9. The Contractor shall protect the concrete from the adverse effect of rain at all times during and immediately after placement. He shall have available adequate covering material to protect the exposed surfaces of unhardened concrete.

b. Culverts

1. The base slab or footing of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed.

2. In the construction of box culverts 1.5 meters or less in height, the sidewalls and top may be constructed as a monolith.

3. In the construction of box culverts more than 1.5 meters in height, the concrete in the walls shall be placed and allowed to set before the top slab is placed.

4. Each wing wall shall be constructed, if possible, as a monolith. Construction joints, where unavoidable, shall be as shown on the plans or approved by the Engineer.

c. Girders, Slabs and Columns

1. For simple spans, concrete shall be deposited by beginning at the center of the span and working from the center toward the ends unless otherwise directed by the Engineer. Concrete in girders shall be deposited uniformly for the full length of the girder.

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

3. The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified, in which case special shear anchorage shall be provided to insure monolithic action between girder and floor.

4. Concrete in T-beam or deck girder spans may be placed in one continuous operation or may be placed in two separate operations, each of which shall be continuous; first to the top of the girder stems, and second, to completion. In the latter case, the bond between stem and slab shall be positive and mechanical, and shall be secured by means of suitable shear keys on the top of the girder stem. The size and

location of these keys shall be as shown on the plans. The period between the girder stem pour and the slab pour shall be at least 24 hours. Before the second pour, the Contractor shall check the falsework for shrinkage and settlement and shall tighten wedges or screws to insure minimum deflections of stems when slab is poured.

5. Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 12 hours before the caps are placed unless otherwise shown on the plans.

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

601-3.08 Adverse Hot Weather Conditions

a. Concrete shall be properly protected from adverse hot weather conditions before, during and after placement. The initial concrete placement temperature shall not exceed 100°F (38°C). All necessary precautions shall be taken to see that the concrete is promptly placed on arrival at the job and immediately vibrated after placement. The concrete shall be protected from excessive drying during finishing and curing operations which shall be performed without delay as soon as the concrete is ready for them.

b. Concrete shall not be placed in bridge decks and other exposed slabs when any combination of air temperature, relative humidity, concrete temperature and wind speed is

expected to result in an evaporation rate in excess of 0.2 pound per square foot per hour. Table 601-2 may be used as a guide to determine concrete speeds and relative humidity combination at which evaporation rates in excess of 0.2 lb/ft.^{2}/hr, at an ambient temperature of 90°F, may be expected.

c. The Engineer may authorize, at his discretion, the placing of concrete in bridge desks and other exposed slabs at concrete temperatures in excess of the critical values if the Contractor submits for approval acceptable procedures which will effectively reduce the evaporation rate throughout the placement area to less than 0.2 lb/ft^2/hr. Such procedures shall include one or more of the following:

1. Shading and cooling aggregates and other components at the batching plant.

2. Dampening subgrade and forms.

3. Erecting windbreaks to effectively reduce the wind speeds throughout the placement area.

4. Placing concrete at the lowest possible temperature by reducing the time between mixing and placing.

5. Fog spraying throughout the placement area to effectively increase the relative humidity.

6. Placing concrete at lower ambient temperature such as early morning, late afternoon or at night.

d. Water reducing and retarding admixtures may be used to offset the undesirable effects of placing concrete at high temperatures provided the design mix requirements for the specified strength are met.

TABLE 601-2

TYPICAL CRITICAL CONCRETE TEMPERATURES FOR VARIOUS WIND SPEEDS AND RELATIVE HUMIDITIES(1)

Concrete Temperature (°F)	Relative Humidity % at 10 mph	Relative Humidity % at 15 mph	Relative Humidity % at 20 mph	Relative Humidity % at 25 mph
100	80	95	(2)	(2)
95	65	80	85	90
90	45	60	70	75
85	30	45	55	60
80	20	35	40	45
75	10	20	30	35

(1) Maximum concrete temperatures at an ambient temperature of 90ºF for different wind speeds and relative humidities to limit the rate of evaporation to about 0.2 lb/ft.^{2}/hr.

(2) Required relative humidities in excess of 100%.

601-3.09 Pneumatic Placing of Concrete

a. Pneumatic placing of concrete will be permitted only if specified in the contract documents or if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete. The use of aluminum and magnesium alloys pipes for placing concrete will not be allowed.

b. Where concrete is conveyed and placed by pneumatic means the equipment shall be suitable in kind and adequate in capacity for the work. The machine shall be located as close as practicable to the place of deposit. The position of the discharge end of the line shall not be more than 1.5 meters from the point of deposit. The discharge lines shall be horizontal or inclined upwards from the machine.

601-3.10 Pumping Concrete

a. Placement of concrete by pumping will be permitted only if specified in the contract documents or if authorized by the Engineer. The equipment shall be so arranged that no vibrations result which might damage freshly placed concrete. Equipment having components of aluminum and magnesium alloys in contact with the concrete shall not be permitted.

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

c. An admixture to aid in pumping the concrete may be used provided it has no deleterious effect on the concrete and subject to previous approval by the Engineer.

601-3.11 Construction Joints

a. Construction joints shall be shear key type and shall be made only where shown on the plans or in the pouring schedule, unless otherwise approved by the Engineer. If not detailed on the plans, or in the case of emergency, construction joints shall be placed as directed by the Engineer. Joints shall be perpendicular to the principal lines of stress and, in general, shall be located at points of

minimum shear. Necessary dowels, load transfer bars and bonding devices shall be placed as shown on the plans or directed by the Engineer.

b. Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened in a manner that will not leave loosened particles of aggregate or damaged concrete at the surface. It shall be thoroughly cleaned of foreign matter and laitance, and saturated with water. To insure an excess of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and saturated surface, including vertical and inclined surfaces, shall first be thoroughly covered with a thin coating of mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set.

c. The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation. At horizontal construction joints, gage strips 4 centimeters thick shall be placed inside the forms along all exposed faces to give the joints straight lines.

601-3.12 Expansion Joints

a. All expansion joints shall be located and constructed according to the details shown on the plans.

b. Open joints shall be placed at the locations shown on the plans and shall be constructed by the insertion and subsequent removal of a wood strip, metal or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the plans. Concrete corners shall be chamfered 2.5 centimeters or as shown on the plans.

c. Filled expansion joints shall be constructed similar to open joints. When premolded types are specified, the filler shall be placed correct position as the concrete on one side of the joints is placed. When the form is removed, the concrete on the other side shall be placed. Water stops shall be carefully placed as shown on the plans. When during construction, an opening of 0.3 cm. or more appears in any joint over which traffic will occur, the opening shall be completely filled with hot tar or asphalt as directed by the Engineer.

d. Premolded expansion joint fillers shall be used where called for on the plans or as authorized by the Engineer. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape by stapling or other positive fastening satisfactory to the Engineer.

e. The plates, angles or other structural shapes for steel joints shall be accurately shaped at the shop to conform to the section of the concrete floor. The fabrication and painting shall conform to the requirements of the specifications covering those items. When called for in the contract documents the material shall be galvanized in accordance with Specification 715 in lieu of painting. Care shall be taken to insure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that designated on the plans at normal temperature, and care shall be taken to avoid impairment of the clearance in any manner.

f. Water stops shall be furnished and placed as provided on the plans. They shall be spliced, welded, or soldered, to form continuous watertight joints.

601-3.13 Anchor Bolts and Bearing Devices

a. All necessary anchor bolts in piers, abutments or pedestals shall be accurately set either in the concrete as it is being placed or in holes formed while the concrete is being placed, or in holes drilled after the concrete has set. Preformed holes and drilled holes shall be at least 2.5 cm. in diameter larger than the bolts used. Bolts set in holes shall be permanently fixed with a non-shrink grout completely filling the holes.

b. Bearing plates, rockers and other expansion devices shall be constructed according to details shown on the plans. Unless set in plastic concrete or as otherwise specified, they shall be set in grout to insure uniform bearing.

c. The anchor bolts, rockers or other expansion devices shall be set to conform to the temperature at the time of erection.

d. When called for in the contract documents these materials shall be galvanized in lieu of painting.

601-3.14 Removal of Falsework and Forms

a. Falsework and forms shall not be removed without the consent of the Engineer, however, the Engineer's consent shall not relieve the Contractor of responsibility for the safety of the work.

b. When concrete strength tests are used for controlling the removal of forms and supports, such removal shall not begin until the concrete has attained the percentage of the design strength specified in the contract documents. Concrete strength tests used for this purpose may include, in addition to test cylinders, Penetration Resistance of Hardened Concrete (ASTM C 803), Rebound Number of Hardened Concrete (ASTM C 803) and Pullout Strength of Hardened Concrete (ASTM C 900), subject to approval by the Engineer.

c. If falsework and forms removal is not controlled by cylinder tests, the falsework and forms for the various parts of the structure shall not normally be removed before the time indicated below has elapsed after placing the concrete, unless otherwise specified in the contract documents or authorized by the Engineer. The exact number of days shall be determined by the Engineer and will be dependent on the class of concrete, curing conditions and other factors.

1.	Mass piers except pier caps, mass abutments, columns and wall faces (not supporting loads)...	1 day
2.	Traffic railing and median barriers…….	1 day
3.	Pier caps continuously supported……	7 days
4.	Slabs supported on stringers or prestressed concrete girders……..	7 days
5.	Box girders, continuous slabs, box culvert top slabs, centering under girders, beams an arches……..	14 days

d. Items (3), (4) and (5) above apply to falsework and forms supporting the full load of the concrete. Side forms and forms not supporting any loads may be removed after 12 hours to facilitate the finishing of exposed faces.

e. The above periods may be reduced as directed by the Engineer when early strength concrete is used.

f. Methods of form removal likely to cause overstressing of the concrete shall not be used. Supports shall be removed in such manner as to permit the concrete to uniformly and gradually take the stress due to its own weight.

g. Centers shall be gradually and uniformly lowered in such manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the

sequence of striking centers shall be specified or approved by the Engineer.

601-3.15 Depositing Concrete Under Water

a. Concrete, except for cofferdam seals, shall not be deposited under water except with the approval of the Engineer and under his immediate supervision. The method of placing concrete under water shall be as hereinafter described.

b. Concrete deposited under water shall be Class A concrete with 10 percent excess cement. No extra payment will be allowed for the excess cement used. To prevent segregation, the concrete shall be carefully placed in a compact mass, in its final position, by means of a tremie, a bottom dump bucket or other approved method, and shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit. Pumping shall be discontinued while depositing foundation concrete if it results in a flow of water inside the forms. The Contractor may submit for consideration the use of an appropriate additive to reduce the need for the excess cement.

c. Care shall be exercised to prevent the formation of laitance. Concrete shall not be deposited until any laitance which may have formed on concrete previously placed has been removed. The use of aluminum pipes for depositing concrete will not be allowed.

d. For parts of structures under water, concrete seals shall be placed continuously from start to finish. As many tremies or dump buckets shall be provided and used as needed to insure that the work progresses without interruption until completed. The surface of the concrete shall be kept as nearly horizontal as practicable at all times. To insure thorough bonding, each succeeding layer of a seal shall be placed before the preceding layer has taken initial set.

e. A tremie shall consist of a tube having a diameter of not less than 25 centimeters and constructed in sections having flanged couplings fitted with gaskets. The tremie shall be supported so as to permit free movement of the discharge end over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be entirely sealed at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it submerged in the deposited concrete. The flow shall be continuous until the work is completed.

f. In depositing concrete by a bottom dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The bucket shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete. The mound of concrete shall be maintained between 10 and 20 centimeters.

g. Dewatering may proceed when the concrete seal is sufficiently hard and strong. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, chipping, or other means which will not injure the surface of the concrete.

h. Tremie concrete used for bridge foundations shall be cored at the Contractor's expense for testing for compressive strength and for quality of the concrete. Coring shall be as specified in Article 601-2.10j.

601-3.16 Rubble Concrete

a. Rubble concrete shall consist of Class B concrete containing large embedded stones. It shall be used only where shown on the plans or directed by the Engineer in massive piers, gravity abutments, and heavy footings. One-man and derrick stone used in rubble concrete shall consist of tough, sound, and durable rock. The stone shall be free from coating, seams or flaws of any character. The stone shall be angular in shape and shall have a rough surface which will thoroughly bond with the surrounding mortar.

b. The stone shall be carefully placed, not dropped or cast, so as to avoid injury to the forms or to the partially set adjacent masonry. Stratified stone shall be placed upon its natural bed. All stone shall be washed and saturated with water before placing.

c. The total volume of the stone shall not be greater than one third of the total volume of the portion of the work in which it is placed. For walls or piers greater than 60 centimeters but not over 1.2 meters in thickness, one-man stone shall be used with each stone surrounded by at least 15 cm. of concrete and no stone closer than 30 cm. to any top surface nor any closer than 15 cm. to any coping. For walls or piers greater than 1.20 meters in thickness, derrick stone may be used with each stone surrounded by at least 30 cm. of concrete and no stone shall be closer than 60 centimeters to any top surface nor closer than 20 centimeters to any coping.

d. Unless prohibited in the contract documents, the Contractor may supply all Class B concrete in lieu of rubble concrete.

601-3.17 Finishing Concrete Surfaces

a. General

1. Concrete surface finishes, except for bridge decks, sidewalks, and concrete pavements, shall be classified as follows:

Class 1……	Ordinary Finish
Class 2……	Rubbed Finish
Class 3……	Float Finish

2. All concrete, except bridge decks, sidewalks and concrete pavements, shall be given Class 1, Ordinary Finish, and in addition, such other type of finish as specified in the plans or special provisions. If not otherwise specified, the following surfaces shall be given a Class 2, Rubbed Finish.

(a) The exposed faces of piers, abutments, wing walls and retaining walls. The surface finish on piers and abutments shall be limited to all exposed surfaces below bridge seats to 30 cm. below low water elevation, or 60 cm. below finished ground line when such ground line is above the water surface. Wing walls shall be finished from the top to 60 cm. below the finished slope lines on the outside face, and shall be finished on top and for a depth of 30 cm. below the top on the back sides.

(b) The outside faces of fascia girders, beams, slabs, columns, brackets, curbs, headwalls, railings, arch wings, spandrel walls and parapets.

3. The bottoms of deck slabs, bottoms of beams and girders, sides of interior beams and girders, backwalls above bridge seats and the underside of copings require only a Class 1 finish.

4. Unless otherwise specified, concrete floors of minor structures shall be given a Class 3, Float Finish.

5. Finish for concrete pavements shall be in accordance with the provisions of Specification 501 and for sidewalks in accordance with Specification 608.

6. Bridge decks shall be finished in accordance with Article 601-3.18e of this specification.

b. Class 1 - Ordinary Finish

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

2. The resulting surface shall be true and uniform. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be rubbed as specified for Class 2, Rubbed Finish.

c. Class 2 - Rubbed Finish

1. After removal of forms the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water. Sufficient time shall have elapsed before wetting down to allow the mortar used in the pointing of holes and defects to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections, and irregularities have been removed, all voids filled and a uniform surface has been obtained. The paste produced by this rubbing shall be left in place at this time.

2. After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform color.

d. Class 3 - Float Finish - The finish for horizontal surfaces, except for bridge decks, concrete pavements and sidewalks, shall be achieved by placing an excess of material in the form and removing or striking off the excess with a template, forcing the coarse aggregate below the mortar surface. Creation of concave surfaces shall be avoided. After the concrete has been struck off, the surface shall be thoroughly worked and floated with a suitable floating tool. Before the finish has set, the surface cement film shall be

removed with a fine brush in order to have a fine grained, smooth but sanded texture.

e. Finishing bridge deck and other concrete surfaces intended to be used as traveled way.

1. General

(a) Unless otherwise specified, machine finishing shall be used on all bridge decks with the exception of small irregular areas.

(b) Screed supports shall be accurately set and of substantial construction so that the finished roadway surface will conform to the profile and transverse sections shown on the plan. Screed supports shall be placed and adjusted to properly allow for the deflection of forms, falsework and structural supporting members which will occur during the placement of concrete.

(c) The bridge deck surface shall be uniformly smooth, dense and even. Variation in the pavement surface in excess of 7 mm. above or below the elevations required by the plans, or pavement surface irregularities of more than 3 mm. in 3 meters will not be accepted. The 3-meter straight edge shall be furnished by the Contractor and maintained in good condition at the paving site at all times.

(d) Surface irregularities in excess of the above stated limits shall be corrected as the Engineer may direct or approve. Surface irregularities shall be filled, while the pavement concrete is still plastic, with concrete of the same consistency, as specified for the paving operation. Excess thin mortar

and laitance accumulating ahead of the finishing screeds or lutes shall be removed and not used in filling depressions.

2. Machine Finishing

(a) Machine finishing shall be accomplished with power driven transverse finishing machines. The specific method and equipment that the Contractor proposes to use shall be subject to the approval of the Engineer. Approval of the method and equipment will not relieve the Contractor of full responsibility for obtaining the required finished surface.

(b) Finishing machines shall be equipped with adjustable strike-off and finishing screeds, the bottom surface of which shall be adjusted to produce the required contour of the finished surface. Machine shall be kept in true adjustment. Machines out of adjustment shall not be used until proper adjustments have been approved by the Engineer.

(c) Just prior to beginning concreting operation, the finishing machine shall be operated over the full length of the bridge segment to be paved. This test run shall be made with the screed adjusted to its finishing position. While operating the finishing machine in this test the screed rails shall be checked for deflection and proper adjustment, the cover on slab reinforcement measured and the controlling dimensions of slab reinforcement and forms checked. All necessary corrections shall be made before concreting is begun.

(d) After the concrete has been placed, spread and consolidated to provide a uniformly dense structural slab, the surface shall be struck of immediately by the passage of the finishing machine. The finishing machine shall carry sufficient concrete in front of the screed to fill low places. This operation shall be repeated as may be necessary to produce a uniformly consolidated dense smooth surface of the required contour. The first passages of the finishing machine shall provide a concrete surface slightly above grade so that after settlement, if any, and the disappearance of excess water from the surface, a final passage or passages of the finishing machine will result in a uniform surface at the required grade and contour over its entire area.

3. Hand Finishing - Hand finishing, where permitted, shall be performed in such a manner as to produce the same wearing surface quality and uniformity as that produced by machine finishing. Finishing screeds shall be 25 centimeters or more in width and the contacting surfaces shall be steel. Hand operated screeds shall be used in such a manner as to duplicate the action of a transverse finishing machine. Hand finishing shall be performed in the same sequence and manner as machine finishing unless otherwise directed by the Engineer.

4. Final Finish - Following the straightedging and after all excess moisture has disappeared, but before the application of curing compound, the concrete deck surface shall be given a grooved texture with a set of spring steel tines. The grooves shall be perpendicular to the centerline of the concrete deck. Down pressure on the concrete surface shall be maintained at all times during texturing so as to obtain uniform texturing. The spring steel tines of the grooving

device shall be rectangular in cross section, approximately 0.32 cm. (1/8") wide and placed on 1.9 cm. (3/4") centers. The tines shall be of sufficient length, thickness and resilience to form grooves approximately 0.48 cm. (3/16") deep in the fresh concrete surface. Final texture shall be uniform in appearance with substantially all grooves having a depth of 0.48 cm. (3/16") $\pm$ 0.16 cm. (1/16"). Grooving will be terminated a distance of 2.5 cm. on either side of transverse contraction or construction joints. The tine head may be operated by hand or mechanically. In any case, the tines shall be operated with their longitudinal axis at an approximate angle of 45° to the concrete surface to eliminate dragging of mortar by the tines. The tines shall be kept free of hardened concrete particles.

601-3.18 Curing of Concrete

a. General

1. All newly-placed concrete, except for concrete surfaces to be exposed to traffic, shall be cured in accordance with one of the methods described below. Unless the contract documents require a specific method, the Contractor may use either method at his discretion. Curing shall be initiated immediately after placing and finishing. Curing shall be done so that moisture is always present and shall be an integral part of the concreting operations. Improperly cured concrete will be considered defective and the Engineer will stop all the Contractor's concrete placing operations until proper curing procedures are put into effect.

2. Concrete surfaces which call for a Class 2, Rubbed Finish, shall be kept moist before and during the rubbing, and the wet curing shall be initiated immediately following the first rub while the concrete is still moist.

3. Curing of all concrete surfaces to be exposed to traffic shall be made by the water method for a period of at least 7 days.

4. When deemed necessary by the Engineer during periods of hot weather, water shall be added to the concrete surfaces being cured by the curing compound method or by the forms in-place method, until the Engineer determines that the cooling effect is no longer required. Such application of water will be paid for as extra work.

b. Water Method

1. This method includes supplying additional moisture to the concrete by ponding, sprinkling or fogging. All surfaces shall be kept wet for at least 7 days and shall be protected from the sun and wind by using coverings such as burlap, which retain the additional water supplied. Surfaces requiring a Class 2, Rubbed Finish, may have the cover temporarily removed while finishing but the cover shall be restored as soon as the finishing is completed.

2. In Concrete slabs, continuous fogging shall be applied immediately after finishing and until ponding or covering with wet burlap, cotton mats or other suitable moisture retaining material that shall be kept continuously and thoroughly wet for at least seven days.

3. Coverings which cause unsightly discoloration or staining of the concrete shall not be used. Any

method which results in the concrete being alternately wet and dry will be considered improper curing procedure.

c. Membrane Curing Compound Method

1. This method shall consist of preventing moisture loss from the concrete by the use of a membrane forming, white pigmented, curing compound, approved by the Engineer, which will retard the loss of water during the early hardening period and which will, because of its white pigment, reduce the temperature rise in the concrete exposed to the sun's radiation.

2. All surface shall be given the required surface finish prior to application of the curing compound. During the finishing period, the concrete shall be protected by the water method of curing.

3. The curing compound shall be applied by power-operated atomizing spray equipment to obtain a uniform coating. The surface shall be sprayed in one direction and then followed within 30 minutes with a second application sprayed at right angles to the first one.

4. The rate of application of curing compound will be as prescribed by the Engineer with a minimum spreading rate per application of one gallon of liquid coating for each 15 square meters of concrete surface. The coat shall be applied immediately after stripping of forms and acceptance of the concrete finish. If the surface is dry, the concrete shall be thoroughly wetted with water and the curing compound applied just as the surface film of water disappears. During curing operations, any unsprayed surface shall be kept wet with water.

5. The coating shall be protected against marring for a period of at least 7 days after application. Any coating marred or otherwise disturbed shall be given an additional coating. Should the surface coating be subjected continuously to injury, the Engineer will require that the water curing method be applied at once, and continuously until the membrane curing compound can be reapplied over the affected areas.

6. The curing compound shall be thoroughly mixed within an hour before use. It shall be of such character that the film will harden within 30 minutes after application.

7. If the use of a curing compound results in a streaked or blotchy appearance, the method shall be stopped and water curing applied until the cause of the defective appearance is corrected.

8. Any curing compound adhering to a surface to which new concrete is to be bonded shall be completely removed by sand blasting, powered steel brush or grinder, or other approved means.

9. If the Contractor cannot obtain a uniform curing compound membrane throughout the entire surface by means of spraying equipment, then the membrane shall be applied by brush or roller.

10. All exposed reinforcing steel shall be covered before curing compound is applied. Any curing compound adhering to a surface to which new concrete is to be bonded shall be completely removed by approved means.

11. The liquid membrane-forming compound shall be delivered in the manufacturer's original, clean, sealed containers. No liquid membrane-curing compound shall be accepted in containers other than manufacturer's original.

12. If rain falls on the newly coated concrete before the film has dried sufficiently to resist damage, or if the film is damaged in any other manner during the curing period, a new coat of the solution shall be applied to the affected portions equal in curing value to that above specified.

d. Forms-In-Place Method

1. Formed surfaces of concrete may be cured by retaining the forms in place without loosening for the required time.

e. The Contractor will be held responsible for any cracking of the concrete and will be the Contractor's responsibility to repair or remove and replace the affected concrete at no cost to the Authority.

601-4 METHOD OF MEASUREMENT

601-4.01 Structural concrete of each class included in the contract will be measured by the cubic meter in accordance with the dimensions shown on the plans or ordered by the Engineer. The measurement will not include concrete used in the construction of cofferdams or falsework. No deductions in volume will be made for the volume of reinforcing steel, drainage holes, weep holes, timber bumpers, pipes and conduits less than 30 cm. in diameter, or pile heads embedded in the concrete.

601-4.02 Concrete in reinforced bridge approach slabs and concrete pedestals for lighting standards on structures will be measured for payment under structural concrete of the class specified in accordance with the dimensions shown on the plans or ordered by the Engineer.

601-4.03 The volume obtained as stated above will not include any concrete required under any other item of work included under other specifications, when such other item provides that payment for the same includes payment for any concrete which forms part of it.

601-4.04 Reinforcing steel and other contract items which are included in the completed and accepted structure will be measured for payment in the manner prescribed in their respective specifications.

601-5 BASIS OF PAYMENT

601-5.01 The completed and accepted quantities of each class of structural concrete will be paid for at the contract unit price per cubic meter except as specified in Article 601-5.05 below. Such prices and payment shall constitute full compensation for furnishing, placing, finishing and curing the concrete and for all materials, equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

601-5.02 The unit prices include full compensation for furnishing and placing all subsidiary items necessary to complete the structure such as joint fillers, flashing, metal drains, expansion joints, bearings and miscellaneous materials called for in the contract documents unless they constitute or are specifically covered by other pay items included in the contract.

601-5.03 No separate pay allowance will be made for any increased cement content, for any admixtures, nor for any finishing of any description for concrete surfaces indicated on the plans or required by the specifications.

601-5.04 No additional payment will be made for any concrete over dimensions stipulated in the contract documents nor for strength in excess of that specified. No payment will be made for the removal and disposal of any concrete found deficient and not accepted.

601-5.05 Concrete found deficient in strength but which is accepted by the Authority under the provision of Article 601-2.10 of this specification will be paid for at a reduced unit price.

a. The reduction in unit price will be computed in accordance with the following formula:

$R = 0.05D$

where R = Percentage reduction in unit price of the concrete.

D = Deficiency in psi of the moving average value from the specified strength.

b. The price reduction will be applied to all the volume of concrete represented by the three cylinder sets in a moving average subject to the following:

1. No price reduction will be applied when the deficiency "D" in the moving average does not exceed 100 psi.

2. The price reduction will be applied to any given volume of concrete only once. It will be applied on the basis of the value of the first deficient moving average of which it is a component.

3. When the Contractor opts for drilling and testing cores as per paragraph 601-2.10j in lieu of accepting unit price reductions based on the cylinder tests, and the core strength values fail to meet the acceptance criteria specified in paragraph 601-2.10j(4), the core strength values will be divided by 0.85 and if the resulting values are below the required

concrete strength by more than 500 psi the concrete represented by the core strength will be rejected. If the core strength values divided by 0.85 are not below the required concrete strength by more than 500 psi, the resulting values will be substituted in the moving average computations (and will be subjected to the strength acceptance criteria specified for the moving averages) for computing the deficiency "D" and the applicable price reductions.

4. The cylinder sets values and the core values of concrete which is classified as deficient, is rejected and ordered removed, as per paragraph 601-2.10j will be omitted from the moving average and price reduction computations.

601-5.06 Payment will be made under:

Pay Item		Pay Unit
Class A Concrete	…….	Cubic Meter
Class A-4 Concrete	…….	Cubic Meter
Class A-6 Concrete	…….	Cubic Meter
Class A-7 Concrete	…….	Cubic Meter
Class A-8 Concrete	…….	Cubic Meter
Class A-9 Concrete	…….	Cubic Meter
Class B Concrete	…….	Cubic Meter

SPECIFICATION 602- REINFORCING STEEL

602-1 DESCRIPTION

602-1.01 Scope - This work shall consist of furnishing and placing reinforcing steel in accordance with these specifications and in conformity with the plans or as established by the Engineer.

602-2 MATERIALS

602-2.01 Reinforcing steel shall be of the grade and class called for in the plans and meet the requirements of Article 709-1 of Specification 709. When the grade of the reinforcing steel is not specified in the plans, Grade 60 shall be provided.

602-2.02 Prestressing Reinforcing Steel shall meet the requirements of the plans and of Article 709-2 of Specification 709.

602-2.03 Epoxy Coated Reinforcing Steel shall meet the requirements of the plans and of Article 709-3 of Specification 709.

602-2.04 The Contractor shall submit to the Engineer manufacturer's certificates of compliance with the specifications for the prestressing steel and the epoxy coated reinforcing steel. The Engineer may, at his discretion, also require such compliance certificates for the reinforcing steel.

602-2.05 The Engineer will select for testing by the Authority such samples as may be deemed necessary in line with the Highway Authority's Construction Manual.

602-3 CONSTRUCTION REQUIREMENTS

602-3.01 Bar Lists and Bending Diagrams

a. Before ordering the reinforcing steel, bar lists and bending diagrams shall be furnished by the Contractor to the Engineer for approval, and no materials shall be fabricated until such lists and bending diagrams have been approved. The approval of bar lists and bending diagrams shall in no

way relieve the Contractor of his responsibility for their correctness. Any revision of materials furnished in accordance with such lists and diagrams that may be required to comply with the design drawings shall be at the Contractor's expense.

b. Vertical reinforcement in columns, walls, piers and shafts shall not be fabricated until footing elevations are established in the field.

c. Reinforcement bars shall be shipped in standard bundles, tagged and marked. Each bundle shall have a tag attached identifying the purchaser by name an address or by order number. In addition, each bundle of bars, whether straight or bent, shall be identified with the number of pieces, size, length, and mark number as shown on the structure drawings and schedules.

d. Substitution of different size bars will be permitted only upon written authorization of the Engineer. The substituted bars shall have an area equivalent to the design area, or larger, and shall conform to the AASHTO requirements for distribution of flexural reinforcement.

602-3.02 Protection of Materials

a. Steel reinforcement shall be stored above the surface of the ground upon platforms, skids or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust.

b. When placed in the work, the reinforcing steel shall be free from dirt, detrimental rust, loose scale, paint, grease, oil or other foreign materials. The steel shall also be free from injurious defects such as cracks and laminations. Rust, surface seams, surface irregularities, or mill scale will not be cause for rejection, provided the minimum dimensions, cross section area, and tensile properties of a hand wire brushed

specimen meets the physical requirements for the size and grade of steel specified.

602-3.03 Bending

a. All steel reinforcing bars requiring bending shall be bent cold to the required shapes. Unless otherwise shown on the plans or authorized by the Engineer, the minimum diameter of bends for Grades 40 and 60 steel, measured on the inside of the bar, shall be as indicated below, except as provided in subsequent paragraphs b., c. and d.

Bar Size No.	Minimum Diameter
3 through 8…….....	6 bar diameters
9, 10 and 11…….....	8 bar diameters
14 and 18…….....	10 bar diameters

b. Bends in stirrups and tie bars of No. 5 or smaller size and shall have an inside diameter of not less than 4 bar diameters.

c. For bends not exceeding 180 degrees in Grade 40 bars sizes No. 3 to 11 inclusive, the minimum diameter shall not be less than 5 bar diameters.

d. The inside diameter of bends in smooth or deformed welded wire fabric for stirrups and ties shall be not less than 4-wire diameters for deformed wire larger than D-6 and 2-wire diameters for all other wires. Bends with inside diameter of less than 8-wire diameters shall not be less than 4-wire diameters from the nearest welded intersection.

e. Bars partially embedded in the concrete shall not be field bent except as shown on the plans or specifically authorized by the Engineer.

f. Epoxy coated reinforcement bars on which the coating is damaged by the bending work shall be evaluated by the Engineer who will decide whether they shall be repaired or replaced. Material used for coating repair shall be that provided by the coating applicator.

g. Cutting and bending, whether done at a shop or in the field, shall be performed by qualified operators using the proper appliances.

602-3.04 Placing and Fastening

a. All reinforcing steel shall be accurately placed in the positions shown on the plans and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections except where the spacing is less than 30 centimeters in each direction in which case alternate intersections shall be tied.

b. Distance from the forms shall be maintained by means of approved supports. Blocks for holding reinforcement from contact with the forms shall be precast mortar blocks of approved shape and dimensions or approved metal chairs. Metal chairs which are in contact with the exterior surface of the concrete shall be galvanized. Layers of bars shall be separated by precast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks will not be permitted. The spacing of bars shall be as shown on the drawings or as directed by the Engineer.

c. The supports for reinforcement steel shall not be spaced more than 1.20 meters apart transversely or longitudinally. The placement of deck reinforcing shall not deviate more than $\pm$ 0.63 centimeters (1/4”) in the vertical direction. The horizontal spacing of parallel bars shall not vary by more than $\pm$ 2 centimeters, but the average of any two adjacent spaces shall not exceed the plan spacing.

d. Placing bars in layers of fresh concrete as the work progresses and adjusting bars during the placing of concrete will not be permitted except where specifically required as part of the construction process.

e. Wire mesh reinforcement which is received in rolls shall be straightened out into flat sheets prior to placing.

f. All reinforcement shall be furnished in the full length indicated on the plans. Splicing, except where shown on the plans, will not be permitted without the approval of the Engineer and shall comply with the following:

1. Splices shall be staggered as far as practicable and shall be located at points of low tensile stress.

2. Lap splices shall not be used for bars larger than No. 11 except as provided in the AASHTO Standard Specifications for Highway Bridges.

3. Splices shall not be permitted unless a minimum of 5 centimeters can be provided between the spliced bar and the nearest adjacent bar or concrete surface.

4. Unless otherwise shown on the plans, all bars No. 11 or smaller be spliced by lapping 40 diameters and wiring together the full length of the lap.

5. Reinforcing bars larger than No. 11 size, the bars shall be spliced in accordance with the requirements of the AASHTO Standard Specification for Highway Bridges.

6. Wire mesh or bar mat reinforcement shall be spliced by overlapping sufficiently to maintain uniform strength and shall be securely fastened at the edge and end laps. The edge lap shall be not less than one full mesh in width.

7. Welding of reinforcing steel shall be done only if detailed on the plans or authorized in writing by the Engineer. Welding shall conform to the latest edition of the American Welding Society publication "Structural Welding Code, Reinforcing Steel".

602-3.05 Epoxy Coated Reinforcing Bars - The handling, fabrication and installation of epoxy coated reinforcing bars shall be in accordance with the requirements specified in AASHTO M 284.

602-3.06 Inspection - No concrete shall be placed until the completed reinforcing steel has been inspected and permission for placing concrete granted by the Engineer. Concrete placed in violation of this provision may be rejected and, if ordered by the Engineer, shall be removed by the Contractor at his expense.

602-4 METHOD OF MEASUREMENT

602-4.01 Reinforcing Steel

a. Steel reinforcement incorporated in the concrete will be measured in pounds based on the total computed weight for the sizes and length of bars, mesh or mats shown on the plans or authorized by the Engineer.

b. The weight of round bars will be computed on the basis of the nominal weights in pounds per foot specified in Table 1 of AASHTO M 31 for bar sizes No. 3 to No. 18 inclusive. For No. 2 (1/4") bars a weight of 0.167 lbs. /ft will be used.

c. The weight of wire mesh reinforcement will be computed from the theoretical weight of plain wire. If the weight per square foot is given on the plans, that weight shall be used.

d. The weight of reinforcement used in railings, when railings are paid for on a linear meter basis, and of reinforcement steel in prestressed units, precast piles,

reinforced concrete pipes and other items where the reinforcement is included in the contract price for the item, will not be measured for payment.

e. No allowance will be made for clips, wire, separators, wire chairs, and other material used in fastening the reinforcement in place. If bar sizes are substituted at the Contractor's request and result in more steel being used than specified, only the amount specified on the plans will be included in the measurement for payment.

f. When laps are made for splices, other than those shown on the plans, for the convenience of the Contractor, the extra reinforcing steel will not be included in the measurement for payment.

g. Whenever there are no bid items for reinforcing steel included in the contract, the required reinforcing steel shall be considered a subsidiary obligation of the Contractor with its cost included in the contract price for the concrete items, and no separate measurement for payment will be made.

602-4.02 Epoxy Coated Reinforcing Steel - Will be measured as provided under Article 602-4.01 above for uncoated reinforcing steel, using the same nominal weights per foot. When no separate pay item is provided in the contract, any epoxy coated reinforcement steel required by the plans will be measured for payment as uncoated reinforcing steel under the same conditions provided in Article 602-4.01 above.

602-4.03 Prestressing Reinforcing Steel - Will not be measured for direct payment. The cost of this material is included in the unit cost of the respective prestressed units.

602-5 BASIS OF PAYMENT

602-5.01 The completed and accepted quantities of reinforcing steel, determined as provided above, will be paid for at the contract unit price per pound. Such prices and payment shall constitute full

compensation for furnishing, fabricating, and placing the reinforcing steel and for all materials, labor, equipment, tools and incidentals necessary to complete this work as required by the plans and specifications.

602-5.02 Payment will be made under:

Pay Item	Pay Unit
Reinforcing Steel……..	Pound
Epoxy Coated Reinforcing Steel……..	Pound

SPECIFICATION 603 – PIPE CULVERTS AND STORM DRAINS

603-1 DESCRIPTION

603-1.01 Scope

a. This work shall consist of the construction or reconstruction of pipe culverts and storm drains in accordance with these specifications and in conformance with the lines and grades shown on the plans or established by the Engineer. The types, classes (including stiffness), sizes and the location of pipe culverts and storm drains shall be as shown on the plans or as directed by the Engineer.

b. When the type of pipe is not specified, the Contractor will provide reinforced concrete pipe (RCP), polyvinyl chloride profile wall (PVC) pipe or corrugated polyethylene Type S pipe (PEP). When more than one type of pipe is indicated, the Contractor will choose among the permissible alternatives provided. When choosing among alternates, the Contractor will include in his proposal the installation of the selected type of pipe in conformance with the Authority's standard drawings, including but not limited to the class or stiffness of pipe, type of trench, type of backfill, and type of bedding as a subsidiary obligation for the height of soil above the pipe.

c. When the plans do not indicate the type of pipe, type of trench, or type of bedding the Contractor shall perform the installation in conformance with the requirements of the standard drawings.

603-2 MATERIALS

603-2.01 Materials shall conform to the requirements of the standard drawings and the following specifications:

SPECIFICATION 603 – PIPE CULVERTS AND STORM DRAINS

Material	Specification
Reinforced Concrete Pipe……..	706-1.01
Reinforced Concrete Pipe Arch…….	706-1.03
Reinforced Concrete Elliptical Pipe……..	706-1.04
Reinforced Concrete D-Load Pipe…….	706-1.02
Reinforced Concrete Box Sections……	706-3
Bituminous Coated Galvanized Corrugated Steel Pipe and Pipe Arches…….	707-1
Slotted Corrugated Steel Pipe, Bituminous Coated……	707-3
Polyvinyl Chloride Profile Wall Pipe……...	M-304
Corrugated Polyethylen Pipe…….	M-294
Joint Mortar……...	705-2
Rubber Gaskets……...	705-3
Plastic Sealing Compound…….	705-7

603-2.02 When the construction plans do not indicate the class of pipe for reinforced concrete pipe, the stiffness for polyvinyl chloride pipe and polyethylene pipe, or the size of corrugations and sheet thickness for corrugated steel pipes, the requirements specified in the standard drawings for the height of soil above the pipe shall be followed.

603-2.03 At the option of the Authority, the plants will be inspected for compliance with specified manufacturing methods and material samples obtained for laboratory testing for compliance with materials quality requirements. Manufacturers' certificates, for these materials shall be furnished by the Contractor. Manufacturers' certificates shall include all information necessary to show that the materials comply with the specification. These certificates can be the basis for acceptance of manufacturing lots as to quality.

603-2.04 Prior to and during incorporation of materials in the work, these materials will be subject to inspections and checks by the Engineer at the latest practicable time.

SPECIFICATION 603 – PIPE CULVERTS AND STORM DRAINS

603-2.05 All contiguous pipes shall be of the same kind of material, unless indicated otherwise in the plans. Concrete and metallic pipe ends may be used on polyvinyl chloride and polyethylene pipes.

603-2.06 When required by the Engineer, the Contractor shall mandrel test polyvinyl chloride and polyethylene pipes as described in Appendix A as a subsidiary obligation.

603-3 CONSTRUCTION REQUIREMENTS

603-3.01 Excavation

a. Trenches shall be excavated in accordance with the requirements of Specification 205 - Trench Excavation, the standard drawings or as directed by the Engineer. Excavation widths shall be sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill under and around the pipe. Trench width shall never be less than the minimum trench widths specified in the standard drawings.

b. The completed trench bottom shall be firm for its full length and width. In the case of cross drains, the trench shall have a longitudinal camber of the magnitude specified.

c. The method of installation shall be in strict conformance with the details and materials indicated in the standard drawings for the type of pipe, class of pipe or stiffness, type of trench, type of bedding, and type of backfill consistent with the height of soil above the pipe.

603-3.02 Bedding

a. For reinforced concrete, polyvinyl chloride and polyethylene pipes the bedding shall be in strict conformance with the requirements contained in the standard drawings.

All beddings will not be measured for payment and shall be a subsidiary obligation of the contract.

b. For corrugated metal pipe, the bed shall be roughly shaped and a bedding blanket of sand or sandy soil classifiable as A-1, A-3, A-2-4 or A-2-5 shall be provided as follows:

Pipe Corrugation Depth	Minimum Bedding Depth
½ inch	1 inch
1 inch	2 inches
2 inch	3 inches

603-3.03 Laying Pipe

a. The pipe laying shall begin at the downstream end of the pipe line. The bottom portion of the pipe shall be in contact with the shaped bedding throughout its full length. Bell or groove ends of pipe and outside circumferential laps of corrugated metal pipe shall be placed facing upstream. Metal pipe shall be placed with longitudinal laps or seams at the sides.

b. Paved or partially lined pipes shall be laid so that the longitudinal centerline of the paved segment coincides with the flow line. Elliptical pipes, when installed with the major axis vertical, shall be placed with the major axis within 5 degrees of a vertical plane through the longitudinal axis of the pipe.

c. When concrete pipe with quadrant reinforcement or concrete circular pipe with elliptical reinforcement is used, the pipe shall be installed in such a position that the manufacturer’s marks designation the top and bottom of the pipe shall be no more than 5 degrees from the vertical plane through the longitudinal axis of the pipe.

SPECIFICATION 603 – PIPE CULVERTS AND STORM DRAINS

603-3.04 Joining Pipe

a. Reinforced concrete pipe may be of the bell and spigot or tongue and groove design unless one type is specified. The method of joining pipe sections shall be such that the ends are fully entered and the inner surfaces are reasonably flush and even.

b. Joints on concrete pipes shall be sealed with rubber gaskets as indicated in the standard drawings.

c. Corrugated metal pipes and corrugated polyethylene pipes shall be firmly joined by water tight coupling bands.

d. Polyvinyl profile wall and polyethylene pipes shall be joined as indicated in the standard drawings.

e. Connection of all pipes to concrete structures such as headwall, catch basins, inlets, etc. shall be as indicated in the standard drawings.

f. Pipes shall be inspected before any backfill is placed. Any pipe found to be out of alignment or unduly settled shall be taken up and relaid at the Contractor's expense. Any damaged pipe which is not repairable shall be removed and replaced at the Contractor's expense.

603-3.05 Shop Elongation - Where required by the plans, the vertical diameter of circular corrugated metal pipes shall be increased 5 percent by shop elongation.

603-3.06 Backfilling

a. After the pipe is installed, the trench shall be backfilled and compacted in accordance with Article 3.07 of Specification 205 - Trench Excavation and the requirements of the standard drawings.

b. When the top of the pipe is even with or below the top of the trench (negative projection), backfill material shall be placed at or near optimum moisture content and compacted in layers not exceeding 15 centimeters in thickness (compacted) on both sides to an elevation 30 centimeters above the top of the pipe. Care shall be exercised to thoroughly compact the backfill under the haunches of the pipe. The backfill shall be brought up evenly on both sides of the pipe for the full required length. The backfill material shall be placed and compacted for the full depth of the trench except where the induced trench installation method is specified.

c. When the top of the pipe projects above the top of the trench (positive projection), backfill shall be placed at or near optimum moisture content and compacted in layers as specified in paragraph 3.06 b above for the full length of the pipe and to an elevation of 30 centimeters above the top of the pipe. The width of the backfill on each side of the pipe for the portion above the top of the trench shall be equal to twice the diameter of the pipe or 3.6 meters, whichever is less. The backfill material used in the trench section and the portion above the top of the trench for a distance on each side of the pipe equal to the horizontal inside diameter and to 30 centimeters above the top of the pipe shall conform to the requirements for backfill material specified in the standard drawings. The remainder of the backfill shall consist of material acceptable for embankment construction.

d. All pipe after being bedded and backfilled as specified herein shall be protected by a minimum 1.20 meter cover of fill before heavy equipment is permitted to cross during construction of the roadway.

603-3.07 Induced Trench Method

a. When the installation of a concrete pipe in an embankment by the induced trench method is specified, the

construction shall proceed as shown on the standard drawings.

b. There will be no payment for the double handling and double excavation inherent in the induced trench method and said operations shall be considered a subsidiary obligation.

603-3.08 Slotted Pipe

a. Slotted pipe shall be installed as shown on the plans and standard drawings and in accordance with the applicable provisions for excavation, bedding, laying, joining and backfilling with the following additional requirements.

b. The slot shall be covered with a heavy duty tape or other approved covering during backfilling and paving operations to prevent infiltration of material into the pipe. The Contractor will be responsible to clean all pipes affected by his operations as a subsidiary obligation.

c. The concrete apron and backfill of the pipe shall be constructed as shown on the plans and standard drawings as a subsidiary obligation.

603-3.09 Damaged Pipe

a. Pipe that is damaged or disturbed by the Contractor's operations prior to acceptance of the contract shall be repaired, realigned or replaced as directed by the Engineer at the Contractor's expense. Pipe which is defective form any cause, including damage caused by handling and determined by the Engineer to be unrepairable, shall be unacceptable for installation, and shall be replaced as directed by the Engineer at no cost to the Authority.

b. Concrete pipe and concrete end sections with minor damage resulting from occasional imperfections in manufacturing or accidental injury during handling, may be

repaired if so determined by the Engineer. The repairs shall be sound, properly finished and cured, and the repaired pipe shall conform to the requirements of the specifications.

c. Damage to bituminous coatings or bituminous paved inverts may be repaired in the field by a hot application of asphalt cement subject to approval by the Engineer.

603-3.10 Relaying Pipe -These construction specifications shall equally apply in the case of relaid pipes. In addition, all pipe salvaged for relaying shall be cleaned of all foreign material prior to reinstallation.

603-4 METHOD OF MEASUREMENT

603-4.01 Pipes of the different types and sizes, both new and relaid, will be measured along the invert by the linear meter, to the nearest tenth of a meter, in place and accepted.

603-4.02 Elbows and branch connections will be included in the length measurement for pipes.

603-4.03 Special end sections, including tapered inlets, will be measured by the number of units installed.

603-4.04 Portland cement concrete for Class A bedding will not be measured for direct payment and will be a subsidiary obligation of the Contractor with its unit cost included in the contract unit price of the respective pipes.

603-4.05 Portland cement concrete for slotted pipe aprons and backfill will not be measured for direct payment but shall be a subsidiary obligation of the Contractor with its cost included in the contract unit price for slotted pipe.

603-4.06 Material for Class B and Class C beddings will not be measured for direct payment. These materials shall be a subsidiary

obligation of the Contractor with its cost included in the unit price for the respective pipes.

603-4.07 Backfill will not be measured for direct payment, regardless of class, as this is a subsidiary item under the pay item of Trench Excavation.

603-5 BASIS OF PAYMENT

603-5.01 The accepted quantities of pipe and end section, measured as provided below, will be paid for at the contract unit prices per unit of measurements for the types, classes and sizes specified complete in place. Such prices and payment shall constitute full compensation for the furnishing and placing of all materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

603-5.02 Excavation for pipe culverts and storm drains, including excavation in embankments and removal of unsuitable materials will be measured and paid for as provided in Specification 205 -Trench Excavation. When the contract does not contain an estimated quantity and unit price for trench excavation, this excavation will be subsidiary obligation of the Contractor with its cost included in the unit prices for the respective pipes.

603-5.03 Concrete for Class A bedding will not be paid and will be subsidiary obligation of the Contractor with its cost included in the unit prices for the respective pipes.

603-5.04 Payment will be made under:

Pay Item	Pay Unit
___ inch PVC Pipe, Stiffness ____……..	Linear Meter
___ inch PEP Pipe, Stiffness ____……....	Linear Meter

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	Pay Item	Pay Unit
___	inch Reinforced Concrete Pipe, Class……..	Linear Meter
___	inch Reinforced Concrete Pipe, D-Load…..	Linear Meter
___	inch End Section (RCP or PEP)……	Each
___	inch Reinforced Concrete Culvert End Section……..	Each
___	inch rise, ____inch span, Elliptical Reinforced Concrete Pipe; Class ____……..	Linear Meter
___	inch rise,____ inch span, Elliptical Reinforced Concrete Pipe End Sections……	Each
___	inch (or meter) span, ____inch (or meter) rise, Precast Reinforced Concrete Box Sections…….……	Linear Meter
___	inch, Bituminous Coated Corrugated Steel Pipe Type ____, Gage ____, Corrugations ____……...	Linear Meter
___	Bituminous Coated Corrugated Steel End Section, Type ____, Gage ____, Corrugations ___……...	Each
___	inch span, ____inch rise, Bituminous Coated Corrugated Steel Pipe Arch, Type ____, Gage ____ Corrugation ____……..	Linear Meter
___	inch span, ____ inch rise, Bituminous Coated Corrugated Steel Pipe Arch, End Sections, Type ____, Gage ____, Corrugations ____…….	Each

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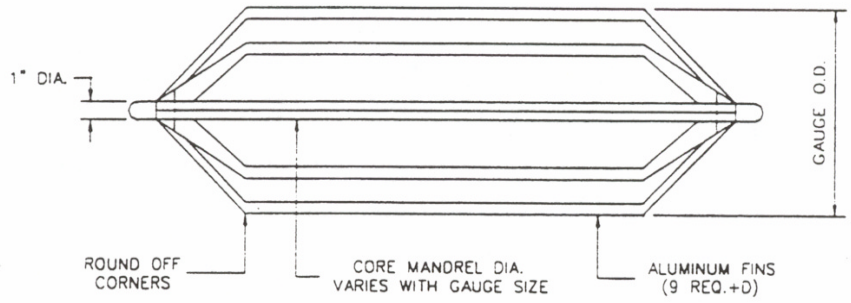
	Pay Item	Pay Unit
___	inch, Bituminous Coated Slotted Corrugated Steel Pipe, Type ____, Gage ____, Corrugations ____…….…	Linear Meter
___	Relaying of ____ inch (RCP, PVC, PEP or CM) Pipe ……..	Linear Meter

Abbreviations: RCP -Reinforced Concrete Pipe, PVC - Profile Wall Polyvinyl Pipe, PEP Corrugated Type S Polyethylene Pipe, CM Bituminous Coated Corrugated Steel Pipe

SPECIFICATION 603 – PIPE CULVERTS AND STORM DRAINS

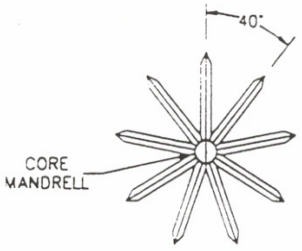
Appendix A
Mandrel Testing for PVC and PEP Pipes

When required by the Engineer, the Contractor shall be responsible to perform the mandrel deflection testing on the pipeline installation not less than 30 days after installation has been completed. This testing shall be accomplished by pulling an approved mandrel (see detail below) through every completed pipeline. Deflection shall be limited to 5%. Any line failing this test shall be removed, then relaid if the pipe is not damaged, or replaced with acceptable new pipe at the Contractor's expense, then retested. The cost of deflection testing and any corrective actions shall be borne by the Contractor and shall be incidental to the bid item. The use of vibratory re-rounding device of any kind is strictly prohibited.



SIDE OR TOP VIEW

SIZE	GAUGE O.D.	GAUGE WT.
12"	11.46"	10 LBS.
15"	14.33"	10 LBS.
18"	17.19"	19 LBS.
24"	22.92"	19 LBS.
30"	28.65"	20 LBS.
36"	34.38"	22 LBS.
48"	45.80	22 LBS.



END VIEW

MANDREL DEFLECTION TESTING

SPECIFICATION 604 – MANHOLES, INLETS AND CATCH BASINS

604-1 DESCRIPTION

604-1.01 Scope

a. This work shall consist of the construction of manholes, inlets, catch basins, valve boxes.

b. This work shall also include the adjustment of existing manholes, inlets catch basins, valve boxes, junction boxes, pull boxes and similar miscellaneous structures shown on the plans to be adjusted or which are required to be adjusted for the satisfactory completion of the work. In addition, this work will include the conversion of catch basins and inlets to manholes. These adjustments and conversions shall match the new or revised lines and grades shown on the plans or established by the Engineer.

604-2 MATERIALS

604-2.01 Portland cement concrete for these structures shall be of the classes called for in the plans and shall meet the requirements of Specification 601 - Structural Concrete.

604-2.02 Other materials shall conform to the requirements of the following specifications:

Material	Specification
Concrete Joint Fillers…….....	705-1
Joint Mortar……..	705-2
Joint Gaskets…….	705-3
Reinforcing Steel……..	709-1
Precast Concrete Units……..	712-5
Frames, Grates, Covers and Ladder Rungs……..	712-6

604-2.03 Precast reinforced concrete manhole units shall comply with the requirements of AASTHO M 199 or M 199M as modified and supplemented by the plans and these specifications.

604-2.04 When the location of manufacturing plants allows, the plants will be inspected periodically for compliance with specified manufacturing methods, and material samples will be obtained for laboratory testing for compliance with materials quality requirements. In addition to the above, manufacturer's certificates of compliance with the requirements of these specifications shall be furnished by the Contractor. Manufacturer certificates shall comply with the Engineer's requirements. This can be the basis for acceptance of manufacturing lots as to quality when the plant has been inspected and approved within the previous 12 months.

604-2.05 All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

604-3 CONSTRUCTION REQUIREMENTS

604-3.01 Excavation, bedding and backfill shall be performed in accordance with the requirements of Specification 205 - Trench Excavation.

604-3.02 Concrete units may be either cast-in-place or precast at the option of the Contractor, except when otherwise provided in the contract documents. Concrete construction shall conform to the requirement of Specification 601 - Structural Concrete. The finished concrete surfaces shall present a neat and smooth appearance and shall have a Class 1 ordinary finish unless otherwise called for in the plans.

604-3.03 When the Contractor elects to furnish and install precast units, he shall submit shop drawings for approval by the Engineer.

604-3.04 Joints for precast manhole sections shall include an approved rubber gasket and be sealed with portland cement mortar. The completed mortar joint shall be formed with a bead on the outside and finished smooth on the inside of the sections, and be

suitably cured. The rubber ring gasket shall be installed so as to form a flexible watertight seal. A mastic joint filler may be used in lieu of rubber gasket, if approved by the Engineer, provided it can form a watertight seal.

604-3.05 Metal frames shall be set and anchored as shown on the standard drawings. Pipe sections connecting at the walls of the structure shall be flush on the inside face of the wall and shall project outside the wall a sufficient distance to allow for proper connection with the adjoining pipe section.

604-3.06 When adjustment of an existing structure to a new grade is specified the following procedures apply:

a. Frames, covers and gratings shall be removed and the existing walls reconstructed as required.

b. More than one adjustment to a structure may be required as shown on the plans, or ordered by the Engineer, to cover temporary conditions.

c. The frames shall be cleaned and reset at the required elevation.

d. If the Engineer determines that the existing manhole cover frame and supporting walls are in good condition, a device acceptable to the Engineer may be used to adjust the manhole casting cover to the correct grade without reconstructing the walls or resetting the frame.

e. Upon completion, each structure shall be cleaned of any accumulation of silt, debris or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

f. If an existing casting is unfit for further use, the Contractor shall furnish a new casting, the cost of which shall be considered as being included in the unit price for adjusting

the structure and no additional compensation will be paid.

g. When catch basins and inlets are altered to a new grade and will abut existing concrete construction, the casting shall be entirely separated from the adjacent existing concrete by a preformed expansion joint filler no less than 5 millimeters (3/16") in thickness. The cost of furnishing and installing this joint filler shall be considered as included in the unit price of altering the structure and no additional compensation will be paid to the Contractor.

h. On resurfacing contracts, adjustment of existing frames to the new grade shall be made, unless otherwise permitted or directed, after the last binder course has been laid and before placing the final surface course.

604-3.07 In the conversion of existing catch basins and inlets to manholes, the frames and gratings shall be removed and the walls reconstructed as shown on the plans or ordered by the Engineer. Ladder rungs as shown on the standard drawings will be installed as required. The removed frames and gratings shall be disposed of as ordered by the Engineer. The completed structure shall be cleaned of any debris and foreign matter and shall be kept clean until final acceptance of the work.

604-4 METHOD OF MEASUREMENT

604-4.01 Standard manholes of different types, diameter and height will be measured by the number of units of each completed and accepted. Types shall be as shown on the plans, and the diameter and height shall be expressed in meters. Standard inlets and catch basins will be measured by the number of each type installed and accepted.

604-4.02 When manholes, inlets and catch basins to be installed require modifications from the standard drawings due to existing obstructions, these structures will not be paid by the unit but will be

measured for payment by their as-built volume of concrete under the tem P.C. concrete for drainage structures.

604-4.03 Adjustment of existing manholes, inlets, catch basins, valve boxes, junction boxes, pull boxes and miscellaneous structures will be measured by the number of each type of unit satisfactorily adjusted. When more than one adjustment to a structure is shown on the plans or is ordered by the Engineer, except when the adjustment is required due to the Contractor's fault, each adjustment will be measured as a separate pay unit.

604-4.04 Conversions of catch basins and drop inlets to manholes will be measured by the number of each unit satisfactorily converted.

604-4.05 No separate measurement for payment will be made of reinforcing steel, frames, covers, grates, ladder rungs and other required fittings and appurtenances. These items shall be a subsidiary obligation of the Contractor under the pay items for manholes, inlets and catch basins, and P.C. concrete for drainage structures.

604-4.06 Excavation, bedding and backfill for manholes, inlets and catch basins will be measured for payment under the provisions of Specification 205 - Trench Excavation.

604-4.07 Replacing of pavement where required for the adjustment of manholes, inlets, catch basins and other structures, and for the conversion of catch basins and drop inlets to manholes, will not be measured for payment but shall be a subsidiary obligation of the Contractor under these pay items.

604-5 BASIS OF PAYMENT

604-5.01 The accepted quantities, determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract price per unit of measurement. Such price and payment shall constitute full

compensation for furnishing and placing all materials required to complete the items, including frames, covers, grates, ladder rungs, fittings and other appurtenances; for making the necessary pipe connections; and for all labor, equipment, tools and incidentals necessary to complete the work as required by the plans and specifications.

604-5.02 Payment for excavation, bedding and backfill will be made in accordance with the provisions of Specification 205 - Trench Excavation.

604-5.03 Payment will be made under:

Pay Item	Pay Unit
Manholes, Type ___, Diam. ___, Height___…….	Each
Inlets, Type ___…….	Each
Catch Basins, Type ___…….	Each
Manhole Adjustments……	Each
Inlet Adjustments…….....	Each
Catch Basin Adjustments……...	Each
Valve Box Adjustments…….	Each
Pull or Junction Box Adjustments…….	Each
Miscellaneous Structure Adjustments……	Each
Conversions of Inlets and Catch Basins to Manholes…….	Each
Portland Cement Concrete for Drainage Structures……	Cubic Meter

SPECIFICATION 605- UNDERDRAINS

605-1 DESCRIPTION

605-1.01 Scope - This work shall consist of constructing underdrains using pipe and granular filter material, underdrain pipe outlets, french drains using granular material and, when called for in the plans, plastic filter cloth; all in accordance with these specifications and in conformity with the lines, grades and details shown on the plans or established by the Engineer.

605-2 MATERIALS

605-2.01 Underdrain Pipe

a. Any one of the types of pipe listed in paragraph b. below may be used, at the option of the Contractor, unless a particular type is specifically called for in the contract documents.

b. Underdrain pipe shall meet the requirements of the following specifications:

Type	Specification
Perforated Concrete Pipe…….....	706-2
Perforated Polyvinyl Chloride (PVC) Pipe…….	706-4
Perforated Corrugated Polyethylene Pipe…….	706-5
Bituminous Coated Corrugated Metal Pipe (Perforated)…….	707-2

605-2.02 Filter Material - Permeable granular backfill filter material for underdrains shall consist of hard, durable, clean sand, gravel, crushed gravel or crushed stone, free of organic materials, clay, dirt or other deleterious substances and meeting the requirements of either of the alternates included in Article 209-2.01 of Specification 209 - Sheathing.

SPECIFICATION 605- UNDERDRAINS

605-2.03 Geotextile - Shall meet the requirements of Article 712-7 of Specification 712.

605-2.04 Materials Certificates - Contractor shall submit manufacturer's certificates of compliance with specifications and certified copies of tests reports as applicable for underdrain pipes and plastic filter cloth prior to incorporation into the work.

605-3 CONSTRUCTION REQUIREMENTS

605-3.01 Trench Excavation - Trenáches for underdrains and french drains shall be excavated to the dimensions and grades required by the plans. Unless otherwise shown, trenches for underdrains shall be excavated so as to permit a minimum bedding of 10 centimeters of granular backfill material under the pipe and a minimum of 30 centimeters of the granular backfill material above the pipe.

605-3.02 Pipe Installation

a. A minimum 10 cm. bedding layer of the granular backfill material shall be placed and compacted in the bottom of the trench for its full width and length.

b. Underdrain pipe of the type selected and the specified diameter shall be bedded firmly on the backfill material in the bottom of the trench with the perforations facing down and the joints securely made with the appropriate coupling fittings or bands.

c. The influent end of the pipe shall be protected with a suitable plug to prevent any soil from entering the pipe. Lateral connections shall be made with special sections or fittings as required.

d. After the pipe installation has been inspected and approved by the Engineer, granular backfill material shall be placed to a height of 30 centimeters above the top of the pipe. The remainder of the granular backfill shall then be placed

and compacted in layers not exceeding 15 centimeters in thickness to the heights shown on the plans. Special care shall be taken to avoid damaging or displacing the pipe.

e. When indicated on the plans, the top of the trench shall be completed to the depth specified or shown on the standard drawings, with a layer of impervious clay material meeting the requirements of a Class D borrow as specified in paragraph 203-2.03 d. of Specification 203 - Excavation and Embankment. Otherwise, the remainder of the trench above the specified filter material elevation shall be filled with suitable pervious material compacted in 15 cm. layers.

605-3.03 Plastic Filter Cloth - When called for in the plans, plastic filter cloth shall be laid in the trench to cover the bottom and sides of the trench prior to placing the granular backfill and pipe, in order to prevent the penetration of fines from the adjacent soil into the granular filter material. Sufficient width of filter cloth shall be placed to allow the folding and overlapping of the cloth over the top to form an envelope around the granular material once the backfill has been completed. Any specific instruction of the filter cloth manufacturer shall be followed in its installation.

605-3.04 Underdrain Outlets - Trenches for underdrain outlets shall be excavated to the width and depth shown on the plans. Non perforated pipe shall be laid in the trench with all ends firmly joined by the applicable methods and means. After inspection and approval of the pipe installation the trench shall be backfilled with suitable material in layers and compacted as provided for drainage pipe.

605-3.05 French Drains - Trenches for french drains shall be excavated to the width and depth shown on the plans. The trench shall be filled with granular backfill material to the depth required by the plans. Any remaining upper portion of trench shall be filled with either granular or impervious material as may be specified. All backfill material above the filter material shall be thoroughly compacted.

SPECIFICATION 605- UNDERDRAINS

605-4 METHOD OF MEASUREMENT

605-4.01 Underdrains and underdrain outlets will be measured by the linear meter, to the nearest tenth of a meter, of pipe in place of the type and size specified, completed and accepted. Non-perforated pipe underdrain outlet sections will be measured in the same manner as the perforated pipe underdrain sections.

605-4.02 French drains will be measured by the linear meter, to the nearest tenth, completed and accepted.

605-4.03 Trench excavation, plastic filter cloth, granular backfill material, Class "D" impervious backfill and outlet apron slabs or riprap will not be measured directly for payment. These items shall be a subsidiary obligation of the Contractor with their cost included in the underdrain and french drain pay items.

605-5 BASIS OF PAYMENT

605-5.01 The accepted quantities, determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract price per unit of measurement. Such price and payment shall constitute full compensation for furnishing and placing all required materials and for all labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications.

605-5.02 Payment will be made under:

Pay Item	Pay Unit
_____ inch Pipe Underdrain, Type ___…….....	Linear Meter
French Drains, Type ___……	Linear Meter

SPECIFICATION 606 – GUARD RAIL

606-1 DESCRIPTION

606-1.01 Scope

a. This work shall consist of furnishing and erecting corrugated steel beam guard rail and other types of metal barriers, all the named collectively as guard rail, in accordance with these specifications, the standard drawings and in conformity with the lines, grades, types, details and locations shown on the plans or established by the Engineer.

b. The work shall also include, when called for in the contract documents:

1. The removal and resetting of existing guard rail as shown on the plans or ordered by the Engineer.

2. The removal, storage and delivery to the Authority, or to the Department of Transportation and Public Works, of existing guard rail as shown on the plans or ordered by the Engineer.

c. The construction of the guard rail system shall include the assembly and erection of all component parts and materials complete at the locations shown on the plans standard drawings or as directed by the Engineer.

606-2 MATERIALS

606-2.01 Materials for corrugated steel beam guard rail shall conform to the standard drawings and the following articles of Specification 710:

Material	Article
Corrugated Galvanized Steel Beam Gaud Rail…..	710-6
Guard Rail Posts…….	710-7

606-2.02 Manufactured materials will be accepted on the basis of manufacturer's certificates of compliance with the specifications to be furnished by the Contractor in a form meeting the Engineer's requirements. The certification shall clearly refer to the specific materials being delivered to the project site and shall be furnished prior to starting the erection of the guard rail. The Authority reserves the right to inspect the manufacturing plant, to test such samples of materials as it deems appropriate.

606-2.03 All materials shall be new. The use of reconditioned used materials will not be permitted except as provided under paragraph 606-1.01b(1) above.

606-3 CONSTRUCTION REQUIREMENTS

606-3.01 Posts

a. Posts shall be driven unless otherwise specified on the plans or by the Engineer. The driving shall be accomplished with approved equipment and methods that will drive the posts plumb in their final position, free of any distortion, burring or damage.

b. When driving is not possible, the posts shall be set in dug holes which shall be backfilled with acceptable material placed in layers and thoroughly compacted with mechanical tampers. Posts shall be attached to concrete structures as indicated in the standard drawings.

c. When posts are driven or holes cut through concrete or treated material, the Contractor shall backfill the area around the post with material similar in kind and depth to that damaged or removed.

d. All posts shall be aligned to a tolerance of 0.6 centimeters for plumb and grade line.

SPECIFICATION 606 – GUARD RAIL

606-3.02 Rail Elements - Rail elements shall be erected in a manner resulting in a smooth, continuous installation. Washers shall be used at both the face of the guard rail and the rear of the posts.

All bolts shall be drawn tight with adjustment bolts to be tightened after adjustments are completed. Bolts shall be of sufficient length to extend beyond the nuts. Rail plates shall be spliced by lapping in the direction of traffic.

606-3.03 Repair of Galvanized Surfaces - Galvanized surfaces which have been abrased during handling and erection so that the base metal is exposed, threaded portion of all fittings and fasteners, and cut ends of bolts shall be painted with two coats of zinc-dust, zinc-oxide paint conforming to Federal Specification TT-P-641.

606-3.04 Removing and Resetting Guard Rail

a. The contractor shall carefully remove and store existing guard rail sections, including posts, from the locations shown on the plans. He shall reset the reusable components at the locations shown on the plans or ordered by the Engineer.

b. The Engineer will determine which components are reusable. Existing concrete posts and wood blocks shall not be reused but shall be replaced by steel posts and blocks in accordance with the standard drawings.

c. Unusable or missing components shall be replaced with new materials by the Contractor at his expense as a subsidiary obligation under this pay item.

d. Reusable components that have rusted portions shall be thoroughly sanded to remove the rust and these portions shall be painted with two coats of zinc-dust, zinc-oxide paint meeting the requirements of Federal Specification TT-P-641 prior to resetting, at no extra cost.

e. Holes left when guard rail posts have been removed, shall be backfilled with suitable material and compacted in a manner approved by the Engineer.

f. Resetting of guard rail shall be accomplished in the same manner specified in Article 3.01, 3.02 and 3.03 above for new guard rail installations.

g. Unusable material shall be disposed of by the Contractor away from the project site. Usable surplus materials shall be delivered to the Authority or to the Department of Transportation and Public Works as indicated.

606-3.05 Removing, Storing and Delivering Guard Rail

a. The Contractor shall carefully remove and store existing guard rail, including posts, from the locations shown on the plans or directed by the Engineer. The work shall be done in a neat and workmanlike manner so as to salvage all reusable parts.

b. Unusable material, such as concrete posts and wood blocks, as determined by the Engineer, shall be disposed of by the Contractor off the project site or buried at locations within the project approved by the Engineer.

c. Usable materials shall be delivered by the Contractor to the location indicated by the Highway Authority.

d. All holes left from removal of guard rail shall be backfilled as indicated in paragraph 606-3.04e. above.

606-4 METHOD OF MEASUREMENT

604-4.01 The quantity of new corrugated steel beam guard rail measured for payment will be the number of linear meters, to the nearest tenth of a meter, of guard rail erected and accepted, measured from center to center of end posts, except where end connections are made to structures in which case measurement will be to the face of

such structures. Single and double faced guard rails will be measured individually as they are separate pay items.

606-4.02 All terminals except the MELT terminal, return sections, connections, transitions and anchorages will not be measured separately but will be included in the quantity of guard rail measured as provided in Article 606-4.01 above. MELT terminals will be measured and paid for each installation as described in the standard drawings.

604-4.03 The quantity of removal and resetting of guard rail measured for payment will be the number of linear meters, to the nearest tenth of a meter, of guard rail reset and accepted measured as provided for new guard rail in Articles 606-4.01 and 606-4.02 above.

606-4.04 The quantity of removal, storage and delivery of guard rail measured for payment will be the actual number of linear meters, to the nearest tenth of a meter, of guard rail removed and delivered or disposed of as per Article 606-3.05 above, measured from center to center of end posts or structure end connection. Anchorage and terminals and return sections will not be measured separately but will be considered as included in the quantity of guard rail removed and measured as indicated herein.

606-4.05 Excavation and backfill will not be measured for payment but shall be a subsidiary obligation of the Contractor under the items of guard rail.

606-5 BASIS OF PAYMENT

606-5.01 The accepted quantities of the various guard rail items included in the contract, measured as provided above, will be paid for at the corresponding unit price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and installing all materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans, standard drawings and specifications.

SPECIFICATION 606 – GUARD RAIL

606-5.02 Payment will be made under:

Pay Item	Pay Unit
Corrugated Steel Beam Guard Rail (SP or WP), Single Face……..	Linear Meter
Corrugated Steel Beam Guard Rail (SP or WP), Double Face…….	Linear Meter
MELT Terminal…….	Each
Box Beam Guard Rail…….....	Linear Meter
Box Beam Median Barrier…….	Linear Meter
Removal and Resetting of Existing Guard Rail (SP, WP or BB)…….	Linear Meter
Removal, Storage and Delivery of Existing Guard Rail (any type)……	Linear Meter

Abbreviations: SP – Strong Post, WP – Weak Post, BB – Box Beam

SPECIFICATION 607 – FENCES AND GATES

607-1 DESCRIPTION

607-1.01 Scope

a. This work shall consist of the furnishing and erecting chain-link and barbed wire fences, and chain-link gates, in accordance with these specifications and in conformity with the details, lines and grades shown in the plans or ordered by the Engineer.

b. Barbed wire fences and gates shall be of the following types as shown on the plans. Type A shall be provided when no particular type is specified on the plans.

Type A - Barbed wire on precast reinforced concrete posts.
Type B - Barbed wire on timber posts.
Type C - Barded wire on metal posts.

c. Chain-link fences shall be of the following types as shown on the plans. Type B shall be provided when no particular type is specified on the plans.

Type A - Galvanized steel chain-link fencing on galvanized steel frame with top rail.

Type B - Galvanized steel chain-link fencing on galvanized frame with top rail.

Type C - Vinyl coated galvanized steel chain-link fencing on coated steel frame.

d. Chain-link gates shall be of the following types as shown on the plans. When the type is not indicated in the plans, the type consistent with the adjoining fence type shall be provided.

Type A - Galvanized steel.
Type C - Vinyl coated galvanized steel.

607-2 MATERIALS

607-2.01 Materials for fences and gates shall meet the applicable requirements of the following articles of Specification 710.

Material	Article
Barbed Wire…….	710-1
Chain-Link Fabric and Fittings……	710-2
Tension Wire……	710-3
Fence Posts, Rails, Expansion Sleeves And Braces….	710-4
Gates……	710-5

607-2.02 Gates shall be of standard commercial types, of one or two leaves, of the dimensions called for in the plans and complete with all necessary hardware.

607-2.03 The ties for fastening chain-link fabric and barbed wire to the fence posts and tension wires shall be No. 9 gauge aluminum wire unless otherwise shown on the plans.

607-2.04 All materials shall be new. The use of reconditioned used materials will not be permitted unless specifically authorized in the contract documents.

607-2.05 Manufactured materials will be accepted on the basis of manufacturer's certificates of compliance with the specifications to be furnished by the Contractor in a form meeting the Engineer's requirements. The certificates shall clearly refer to the specific materials being delivered to the project site and shall be furnished

prior to starting the erection of the fences. The Authority reserves the right to inspect the manufacturer's plant and to test such samples of materials as it deems appropriate.

607-2.06 Portland cement concrete used for bases and foundations shall conform to the requirements of Specification 601 and shall be Class B unless otherwise specified in the contract documents.

607-3 CONSTRUCTION REQUIREMENTS

607-3.01 General

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

b. Fences shall generally follow the existing ground profile. Minor grading shall be performed where necessary to provide a neat appearance.

c. The bottom of the fabric on chain-link fences shall be no less than 2.5 centimeters nor more than 10.0 centimeters above the ground surface. Where abrupt changes in ground profile in low areas make it impractical to maintain these clearances, longer posts may be used and multiple strands of barbed wire stretched thereon below the chain-link fabric to cover the open space. The vertical spacing between the strands of barbed wire shall not exceed 15 centimeters.

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

e. When the plans require that posts, braces or anchors be embedded in concrete, the Contractor shall install temporary guys, or braces as may be required to hold the posts in proper position until such time as the concrete has set

sufficiently to hold the posts. Unless otherwise permitted, no materials shall be installed on posts or strain placed on guys and bracing set in concrete until seven days have elapsed from the time of placing of the concrete.

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

g. Chain-link fabric or barbed wire of the size and type specified shall be firmly attached to the posts and braces in the manner indicated. All wire shall be stretched taut and be installed to the required elevations. The spacing of ties of the chain-link fabric shall not exceed 60 centimeters on the top rail or tension wire and 35 centimeters on line posts, unless otherwise shown on the plans. The spacing of ties for barbed wire shall not exceed 30 centimeters and there shall be a tie at each intersection of wire and post.

h. When chain clink fence is erected in a curved alignment, additional evenly spaced intermediate posts shall be installed as required to prevent the strain on the fence from bending the line posts.

607-3.02 Shop Drawings - The Contractor shall furnish detailed shop drawings of the gates and fences to be furnished and erected for approval by the Engineer.

607-3.03 Grounds

a. At each location where an electric transmission, distribution or secondary line crosses any of the types of fences covered by these specifications, the Contractor shall furnish and install a ground in accordance with the following:

1. A galvanized or copper coated steel ground rod of 1/2-inch minimum diameter and 2.5 meters long shall be driven vertically into the ground, directly

below the point of crossing, until the top of the rod is 15 centimeters below the ground surface. When acceptable vertical penetration of the ground rod cannot be obtained, an equivalent horizontal grounding system meeting the requirements of subsection 9 of the National Electric Safety Code will be accepted.

2. A No. 8 AWG solid copper wire or equivalent shall be used to connect each fence element to the grounding rod. The clamp connecting the ground wire to the ground rod shall consist of a single piece bronze core or steel core with a heavy copper coating. It shall be of the safety screw type.

b. When a power line runs parallel or nearly parallel to and above the fence, the fence shall be grounded at each end or gatepost or at intervals not to exceed 500 meters.

607-4 METHOD OF MEASUREMENT

607-4.01 Fence will be measured by the linear meter to the nearest tenth of a meter. Measurement will be along the top of the fence from outside to outside of end posts for each continuous run of fence.

607-4.02 Chain-link gates will be measured for payment as complete units of each type and size specified in the contract documents.

607-4.03 Any necessary clearing and grubbing, and grading for the fence; excavation, backfill and concrete for post foundations; and grounds will not be measured directly for payment but shall be a subsidiary obligation of the Contractor with their cost included in the contract prices for the fence and gates pay items.

of the particular pay items listed below that is included in the contract. Such prices and payment shall be full compensation for furnishing and placing all materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

607-5.02 Payment will be made under:

Pay Item	Pay Unit
Barbed Wire Fence, Type ___ ……..	Linear Meter
Chain-Link Fence, Type ___ ……	Linear Meter
Chain-Link Gate, Type ___ One Leaf, Width ___ ...	Each
Chain-Link Gate, Type ___ Two Leaves, Width ___	Each

SPECIFICATION 608 – SIDEWALKS

608-1 DESCRIPTION

608-1.01 Scope

a. This work shall consist of the construction and construction of concrete or bituminous sidewalks, in accordance with these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

b. The paving of medians, malls and traffic separators with P. C. concrete or bituminous concrete is included under this item when indicated on the plans, unless another type of surfacing is specified.

c. This work also includes the construction of driveway ramps and ramps for wheel chairs and handicapped persons in accordance with the details and at the locations shown on the plans or ordered by the Engineer.

608-2 MATERIALS

608-2.01 Materials for sidewalks shall meet the requirements of the following specifications:

Material	Specification
Portland Cement Concrete……...	601
Reinforcing Steel……..	709-1
Joint Fillers……...	705-1
Bituminous Concrete……	401
Bed Course Material……	703-5

608-2.02 P.C. concrete for sidewalks shall be Class B unless otherwise indicated on the plans.

SPECIFICATION 608 – SIDEWALKS

608-2.03 Bituminous concrete for sidewalks shall conform to Mix S-2 unless otherwise indicated on the plans.

608-2.04 All materials will be subject to inspection for acceptance as to condition at the latest practicable time the Engineer has the opportunity to check for compliance prior to or during incorporation of materials in the work.

608-3 CONSTRUCTION REQUIREMENTS

608-3.01 Portland Cement Concrete Sidewalks, Ramps, Medians

a. Excavation - Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms.

The foundation shall be shaped and compacted to a firm even surface conforming to the section shown on the plans. All soft and unsuitable material shall be removed and replaced with bed course material.

b. Forms - Forms shall be of wood, metal or other approved material and shall extend for the full depth of the concrete. All forms shall be straight, free from warps and of sufficient strength to resist the pressure of the concrete without springing. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal.

c. Reinforcement - Where the plans call for steel reinforcement to be placed in the sidewalk, such reinforcement shall be placed in conformance with the requirements of Specification 602 - Reinforcing Steel. Unless otherwise shown on the plans, the reinforcement shall be embedded at mid-depth in the slab.

d. Handling and Placing - The foundation shall be thoroughly moistened immediately prior to the placing of the concrete. The handling and placing of the concrete shall be in accordance with the requirements of Specification 601 – Structural Concrete. The concrete shall be placed in one course to the full depth shown on the plans.

e. Finishing - The concrete shall be finished with a wooden float to produce a smooth surface and then broomed in a transverse direction to a uniform texture.

All outside edges of the slab and all joints shall be finished with an edging tool having a 1/4" radius.

f. Joints

1. Expansion joints shall be of the dimensions specified, and shall be filled with the type of premolded expansion joint filler indicated on the plans.

2. The sidewalks shall be divided into sections by dummy joints formed by a jointing tool or other acceptable means as directed. These dummy joints shall extend into the concrete for at least 1/4 to 1/5 of the depth and shall be approximately 3mm. (1/8") wide. Dummy joints shall be spaced as shown on the plans. They shall match as closely as possible adjacent joints in abutting curbs or pavements. Dummy joints may be sawed in lieu of forming with a jointing tool.

3. Construction joints shall be formed around all appurtenances such as manholes, utility poles, etc., extending into and through the sidewalk. Premolded expansion joint filler 1/4 to 1/2 inch thick shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete sidewalks and any fixed structure such as a building

or bridge. This expansion joint material shall extend for the full depth of the sidewalk.

g. Curing - Concrete sidewalks shall be cured in accordance with the requirements for curing concrete included in Specification 601. No traffic shall be allowed on the sidewalks during the curing period.

608-3.02 Bituminous Concrete Sidewalk, Ramps, Medians

a. Excavation and Forms - Excavation and forms shall meet the requirements of subparagraphs 608-3.01a and b above.

b. Bed course - Bed course material shall be placed in layers not exceeding 10 centimeters in depth and each layer shall be thoroughly compacted. All irregularities or depressions that develop during compaction shall be corrected by loosening the surface and adding or removing material and recompacting the surface until it is smooth and regular.

c. Placing Bituminous Material - The bituminous pavement mix shall be placed only when the bed is sufficiently dry and weather conditions are suitable for paving. The material shall be placed on the compacted bed course in one or more courses as indicated so as to give the required depth when rolled. Compaction shall be accomplished by means of a power roller of a type and weight acceptable to the Engineer. In areas inaccessible to the roller, compaction shall be accomplished by means of a manually guided mechanical vibratory plate compactor.

608-3.03 Reconstruction of Existing Sidewalk-

The reconstruction of P.C. concrete and bituminous concrete sidewalks will be performed in accordance with the

requirements included in Articles 608-3.01 and 608.3.02 above, as applicable.

608-4 METHOD OF MEASUREMENT

608-4.01 New P.C. concrete sidewalks will be measured by the square meter of completed and accepted sidewalk surface. The areas of ramps for wheel chairs and handicapped persons, driveway ramps, and paving of medians, malls and traffic separators called for in the plans or ordered by the Engineer will be included in the sidewalk area measurement.

608-4.02 Bituminous sidewalks will be measured by the square meter or by the ton, whichever is called for in the contract, of sidewalks completed and accepted. Ramps for wheel chairs and handicapped persons, driveway ramps, and paving of medians, malls, and traffic separators will be included in the measurement.

608-4.03 Reconstruction of sidewalks will be measured by the square meter of P.C. concrete or bituminous sidewalk reconstructed and accepted as called for in the plans or ordered by the Engineer.

608-4.04 Excavation, bed course, reinforcing steel, backfill, disposal of excess material and other miscellaneous items will not be measured directly for payment. These items and work shall be a subsidiary obligation of the Contractor with their cost included in the sidewalk pay items.

608-4.05 The demolition and disposal of existing sidewalks to be reconstructed shall be a subsidiary obligation of the Contractor under the pay item for sidewalk reconstruction.

608-5 BASIS OF PAYMENT

608-5.01 The accepted quantities, determined as provided above for the pay items listed below, which are included in the contract, will be paid for at contract price per unit of measurement. Such price and payment shall constitute full compensation for

furnishing and placing all required materials and for all labor, equipment tools and incidentals necessary to complete each item as required by the plans and specifications.

608-5.02 Payment will be made under:

Pay Item	Pay Unit
Portland Cement Concrete Sidewalk…..	Square Meter
Bituminous Concrete Sidewalk……..	Square Meter or Ton
Reconstruction of Existing Sidewalk…..	Square Meter

SPECIFICATION 609 – CURB AND GUTTER

609-1 DESCRIPTION

609-1.01 Scope

a. This work shall consist of the construction of curb, gutter or combination curb and gutter in accordance with these specifications and in reasonably close conformity with the lines, details, and grades shown on the plans or established by the Engineer.

b. The types of curbs and gutters covered by these specifications are as follows:

1. Cast in place concrete curb.

2. Cast in place concrete gutter.

3. Cast in place combination concrete curb and gutter.

4. Precast concrete curb.

5. Precast combination concrete curb and gutter.

c. Unless otherwise specified in the contract documents, the Contractor may, at his option, furnish either cast in place or precast curb or curb and gutter.

609-2 MATERIALS

609-2.01 Portland cement concrete for cast in place concrete curb, gutter and combination concrete curb and gutter shall meet the requirements of Specification 601 - Structural Concrete for the class of concrete indicated on the plans. If no class is specified in the plans, Class B concrete shall be provided.

609-2.02 Precast concrete curb and curb and gutter shall meet the requirement specified in Section 712-4 of Specification 712 -

Miscellaneous Materials. Precast sections shall be reinforced as required to permit lifting, hauling and placing without damage.

609-2.03 Other materials shall meet the requirements of the following specifications:

Material	Specification
Bed Course Material…….	703-5
Joint Filler…….	705-1
Joint Mortar……..	705-2
Curb Paint…….	716-1
Glass Beads for Reflectorized Paint……...	716-2
Reflectorized Paint……	716-3

609-2.04 Concrete and manufactured curbing materials will be subject to inspection and tests at the plants for compliance with quality requirements.

609-3 CONSTRUCTION REQUIREMENTS

609-3.01 Cast in Place Concrete Curb and Curb and Gutter

a. Excavation and Bedding - Excavation shall be made to the required depth, and the base upon which the curb is to be set shall be compacted to a firm, even surface. All soft and unsuitable material shall be removed and replaced with bed course material which shall be thoroughly compacted.

b. Forms - Forms shall be of metal and shall extend for the full depth of the concrete. Wooden forms may be used, when authorized by the Engineer, on short radius curves such as at street intersections and at such other locations for which curved metal forms may not be available. All forms shall be free from warp and of sufficient strength to resist the pressure of the concrete without displacement. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. All forms shall be cleaned and coated with an approved form release agent or

form oil before concrete is placed. Divider plates shall be of metal. Forms shall conform to the specified radius when placed on curves.

c. Mixing and Placing - Concrete shall be proportioned, mixed and placed in accordance with the requirements for the class of concrete specified. Consolidation of concrete placed in the forms shall be by mechanical vibration or other methods acceptable to the Engineer. Forms shall be left in place for 24 hours or until the concrete has set sufficiently so that they can be removed without injury to the curbing.

d. Finishing - Immediately upon removal of the forms the exposed surfaces of the curbing shall be given a Class 2 - Rubbed Finish with a carborundum stone in accordance with Specification 601 - Structural Concrete. For the purpose of matching adjacent concrete finishes or for other reasons, the Engineer may permit other methods of finishing. Plastering will not be permitted.

e. Sections - Curbing shall be constructed in sections having a uniform length of 3 meters, unless otherwise ordered. Sections shall be separated by open joints 3mm wide except at expansion joints. Where the curbing is constructed adjacent to concrete pavement, these open joints in the curbing shall match the contraction joints in the pavement.

f. Expansion Joints - Expansion joints shall be formed at the intervals shown on the plans using a preformed expansion joint filler having a thickness of 19mm. When the curb is constructed adjacent to or on concrete pavement, expansion joints shall be located opposite to or at expansion joints in the pavement.

g. Curing - Immediately upon completion of the finishing, the curbing shall be moistened and kept moist for three days, or the curbing shall be cured by the use of membrane forming material meeting the requirements of Section 711-1 of Specification 711. If after removal of the

forms back-filling is not done immediately, the surfaces thus exposed shall also be cured by the use of an approved membrane curing compound. The method and details of curing shall be subject to the approval of the Engineer.

h. Backfilling - After the concrete has set sufficiently, the spaces in front and back of the curb shall be refilled to the required elevation with suitable material, which shall be thoroughly tamped in layers of not more than 15 centimeters in depth. Backfilling at both front and back of new curb or curb and gutter constructed on projects open to traffic shall be completed within 48 hours after removal of the forms.

i. Curb Machine - The curb or curb and gutter may be constructed by the use of an automatic curb forming machine meeting the following requirements:

1. The weight of the machine shall be such that required compaction is obtained without the machine riding above the bed on which curbing is constructed.

2. The machine shall form curbing that is uniform in texture, shape and density.

3. The Engineer may permit the construction of curbing by means other than the automatic curber or machine, when short sections or sections with short radii are required, or for such other reasons as may seem to him to be warranted. The resulting curbing shall conform in all respects to the curbing produced by the use of the machine.

609-3.02 Precast Concrete Curb and Curb Gutter

a. Excavation and Bedding - Excavation and bedding shall conform to the requirements of paragraph 609-3.01a. above.

b. Installation - The curb shall be set so that the top lines conform to the line and grade required. All spaces under the curbing shall be filled with material conforming to the requirements of the material for bed course. This material shall be thoroughly tamped.

c. Joints - All joints, except expansion joints, shall be filled with mortar. In those cases where a portland cement concrete pavement is to be constructed contiguous to a curbing, joints shall be constructed in the curbing directly in line with the pavement expansion joints. These joints in the curb shall be l9mm in width and shall be filled with an expansion joint filler of the same nominal thickness as the pavement joint. Any voids between the filler and the precast curb shall be filled with mortar.

d. Backfilling - After the curb has been set, excavated areas shall be filled with approved material. This material shall be placed and thoroughly tamped in layers not exceeding 15 centimeters in depth.

609-3.03 Reconstruction of Concrete Curb and Gutters - The reconstruction of existing concrete curbs, gutters and combination curbs and gutters will be performed in accordance with the requirements included in Articles 609-3.01 and 609-3.02 above, as applicable.

609-3.04 Painting Concrete Curbs

a. When called for on the plans, the exposed faces of concrete curbs shall be painted within the longitudinal limits indicated. Paint shall be reflectorized yellow paint unless otherwise shown on the plans.

b. Painting shall be performed in accordance with the applicable construction requirements specified under Section 639-3 of Specification 639-Painted Pavement Markings.

SPECIFICATION 609 – CURB AND GUTTER

609-4 METHOD OF MEASUREMENT

609-4.01 For both new construction and reconstruction, curb will be measured by the linear meter, to the nearest tenth, along the front face of the section at the finished grade elevation. Combination curb and gutter will be measured along the face of the curb. Concrete gutter will be measured along the centerline of the gutter.

a. No deduction in length will be made for drainage structures, such as grate inlets, installed adjacent to the curbing when the curb is constructed independent of the drainage structure.

b. When the drainage structure, such as curb type inlets, include their own section of curb, the length of such structure curbing will be omitted from the measurement of curb and curb and gutter.

c. No deduction in length will be made for driveway ramps or for wheel chair ramps where the gutter is carried across the ramp.

609-4.02 Excavation, bed course, backfill, disposal of excess material and other miscellaneous items will not be measured directly for payment. These items and work shall be a subsidiary obligation of the Contractor with their cost included in the curb and curb and gutter pay items.

609-4.03 The demolition and disposal of existing curbs, gutters, and combination curb and gutters to be reconstructed shall be a subsidiary obligation of the contractor under the pay items of curb, gutter, and curb and gutter reconstruction.

609-4.04 The painting of concrete curb will be measured by the linear meter, to the nearest tenth, along the front face of the painted curbs.

SPECIFICATION 609 – CURB AND GUTTER

609-5 BASIS OF PAYMENT

609-5.01 The accepted quantities, determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract price per unit of measurement. Such price and payment shall constitute full compensation for furnishing and placing all required materials and for all labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications.

609-5.02 Payment will be made under:

Pay Item	Pay Unit
Concrete Curb, Type ___ ……..	Linear Meter
Concrete Gutter, Type ___ ……...	Linear Meter
Combination Concrete Curb and Gutter, Type ___ ..	Linear Meter
Reconstruction of Existing Curb, Type …….	Linear Meter
Reconstruction of Existing Gutter, Type ……...	Linear Meter
Reconstruction of Existing Curb and Gutter, Type...	Linear Meter
Painting Concrete Curb…….	Linear Meter

SPECIFICATION 610- UNDERDRAINS

610-1 DESCRIPTION

610-1.01 Scope

a. This work shall consist of constructing portland cement concrete barriers in accordance with these specifications and in conformity with the lines, dimensions, typical sections and other details shown on the plans, standard plans, or established by the Engineer.

b. This item also includes all reinforcing steel, fittings, dowels, cover plates, materials, excavation, backfill and all incidentals necessary to complete the item.

c. The concrete barrier may be constructed either cast-in-place or by slip forms at the option of the Contractor, unless otherwise specified in the contract documents.

610-2 MATERIALS

610-2.01 The portland cement concrete shall meet the requirements of Specification 601 - Structural Concrete for the class of concrete specified for each type of barrier. Sampling and testing of concrete shall be as specified in Article 601-2.09 except that a set of six cylinders for testing at 7 and 28 days shall be obtained for each 100 linear meters of barrier constructed with Class A concrete and for each 200 lineal meters of barrier using Class B concrete. Acceptability of the concrete shall be determined as provided in Article 601-2.10.

610-2.02 Reinforcing steel shall meet the requirements of Specifications 602 and 709.

610-2.03 Other materials shall meet the applicable requirements of the following specifications:

Structural Steel……	Specification 715-1
Joint Fillers……..	Specification 705-1

SPECIFICATION 610- UNDERDRAINS

610-3 CONSTRUCTION REQUIREMENTS

610-3.01 General - The following general requirements apply whether the barrier is constructed cast-in-place or by the slip form method.

a. The concrete barriers shall be constructed in conformity with the details shown on the plans for the applicable cases and barrier types, including the anchorage and joint requirements.

b. Concrete barriers shall present a smooth and uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the plans or ordered by the Engineer. When a 3-meter straight-edge is laid on top and faces of the barrier, the surfaces shall not vary more than 0.7 centimeter from the edge of the straightedge, except at grade changes and curves.

c. Curing of the concrete barrier shall conform to the requirements of Specification 601 - Structural Concrete.

d. Openings for drainage flow, lighting standard installation and pedestrian crossings shall be constructed in conformance with the details shown on the plans and at the locations shown on the plans or ordered by the Engineer.

e. When concrete barriers are to be constructed on an existing pavement or an existing bridge deck, the height of the barrier shall be adjusted to compensate for irregularities in the grade of the existing pavement or deck. The amount of the adjustment will be determined by the Engineer and will be ordered before the concrete is placed.

f. When a concrete barrier is to be constructed on an asphaltic concrete pavement that is being reconstructed, the barrier shall be erected after the leveling course has been placed but prior to the placing of the final surface layer.

SPECIFICATION 610- UNDERDRAINS

610-3.02 Cast-in-Place Construction

a. Forms may be either steel or plastic coated exterior plywood and shall have the necessary strength and bracing to retain their true shape and dimensions throughout their use without any deformation of the barrier. End sections and variable transition sections may be cast in wood forms.

b. Forms shall have smooth joints and inside surfaces accessible for adequate cleaning after each use. Corners and angles shall be mitered or rounded. Form ties shall be either of the threaded type or snap-off type so that no form wires or metal pieces will be left at the surface of the finished concrete.

c. The batching, mixing, handling, placing, finishing and curing of the concrete shall be in conformity with the applicable requirements of Specification 601 - Structural Concrete. Unless otherwise specified on the plans, all cast-in-place barriers shall be given a Class 2 - Rubbed Finish.

610-3.03 Slip-Form Construction

a. Concrete barriers may be constructed by using slip form machine capable of providing a well compacted, dense concrete with the finished barrier true to lines and grades and the exposed surfaces conforming to the requirements of this specification. The Contractor may be required to furnish evidence of previous successful operation of the slip form machine or other equipment.

b. The concrete shall meet all the pertinent requirements of Specification 601 not in conflict with this specification. It shall be of such consistency that after extrusion it will maintain the shape of the barrier without support.

c. The concrete shall be vibrated, rammed, tamped or worked with suitable appliances until the concrete has been consolidated to the maximum practicable density, free of

pockets, and closes snug against the form surfaces. The equipment shall be operated under sufficient uniform restraint to forward motion to produce the required consolidation.

d. The concrete barrier shall be given a water spray and steel trowel finish immediately after extrusion to provide a smooth, dense surface.

e. Expansion joints may be formed or sawed as indicated on the plans or ordered by the Engineer. Insertion of joint filler will not be required unless called for in the plans. If sawing or forming of joints is performed before the concrete has hardened, the adjacent portions of the barrier shall be firmly supported with close fitting shields. When sawing or forming of joints is performed after the application of curing compound, the exposed surface of the barrier in the vicinity of the joint shall be again treated with curing compound after the sawing or forming.

610-3.04 Temporary End Sections or Temporary Impact Attenuators

When concrete barrier is being constructed adjacent to lanes of roadway open to traffic, temporary end sections or impact attenuators of the design shown on the plans shall be placed at the end of the median barrier constructed each day. These temporary end sections or impact attenuators shall be located as called for by the construction schedule or ordered by the Engineer. The temporary end sections or impact attenuators shall remain in place until the construction of the barrier is continued or replaced by a permanent end section.

610-4 METHOD OF MEASUREMENT

610-4.01 The quantities of concrete barrier to be paid for under this item shall be the number of lineal meters, measured to the nearest tenth of a meter, of each case and type of barrier completed in place and accepted, measured along the top of the barrier. The measurement will include the lengths of the permanent end sections which shall be taken as the length of the horizontal projection or

footprint of the section extending from the nose to where the section joins the normal barrier section. No deduction will be made for pedestrian openings. However, openings for placing lighting or traffic signal standards will not be included in the measurement as these include their own concrete base.

610-4.02 On Type F barrier each half section of barrier will be measured independently with the length extending between the points where the Type F begins and ends as separate barriers at the junctions with a normal Type A barrier section or with a permanent end section.

610-4.03 Any excavation or borrow backfill that may be necessary in Case II construction on an existing raised or depressed median shall be measured for payment under the items of excavation or borrow, Specification 203, as the case may be.

610-4.04 The removal of any existing curb that may be necessary in Case II construction will be measured for payment under the appropriate pay item under Specification 202 if such pay item is included in the contract. However, if no separate pay item is provided in the contract, the removal of such existing curb shall be a subsidiary obligation of the Contractor under other contract items and no direct measurement for payment will be made.

610-4.05 Any new pavement built under or adjacent to the barrier in Case I, II or III construction will be measured for payment under the respective pavement pay items.

610-4.06 The following items will not be measured for direct payment as these will be a subsidiary obligation of the Contractor with their cost included under the concrete barrier pay items:

a. All reinforcing and structural steel used within the barrier system including dowels and anchors.

b. Temporary end sections or temporary impact attenuators.

c. The fill between the half-sections and the top concrete slab on Type F barriers.

d. The raising of manhole shafts and covers on Type F barriers.

e. The adjustment of the height of concrete barriers to compensate for irregularities in the grade of existing pavements or decks as required on article 610-3.01.

610-5 BASIS OF PAYMENT

610-5.01 The accepted lengths of each Case and Type of barrier measured as provided above will be paid at the contract unit price for each item. Such price and payment shall be full compensation for furnishing all materials, equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

610-5.02 Barriers for which the concrete is found deficient in strength but which are accepted by the Authority under the provisions of Article 610-2.01 of this specification will be paid for at a reduced unit price. The reduction will be computed in accordance with the criteria established in Section 601-5 of Specification 601 - Structural Concrete.

Pay Item	Pay Unit
Concrete Barrier, Case ___, Type ___ ……...	Linear Meter

SPECIFICATION 611 – FIELD OFFICE AND LABORATORY

611-1 DESCRIPTION

611-1.01 Scope

a. This work shall consist of providing, furnishing and maintaining in good condition one or more wood frame or metal buildings for the exclusive use of the Engineer and the inspection force during the construction period as field and laboratory office.

b. The type or types of buildings to be provided shall be as called for in the Proposal Schedule. The buildings shall be as described herein or as shown on the Standard Drawings. However, with the prior written approval of the Engineer, the Contractor may provide equivalent field and laboratory office spaces that meets the requirements of this specification. The alternatives may be suitable mobile trailers, prefabricated buildings, or space in existing buildings which are conveniently located with respect to the project. When trailers are provided, these shall be furnished with air conditioning equipment meeting the requirements of paragraph 611-2.01n of this specification.

611-2 MATERIALS

611-2.01 General Requirements for all Buildings

a. Each building shall be constructed in a workmanlike manner. They shall be adequately roofed and floored and made weather-tight.

b. Lumber for the construction of the buildings shall be of the kind and class best suited for the purpose. It shall be new except that the use of approved, sound, used lumber may by authorized by the Engineer.

c. Each building shall have a minimum ceiling height of 8 feet and louver type windows (Miami Type) to provide adequate ventilation. All windows shall be screened.

d. Each outside door shall be equipped with a cylinder lock and a screen door. Each inside door to offices and closets shall also be provided with a cylinder lock. Two keys shall be provided for each lock. Doors to toilet rooms shall be provided with privacy lock.

e. Each toilet room shall be provided with a flush type toiled and lavatory with running water complying with the sanitary code. Whenever possible, fresh water and sewer connections to facilities of the Puerto Rico Aqueduct and Sewer Authority (P.R.A.S.A.) shall be made. Where these are not available within a reasonable distance, an adequately sized cesspool for sewage disposal, or other acceptable method of disposal provided, and a 50-gallon elevated potable water tank shall be installed. The water tank shall be refilled daily by the Contractor with water safe for drinking and sanitary use.

f. The sink at the laboratory shall also be provided with running water. Where P.R.A.S.A. facilities are not available, an additional elevated 50-gallon water tank shall be provided for the laboratory and refilled daily by the Contractor while the laboratory is in use.

g. All storage closets shall be provided with at least four shelves totaling a minimum of 24 square feet of shelf space.

h. Each building shall be provided with an approved electrical system connected to the Puerto Rico Electric Power Authority (P.R.E.P.A.) facilities with a sufficient number of no glare type ceiling luminaries to provide a minimum illumination level of 100 foot-candles at desk height level. A sufficient number of electrical power wall outlets, distributed around the building, shall be installed to provide at least one double outlet per every 50 square feet of floor space or fraction thereof.

i. Each building shall be provided with at least one non-toxic, dry chemical fire extinguisher of commercial quality meeting Underwriters Laboratories, Inc. approval for Class A,

B and C fires with a minimum rating 2A: 10B: 10C for every 160 feet of floor space.

j. Off-street parking space with a capacity of at least five passenger cars shall be provided close to each field office building and separate from parking space provided for Contractor's personnel.

k. Where P.R.A.S.A. water facilities are available, each field office shall be provided with an electric water cooler. In other cases, a thermos jug of at least three gallon capacity shall be provided and filled daily with fresh potable water and ice by the Contractor.

l. A first-aid kit complying with OSHA requirements shall be provided at each field office and kept properly stocked by the Contractor at all times.

m. A standard pencil sharpener.

n. For field offices, air conditioning equipment having the capacity to maintain an ambient temperature of 70ºF ± 5º shall be provided.

611-2.02 Specific Requirements for Each Building

a. Field and Laboratory Office Model 1 - This building shall be 3.66 m (12 ft.) by 6.71 m (22 ft.) and shall provide a minimum area of 24.56 square meters (264 square feet) of floor space with one outside door. The building shall be constructed in conformance to details on Standard Drawing FILA 1 of 5. The building also includes tables, benches and equipment shown on this page.

b. Field and Laboratory Office Model 2 - This building shall be 6.09 m (20 ft.) by 4.88 m (16 ft.) and shall provide a minimum area of 29.72 square meters (320 square feet) of floor space with two outside doors. The building shall be constructed in conformance to details on Standard Drawing

FILA 2 of 5. The building shall be partitioned to provide a private office, approximately 3.05 m by 3.05 m, lavatory, toilet room, and two closets, approximately 0.91 m by 1.22 m for storage of equipment and supplies.

c. Field and Laboratory Office Model 3 - This building shall be 3.05 m (10 ft.) by 4.88 m (16 ft.) and shall provide a minimum area of 14.88 square meters (160 square feet) of floor space with one outside door. The building shall be constructed in conformance to details on Standard Drawing FILA 3 of 5. The building shall be partitioned to provide an office, lavatory, toilet room, and one closet, approximately 0.96 m by 1.19 m for storage of equipment and supplies.

d. Field and Laboratory Office Model 4 - This building shall be 3.05 m (10 ft.) by 4.88 m (16 ft.) and shall provide a minimum area of 14.88 square meters (160 square feet) of floor space with one outside door. The building shall be constructed in conformance to details on Standard Drawing FILA 4 of 5. The building shall provide one closet, approximately 0.91 m by 1.37 m for storage of equipment and supplies, a sink equipped with water faucet and drain line on a work counter of at least 10 feet long by 2 feet wide and a height of 3 feet. The work counter shall be provided with a minimum shelf space underneath of 20 square feet in area. A covered water tank, 6 feet long, 4 feet wide and 2½ feet high shall be provided outside the laboratory building.

e. Field and Laboratory Office Model 5 - This building shall be 3.05 m (10 ft.) by 7 92 m (26 ft.) and shall provide a minimum area of 24.16 square meters (260 square feet) of floor space with one outside door. The building shall be constructed in conformance to details on Standard Drawing FILA 5 of 5. The building shall be partitioned into an office 3.05 m by 3.05 m of floor area and a laboratory section. Each section shall have an outside door and in addition:

1. The office section shall be provided with the same lavatory and toilet room, and closet facilities as

required for Field and Laboratory Office Model 3 in paragraph “c” above.

2. The laboratory section shall be provided with the same sink, work counter and closet facilities as required for Field and Laboratory Office Model 4 in paragraph “d” above, except that the work counter may be reduced to a length of 7 feet with 14 square feet of shelf space underneath and closet of 3 feet wide by 2 feet deep and located next to the work counter. The outdoor covered water tank may be omitted in projects where no Portland cement concrete is to be used.

611-2.03 Field Office Equipment

a. Each Field and Laboratory Building Model 1 and Model 2 shall be provided with the following equipment in good working conditions and of quality satisfactory to the Engineer.

1. One typewriter, manual or electric, with standard keyboard and a 19 inch carriage.

2. One electric calculating machine, tape type, fully automatic with answer registered to at least ten (10) digits.

3. One standard office desk, 30” x 60”, plastic laminated top, six-drawer type with locks and keys, and with executive type, adjustable chair.

4. One standard secretarial type desk with adjustable secretarial chair.

5. One standard 4-drawer file metal cabinet, legal size and with lock and keys.

6. One standard drafting table, 36” x 60” minimum size.

7. Two adjustable draftsperson stools.

8. One 36” x 72” office table with plastic laminated top.

9. Four office chairs.

10. Two vertical filing plan racks with capacity for four sets of 22” x 36” plans each rack.

11. One roll file unit with eight 6” x 6” compartments capable of holding eight rolls of paper, each 22” wide.

12. One 35 mm camera.

13. One thirty six exposure 35 mm film and film development per month.

14. Copier machine capable of handling letter and legal size paper.

15. Plain paper fax machine.

16. Telephone line and monthly payment of telephone bills.

b. Each Field and Laboratory Office Model 3 and Model 5 shall be provided with the following equipment in good working condition and of quality satisfactory to the Engineer.

1. All the same equipment as listed in items (1) to (7) and (12) to (16) under paragraph “a” above for Field and Laboratory Office Model 1 and Model 2.

2. Two office chairs.

3. One vertical plan rack with capacity for four (4) sets of 22” x 36” plans.

4. One roll file unit with four 6” x 6” compartments capable of holding four rolls of pager, each 22” wide.

c. For each building, the Contractor shall furnish necessary miscellaneous items to include calculating machine paper, typewriter ribbons, paper cups, sanitary paper, and cleaning materials (brooms, mops, pails, detergents, etc.).

d. The Contractor shall furnish and install the following computer equipment and software for Field and Laboratory Office Models 1, 2, 3 and 5.

1. Hardware with the following minimum specifications.

(a) 2.0 GHz Pentium 4 microprocessor

(b) 256 MB RAM

(c) 40 GB Hard Drive

(d) 32 MB AGP Video

(e) 1.44 MB Floppy disk drive

(f) 700 MB CD- Writer

(g) 17 inch Color Monitor (1024 x 768)

(h) 56K Fax/Modem

(i) Laser Printer (capable of handling letter and legal size paper)

(j) 650VA UPS

2. Software – the latest release of the following titles:

(a) Windows XP Professional

(b) Office XP Professional

(c) AutoCAD

(d) Primavera Project Planner or Microsoft Project Professional

(e) Norton Antivirus

3. The Contractor shall provide all consumable materials for the computer equipments such as floppy disks, printer paper (letter and legal size), toner, CD-R disks and any other material needed for the operation of the equipment. Also, he shall be responsible for the repair, maintenance or upgrade work that may be needed on said equipment.

4. The Contractor shall provide a certification that all software provided for the use of the project has been legally acquired and is properly licensed. He shall exempt the Authority from any legal claim that may occur due to the improper use of the software.

5. Upon the completion of the project, the computer equipment and software shall revert to the Contractor.

611-2.04 Field Laboratory Equipment - Field laboratories on Field and Laboratory Office Models 4 and 5 shall be provided with the following equipment in good working condition. The laboratory equipment shall be equal or approved equal to that manufactured by Soiltest Inc., Karol-Warner Inc., or W.H. Curting.

a. One standard desk or writing table, 30” x 60”, with chair.

b. One field scale of 35-lb capacity accurate to 0.01 pound.

c. One triple beam scale, with brass scoop, of 2610 gram capacity, accurate to 0.1 gram.

d. One double burner electric hot plate or a kerosene or bottled gas stove suitable for drying soil or moisture samples.

e. One electric motorized or mechanical sieve shaker with a capacity of no less than six (6) sieves and 1 pan of 8-inch diameter.

f. One set of U.S. Standard Brass, 8-inch diameter woven-wire sieves conforming to AASHTO M 92. The sieve set shall include 2”, 1 ½”, 1”, ¾”, ½”, and $^{3}/_{8}$”, sieves and Nos. 4, 8, 10, 16, 30, 50 and 200 sieves, and sieve pan.

g. Six rectangular aluminum pans, 9 ¾” x 13” x ¾” deep.

h. For projects including earthwork operations under Specification 203 and/or the construction of aggregate base or surface courses, a nuclear testing device capable of measuring the in-place density of soil and soil-aggregate courses in accordance with AASHTO T 238, and a licensed operator to operate it when required by the Engineer. The Authority may relieve the Contractor of this requirement, at its discretion, on projects where the earthwork operation and the construction of aggregate base and surfaces are minor and incidental to the main construction items.

i. Apparatus to determine the liquid of soils as per AASHTO T 89 and the plastic limit as per AASHTO T 90.

j. Apparatus required to determine the moisture density relations of soils using the AASHTO T 180 Method D to include:

1. One 6-inch diameter compaction mold.

2. One 10-lb. Compaction rammer.

3. One hardened steel 10-inch straight edge with one beveled edge.

k. A concrete block 12” x 12” x 12” for soil compaction tests.

l. Apparatus required to determine the in-place density of soils by AASHTO T 191 (Sand-Cone Method). This item may be omitted on projects where no crushed gravel or crushed stone base or surface courses are included.

m. Twelve cylindrical metal molds with their bases or for making concrete specimens for compression strength tests. These molds shall be 6 inches diameter, 12 inches high and ¼ inch thick. The bases shall be 8 inches by 8 inches by ¼ inch thick. In lieu of metal molds, the Contractor shall provide all required single use plastic molds with lids, conforming to AASHTO M 205 and T 23, that are necessary to comply with the required frequency of concrete specimens sampling. Stripping tools for the removal of the samples from the mold shall be provided.

n. Two tamping rods with rounded tips.

o. Two truncated cone molds, 8” diameter at bottom, 4” diameter at top, 12” high, with a minimum gage thickness of No. 16, suitable for slump tests of concrete using AASHTO T 119.

p. For projects including earthwork operations and the construction of base and/or surface courses (aggregate, P.C.

concrete, or asphaltic), the Contractor shall provide an accurate 3-meter straightedge for checking surface tolerances.

q. Such special testing equipment or devices as specially required to be furnished by the Contractor in the specifications for construction items included in the contract.

r. The Contractor shall also furnish miscellaneous tools such as shovels, trowels, mixing spoons, spatulas, floats, pails, sample containers with close-fitting lids, etc. as may be required by the Engineer to collect and prepare samples for testing.

611-3 CONSTRUCTION REQUIREMENTS

611-3.01 General

a. The buildings shall be constructed near the site of the work, at a location acceptable to the Engineer. They shall be independent units, detached from any office, storage or warehouse building occupied by the Contractor. The building may be built on the project right-of-way (ROW) when space is available. If no space is available within the ROW, the Contractor shall obtain, at his expense, the necessary space at an approved location.

b. The buildings shall be completed and be fully equipped as required by this specification, to the satisfaction of the Engineer, prior to the start of any contract work. The building shall be removed by the Contractor outside of the project site after acceptance by the Authority of the work under the contract, unless otherwise ordered or authorized by the Engineer.

611-3.02 Maintenance

a. The Contractor shall maintain all buildings and equipment in good condition throughout the duration of the project and he shall promptly repair and replace any item

damaged through normal usage or by any causes other than negligence on the part of the Engineer and his personnel.

b. The Contractor shall perform routine cleaning of the field office twice a week such as but not to: sweeping, dusting, moping and toilet room cleaning.

c. Laboratory equipment, calculating machines and typewriters not in good operating condition or damaged shall be repaired or replaced within five (5) days of the date of notification to the Contractor.

d. Should the Contractor fail to repair or replace an item not in adequate working condition, the Engineer may order such item repaired or replaced with the cost deducted from any payment that may be due the Contractor of he may apply the provisions of Article 611-5.04 of this specification, at his discretion.

e. After the usage of the buildings is terminated by the Engineer, these shall be removed from the project by the Contractor, the areas cleaned and left in a neat acceptable condition.

611-4 METHOD OF MEASUREMENT

611-4.01 The unit of measurement for each field and laboratory office specified and used on the project will be by the month measured from the date each building is completely furnished and ready for occupancy, as determined by the Engineer, to the date that it is released back to the Contractor for removal. Periods of less than one month will be computed at the rate of 1/30 of the unit price per month for each day of occupancy by the Engineer.

611-5 BASIS OF PAYMENT

611-5.01 Payment for each accepted building, constructed and furnished complete as specified herein, will be paid for at the corresponding contract unit price. Such price and payment shall

constitute full compensation for furnishing the site of the building, for furnishing and erecting the building, furnishing of the specified utilities and payment of utility charges, furnishing of the specified office and laboratory equipment, maintenance of the building and cleaning of the site upon completion of each item as required by the plans and specifications.

611-5.02 Payment will be made under:

Pay Item		Pay Unit
Field and Laboratory Office Model 1	……...	Month
Field and Laboratory Office Model 2	……...	Month
Field and Laboratory Office Model 3	……...	Month
Field and Laboratory Office Model 4	……...	Month
Field and Laboratory Office Model 5	……...	Month

611-5.03 No payment will be made for time periods for which the Contractor is subject to assessment of liquidated damages under Section 108.09 of the General Provisions.

611-5.04 No payment will be made for periods of time in which the Contractor fails to comply with any of the requirements of this specification

611-5.05 Deductions under paragraphs 5.03 and 5.04 above will be assessed at 1/30 of the monthly unit price per day of penalty or non-compliance. These deductions will be non-refundable.

SPECIFICATION 612 – HIGHWAY LIGTHTING SYSTEM

612-1 DESCRIPTION

612-1.01 Scope

a. This work shall consist of furnishing and installing highway lighting systems, including temporary ones, in accordance with these specifications and in conformity with the lines, dimensions and details shown on the plans, or established by the Engineer. It shall be connected to the Puerto Rico Electric Power Authority (PREPA) power distribution system and be fully operational when completed.

b. This work shall also cover the removal, relocation and/or rehabilitation of existing highway lighting systems in accordance with this specification and with the details shown on the plans.

c. The system shall include the lighting standards, bases, foundations, luminaries, lamps, ballasts, pull boxes, junction boxes, service pedestals, substations, protective devices, conduits, conductors, control devices, and all hardware, fittings and other materials and equipment required to provide a complete operational facility as specified and shown on the plans.

612-2 MATERIALS

612-2.01 General

a. All electrical equipment shall conform to the applicable standards of the National Electrical Manufacturers Association (NEMA), the Underwriters Laboratories, Inc. (UL), and the Electronics Industries Association (EIA). In addition to the requirements of the plans, these specifications and the special provisions, all materials and workmanship shall conform to the requirements of the P. R. Electric Power Authority (PREPA) and the National Electrical Code (NEC) and to the applicable standards of the Illuminating Engineering Society (IES), the Edison Electric Institute

(EEI), the Insulated Power Cable Engineers Association (IPCEA), the American National Standards Institute (ANSI), the Institute of Electronic and Electrical Engineers (IEEE) and the American Society for Testing and Materials (ASTM).

b. Wherever reference is made to any of the standards or codes mentioned above, the reference shall be construed to mean the standard or code that is in effect on the date the contract is advertised for bids. Differences in standards or code requirements shall be resolved as determined by the Engineer.

c. Where a criterion specification is designated for any material or equipment to be installed by the name or catalog number of a specific manufacturer, such designation is intended only for the purpose of establishing the style, quality, and performance characteristics, and is not intended to limit the acceptability of competitive products. Products of other manufacturers which meet the specification requirements and which are approved as similar and equal will be acceptable.

612-2.02 Highway Lighting Materials - The following materials used in highway lighting systems shall meet the requirements of the specification indicated:

Material	Specification
Aluminum Lighting Standards…….	714-1
Concrete Lighting Standards……	714-2
Wood Lighting Standards…….	714-3
Luminaries……	714-4
Lamps……...	714-5
Lamp Ballasts……...	714-6
Substations……	714-7
Lighting Controls……..	714-8
Galvanized Steel Conduit…….	714-9
Rigid Plastic Conduit……	714-10
Junction Boxes……..	714-11

SPECIFICATION 612 – HIGHWAY LIGTHTING SYSTEM

612-2.03 Concrete - Shall conform to the requirements of Specification 601 - Structural Concrete and shall be Class A unless otherwise specified.

612-2.04 Reinforcing Steel - Shall conform to the requirements of Specification 602 - Reinforcing Steel.

612-2.05 Paints - Shall conform to the requirements of the following AASHTO specifications unless otherwise specified.

Aluminum Paint…….	M 69
White and Tinted Ready-Mixed Paint……...	M 70

612-2.06 Equipment List and Shop Drawings

a. The Contractor shall submit to the Engineer for review, within 30 days following the award of contract and before purchasing materials or equipment for this work, a list of the equipment and materials which he proposes to install. The list (seven copies) shall be complete as to the name of manufacturers, size, and identifying number of each item. Such list shall be supplemented by descriptive literature, drawings, specifications, manuals and such other data as may be required.

b. The Contractor shall also submit to the Engineer for review and approval, seven copies of manufacturer's shop drawings, structural design computations, and schematic wiring diagrams. The approval of shop drawings and diagrams by the Engineer shall not relieve the Contractor of responsibility for erroneous or inconsistent dimensions, notations, omissions or other errors, or for the proper functioning of the completed installation.

c. The Contractor shall submit to the Engineer three sets of the photometric data for the luminaries he proposes to use.

612-2.07 Warranties, Guarantees, Parts Lists and Instruction Sheets

The Contractor shall deliver to the Engineer prior to acceptance of the project, the manufacturers' warranties and guarantees furnished for materials and equipment used in the work and the parts lists and instruction sheets supplied with any equipment.

612-3 CONSTRUCTION REQUIREMENTS

612-3.01 General

a. The construction of the highway lighting system shall be in accordance with the regulations and standards of PREPA, NEC, IES, IEEE, EEI, and IPCEA.

b. Construction shall conform to the details shown on the plans; however, the location of lighting standards and appurtenances shown on the plans are approximate only and the exact location will be established by the Engineer in the field.

c. Upon completion of the work the Contractor shall submit "As Built" plans incorporating any changes in the original plans.

d. The Contractor shall obtain all necessary permits and inspections required by PREPA and other laws and regulations, and all required fees shall be included in the contract price.

e. Existing and temporary highway lighting systems shall be kept in effective operation for the benefit of the traveling public during the progress of the work, except when a shutdown is permitted to allow for alterations or final removal of the systems. The Contractor shall notify the

Engineer and PREPA prior to performing any work on existing systems.

612-3.02 Excavation and Backfilling

a. Before making excavations for any underground work, the Contractor shall notify the Engineer a minimum of two weeks in advance so that the location of all underground installations in the project area may be determined. It will be the responsibility of the Contractor to make the necessary contacts with utilities and others who have underground installations in the project area. Any damage to existing facilities caused by negligence by the Contractor shall be repaired by the Contractor at no expense to the Authority.

b. Unless otherwise indicated in the contract documents, the Contractor shall do all excavation, backfilling and resurfacing work, including removal and replacement of curbs, sidewalks, paved surfaces and other materials necessary to complete the work in accordance with the plans and specifications.

c. Excavation and backfilling shall conform to the applicable requirements of Specification 205 - Trench Excavation and Specification 206 - Excavation for Structures, supplemented as follows:

1. The location of conduit trenches are shown approximately on the plans and will be located in the field by the Engineer. All conduit trenches shall be dug to the depth and details shown on the plans and in compliance with PREPA requirements. Unless otherwise shown on the plans, trenches shall have a minimum width of 15.2 centimeters and have such depth as to provide for 5.1 centimeters of sand fill under the lowest conduit and a minimum cover of 91 centimeters over the top of conduits for conductors of less than 600 volts and 122 centimeters for conductors of 600 volts and higher voltage.

2. In making excavations in paved surfaces, cuts shall be made with diamond blade or abrasion disk type power saw along the neat boundaries of the area to be removed as specified in paragraph 3.03b below.

3. Backfill shall be done in 15-centimeter layers, compacted by mechanical tamping tools, with material approved by the Engineer.

4. All excavations for pole or pedestal foundations shall be made to the neat lines of the foundations. No backfilling will be permitted as the concrete must be placed directly against the sides of the excavation. On completion of the work, the top surfaces shall be replaced and finished to correspond with the existing surrounding surfaces.

5. Unless otherwise authorized by the Engineer, all surplus excavated material shall be removed and disposed of, within 48 hours, outside the right-of-way or at locations within the project approved by the Engineer. The excavation site shall be cleaned up and left in a neat condition satisfactory to the Engineer.

612-3.03 Removing and Replacing Improvements

a. Improvements such as sidewalks, curbs, gutters, guard rails, P.C. concrete and asphaltic concrete pavements, underlying materials, lawn and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of materials as found in the work or with materials of equal quality acceptable to the Engineer.

b. The outline of all areas to be removed in pavements sidewalks, curbs, gutters and driveways shall be cut to a minimum depth of five (5) centimeters with a diamond blade or abrasion disk type saw, prior to removing the existing

material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

612-3.04 Foundations

a. Foundations for lighting standards and pedestals shall be of plain or reinforced concrete conforming to the details shown on the plans.

b. The concrete foundations shall rest on solid ground. Forms shall be true to line and grade. Tops of foundations shall be finished to roadway, sidewalk or curb grade or as directed by the Engineer. Forms shall be rigid and securely braced and shall be held in place until the concrete has set up. Conduit ends and anchor bolts shall be placed in proper position and to proper height, and shall be held in place by means of a template until the concrete has set up.

c. All exposed portions of concrete structures shall be finished to present a neat appearance. The exposed foundations for poles and pedestals shall be finished square, with all holes filled, and the concrete surfaces finished smooth. The projection of foundations above adjacent surfaces shall be as shown on the plans or as ordered by the Engineer.

d. Where obstructions prevent the construction of planned foundations, the Contractor shall construct an effective foundation satisfactory to the Engineer or relocate the foundations to a location designated by the Engineer.

e. Foundations for lighting standards shall be provided with conduits for the conductor systems and for the ground connection as shown on the plans.

f. Special foundations shall conform to the applicable portions of the specifications listed herein, to the details shown on the plans and to any special requirements.

SPECIFICATION 612 – HIGHWAY LIGTHTING SYSTEM

612-3.05 Erecting Lighting Standards

a. General

1. Lighting standards shall be erected at the locations and in accordance with the details shown on the plans or ordered by the Engineer. Unless otherwise approved, bracket arms shall be fastened to the pole or shaft prior to erection.

2. The protective wrapping shall not be removed from any of the aluminum shafts or bracket arms until authorized by the Engineer. The Contractor shall be responsible for any damage to the lighting standards resulting from rough handling during loading, shipping, unloading, storage and erection. The Contractor shall satisfactorily repair or replace, at his expense, any component so damaged

b. Aluminum Standards

1. Each aluminum lighting standard shall be set vertically on the foundation or anchorage, employing approved galvanized steel shims when necessary. Unless otherwise shown on the plans, transformer bases shall be used in all cases except that anchor bases (shoe bases) only will be used for lighting standards mounted on concrete barriers or bridge parapets. The transformer base or anchor base shall be securely bolted to the anchorage by the anchor bolts previously set.

2. When necessary the lighting standard shall be erected with sufficient rake so that it will assume a vertical position after all attachments and appurtenances are in place.

c. Concrete Lighting Standards

1. Concrete poles shall be installed directly in the ground or as indicated on the plans. When installed on the ground, a 1.52-meter deep hole shall be dug for installation of the pole.

2. A thin steel wire shall be pulled through each pole, prior to installation, from the bottom hole to the top hole by the manufacturer to facilitate the pulling of conductors after pole has been erected.

3. The flat surfaces of the octagonal poles with the holes for wiring shall lie parallel to the centerline of the highway or street. After installing the pole in the pole hole, backfill shall be placed in layers not thicker than 15 centimeters and thoroughly compacted with mechanical tamping tools. Care shall be exercised in handling the concrete pole so as not to chip off the concrete. Concrete scars in the pole less than 1.25 cm. in depth shall be mended in the field. Poles with concrete scars which reach the reinforcing steel will be rejected.

4. Bracket arms shall be of the type specified in the contract documents. If the type is not specified, aluminum bracket arms shall be used.

d. Wood Lighting Standards

1. Wood poles shall be set to such depth as required in the PREPA standards for its distribution lines. Backfill for wood poles shall be placed as required for concrete poles in paragraph 3.05c(3) above.

2. Bracket arms may have to be installed on PREPA distribution line poles when new lighting poles would interfere with existing aerial power lines.

Such installations shall be coordinated with and meet the approval of PREPA.

3. Bracket arms shall be of the type specified in the contract documents. If the type is not specified, aluminum bracket arms shall be used.

612-3.06 Conduits

a. General

1. All conductors shall be run in conduit except overhead and temporary installations and where conductors are run inside poles and bracket arms.

2. Conduits shall be of the sizes shown on the plans. The Contractor may, at his option and expense, use conduit of a larger size than specified provided the larger size is used for the entire length of the run from outlet to outlet. No reducer couplings shall be permitted.

3. Conduit runs shown on the plans may be changed as to location only, with the approval of the Engineer, to avoid obstructions.

4. All conduit bends shall be standard factory bends. Where factory conduit bends are not commercially available, or for locations requiring special bends, conduit may be bent in the shop or field provided that:

(a) Radius of bends shall be the longest practicable but not less than six times the inside diameter of the conduit.

(b) The bends are made without any crimping, flattening or appreciably reducing the internal diameter of the conduit.

(c) No bends will be accepted for steel conduit which show any evidence of destruction of the protective coating.

5. The ends of conduits whether field or shop cut shall be made square and true so that the ends will butt or come together for the full circumference thereof. When a standard coupling cannot be used for coupling steel conduit, an approved threaded union coupling shall be used. All couplings for steel conduit shall be tightened until the end of the conduits are brought together, providing a good connection throughout the entire length of the run.

6. All steel conduit ends shall be threaded and capped with standard pipe caps until wiring is started. When caps are removed, the threaded ends of the conduit, including conduit nipples in cabinets, shall be provided with a metallic conduit ground bushing having a smoothly rounded molded insulated insert. Grounding type bushings shall always be used for steel conduits unless otherwise specified. When an open conduit ends below ground, the Contractor shall furnish and install a non-hardening compound that will prevent the entrance of moisture.

7. Underground conduit runs and conduit risers in poles shall be installed as needed even though not shown in plans.

8. Non-metallic type conduit shall be cut with a hacksaw or other approved tool and connections shall be of the solvent weld type. The ends of these conduits shall be capped until wiring is started.

9. All spare conduits for future use shall be capped at both ends and shall be provided with a #14 galvanized steel fish wire.

b. Underground Conduit

1. Conduit shall be installed as indicated on the plans within the required excavations. The bottom of the trench shall be free of rocks and sharp objects. At 30 centimeters below the finished grade and above any underground conductor, a warning yellow color electrical identifying polyvinyl chloride tape, 15 cm. wide, shall be installed. The identifying tape shall be permanently printed with continuous black letters, 3.2 cm. x 1.6 cm. with the words "PELIGRO – PELIGRO" on the top half and "LINEAS ELECTRICAS DEBAJO" on the bottom half as per PREPA standards. Conduit crossings under pavements shall be identified by a square concrete marker slab, 0.3 M X 0.3 M X 0.15 M in depth, placed over each end of the conduit as per plan details.

2. Unless otherwise specified in the contract documents, conduit for underground conductors shall be PVC Schedule 40.

3. When installed under pavements, PVC conduit shall be protected by a concrete encasement as per PREPA standards.

c. Conduit in Structures

1. Conduit which is to be embedded in structural concrete shall be either rigid galvanized steel or rigid PVC unless otherwise specified. An expansion joint of an approved type shall be installed at every expansion joint in the structure that the conduit crosses.

2. For exposed installation in structures, the conduit shall be rigid galvanized steel and shall be attached with approved clamps or straps.

3. For lighting systems installed on a concrete barrier, the conduit shall be PVC Schedule 40. Where conductors connect from a concrete median barrier to serve lighting standards outside of the shoulders, the conduit shall be installed perpendicular to the construction centerline.

d. Conduit in Junction Boxes - Conduit entering the sides of junction boxes shall terminate approximately 25 mm. inside the box wall. Conduit entering through the bottom of the junction boxes shall be located near the end walls to leave the major portion of the box clear. At all outlets, conduits shall enter from the direction of the run.

e. Conduit in Foundations

1. The conduit for the lighting conductors shall be installed on each side of the foundation that faces an underground conduit.

2. The conduit for the ground conductor shall be installed on the side of the foundation adjacent to the driven ground rod and shall terminate a minimum of 15 cm. below the finished grade at the ground rod location.

3. Steel conduits placed on foundations shall be so grouped that, with the pole in place, it is possible to place an insulated ground bushing on each conduit end.

f. Testing

1. All conduits installed shall be tested for clear bore and correct installation by the Contractor using an appropriate snake before the installation will be accepted. Snaking of the conduits shall be done by the Contractor in the presence of the Engineer or his representative. Any obstructed conduit shall be

cleared by the Contractor and he shall replace any defective conduit at his expense.

2. A record shall be kept as the conduits are tested and, after testing, all the empty conduits and duct openings shall be capped or plugged by the Contractor as directed.

612-3.07 Pull and Junction Boxes

a. Pull and junction boxes shall be installed at the approximate locations shown on the plans. In long conduit runs they shall be spaced in accordance with the pull tension capabilities of the conductors. The Contractor may, at his expense, install additional junction or pull boxes to facilitate his work. Additional boxes shall not be of smaller size than that required by the NEC for the number of conductors to be placed in the box. All junction and pull box locations shall be noted by the Contractor on the plans, both as to location and depth below the surface.

b. Sizes of pull and junction boxes shown on the plans or called for in the contract documents are inside dimensions. The Contractor may, at his option and expense, use pull or junction boxes of a larger standard size than shown or specified.

c. The tops of pull and junction boxes installed in sidewalk or paved areas shall be flush with the surrounding grade or top of adjacent curb. Those installed in the ground shall have the tops projecting 5 cm. above the adjacent grade.

d. All conduit entrances into pull or junction boxes shall be made watertight.

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612-3.08 Service Pedestals

a. The Contractor shall excavate holes 45 cm. deep and 50 cm. in diameter at the places indicated on the plans or as directed by the Engineer.

b. Before placing the service pedestals, the bottom of the hole shall be free of rocks and sharp objects and shall be covered with 15 cm. of sand. The pedestal enclosure shall be fixed within the hole by close compacted backfill. All connections shall be done by means of PREPA approved universal service taps.

612-3.09 Conductor

a. Either multiple-conductor or single-conductor cable may be used provided they meet the requirements of Article 714-13 of Specification 714. All cable shall be new, free from defects, and shall be delivered and stored in reels.

b. Wire from the pole base to the high-pressure sodium lamp ballast shall be No. 10 AWG XLP cooper conductor.

c. Wiring shall be done in conformance with the NEC and PREPA standards. Conductors within fixtures and service cabinets shall be neatly arranged and shall be cabled together as appropriate with self-clinching nylon cable ties, waxed lacing or other approved method.

d. An UL approved inert lubricant shall be used when inserting conductor in conduit. Conductors shall be pulled into conduit by hand exercising care so as not to damage them. The use of winches or other power actuated pulling equipment will not be permitted.

e. All stranded conductors to be connected to terminal screws shall have spade type pressure terminals on the ends of the conductors.

f. Unless otherwise specified or authorized by the Engineer, splicing will only be permitted as follows:

1. In pull boxes.

2. In junction boxes.

3. In the bases of lighting standards.

4. In pedestals.

g. All splices shall:

1. Be made with solderless connectors or compression sleeves.

2. Meet UL and PREPA requirements.

3. Be insulated to provide a watertight connection and shall be capable of satisfactory operation under continuous submersion in water.

h. Unless otherwise shown on the plans, fused splice connectors shall be installed in the conductors between the line and the ballast at the base of each lighting standard as shown in PREPA standards STL-1, 3, 4 and 6. The fused splice connectors shall be PREPA approved Elastimold connector or approved equal. These connectors shall be of the breakaway type designed to separate with the fuse held on the load side when the lighting standard is dislodged. The connector shall have no exposed metal parts except that the heads of stainless steel assembly screws pay be exposed. The splice connector shall completely enclose the fuse and shall protect it against damage from water and weather.

i. Highway illumination circuits paralleling or crossing any other underground electrical circuit, or other utilities, shall be physically separated at least 33 cm. as required by PREPA.

SPECIFICATION 612 – HIGHWAY LIGTHTING SYSTEM

612-3.10 Substations

a. General

1. The location of substations, and primary lines connectors shown on the plans are approximate only and may be changed by the Engineer within a 50-meter radius of the plan location at no extra expense to the Authority.

2. The installation of the substations shall be performed by the Contractor except when the installation interferes in any manner with an energized line, in which case the installation shall be performed by PREPA at the Contractor's expense.

b. The types of substations used are as called for on the plans.

1. Pole mounted substation shall be single phase and consist of:

(a) A distribution transformer.

(b) Lighting control equipment for centralized system, if applicable, housed in a PREPA approved hot-dip galvanized and bonderized steel cabinet if located one mile or further from the sea. Cabinets located less than one mile from the sea shall be made of either stainless steel or aluminum.

(c) Fuses or breakers for circuit protection located in hot-dip galvanized and bonderized steel cabinet, PREPA approved. If within one mile from the sea, this cabinet shall be of either stainless steel or aluminum.

(d) Concrete utility pole.

(e) Service risers.

(f) Primary fuse cutouts.

(g) Lightning arresters.

(h) Grounding system.

(i) Secondary risers including connectors.

(j) Metallic cross arms or other support system and all necessary hardware.

(k) Meter base and equipment and concrete pedestal or protection.

(l) Slack tap primary connection as indicated on the plans.

2. Pad mounted substations include the same items (a), (d), (f), (g), and (h) above plus the following:

(a) Steel enclosure on concrete pad which shall be weatherproof, tamperproof, free standing of self supporting construction, designed for outdoor mounting on a concrete foundation and requiring no additional fencing to make it completely safe. The unit shall be constructed in accordance with standards of PREPA. The enclosure shall be constructed of AISI Grade 304 stainless steel and shall have a 95KV basic insulation level. However, when located within one mile from the sea, the enclosure shall have a 110KV basic insulation level. Manufacturer's shop drawings shall be approved by PREPA prior to installation of the unit.

(b) Cable terminations and conduit bushings.

(c) Stress relief cones.

(d) Cable and bus connections.

(e) All necessary hardware.

(f) Underground primary feeder installation as per PREPA standard URD-9 and concrete pole and riser (PREPA URD-5) to connect to PREPA primary lines. A spare conduit with end caps shall be included and a primary 15 KV underground shielded feeder as indicated on the plans.

(g) 15KV disconnect type power fuse.

(h) Secondary main breaker.

(i) Secondary distribution section with breakers.

(j) Meter section with metering equipment.

(k) Lighting control equipment for centralized system including photo cell installation on a separate pole or pedestal as required by PREPA.

c. Transformers

1. Transformers shall be of the ratings and primary voltages indicated on the plans.

2. The size of wire from the PREPA secondary, when not shown on the plans, shall be as specified by

the NEC, and not less in current carrying capacity than the circuit breaker rating.

d. Primary fuse cutouts shall be of the ratings indicated on the plans and shall conform to the requirements of paragraph 714-7.01f of Specification 714 and to PREPA specifications.

e. Lighting arresters shall be distribution type of the ratings indicated on the plans and shall conform to the requirements of Article 714-7.02 of Specification 714 and to PREPA standards.

f. Electrical Service Installation

1. The electrical service equipment, materials, and installation shall conform to PREPA requirements.

2. The Contractor shall furnish and install meter socket and appurtenances for the meter to be subsequently installed by PREPA.

3. The Contractor shall arrange with PREPA for the completion of service connections and shall pay all costs and fees required by PREPA.

612-3.11 Lighting Controls

a. Lighting control shall be by centralized or individual system as specified on the plans.

b. The photoelectric controls shall be of the ratings specified on the plans. For centralized systems, the lighting control shall have the capacity for switching the whole multiple systems directly.

c. Relays shall have a delayed circuit response to prevent false operation, separate built-in surge lighting protection, and adjustable operation light levels from one (1) to six (6) footcandles.

d. The installation of the controls and related equipment shall be done by the Contractor in such a manner that there will be no interference with the PREPA power lines or service.

612-3.12 Grounding

a. Individual grounds shall be provided for electrical equipment and lines as follows:

1. Secondary lines - One side of two wire system secondary lines, neutral wire.

2. Lightning arrester ground terminals.

3. Switch frames, disconnecting switch cases, transformers and transformer enclosures, and all other equipment cases.

4. Lighting standards and luminaries, in accordance with PREPA requirements, except that the grounding of lighting standards mounted on structures shall be as indicated on the plans.

b. Grounding shall be in strict accordance with NEC and PREPA requirements.

c. Ground rods shall be driven full length with the end approximately 30 cm. below the finished grade at the ground rod locations. In rock locations that prevent full length driving, special provisions shall be made to obtain satisfactory grounds by connection to water mains or to adjacent well-grounded secondary neutral, or the Contractor may install, with the approval of the Engineer, a buried iron

or copper plate at the bottom of the concrete foundation hole. Particular care shall be taken to insure that the low ground resistance secured at the time of installation will be maintained. The ohmic resistance of the buried plate ground shall be equivalent to the rod resistance.

612-3.13 Luminaries

a. Luminaries of the type and wattage specified, complete with lamps, conductors and accessories, shall be mounted as shown on the plans.

b. Standard mount luminaries shall be installed on the lighting standard bracket arms in accordance with the manufacturer's instructions, at the specified mounting heights, leveled in both the transverse and longitudinal directions so as to be in a completely horizontal position, and placed so that the light pattern is correctly distributed along the roadway.

c. Wall type luminaries for tunnels and underpasses shall be installed on outlet boxes flush with the surface of the wall.

d. Cast aluminum bodies of luminaries which are to be cast into or mounted against concrete shall be given a thick application of alkali-resistant bituminous paint on all surfaces which are to be in contact with the concrete.

612-3.14 Ballasts - Ballasts shall be installed and connections made in accordance with the manufacturers' recommendations.

612-3.15 Painting

a. All electrical equipment requiring painting, shall be painted in accordance with the applicable provisions of Specification 616 - Steel Structures as supplemented herein.

b. All ungalvanized ferrous surfaces to be painted shall be factory cleaned and a prime coat applied both inside and outside.

c. Aluminum, stainless steel and galvanized steel equipment; and concrete and wood poles will not be painted unless specified in the contract documents.

d. In order to determine the number of paint applications, the Contractor shall use, except for the final coat, an off-shade of the specified paint. The final coat of paint shall be applied only after all equipment has been placed in final position and all attachments and appurtenances completely assembled and all scars and abraded places spot coated with primer and two coats of the specified paints.

e. The bases of aluminum standards which are to be installed in contact with concrete foundations shall be given a thick coating of alkali-resistant bituminous paint or equivalent paint.

f. Any dissimilar metal, except stainless or galvanized steel, that is to be installed in contact with aluminum shall be given a prime coat of zinc chromate followed by two coats of aluminum paint. Such paint shall not contain lead pigmentation.

612-3.16 Temporary Highway Lighting

a. Temporary highway lighting shall be furnished, installed, operated and maintained by the Contractor as shown on the plans or as ordered by the Engineer. The temporary lighting units shall remain in place and in operation until their relocation and/or removal is ordered by the Engineer.

b. Temporary lighting standards shall be relocated as shown on the plans or as ordered by the Engineer.

c. After the new lighting installation is complete and operational and when ordered by the Engineer, the Contractor shall remove the temporary highway lighting system and shall deliver the salvaged materials to the specified location.

d. The electric power consumption and the maintenance of the temporary highway lighting shall be at the Contractor's expense as a subsidiary obligation under the temporary highway lighting standards pay items.

612-3.17 Relocation of Existing Lighting Standards

a. Existing lighting standards shall be relocated as indicated on the plans or as ordered by the Engineer.

b. For each standard to be relocated, the Contractor shall provide the necessary foundation, base, anchorage, conductors, fuses and all hardware and appurtenances necessary to complete the installation at the new location. The existing pole, bracket arm, luminaire and other components which are damaged shall be repaired or replaced as necessary. Any missing components and hardware shall be replaced.

612-3.18 Rehabilitation of Existing Lighting System

a. Existing light standards to be rehabilitated shall be as indicated on the plans.

b. The rehabilitation work shall include the replacement of any missing hardware and components and the repair or replacement of any damaged components.

c. When new conductors are to be placed in existing conduits, the existing conductors shall be removed and any obstructions removed. This work shall be a subsidiary obligation of the Contractor under the pay items for the new conductors.

612-3.19 Removal of Existing Lighting System

a. Existing and temporary lighting standards and substations shall be removed as indicated on the plans or as ordered by the Engineer.

b. The Contractor shall restore and close any existing series or multiple circuits affected by the removal to insure that the portions of the systems to remain are operational. This electrical system restoration work shall be a subsidiary obligation of the Contractor under the removal pay items.

c. The removed lighting standards shall each be disassembled into its major components (pole, bracket arms, luminaries) for delivery to the location designated in the contract documents.

d. The removal of existing substations shall be performed in accordance with accepted industry practices. Removed substations shall be delivered to the designated locations.

e. The removal work includes the demolition of the foundations and anchorages of lighting standards and substations to be removed. Such work shall be a subsidiary obligation of the Contractor under the removal pay items.

612-3.20 Testing of the Installation

a. Upon completion of the work, the installation shall be tested by the Contractor, at his expense, to insure that the lighting system meets all plans, specifications and PREPA requirements. The Contractor shall furnish all labor, materials and equipment necessary for making the required tests and shall maintain a record of the results.

b. The testing shall be witnessed by representatives of PREPA and the Authority. It shall be the responsibility of the Contractor to make all arrangements with PREPA for the necessary power connections for the testing and for their attendance at the testing.

c. Field testing shall include all required PREPA tests including but not limited to:

1. Each circuit, including primary and secondary distribution, shall be tested for continuity, grounds, shorts, high potential and proper current to insure that it is in satisfactory working condition.

2. Light distribution to insure that the design distribution is met.

d. A functional test shall be made to demonstrate that each and every part of the system functions as specified. This functional test shall consist of not less than seven (7) days of continuous satisfactory operation of the system under normal conditions.

e. Any deficiencies in the system and any of its components encountered during the field testing, and any unsatisfactory performance detected during the functional testing, shall be corrected by the Contractor, at his expense, and to the satisfaction of the Authority and PREPA.

612-3.21 Final Inspection and Acceptance

a. At the time of final inspection, connections from PREPA power supply to the transformers and equipment shall be completed together with all ground connections. Transformer fuses must be in place and the circuits continuous to all lighting fixtures in the system. The final inspection will be made by representatives of PREPA and the Authority. A list of deficiencies found will be furnished to the Contractor who shall correct them to the satisfaction of the said representatives before the project is accepted.

b. Final acceptance will be withheld until the system has completed a 7-day period of satisfactory performance.

c. Where the highway lighting system construction is included in a contract with other highway work, final acceptance of the lighting system will be withheld until it has satisfactorily completed its functional testing or until all other work under the contract has received final acceptance, whichever occurs later. Any defects in materials or workmanship which might appear during the period of delayed acceptance shall be corrected by the Contractor at his expense.

d. For highway lighting system works, the Contractor shall obtain partial certifications every three months for the work executed. These certifications shall be performed and duly signed by a Puerto Rico licensed Electrical Engineer according to PREPA requirements and submitted to PREPA for acceptance. When all lighting works are completed, a final certification shall be submitted to PREPA for final acceptance and the Contractor shall furnish to the Authority PREPA's certification accepting the works.

612-4 METHOD OF MEASUREMENT

612-4.01 Where a lump sum method of payment is specified in the contract, the complete lighting system will be considered a single unit and no separate measurement will be made of any of its individual components.

612-4.02 When the various components of the system are included as separate pay items these will be measured as follows:

a. New and temporary lighting standards of each specified type and materials furnished, installed complete and accepted will be measured as a unit. Each lighting standard unit shall consist of the complete installation, ready for operation, including foundation, poles, bases, anchor bolts, bracket arms, luminaries, lamps, ballast, wiring from fuse disconnect to lamps, ground wire and rod, photoelectric control (if applicable), connectors, and all necessary hardware and appurtenances.

b. Conduit will be measured by the linear meter of each type and size specified, installed complete according to the plans or as ordered by the Engineer and accepted, and with all fittings, hangers, expansion devices, fish wire for spare conduits, warning ribbon and other required items. The pay unit for galvanized steel conduits installed on bridges shall include all the straps, clamps, expansion joints, couplings, PVC adapters and all other hardware required for their installation.

c. Junction boxes, pull boxes, and service pedestals will be measured as the number of each type and size installed according to the plans or as ordered by the Engineer, and accepted. Each unit shall be complete including frames, covers and necessary hardware.

d. Conductors, including those for temporary lighting systems, will be measured by the number of linear meters of each type and size installed in accordance with the plans or ordered by the Engineer, and accepted, but excluding the wiring from fuse disconnect to lamps which is included as part of the lighting standards.

e. Substations of each specified type (pole or pad mounted) and size furnished, installed and accepted will be measured as a unit. Each substation unit shall consist of the complete installation, ready for operation, including foundation, concrete pad (when required), specified pole and cross arms (when required), transformer, lighting control equipment (when applicable), fuses, breakers, risers, connectors, fuse cutouts, lightning arresters, insulators, grounds, enclosures and cabinets (as required), meter equipment and concrete protection, and all necessary hardware and appurtenances. Extensions of primary or secondary power lines, including poles required, to service the lighting system, within a 50-meter radius of plan location, shall also be included as part of the substation pay unit.

f. New HPS luminaries to be mounted on relocated or rehabilitated lighting standards and wall mounted luminaries for underpasses and tunnels will be measured by the number of luminaries of each specified type, size and wattage installed, complete and accepted. Each unit shall consist of the complete installation, ready for operation including the specified lamp, ballast and all the necessary hardware. The removal and delivery to the specified location of the existing luminaries to be replaced shall be a subsidiary obligation of the Contractor under these pay items.

g. Luminaries installed on PREPA poles will be measured by the number of each specified type and size installed, completed and accepted. Each unit shall consist of the complete assembly, ready for operation, including the bracket arm, luminaire, lamp, ballast, wiring, ground wire and rod, photoelectric control, connectors, fuses, 1" galvanized steel riser conduit to bracket, No. 10 copper XLP conductor up to luminaries, elbows, connection to pedestal and all other hardware and appurtenances necessary to complete the installation. The bracket area shall be of the type indicated but if not indicated, aluminum bracket arms shall be provided.

612-4.03 Each existing lighting standard to be relocated or rehabilitated will be measured as a unit. The relocation and rehabilitation pay units shall include all the materials needed for a completed installation, ready for operation, of the relocated or rehabilitated lighting standard including foundations, poles, bases, anchorages, bracket arms, conductors, fuses, ground wire and rods, luminaries, lamps, ballast, photoelectric controls and all necessary hardware and appurtenances. The pay unit includes the repair or replacement of any damaged or missing components, except that when new HPS luminaries are called for they will be measured as separate items under the corresponding pay items.

612-4.04 Each temporary highway lighting standard to be relocated will be measured as a unit. Each unit will include all the

materials necessary to provide a complete installation of the relocated standard as provided in Article 612-4.03 above.

612-4.05 Any new conduits, junction and pull boxes, service pedestals, conductors and substations required for the relocation and/or rehabilitation of an existing highway lighting system will be measured for payment as provided in paragraphs b, c, d, and e of Article 612-4.02 above.

612-4.06 Each existing and/or temporary lighting standards to be removed will be measured as a unit. The pay unit for removal of lighting standard includes as a subsidiary obligation the removal of the bracket arm, luminarie, conductors and other hardware from the pole and the storage, safekeeping and delivery of the salvaged materials to the specified location.

612-4.07 When the proposal does not include pay items for the removal of existing and/or temporary lighting standards but such work is required, no direct payment will be made for such work and it shall be a subsidiary obligation of the Contractor under other pay items of the contract.

612-4.08 The removal, storage, safekeeping and delivery to the specified location of existing and/or temporary substations and conductors will not be measured for direct payment but such work shall be a subsidiary obligation of the Contractor under the pay items for the installation of new substations and conductors.

612-4.09 Excavation, bedding and backfill required for foundations, poles, service pedestals, pull and junction boxes, and conduit installations will not be measured directly for payment. These items shall be a subsidiary obligation of the Contractor with their cost included under the respective highway lighting pay items.

612-4.10 Concrete and reinforcing steel for foundations, pull boxes, substation pads, conduits and markers, conduit envelope in pavement crossings and other lighting system units, except concrete pedestals for lighting standards on new structures, will not be measured directly for payment but shall be a subsidiary obligation of

the Contractor with their cost included under the respective highway lighting pay items. The concrete and reinforcing steel for lighting standard pedestals on new structures will be measured and paid for under the respective pay items of structural concrete and reinforcing steel for the structure.

612-4.11 The removal and replacing of existing improvements required for the construction of the lighting system, required under Article 612-3.03, will not be measured directly for payment but shall be a subsidiary obligation of the Contractor with the cost included under the highway lighting pay items.

612-4.12 When the lighting system is paid for by separate component pay units rather than as a lump sum item, it shall be understood that the combination of all component pay units shall provide for a complete lighting system ready for operation and that any miscellaneous fees, work, equipment, and materials necessary to complete the system shall be furnished and installed by the Contractor at no extra cost to the Authority. The cost of any of these miscellaneous items be included under the contract pay items.

612-4.13 The costs for obtaining PREPA's certifications and acceptance of the performed works according to article 612-3.21 shall be considered a subsidiary obligation of the Contractor under the pay items of this specification included in the proposal schedule.

612-5 BASIS OF PAYMENT

612-5.01 The accepted quantities, determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such price and payment shall constitute full compensation for furnishing and installing all required equipment and materials, and for all labor, equipment, tools and incidentals necessary to complete each item and to provide a complete highway lighting system as required by the plans and specifications.

SPECIFICATION 612 – HIGHWAY LIGTHTING SYSTEM

612-5.02 Payment for works under this specification will be made according to the following schedule:

a. Eighty percent (80%) of the contract unit price for each pay item will be paid after the initial installation is completed and accepted by the Engineer.

b. The remaining twenty percent (20%) due to the Contractor will be paid to the Contractor after the submittal to the Authority of the certification of final acceptance of the works by PREPA.

612-5.03 Payment will be made under:

Pay Item	Pay Unit
Highway Lighting System……..	Lump Sum
Aluminum Lighting Standards _____ Mounting Height, _____ Bracket, _____ (Length) (single or twin)…….	Each
Concrete Lighting Standards _____Mounting Height, _____ Bracket, _____ (Type*, Length) (single or twin)……..	Each
Wood Lighting Standards _____Mounting Height, _____ Bracket, _____ (Type*, Length) (single or twin)……..	Each
____Galvanized Steel Conduit……. (Size)	Linear Meter
_____PVC Conduit…….. (Size)	Linear Meter
Junction Boxes, _____…….. (Type, Size)	Each

SPECIFICATION 612 – HIGHWAY LIGTHTING SYSTEM

Pay Item	Pay Unit
Pull Boxes, _____ (Type, Size)……..	Each
Service Pedestal _____ (Type, Size)……..	Each
Conductor Cable _____ (Type, Size)……...	Linear Meter
Substations _____ (Type, Size)……	Each
New HPS Luminaries, _____ (Watts)…….	Each
_____, HPS Wall Mounted Luminaries, _____... (Type) (Watts)	Each
PREPA Pole Mounted Luminaries _____ (Type*, Size)...	Each
Temporary Lighting Standard……..	Each
Relocation or Temporary Lighting Standard……...	Each
Relocation of Existing Lighting Standard……	Each
Rehabilitation of Existing Lighting Standard _____ (Type, Size)…….	Each
Removal of Lighting Standard……	Each

*Indicate whether aluminum or galvanized bracket arm.

SPECIFICATION 613 – TRAFFIC SIGNS

613-1 DESCRIPTION

613-1.01 Scope

a. This work shall consist of furnishing and erecting traffic signs, including overhead sign structures, in accordance with these specifications and in conformity with the locations and details shown on the plans or as directed by the Engineer.

b. Traffic signs and sign supports details not shown on the plans shall conform to the "Manual de Señales de Tránsito para las Vías Públicas de Puerto Rico", hereinafter referred to as the MST of the Department of Transportation and Public Works (DTPW), the "Manual de Dispositivos Uniformes para el Control del Tránsito en las Vías Públicas de Puerto Rico" (MDUCT) of the DTPW, and the standard drawings of the Highway Authority which provide details for the fabrication and erection of traffic signs and sign supports.

c. The designation Roadside Traffic Signs applies to all signs erected on the slopes, medians, gores, or sidewalks which do not extend over the traveled roadway. The designation Overhead Traffic Signs applies to signs erected partially or completely over the traveled way, including signs mounted on bridges.

d. Reflectorization of sign backgrounds and/or legends shall be as called for in the MST. Overhead signs shall be illuminated when so called for in the plans.

613-2 MATERIALS

613-2.01 Sign Panels - Sign panels shall be made from aluminum sheets or extrusions conforming to the followings requirements:

a. Sign Sheets – ASTM B 209: 6061-T6, 5052-H36, 5052-H38, 5086-H34, 5153-H36.

b. Extruded Panels – ASTM B 221: 6063-T6.

c. Stiffness of panels shall be as specified in the "Manual de Señales de Tránsito para las Vías Públicas de Puerto Rico (MST)".

613-2.02 Reflective Sheeting - Reflective sheeting for all signs shall be of the high intensity type consisting of spherical lens elements adhered to a synthetic resin and encapsulated by a flexible, transparent, weatherproof plastic having a smooth outer surface. The sheeting shall have a pre-coated adhesive backing protected by a removable cover. The sheeting shall conform to the requirements of AASHTO M 268 modified and supplemented as follows:

a. Color requirements - The colors specified shall be matched visually and be within the tolerance limits shown on the FHWA Color Tolerance Charts.

b. Reflective Intensity - The reflective sheeting shall have minimum reflective intensity values at 0.2° and 0.5° divergence as shown in Table 613-1, expressed as candlepower per foot candle per square foot (candelas per lux per square meter) of material.

The brightness of the reflective sheeting when totally wet shall not be less than 90 percent of the dry values in Table 613-1.

TABLE 613-1

Divergence Angle (º)	Incidence Angle (º)	Silver White	Yellow	Red	Orange	Green	Blue
0.2	-4	250	170	45	100	45	20
0.2	+30	140	100	25	60	25	11
0.5	-4	95	62	15	30	15	7.5
0.5	+30	65	45	10	25	10	5

c. Specular Gloss -The reflective sheeting shall have an 85 degree specular gloss of not less than 50 when tested as per ASTM D-23.

d. Processing - Color processing shall be restricted to sheeting with heat activated Class 2 adhesive, unless otherwise recommended by the manufacturer, and except for reflective sheeting used on construction signs, barricades, drums and other temporary maintenance of traffic devices where pressure sensitive adhesive (Class 1) may be used.

e. Durability - Processed and applied in accordance with recommended procedures, the reflective material shall be weather resistant and, following cleaning, shall show no appreciable discoloration, cracking, blistering or dimensional change and shall not have less than 70 percent of the specified minimum reflective intensity values (Table 613-1) when subjected to accelerated weathering for 2200 hours in accordance with ASTM Standard G23-69, using a Type E or EH Weatherometer.

f. Colorfastness - One of the specimens prepared and subjected to the accelerated weathering test specified above shall be used to test for colorfastness. Wet out the specimen with a mild detergent and water solution and compare it with a similarly treated unexposed specimen under natural (North sky) daylight or artificial daylight having a color temperature of 7500 K. The colorfastness shall be evaluated as follows:

Excellent - No appreciable change in color

Good - Perceptible but no appreciable change in color

Fair - Appreciable change in color

Appreciable change in color means a change that is immediately noticeable in comparing the exposed specimen with the original comparison specimen. If closer inspection or a change of angle of light is required to make apparent a

slight change in color, the change is not appreciable. The reflective material must show "good" colorfastness or better.

g. Fungus Resistance - The reflective material shall be tested for fungus resistance as per paragraph 14.2 of AASHTO M 268.

h. Cleaning Capability - The reflective sheeting surface shall be capable of being readily cleaned and refurbished by cleaning and clear overcoating in accordance with the manufacturer's recommendations.

i. Certification - The Contractor shall present to the Authority certification from the manufacturer of the reflective sheeting that the reflective sheeting used in the traffic signs furnished and erected under the contract meets all the specification requirements.

613-2.03 Legends - Letters, numerals, arrows, symbols, borders, and other features of the sign message shall be of the type, size, and series shown on the plans or as specified by the Engineer. Completed letters, numerals and other units shall be formed to provide continuous stroke width with smooth edges and shall present a flat surface free of warp, blisters, wrinkles, burrs and splinters. Legends shall conform to the MST, the MDUCT and the FHWA standard alphabet, and shall be applied by one of the following methods.

a. Screen Process - The legend shall be applied on the reflective sheeting or opaque background by the direct or reverse screen process. Messages and borders of a color darker than the background shall be applied by direct process. Messages and borders of a color lighter than the sign background shall be produced by the reverse screen process. Opaque or transparent colors, inks and paints used in the screen process shall be of the type and quality recommended by the manufacturer of the reflective sheeting. Signs after screening shall be air-dried or baked in accordance with the manufacturer's recommendations to provide a smooth hard

finish. Any signs on which blisters appear during the drying process shall be rejected.

b. Direct Applied Characters - The letters, numerals, symbols, borders and other features of the legend shall be cut from high intensity reflective sheeting meeting the requirements of Section 612-2.02 above, of the colors specified in the MST, and applied to the reflective sheeting of the sign panel in accordance with the instructions of the manufacturer of the reflective sheeting.

c. Clear Coating - All reflective sheeting signs prepared by screening with transparent process colors shall be clear coated using a coating recommended by the sheeting manufacturer. Faces screened with only black opaque do not need to be coated.

613-2.04 Sign Supports - When no specific design or design criteria is shown on the plans, the design of the sign supports shall follow the AASHTO "Standard Specification for Structural Supports for Highway Signs, Luminaires and Traffic Signals", except that:

a. Ice load need not be considered.

b. Wind loads of 120 mph for roadside signs and 130 mph for overhead sign structures shall be used.

613-2.05 Roadside Sign Posts - Posts used for supporting roadside signs may be either galvanized steel or aluminum alloy at the Contractor’s option unless otherwise provided on the plans.

a. Size and shape of posts shall be as indicated on the standard drawings or shown on the plans.

b. Steel posts shall conform to the requirements of AASHTO M 183 (ASTM A 36) - Structural Steel. AASHTO M 161, M 188, M 222 and M 223 - Grade 50 may also be used for posts and slip-impact bases. All steel posts shall be

galvanized in accordance with AASHTO M 111 (ASTM A 123) after fabrication (punching, drilling, etc.).

c. Aluminum posts shall be of aluminum alloy conforming to ASTM B 221, Alloys 6061-T6, 6351-T5, 6063-T6 or 6005-T5, or ASTM B 308, Alloy 6061 - T6.

d. The lengths of posts to be installed shall be computed by the Contractor for each specific sign location based on the sign dimensions, footing requirements and the required vertical and lateral clearances specified in the MST and the standard drawings, or as shown on the plans. For signs to be erected on two or more posts on a cut or file slope, the length of each post shall be varied as required to conform to the site conditions but maintaining the required footing depth and height and lateral clearances.

e. Sign posts supports for small signs (as described in the Standard Drawings may be any support listed in the latest Federal Highway Administration (FHWA) approved listing at the time of bid opening. Only hot dip galvanized and aluminum posts are accepted. The approved list is available at the Materials Testing Office and the Bids and Estimates Office.

613-2.06 Fittings - Assembly and stringer bars, stiffeners, wind beams, screws, washers, clamps, bolts, nuts and other fasteners and fittings shall be of galvanized steel or aluminum alloy as shown on the standard drawings and plans or as specified by the Engineer. Structural steel assembly bars shall conform to the same requirements as for steel posts included in paragraph 613-2.05 b. above. Galvanizing of steel hardware shall be in accordance with AASHTO M 232 (ASTM A 153). High strength steel bolts, nuts and washers shall conform to AASHTO M 164 (ASTM A 325), Aluminum alloy structural members shall conform to the same requirements as for aluminum posts included in paragraph 613-2.05c. above.

SPECIFICATION 613 – TRAFFIC SIGNS

613-2.07 Overhead Sign Structures - Materials for overhead sign structures shall be as follows:

a. When the plans include a detailed structural design, the materials to be used shall be as indicated on the plans.

b. When the plans include only a general layout and elevations, the Contractor shall develop a detailed design and shop drawings for the structure in accordance with the design criteria, location, dimensions, clearances and foundations specified on the plans. When no specific design criteria is provided on the plans, the provisions of paragraph 613-2.04 above shall apply. The design computations and shop drawings shall be submitted to the Authority for review and approval.

c. Unless otherwise specified on the plans, galvanized structural steel used for overhead steel structures and structural aluminum alloy used for overhead aluminum structures shall conform to the same requirements as specified for these materials in Articles 2.05 and 2.06 above.

613-2.08 Concrete - Portland Cement concrete for foundations and bases of sign posts and overhead sign structures shall conform to the applicable requirements of Specification 601 - Structural Concrete, for the classes of concrete specified in the standard drawings and project plans. When not specified, Class A shall be used for overhead sign structures and Class B for roadside signs.

613-2.09 Reinforcing Steel - Shall conform to the requirements of Specification 602 - Reinforcing Steel.

613-2.10 Illumination Materials

a. Materials for the illumination of overhead signs shall comply with the applicable requirements of Specification 612 - Highway Lighting System, and Specification 714 - Highway Lighting Materials.

b. Unless otherwise specified on the plans the following materials shall be used:

1. Underground electrical conduits shall be PVC DB-120. All exposed conduits shall be rigid galvanized steel except at horizontal mounting supports for sign panels where weatherproof flexible conduit may be used.

2. Power feed conductors from the handhole to fuses shall be not less than No. 10 AWG Stranded XLP (RHH) for use at 90° C. Their ratings shall be selected as required to carry the connected load.

3. Wire from the sign protection fuses to the sign ballast shall be not less than No. 10 AWG Stranded XLP (RHH) for use at 90°C.

4. Grounding electrode conductor at the sign structure columns and power source poles shall be not less than No. 8 bare copper wire. Grounding conductor equipment shall have a current rating in accordance with overcurrent device ahead of equipment as per Article 250 N.E.C. and TW insulation. Ground shall be a 5/8" copper rod 2.5 meters long.

5. Wire from ballasts to sign luminaire units and between lamps holders shall be as recommended by the ballast manufacturer for leads greater than 12 meters.

6. Sign luminaire bodies shall be fabricated of either diecast or extruded aluminum shapes. The aluminum body shall have a removable molded clear acrylic plastic cover. Neoprene sponge rubber gasketing shall be used between the aluminum body and the plastic cover to form a waterproof and dustproof seal. The remainder of the aluminum

housing shall also be of weatherproof and dustproof construction. Retrodispersion and prefocused alzak specular aluminum paracylindrical reflectors shall be utilized to furnish light control. Sign luminaires shall be 175-watt clear mercury vapor, ANSI Code H-39 22 KB, or 250-watt clear mercury vapor, ANSI Code H-37-5KB, equipped for use on 120/240 V. multiple circuit, and with a minimum average rated life of 24,000 hours.

7. Photoelectric controls shall consist of a photoelectric unit and contactors located as shown on the plans. Fuses shall also be included in the outdoor lighting contactors enclosure. A switch to permit manual control of the lighting circuit shall be provided. The cabinet enclosure shall be installed at a height of approximately two meters above the sign structure base.

613-2.11 Certification - The manufacturer of the completed signs shall certify that all signs furnished conform to these specifications and the Contractor shall replace or repair without cost all signs that fail to meet these requirements.

613-3 CONSTRUCTION REQUIREMENTS

613-3.01 Fabrication of Sign Panels

a. Fabrication of sign panels shall be accomplished in a uniform and precise manner. All cutting, punching and drilling of holes shall be completed prior to final surface preparation and application of the reflective sheeting. The surface of all sign panels shall be flat and free of buckles, warp, dents, cockles, burrs, and any other defects resulting from fabrication.

b. Prior to the application of reflective sheeting, the sign blank shall be cleaned and degreased in an inhibited alkaline cleaner or in a vapor degreaser consisting of a saturated vapor

of trichloroethylene. If an inhibited alkaline cleaner is used, the sign shall either be immersed in a tank containing alkaline solutions, controlled and titrated to the solution manufacturer's specifications, or be sprayed with the same solution. Treatment time shall depend upon the amount of soil present and the gauge of the metal. The alkaline cleaner shall be rinsed off with clean running water. After degreasing, the aluminum sheet shall be treated in a proprietary alcoholic phosphoric solution. Then the aluminum sheet shall be thoroughly rinsed again with clean running cold water and dried with warm or forced air. However, the sign blank may be degreased and prepared in accordance with the recommendations of the reflective sheeting manufacturer, particularly if the above method is incompatible with the sheeting.

c. All individual signs up to 48" x 96" shall be fabricated from a single sign panel with no splices. Larger signs may have splices but with closure strips provided as shown on the plans. Only vertical splices will be allowed and a minimum number of panels approximately equal in size shall be used. In no case shall a panel section be less than 24" in width.

d. The back side of aluminum panels and splice bars shall have a uniform dull finish.

613-3.02 Fabrication of Reflectorized Sign Faces

a. Reflective sheeting shall be applied to the prepared sign panels with mechanical equipment and in the manner specified by the manufacturer of the sheeting. The face of the panel shall be completely covered by the sheeting. Fastening of the reflectorized sign panels to the support structure shall include the use of any special fittings recommended by the reflective sheeting manufacturer to prevent damage to the sheeting.

b. Whenever a sign face comprises two or more pieces of reflective sheeting, they must be carefully matched for

color at the time of sign fabrication to provide uniform appearance and brilliance, both at day and at night. Corresponding edges of reflective sheeting shall lie adjacent on the finished sign. Non-conformance may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting which will not be acceptable.

c. Reflective sheeting splices and sign edges shall be sealed with materials supplied by and in the manner specified by the sheeting manufacturer.

d. Any damage to the reflective sheeting appearing in the completed sign shall be cause for rejection. Patched sheeting will not be accepted.

e. The sign legend shall be applied by the painted screen process or by direct application of cut out characters as required to meet the reflectorization conditions for each sign specified in the MST.

613-3.03 Footings

a. The excavation and backfill for the footings of sign post and support structures shall be performed in accordance with Specification 206 - Excavation for Structures.

b. The construction of concrete footings shall be in accordance with the details and dimensions shown on the standard drawings or the project plans, or as designed by the Contractor and approved by the Authority, and in conformance with the applicable requirements of Specification 601 - Structural Concrete.

613-3.04 Erection of Signs and Sign Supports

a. Signs and sign support structures shall be erected at the locations shown on the plans, or selected by the Engineer,

and in accordance with the details shown on the standard drawings, the MST, the MDUCT and the project plans.

b. Fabrication and erection of steel sign support structures shall conform to the applicable requirements of Specification 616 - Steel Structures.

c. Signs supports and stub posts shall be erected at a true vertical. Where two or more posts are required to support a sign, the posts shall be oriented and positioned so that no twist or warp will be imparted to the sign panels.

d. All posts, except for parking and stopping regulation signs (R7 series) in which arrows are used to indicate the extent of restricted zones, shall be erected so that the signs are mounted approximately at right angles to the direction of, and facing, the traffic that they are intended to serve.

e. To eliminate mirror reflection from the sign faces, the sign edge furthest from the travel lanes shall be rotated 3 degrees away from the direction of approaching traffic. At curved alignments the angle of placement shall be determined by the estimated course of approaching traffic rather than by the roadway edge at the point where the sign is to be located. Sign faces are normally vertical but on grades it may be desirable to tilt a sign forward or backward from the vertical to improve the viewing angle. For parking and stopping regulation signs (R7 series), the signs shall be set at an angle of not less than 30 degrees nor more than 45 degrees with a line parallel to the flow of traffic so as to be visible to approaching traffic. Overhead signs shall have the top edge rotated 3 degrees from the vertical towards the approaching traffic.

f. Breakaway features for sign supports requiring such features shall be fabricated and erected in accordance with the details specified in the standard drawings or as shown on the plans. The Contractor shall be responsible for providing a bolt tension calibrating device and for applying the proper

torque to obtain the required residual bolt tension as specified in the standard models or project plans as soon as the sign support structure is erected. A written certificate to this effect shall be submitted by the Contractor for each sign structure completed.

613-3.05 Sign Illumination

a. External illumination for overhead signs requiring such illumination shall be provided as shown on the plans or required by special provisions. The Contractor shall submit design computations and shop drawings of each proposed illumination installation for review and approval by the Authority. The installation of the illumination shall be performed in accordance with the applicable requirement of Specification 612 - Highway Lighting System, and Article 613-2.10 of this specification.

b. Lighting design levels shall be as follows unless otherwise specified on the plans:

1. Luminance - 14 to 28 foot-lamberts. The maximum permissible variation in luminance between any one-square foot area on the sign face and the one-square foot areas adjacent to it is a 2:1 ratio.

2. Illumination - 20 to 40 foot-candles. The uniformity ratio (maximum/minimum) of illumination shall not exceed 6:1. A ratio of 4:1 is preferable.

c. All electric wiring, both above and below ground, shall be installed in electrical conduit, except when tubular type sign supports can provide a raceway. All metal parts shall be grounded.

d. The electrical control equipment shall include:

1. Dual element fuses of the proper rating installed in lighting contactors cabinets on sign

support structures as shown on the plans or as specified. The sign circuit fuses shall be connected to the line side of the ballast.

2. Contactor and fuse cabinets for sign structures and the service entrance cabinets shall be constructed of 10 gage sheet steel, hot-dipped, galvanized after fabrication. Each cabinet shall be rainproof and have a top hinged door provided with a latching device for use with padlock. Each door shall be constructed with a "lock-open" type hinge slot.

e. All sign luminaires shall be bottom mounted. Lamp ballasts shall be of the back-mounted type with attached pipe bracket which extends to the front of the sign to support the luminaire. Ballast shall be of the high power factor and regulated type.

f. The electric power shall be 120/240 V. supplied from the highway lighting system or P.R. Electric Power Authority distribution lines as shown on the plans.

g. Photoelectric controls shall be capable of switching multiple lighting systems directly, shall be controlled by a photocell multiple relay and have 60 amps. rating, 120/240 V., 2-poles with dual element fuses.

h. Additional miscellaneous and incidental materials required to complete the illumination installation, that are not mentioned on the plans or in the Special Provisions, shall be furnished and placed by the Contractor. Such materials shall be of good quality and suitable for the use intended, and shall comply with applicable N.E.M.A. and N.E.C. standards.

613-3.06 Field Inspection

a. All materials and workmanship will be inspected in the field unless it has been previously inspected. Immediately

prior to erection, all material shall be inspected for damage which is attributable to improper transportation, handling or storage procedure and any damaged material shall be repaired or replaced by the Contractor at his expense.

b. An inspection of the completely erected signs shall be made in the daylight for proper location, line and grade of signs and sign supports, appearance and visibility. The signs shall also be inspected at night by the Engineer to check for orientation, specular reflection and possible defects that may be more conspicuous at night.

c. All apparent defects disclosed by the day and night inspections shall be corrected by the Contractor, at his expense, to the satisfaction of the Engineer.

613-4 METHOD OF MEASUREMENT

613-4.01 Roadside traffic signs will be measured for payment by the unit with each individual sign assembly, whether consisting of a single sign or multiple signs, counted as a unit. The sign assemblies are designated by identification code numbers on the plans and contract schedule.

613-4.02 Overhead traffic sign will also be measured for payment by the unit with each individual sign assembly counted as a unit and identified by a code number in the plans and contract schedule.

613-4.03 For the purpose of payment each sign assembly unit shall consist of all the signs mounted on a single structure which may consist of one or more posts, an overhead structure or a bridge mounting. The unit includes all the components necessary to complete the assembly as called for in the plans and specifications including excavation, backfill, footings, supports, breakaway features, sign panels, brackets, hardware, sign illumination and any other special feature indicated. The sign illumination included in the unit measurement shall comprise all equipment and materials

required to complete the illumination from the electric power source (highway lighting system or PREPA lines) to the sign luminaires.

613-5 BASIS OF PAYMENT

613-5.01 The contract unit price for each sign assembly shall be full compensation for the design, shop drawings, fabricating, furnishing and erecting the complete sign assembly and support structure including excavation, backfill, concrete footings, reinforcing steel, posts, structural members, brackets, fittings, hardware, sign panels, sign facings, breakaway features, sign illumination system and all other materials, equipment and labor necessary to complete each unit in accordance with the plans and specifications.

613-5.02 Payment will made under:

Pay Item	Pay Unit
Traffic Sign Assembly Code Number _____…….	Each

SPECIFICATION 614 - GABIONS

614-1 DESCRIPTION

614-1.01 Scope - This work shall consist of furnishing and placing wire mesh baskets (gabions) filled with rock, installed at the locations designated, in accordance with these specifications, and in conformity with the lines, grades, dimensions and arrangements shown on the plans or ordered by the Engineer. This work includes the wide, flat rectangular gabions known as Reno mattresses.

614-2 MATERIALS

614-2.01 Gabions

a. Regular gabions shall be supplied in the various lengths and heights as specified. The lengths shall be multiples (2, 3 or 4) of the horizontal width. The heights shall be fractions (1, 1/2, or 1/3) of the horizontal width. The horizontal width shall be not less than 36" (0.914M and all gabions furnished for a project shall be of uniform width. Gabion dimensions are subject to a tolerance limit of $\pm$ 5% of manufacturers stated sizes.

b. Reno mattress type gabions shall be supplied in lengths of 9 or 12 feet (2.743 or 3.658 M), width of 6 feet (1.829 M), and height of 9 inches (0.229 M) as shown on the plans, or of such other dimensions as specified.

c. The wire mesh shall be made of galvanized steel wire twisted to form hexagonal openings of uniform size. For regular gabions, the maximum linear dimension of mesh opening shall not exceed 4 1/2 inches and the area of the mesh opening shall not exceed 10 square inches. For Reno mattresses, the mesh opening shall be approximately 2 1/2 by 3 1/4 inches. The mesh shall be fabricated in such manner as to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut and subjected to the elasticity test.

d. The galvanized steel wire for the mesh of regular gabions shall have a minimum size of 0.12 inch diameter (U.S. Wire Gage No. 11) and a tensile strength in the range of 60,000 to 85,000 psi. The minimum zinc coating of the wire shall be 0.80 oz./sq. ft. of uncoated wire surface as determined by test conducted in accordance with ASTM A 90.

e. The galvanized steel wire for the edges of the Reno mattress mesh shall be 0.12" diameter (U.S. Wire Gage No. 11) but the remainder of the mesh wire may be 0.09" diameter (U.S. Wire Gage No. 13). Tensile strength and zinc coating shall be as in paragraph 614-2.01d. above.

f. Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. Gabions shall be of single unit construction - base, lids, ends, and sides shall be either woven into a single unit or one edge of these members connected to the base section of the gabion in such a manner that the strength and flexibility at the point of connection is at least equal to that of the mesh.

g. Where the length of the gabion exceeds its horizontal width, the gabion shall be equally divided by diaphragms of the same mesh and gage as the body of the gabion, into cells the length of which does not exceed the horizontal width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this juncture is necessary.

h. All perimeter edges of the mesh forming the gabion shall be securely selvedged so that the joints formed by tying the selvedges have at least the same strength as the body of the mesh. Selvedge wire used through all the edges (perimeter wire) shall be not less than 0.15 inch diameter (U.S. Wire Gage No. 9) for regular gabion and 0.12 inch diameter (U.S. Wire Gage No. 11) for Reno mattress type,

and shall meet the same specifications as the wire for the mesh given in paragraph 614-2.01d above.

i. Tie and connecting wire shall be supplied in sufficient quantity for securely fastening all edges of the gabion and diaphragms and to provide for four (4) cross connecting wires in each cell whose height is 1/3 or 1/2 the width of the gabion and eight (8) connecting wires in each cell whose height equals the width of the gabion. This lacing wire shall be galvanized steel wire no less than 0.09 inch diameter (U.S. Gage No. 13) and shall meet the same specifications as mesh wire.

j. When called for in the contract documents, the mesh, selvedge and lacing wire for the gabions shall be provided with a PVC coating of at least 0.015 inch and meeting the requirements AASHTO M 181.

614-2.02 Elongation Test - The wire mesh shall have sufficient elasticity to permit elongation of the mesh equivalent to a minimum of 10% of the length of the section of the mesh under test without reducing the gage or tensile strength of individual wires to values less than those for similar wire one gage smaller in diameter.

614-2.03 Elasticity Test - A section of a mesh 6 feet long and not less than 3 feet wide, after first being subjected to the elongation test described above, shall withstand a load test of 6,000 pounds applied to an area of one square foot approximately in the center of the section under test. The details of this test are as follows:

An uncut section of mesh 6 feet long, not less than 3 feet wide and including all selvedge bindings shall have the ends securely clamped for 3 feet along the width of the sample. When the width of the sample under test exceeds 3 feet, the clamps will be placed in the middle portion of the width and the excess width will be allowed to fall free on each side of the clamped section. The sample shall then be subjected to sufficient tension to cause 10% elongation of the sample section between the clamps. After elongation and while clamped as described above (and otherwise unsupported), the section

shall be subjected to a load applied to an area of one square foot located approximately in the center of the sample section between the clamps, and in a direction perpendicular to the direction of the tension force. The sample shall withstand, without rupture of any wire, or opening of any mesh fastening, an actual load, so applied, equaling or exceeding 6,000 pounds. The ram head used in the test shall be circular with its edges beveled or rounded to prevent cutting of the wires.

614-2.04 Rock Filler

a. All rock used in the gabions shall be sound and durable and from a source approved by the Engineer. The rock shall have a percent of wear of not more than 45 when tested by AASHTO T 96. Rock samples shall be crushed to less than 1.5 inch size for testing.

b. The filler rock shall be reasonably well graded between the limiting sizes shown below:

Basket or Height	Minimum Rock Dimension	Maximum Rock Dimension
9 inches	3 inches	6 inches
12 inches	4 inches	8 inches
Greater than 12 inches	4 inches	12 inches

614-2.05 Plastic Filter Cloth - Shall meet the requirements of Section 712-7 of Specification 712 - Miscellaneous Materials.

614-2.06 Materials Certificate - Each shipment of gabions to the project shall be accompanied by a manufacturer's certificate to the effect that the gabions being furnished meet all the requirements of this specification. A shipment shall consist of all material arriving at the project site at substantially the same time.

SPECIFICATION 614 - GABIONS

614-3 CONSTRUCTION REQUIREMENTS

614-3.01 Gabions shall be installed according to the manufacturer's recommendations. Any required excavation and preparation of the foundation shall be completed as indicated on the plans or ordered by the Engineer prior to the installation of the gabions. Plastic filter cloth shall be installed between the gabions and the foundation or backfill material unless otherwise indicated on the plans.

614-3.02 Each gabion unit shall be assembled by binding together all vertical edges with wire ties on approximately 15 cm. (6") spacing or by a continuous piece of connecting wire stitched around the vertical edges with a coil about every 15 cms. (6"). Empty gabion units shall be set to line and grade as shown on the plans or as directed by the Engineer. Wire ties or connecting wire shall be used to join the units together in the same manner as described for assembling each gabion unit. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

614-3.03 A standard fence stretcher, chain fall or iron rod may be used to stretch the wire baskets and hold alinement.

614-3.04 The in-place gabions shall be filled with rock placed carefully by hand or machine method, acceptable to the Engineer, to assure alignment, avoid bulges, and have a minimum of voids. Filler stone shall be selected of proper sizes to maintain voids at a minimum. Alternate placing of stone and connecting wires shall be performed every 1/3 of the height of the gabion cell until each gabion has been filled. All gabion baskets in the exterior face of a wall shall be filled by hand except for Reno mattresses which may be filed by machine methods provided results acceptable to the Engineer are obtained.

614-3.05 After each gabion has been filled, the lid shall be bent over until it meets the sides and edges. The lid shall then be secured to the sides, ends and diaphragms with wire ties or connecting wire in the same manner as described for assembling in paragraph 614-3.02 above.

SPECIFICATION 614 - GABIONS

614-4 METHOD OF MEASUREMENT

614-4.01 The quantity of gabions to be paid for will be the number of cubic meters measured to the nearest tenth of a cubic meter, of gabions completed, meeting the requirements of these specifications, placed in accordance with the limits shown on the plans or directed by the Engineer, and accepted by the Engineer. Slope measurement will be used to determine actual area.

614-4.02 The required plastic filter cloth will not be measured for direct payment. This item and work shall be a subsidiary obligation of the Contractor with its cost included in the unit price of the gabions.

614-4.03 Any required excavation and backfill will be measured and paid for as provided in Specification 203. Any required underdrains will be measured and paid for under Specification 605.

614-5 BASIS OF PAYMENT

614-5.01 The quantities of accepted gabions, determined as provided above, will be paid for at the contract unit price per cubic meter which price and payment shall constitute full compensation for furnishing and placing the wire baskets and rock, the required plastic filter cloth, and for all labor, equipment, tools and incidentals necessary to complete the work as required by the plans and specifications.

614-5.02 Payment will be made under:

Pay Item	Pay Unit
Gabions……..	Cubic Meter

SPECIFICATION 615 – PILING

615-1 DESCRIPTION

615-1.01 Scope

a. This work shall consist of furnishing and driving various types of piles, including preboring when necessary, to the specified bearing capacity and required penetration, in accordance with this specification, at the locations indicated, and in conformity with the details shown on the plans or as directed by the Engineer.

b. Foundation and trestle piles shall be cast-in-place concrete, precast concrete (conventionally reinforced or prestressed) or structural steel as shown on the plans and called for in the contract documents. Sheet piling shall be of timber, concrete or steel sheet piles as called for in the contract documents.

c. The length of piles indicated on the plans is to be considered as approximate. The actual length will be determined by the Engineer who will furnish to the Contractor a listing showing the number and length of each type of pile to be furnished except for cast-in-place concrete piles for which no such listing will be furnished. When test piles and load tests are called for in the contract documents, the data obtained from driving the test piles and from the load tests will be used in conjunction with other available subsoil information to determine the length of piles to be furnished. The Engineer will not prepare the list of piles for any portion of a foundation area until all loading tests representative of that portion have been completed. However, for steel H-piles which are not manufactured locally, the Engineer may base his pile listing on the plan data if the Contractor can show that delivery dates will cause excessive delays in the progress of the work.

SPECIFICATION 615 – PILING

615-2 MATERIALS

615-2.01 Precast Concrete Piles

a. Precast concrete piles shall be of the design or designs shown on the plans and shall be constructed of portland cement concrete of the classes indicated and meeting the requirements of Specification 601 - Structural Concrete. When not specified in the contract documents, concrete for all precast concrete piles shall be Class D. Prestressed concrete piles shall meet the applicable requirement of Specification 630 - Prestressed Concrete Structures.

b. Reinforcing steel for precast and prestressed concrete piles shall meet the requirements of Specification 602 - Reinforcing Steel.

c. The piles shall be cast separately or, if alternate piles are cast in a tier, the intermediate piles shall not be cast until four (4) days after the adjacent piles have been poured. Piles cast in tiers shall be separated by tar paper or other suitable separating materials. The concrete in each pile shall be placed continuously. The completed piles shall be free from stone pockets, honeycombs, or other defects, and shall be straight and true to the form specified. The forms shall be built of metal, plywood, or dressed lumber. A 25 mm chamfer strip shall be used in all corners. Forms shall be watertight and shall not be removed within 24 hours after the concrete is placed. Pile surfaces that will be exposed in the complete structure shall be given a Class 1 ordinary finish as called for in Specification 601.

d. Precast piles shall be cast within the following tolerances:

SPECIFICATION 615 – PILING

1.	Length…….	± 2 in. (± 50 mm.)
2.	Width or diameter……	± 3/8 in. (±9.5 mm.)
3.	Sweep (variation from straight line parallel to centerline)……	± 1/8 in. per 10 ft. (± 3 mm. per 3 m.)
4.	Position of tendons……..	± 1/4 in. (±6 mm)
5.	Wall thickness (hollow piles)…..	- 1/4 in. + 1/2 in. (-6 mm. + 13 mm.)
6.	Position of handling devices…...	± 6 in. (±150 mm.)
7.	Position of steel driving tips…...	± 1/2 in. (±13 mm.)
8.	Longitudinal spacing of spiral Reinforcement……..	± 3/4 inc. (±19 mm.)

e. Piles shall be cured in accordance with the requirements of Specifications 601 and 630.

f. Test cylinders shall be made in accordance with AASHTO T 23 and tested for compressive strength in accordance with AASHTO T 22. Piles shall not be removed from the casting bed until the tests indicate a compressive strength of 80 percent of the design 28-day compressive strength. They shall not be transported to the project site or driven until the tests indicate that the design 28-day compressive strength has been attained.

g. When concrete piles are lifted or moved, they shall be supported at the points shown on the plans or, if not so shown, they shall be supported at the quarter points, or as directed by the Engineer. Concrete piles shall be so handled at all times as to avoid damaging them. Piles materially

damaged in handling or driving shall be replaced by the Contractor at his expense.

h. The use of sectional precast concrete piles will not be permitted unless specifically authorized in writing by the Engineer. If the Contractor proposes to drive sectional precast concrete piles for splicing as the driving proceeds, he shall submit to the Engineer for approval complete drawings and description of the proposed piles showing the design and length of the sections; the method of splicing and driving; certified test reports of the proposed splices showing that they meet the full compressive, tensile, bending and shear strength requirements of the pile; and a list of projects on which the proposed sectional piles have been used and proven satisfactory.

615-2.02 Cast-in-Place Concrete Piles

a. Cast-in-place concrete piles shall be of the design shown on the plans. They shall consist of concrete cast in steel shells or pipes driven to the required bearing. Concrete shall be of the class specified on the plans and conform to the requirements of Specification 601. If no class is specified, Class A concrete shall be used.

b. The steel shells shall be made from plate stock, not less than 7 gages, conforming to AASHTO M 183 (ASTM A 36). Shells may be either spirally welded or longitudinally welded, may be either tapered or constant in section, and shall be equipped with heavy steel driving points. Neither the driving points nor the connecting welds shall project beyond the perimeter of the pile tips. Shells driven without a mandrel shall have a minimum 30 cm. (12") diameter at cutoff and a minimum 20 cm. (8") diameter tip for tapered piles, and a minimum nominal diameter of 27 cm (10 3/4") for constant diameter piles.

c. Steel shells to be driven with a mandrel shall be of sufficient strength and thickness to withstand driving without

injury and to resist harmful distortion and buckling due to soil pressure after being driven and the mandrel removed. Butt and tip dimensions shall be as indicated on the plans. If not specified, the tip diameter shall be not less than 20 cm. (8") and the butt cross section area not less than 654 square centimeters (100 square inches).

d. All steel shells shall be sufficiently watertight to exclude the penetration of water during the placing of the concrete.

e. Steel pipes shall be of the diameter shown on the plans. The pipe wall thickness shall be as specified on the plans but in no case less than 4.8 mm. (3/16"). The steel pipe shall conform to the requirements of ASTM A 252, Grade 2. Closure plates for closed end piles shall conform to the requirements of AASHTO M 183. Conical points for pipe closure shall be reinforced at the tip to meet the requirements of AASHTO M 103 (ASTM A 27). The pipe, including enclosures, shall be of sufficient strength to be driven by the specified methods without distortion. Closure plates and connecting welds shall not project beyond the perimeter of the pile tips.

f. Cast-in-place piling shall be reinforced as specified or shown on the plans. Where the shell is more than 3 mm. (0.12 inc.) in thickness, it will be considered as reinforcement except that 1.6 mm. (1/16") will be deducted for corrosion. Reinforcing steel shall conform to the requirements of Specification 602.

615-2.03 Steel H-Piles

a. Structural steel piles shall be rolled steel sections of the weight and shape called for on the plans. They shall be structural steel meeting the requirements of AASHTO M 183.

b. Steel piles when placed in the leads shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise injured will be rejected.

615-2.04 Sheet Piles

a. The following requirements apply only to sheet piling for which a design is included in the plans and which is intended to remain. These do not apply to piling for which the Contractor is responsible for the design and material selection as covered in Article 615-3.10.

b. Timber sheet piles shall be of the dimensions shown on the plans and may consist of any species meeting the requirements of AASHTO M 168 that will satisfactorily stand driving. The timber shall be sawn or hewn with square corners and shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions or other defects which might impair its strength or tightness. The piles shall be drift sharpened at their lower ends so as to wedge the adjacent piles tightly together.

c. When treated timber sheet piles are specified, the timber shall be pressure treated in accordance with the requirements of AASHTO M 133 using the type of preservative indicated on the plans or, if none is specified, using Creosote conforming to AWPA P1. Unless otherwise specified, the treatment method shall be in accordance with AWPA Standard C 1. Each treated pile shall bear a legible brand name or tag indicating the name of the treater and the specification requirements to which the treatment conforms.

d. Concrete sheet piles shall be in accordance with the design shown on the plans and shall meet the applicable requirements governing precast concrete piles included in Article 615-2.01 of this specification.

e. Steel sheet piles shall be of the type, weight and dimensions specified in the contract documents. They shall

conform to the requirements of AASHTO M 202 (ASTM A 328) or AASHTO M 223 (ASTM A 572) Grade 50.

615-2.05 Pile Shoes - Pile shoes shall be as called for in the plans.

615-2.06 Paint - Paint shall conform to the requirement of Specification 708.

615-3 CONSTRUCTION REQUIREMENTS

615-3.01 Test Piles

a. When called for in the contract documents, the Contractor shall furnish and drive test piles of the class, length, dimensions and at the locations shown on the plans or indicated by the Engineer. Test piles shall meet the requirements specified herein for the specified class of piling. The number of test piles shown in the contract documents may be increased or decreased, at the discretion of the Engineer, as deemed necessary to secure the desired information.

b. Test piles shall be driven to refusal or to the tip elevation shown on the plans, whichever occurs first, or as directed by the Engineer. They shall be driven using the same equipment and method that will be used for installing the foundation piles. The ground at each test pile shall be excavated to the elevation of the bottom of the footing before the pile is driven.

c. When load tests are to be performed to determine pile bearing values, the first test pile shall be driven to the specified bearing as determined by the applicable procedure indicated in Article 615-3.04 or to the length shown on the plans, or as directed by the Engineer. Subsequent test piles to be load tested shall be driven to the specified bearing values as determined from the applicable procedure modified by the

results of prior load tests and foundation data, or as directed by the Engineer.

d. When test piles are specified, no piling for the proposed structure shall be ordered until the test pile results and recommendations, including proposed lengths, have been reviewed and approved by the Engineer, except as modified for steel H-piles in Article 615-1.01c, and except for shells for cast-in-place piles.

e. Whenever possible, test piles shall be made a part of the completed work and shall be cut-off or built-up to the required elevation as necessary.

615-3.02 Load Tests

a. When load tests are included in the contract, the number and location of piles to be tested will be designated on the plans or indicated by the Engineer. The load tests shall be performed under the supervision of the Soils Engineering Office of the Authority.

b. Load tests shall be performed by the procedures set forth in ASTM D 1143 using the quick load test method unless otherwise provided in the contract documents or directed by the Engineer. The Contractor shall submit to the Engineer for approval the detailed plans of both the apparatus for applying loads and the apparatus for measuring movements that he intends to use.

c. The loading apparatus shall be so designed and constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles. If the proposed loading arrangement includes a hydraulic jack, such jack shall have an operating capacity of at least three times the design load for the pile being tested. The hydraulic jacks and dial gauges shall be submitted to the Materials Office of the Authority for verification and approval of their calibration.

d. If the approved method requires the use of anchor piles, such anchor piles shall be of the same type and dimensions as the permanent piles and shall be driven at the location of permanent piles, whenever feasible. However, permanent tapered concrete piles shall not be used as anchor piles. Permanent piles used as anchor piles which are raised during the load test shall be redriven at the Contractor's expense, to original grade and bearing, fulfilling the driving criteria.

e. Cast-in-place concrete piles shall not be load tested until the concrete has attained a minimum of 95% of its specified 28-day compressive strength as determined from test cylinders, or until the minimum time interval between concrete pouring and loading specified on the plans has elapsed, whichever is the longer time interval.

f. Piles which are not part of the structure, shall be removed or cut-off at least 30 centimeters below the bottom of the footing or finished elevation of the ground upon completion of the load test. This will also apply to any pile which, after serving its purpose as a test or anchor pile, is found to be unsatisfactory for utilization in the structure.

615-3.03 Pile Driving Equipment

a. Piles shall be driven with steam, air, or diesel hammers, or a combination of hammers with water jets. Hammers shall be in optimum operating condition. The Contractor shall be responsible for any hammer calibration required.

b. The use of a driving rig with a fixed tower is mandatory for driving all piles.

c. The plant and equipment furnished for steam and air hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by

the manufacturer. The boiler or compressor shall be equipped with an accurate pressure gauge at all times.

d. Open end diesel hammers shall have acceptable means of determining the length of the ram stroke above the head of the hammer. Enclosed ram diesel hammers shall be equipped with a gauge and charts which will evaluate the equivalent energy being produced under any driving condition.

e. The pile hammer used shall be capable of developing the minimum energy value indicated in Table 615-1 for the required pile bearing value. In addition, the hammer used shall develop sufficient energy to drive the piles at a penetration rate of not less than 1/8" per blow at the required bearing value. Table 615-1 is not applicable when a wave equation analysis is used for bearing value determination and driving control.

TABLE 615-1

Minimum Pile Hammer Requirements

	Minimum Hammer Energy (ft. –lbs.)	
Required Pile Bearing Value (Tons)	Steam and Air Hammers	Diesel Hammers
50 and under	14,500	18,000
51 to 70	19,000	24,000
71 to 90	26,500	33,000
91 to 100	30,000	37,500

f. The weight of the striking part of air and steam hammers used shall be not less than 1/3 the weight being driven, and in no case shall the striking part weigh less than 2750 pounds.

g. Diesel hammers shall be operated with wide open throttles when blows are being counted for determination of

penetration to use in the safe load formula, except that in the case of diesel hammers with enclosed rams, the throttle settings shall be just short of the settings that would cause non-striking parts of the hammers to rise off the piles as the ram piston travels upward.

h. Pile driver leads shall be constructed in such a manner as to afford freedom of movement of the hammer, and they shall be held in position by guys or stiff braces to insure support to the pile during driving. Except where piles are driven through water, the leads shall be of sufficient length so that the use of a follower will not be necessary. Leads shall be so designed as to permit the proper placing of batter piles.

i. All pile driving equipment shall be equipped with a suitable cap block and cushion assembly that will prevent pile damage and ensure uniform driving behavior. Hammer cushions shall be made of durable, materials provided in accordance with the hammer manufacturer's guidelines.

j. The heads of concrete piles shall be protected by a pile cushion made of plywood or other similar material approved by the Engineer. The minimum plywood thickness placed on the pile head prior to driving shall not be less than 4 (four) inches. The pile cushion shall be maintained at the approved thickness during the driving of all piles. The cushion shall match the cross sectional area of the pile top.

k. The driving of piling with followers shall be done only when authorized in writing by the Engineer. When followers are authorized, one pile from each group of 10 shall be a long pile driven without a follower and shall be used as a test pile to determine the average bearing power of the group.

l. Vibratory hammers may be used for driving steel sheet piling. However, vibratory hammers shall not be used for driving foundation piles.

615-3.04 Pile Bearing Values

a. When load tests are called for in the contract, the minimum number of hammer blows per unit of pile penetration needed to obtain the specified bearing values of piles shall be determined from the load tests as provided in Articles 615-3.01 and 3.02 above, except for piles driven to practical refusal as determined by the Engineer.

b. In the absence of load test data or approved previous calibration data, the bearing values of concrete and steel piles designed for bearing values of 40 tons or more shall be determined by the use of a wave equation analysis. In such cases, all the pile driving equipment to be used by the Contractor shall be subject to approval by the Engineer. As a prerequisite to such approval the Contractor shall submit to the Engineer, at least 30 days prior to driving piles, complete information on the proposed driving equipment on a form to be supplied by the Authority. As a minimum the required information shall include:

1. The weight, diameter and length of the ram; dimensions and weights of the drive head and anvil (if applicable); capblock and cushion data (material thickness, area, modulus of elasticity, coefficient of restitution); net weights of hammer and cylinder, and piston areas for double acting or differential acting air or steam hammers; bounce chamber pressure vs. equivalent energy graphs for closed-end diesel hammers; and mandrel type and weight, if applicable.

2. A wave equation analysis performed by a licensed professional engineer, for each proposed hammer, to the soil resistance value listed on the plans.

c. The data and analysis submitted will be reviewed by the Authority and the Contractor will receive notification of

acceptance or rejection within 21 days of the receipt of the data and wave equation analysis. If the Authority's review shows that pile damage or inability to drive the piles to the desired ultimate capacity will result from the Contractor's proposed equipment or method, the Contractor shall modify the proposed equipment or method until subsequent analysis indicates that the piles can be satisfactorily driven to the desired ultimate capacity without damage.

d. The following will form part of the criteria used in evaluating the Contractor's proposed pile driving systems:

1. The driving system (hammer and cushion) shall be capable of overcoming the driving resistance with less than 20 blows per inch.

2. The point of impending damage in steel piles is defined as the stress of 100 percent of the yield point of the pile material.

3. For prestressed concrete piles, tensile stresses shall not exceed 6 multiplied by the square root of f'c plus the prestress value, and compressive stresses shall not exceed the compressive strength minus the prestress value.

e. During pile driving operations, the Contractor shall use the approved system. No variations in the driving system will be permitted without the Engineer's written approval. Any change in the driving system will be approved only after performing a revised wave equation analysis.

f. During pile driving, the capblock and pile cushion shall be changed before excessive compression or damage takes place. Approval of a pile hammer relative to driving stress damage shall not relieve the Contractor of responsibility for piles damaged because of misalignment of the leads, failure of splices, malfunctioning of the pile hammer, or other improper construction methods. Piles

damaged for such reasons shall be rejected when the Engineer determines that the damage impairs the strength of the pile.

g. The wave equation analysis will also be used for piles designed for bearing values of less than 40 tons when so specified in the contract documents. If not so specified, and in the absence of load test data or approved previous calibration data, the bearing value of concrete and steel piles may be roughly approximated using whichever of the following formulas that is applicable and in which:

P = the safe load per pile in pounds.

W = the weight of the striking part of the hammer in pounds.

H = height of fall in feet for steam and air hammers, and; observed average height of fall in feet, of blows used to determine penetration for diesel hammers with unrestricted rebound of ram.

S = average penetration per blow in inches for the last 10 to 20 blows of steam, air, or diesel hammer.

E = the manufacturer's rating for footpounds developed by double acting steam or air hammers, and; 90 percent of the average equivalent energy in foot-pounds as determined by a gauge attached to the pile hammer and recorded during the period when the average penetration in inches per blow is recorded for diesel hammers having enclosed rams. Hammers of this type shall be equipped with a gauge and applicable charts supplied which will evaluate the equivalent energy being produced under any driving conditions.

1. For single-acting steam or air hammers and for diesel hammers having unrestricted rebound of ram:

$$P = \frac{2\,WH}{S + 0.1}$$

2. For double-acting steam or air hammers and diesel hammers having enclosed rams:

$$P = \frac{2\,E}{S + 0.1}$$

3. The above formulas are applicable only when:

(a) The head of the pile is free from any serious impairment.

(b) The pile penetration is at a reasonably quick and uniform rate.

(c) There is no measurable bounce after the blow. If there is a measurable bounce, twice the height of the bounce shall be deducted from H to determine its value in the formula.

(d) A follower is not used.

h. In all cases when the bearing value of concrete and steel piles is determined by formula, the piles shall be driven to the bearing value specified on the plans but in no case shall they be driven to a computed safe bearing value of less than 30 tons.

i. The safe bearing value of jetted piles shall be determined by actual load tests or by the appropriate formulas given above but no jet shall be used during the test blows.

j. When the safe bearing power of any pile is found by test, or computation, to be less than the design load, longer

piles or additional piles shall be driven as ordered in writing by the Engineer.

615-3.05 Pile Extensions - Extensions of piles, when necessary and approved by the Engineer, shall be made as shown on the plans and in accordance with the following requirements:

a. Precast Concrete Piles - Extensions of conventionally reinforced precast concrete piles shall be made by cutting away the concrete at the end of the driven pile, leaving the reinforcing steel exposed for a length of 40 diameters of each bar. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement equal to that used in the pile shall be fastened securely to the projecting steel and the necessary formwork shall be placed, care being taken to prevent leakage along the pile. Just prior to placing concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement, or other suitable bonding material. The forms shall remain in place not less than 7 days after the concrete has been placed. Curing and finishing shall be in accordance with the requirements of Specification 601.

b. Prestressed Piles - Extensions of prestressed precast concrete piles will generally not be permitted, but when necessary and authorized they shall be made in accordance with subparagraph a. above, but only after driving has been completed. Reinforcement bars shall be incorporated into the pile head for splicing to the extension bars. No additional driving will be permitted. The Contractor, at his option, may submit alternative plans of extensions for consideration by the Engineer.

c. Steel H-Piles, Pipes, and Shells - If the length of a steel H-pile, pipe, or shell is insufficient to obtain the specified bearing value, an extension of the same cross section shall be spliced to it. Unless otherwise shown on the plans, splices shall be made by full penetration butt-welding the entire cross section using the electric arc method in accordance with current AWS Structural Welding Code -

Steel. Manufactured splices for H-piles or pipe shells shall be made from AASHTO M 183 steel.

615-3.06 Driving Piles

a. All piles shall be driven at the locations shown on the plans. All excavation for the foundations in which piles are to be driven shall be completed before driving is commenced. After driving is complete, all loose and displaced materials shall be removed from around the piles, leaving clean solid surfaces to receive the concrete.

b. Piles shall be driven within an allowed variation of 1/4 inch per foot of pile length from the vertical or batter shown on the plans. The maximum allowable variation at the butt end of the pile shall be 3 inches in any direction from the location shown on the plans except that the top of any pile partially exposed or included in an integral abutment shall not vary from the plan location by more than one inch unless otherwise shown on the plans. The Contractor shall furnish an appropriate template provided with a level for use in checking the batter of piles.

c. Piles shall be driven to the tip elevation or bearing specified except that no pile shall have a penetration of less than 10 feet (3M) into hard cohesive or dense granular material nor less than 20 feet (6M) into soft cohesive or loose granular material. The Contractor shall employ whatever means are necessary to secure the required penetration without injury to the pile.

d. When the use of water jets is authorized in writing to facilitate pile driving, the number of jets and the nozzle volume and pressure, as determined by the Contractor, shall be sufficient to freely erode the material adjacent to the piling without affecting the lateral stability of the final in-place piles. Unless otherwise indicated, jets shall be cut off before the required penetration is reached and the piles shall be driven a minimum of 1.5 meters by hammers to final

penetration. The Contractor shall control, treat if necessary, and dispose of all jet water in a manner satisfactory to the Engineer. The Contractor shall be responsible for correcting any damage to the site caused by unapproved or improper jetting operations.

e. In localities where water is not available for efficient jetting operations and/or where the soil is of such material as will not permit jetting, the Contractor shall provide pilot holes as may be necessary to obtain the required pile penetration. Requirements for pilot holes shall be as follows:

1. The size and depth of pilot holes required or permitted shall be determined by the Engineer from the results of trial operations made on the first few piles driven. In general, the maximum diameter of hole permitted will be approximately 4 in. (10 cm.) less than the diagonal of square piling, 2 in. (5 cm.) less that the diagonal of octagonal piling, and 1 in. (2.5 cm.) less than the diameter of round piling. These size requirements may be varied by the Engineer as may be necessary to obtain penetration and/or bearing values contemplated by the structure design.

2. Where pilot holes are required in material which consists of loose sand or gravel overlying a hard material, and which loose materials cannot be sealed off by ordinary "mudding" drilling methods, the casing shall be of sufficient length to extend down through the upper strata of loose material to the firm material and be held in position until the pilot holes are completed and the driving of the concrete piling is started and has progressed to a sufficient depth through the hard material to prevent sand and other loose material from dropping into the pilot holes.

3. In all cases, piling shall be driven with the hammer after being placed in the pilot holes. Such

driving shall be at least sufficient to seat the pile and obtain the required bearing resistance. The load carrying capacity for the pile shall be determined from the results of this driving.

f. When indicated on the plans, holes to natural ground shall be prebored when piles are to be driven through compacted embankments. The prebored holes shall be of a size sufficient to allow frictionless penetration of the pile to the specified depth. The space remaining around any type pile after it is driven shall be completely filled with sand or other approved material. Where non-displacement piles such as H-piles are used, the Contractor may propose use of reinforcement at the tip as an alternate to preboring, subject to approval by the Engineer.

g. For special types of piling, driving heads, mandrels, or other devices in accordance with the manufacturers' recommendations shall be provided so that the pile may be driven without injury.

h. For steel piling the heads shall be cut squarely and a driving cap shall be provided to hold the axis of the pile in line with the axis of the hammer. Where shown on the plans, steel piles shall be capped with steel plates or other acceptable devices.

i. No driving of piles shall be done within 20 feet (6 meters) of concrete which is less than 7 days old.

j. Reinforced pile tips shall be used when shown on the plans or ordered by the Engineer.

k. During pile driving, the cap block and pile cushion shall be inspected after each 10 piles have been driven and, if necessary, shall be changed before excessive compression or pile damage takes place.

SPECIFICATION 615 – PILING

615-3.07 Filling Steel Shells and Pipes

a. The Contractor shall maintain at the project site at all times prior to the filling of the shells and pipes for cast-in-place concrete piles, a light suitable for the inspection of shells and pipes which have been driven. Any shell or pipe which has been improperly driven, broken or is otherwise defective, shall be removed and replaced, or otherwise corrected to the satisfaction of the Engineer, at no extra cost to the Authority.

b. The inside of shells and pipes shall be cleaned and all loose material removed before concrete is placed. The concrete shall be placed in one continuous operation from tip to cut-off elevation and shall be carried on in such a manner as to avoid segregation. The top 10 feet (3 meters) of concrete filled shells and pipes, or to the depth of any reinforcing cage, whichever is greater, shall be consolidated using acceptable vibratory equipment.

c. No shell or pipe shall be filled with concrete until all adjacent shells, pipes, or piles within a radius of 5 feet (1.5 m) or 4 1/2 times the average pile diameter, whichever is greater, have been driven to the required resistance.

615-3.08 Defective Piles

a. The method used in driving piles shall not subject them to excessive and undue abuse producing crushing and spalling of concrete or deformation of the steel.

b. Manipulation of piles to force them into proper position will not be permitted. Any pile damaged by reason of internal defects, or by improper driving, or driven out of its proper location, or driven below the top elevation fixed by the plans or by the Engineer, shall be corrected at the Contractor’s expense by one of the following methods approved by the Engineer.

1. The pile shall be withdrawn and replaced by a new and if necessary longer pile.

2. A second pile shall be driven adjacent to the defective or low pile.

3. The pile shall be spliced or built-up as otherwise provided herein or a sufficient portion of the footing extended to properly embed the pile.

4. The pile cap, when applicable, shall be redesigned or reinforced, at the Contractor's expense as may be required by the Engineer.

c. All piles pushed up by the driving of adjacent piles or any other cause shall be driven down again to the original butt elevation.

d. A concrete pile will be considered defective if it has a visible crack, or cracks, extending around the entire periphery of the pile, exposed reinforced steel in excess of the limits specified in Specifications 601 and 630, or any other defect which the Engineer determines that affects the strength or life of the pile.

615-3.09 Cutting Off Piles

a. Piles shall be cut off level at the elevation indicated on the plans. The length of pile cut-off shall be sufficient to permit the removal of all injured material. The distance from the side of any pile to the nearest edge of the footing shall be a minimum of 9 inches unless otherwise shown on the plans.

b. Steel shell or pipe casings for cast-in-place concrete piles shall be cut off at the designated elevations before being filled with concrete.

c. Cut-offs for steel shells and pipes, and steel H-piles shall be in clean, straight lines, at the required elevation and at right angles to the axis of the pile.

d. When the cut-off elevation for a precast concrete pile or for the steel shell or pipe casing for a cast-in-place concrete pile is below the elevation of the bottom of the cap, the pile shall be built up from the butt of the pile to the elevation of the bottom of the caps by means of reinforced concrete extension constructed as shown on the plans.

e. Piles inaccurately cut off shall be repaired, spliced, extended or built-up to the satisfaction of the Engineer and at no expense to the Authority.

f. After the project needs have been met, the pile cut-off length not needed for construction shall become the property of the Contractor and shall be removed from the project.

615-3.10 Sheet Piles

a. General - The design and construction of sheet piling required for the proper performance of excavation for trenches and structures under Specifications 205 and 206 is a responsibility of the Contractor for which no direct compensation is made unless specifically included in the contract as a pay item under this Specification 615.

b. Sheet piling may be constructed using timber, concrete or steel sheet piles, at the option of the Contractor, when such piling is a subsidiary obligation of the Contractor under Specifications 205 and 206.

c. When sheet piling is included in the contract as a pay item under this specification, it shall be constructed meeting the requirements of the types of the piles identified in the contract documents. If no specific design is provided in the plans, then the Contractor shall be responsible for designing and providing the necessary sheet piling.

d. Sheet piling not designed to remain in place shall be removed and disposed of at the Contractor's expense unless the Engineer authorizes leaving it in place. However, such sheet piling allowed to remain shall be cut off, at the Contractor's expense, to the elevation required by the Engineer.

615-3.11 Painting Steel Piles and Shells - Unless otherwise provided, when steel piles, permanent steel sheet piles or steel pile shells extend above the ground surface or water surface they shall be protected by three coats of paint in accordance with the painting provisions included in Specification 616 - Steel Structures. This protection shall extend from an elevation 60 cm. below the low water or ground surface to the top of the exposed steel.

615-3.12 Pile Driving Monitoring – The Pile Driving Analyzer (PDA) of the Highway and Transportation Authority will be used to monitor Pile Driving Operations (Dynamic Load Test) of all test piles to evaluate any or all of the following:

a. Evaluate suitability of Contractor's driving equipment including hammer, capblock, pile cushion, and any proposed follower.

b. Determime pile capacity.

c. Determine stresses.

d. Determine energy transfer to pile.

e. Evaluate soil variables including quake and damping.

f. Evaluate hammer-pile-soil system for wave equations analysis.

g. Evaluate pile installation problems.

h. Establish pile driving criteria.

i. Other.

This monitoring will be performed by the Soils Engineering Office of the Puerto Rico Highway and Transportation Authority. The Contractor shall notify the Engineer at least ten (10) working days before the test piles driving operations begin or as requested by the Engineer. Restrike with PDA will be performed to all the test piles after an elapsed period (setup). The setup period is to be set at seven (7) days after initial driving of the test pile. Restrike with the PDA could be required to those production piles which have been driven to the established pile driving criteria and remain questionable due to excess/minimal length, doubtful driving records, etc.

The Contractor shall not drive test piles simultaneously so that the Engineer can properly monitor each test pile. He shall also supply a generator, if not supplied by the Authority, to provide approximately 1,000 Watts of 115 Volt AC Power for the monitoring equipment in use and sufficiently long extension cord to reach from the power source to the pile and testing equipment. The Contractor shall provide a stable working platform and suitable shelter for the elements, acceptable to the Engineer at each of the test piles locations.

The Contractor shall prepare the test piles for the necessary gauge (strain transducer and accelerometers) attachments. This requires drilling the top of each pile or pile segment to be monitored with four to six holes (approximately 1/4 inch diameter); the hole's pattern will be established and inspected by the Engineer before the pile is lifted. The Contractor shall also mount the gauges on the pile after the pile has been lifted and is ready for driving. The Contractor shall connect lead wires and cable to the gauges. The Contractor shall be responsible for the replacement of any damaged equipment due to improper installation or handling. Short interruptions during driving may be necessary in case of instrument malfunction. The Contractor shall remove all instruments and

leads, as directed by the Engineer, after pile driving is completed.

The stresses in the piles will be monitored with the Pile Driver Analyzer during driving to ensure that the allowable stresses are not exceeded. If necessary, the Contractor shall add additional cushioning, replace the cushion, or reduce the hammer stroke to maintain stresses below the maximum allowable as directed by the Engineer. If non-axial driving is indicated by dynamic test equipment measurements, the Contractor shall immediately realing the driving system. If the cushion is compressed to the point that a change in alignment of the hammer will not correct the problem, the Contractor shall add cushioning or change the cushion as directed by the Engineer.

The Contractor shall drive the pile to the required penetration and resistance or as directed by the Engineer. The Engineer may require to interrupt driving for short waiting periods (set-checks) during pile driving monitoring.

Restrike tests shall be performed with the same hammer used to drive the test piles. The hammer shall be in optimum condition and shall be warmed up by applying at least 20 blows to a previously driven pile or to timber mats placed in the ground.

The Contractor shall submit for approval of the Engineer the hammer manufacturer's specifications for the driving of the specified pile, together with a wave equation drivability analysis of the hammer-pile soil systems. The hammer shall be capable of developing sufficient energy to drive the pile to the required bearing value as per stated on the project's drawings or as specified by the Engineer. All costs associated with the use of the PDA will be considered a subsidiary obligation of the Contractor under the piles contract pay items (Specification 615 – Piling).

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615-4 METHOD OF MEASUREMENT

615-4.01 Concrete and steel foundation and trestle piles will each be measured by the linear meter, to the nearest tenth of a meter, of piles in place, completed and accepted. Measurement will be from the point of the tip to the plane of pile cut-off.

a. The measurement will not include the length of test piles which are covered in Article 615-4.02 below, whether or not utilized in the completed structure.

b. No allowance will be made for that length of piles, including test piles, driven by the Contractor to replace piles previously accepted by the Engineer that are subsequently lost or those that are damaged during handling, driving or by a load test and are rejected by the Engineer and ordered to be removed from the site of the work or disposed otherwise.

c. In case extensions of piles are necessary, the extension length shall be included in the linear footage of piling.

615-4.02 Test piles called for on the plans or ordered by the Engineer will each be measured by the linear meter, to the nearest tenth of a meter, of test piles completed, in place and accepted. Test piles driven by the Contractor at his option, to calibrate driving hammers or for other reasons, will not be included in the measurement for payment, unless such test piles comply fully with the requirements of the plans and specifications and are accepted by the Engineer to become part of the completed structure, in which case they will be measured for payment under the pay item for the type of pile used but not as a test pile.

615-4.03 Preboring, jetting or other methods used for facilitating pile driving procedures will not be measured directly for payment but shall be a subsidiary obligation of the Contractor under the piling pay items.

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615-4.04 Load tests called for on the plans or ordered by the Engineer will be measured by the number of tests made, completed and accepted. Load tests made by the Contractor, at his option, will not be included in the measurement for payment. Anchor piles which do not become part of the permanent structure will not be measured for separate payment but shall be included in the unit price of each load test. Anchor piles which are accepted as part of the permanent structure will be measured and paid for under the appropriate pile pay item.

615-4.05 Pile shoes will not be measured for direct payment but shall be a subsidiary obligation of the Contractor under the piling pay items.

615-4.06 Timber, concrete and steel sheet piling which is specifically identified for separate payment will be measured by the square meter, to the nearest tenth of a square meter, of vertical projection of wall in place including the buried portions. No measurement for payment will be made of any sheet piling which is a subsidiary obligation of the Contractor under trench excavation, excavation for structures or other contract pay items, or which is installed by the Contractor, at his option, for the performance of work under the contract. No separate measurement will be made of any waling, struts, bracing or any other supporting members required for the sheet piling as this work shall be a subsidiary obligation of the Contractor under the respective sheet piling pay items.

615-4.07 Cut-offs, cut-backs and extensions will be measured as follows:

a. Steel H-Piles - If the cut-off length is in excess of one (1) meter, measurement will be by the linear meter of the portion of pile cut off. No measurement will be made of lengths of cut-offs of one (1) meter and less for steel piles. In addition, cut-offs used for pile extensions will not be measured and paid as cut-off lengths but will be included for measurement and payment under the appropriate pile pay items.

b. Concrete Precast and Prestressed Piles - One half of the actual length of cut-off will be included in the measurement for payment, made as specified in Article 615-4.01 above, for each type of pile.

c. Cast-in-Place Concrete Piles - No allowance will be made for cut-offs.

d. Sheet Piles - Although sheet piles when paid for separately as provided in Article 615-4.06 are measured by the square meter, the cut-offs of piles specified to remain in place, will be measured for payment as provided for steel H-piles in paragraph 615-4.07a. above. However, no payment will be made for cut-offs of sheet piling which is abandoned in place by the Contractor at his option.

e. In case extensions or build-ups of piles are authorized the build-up length will be measured by the linear meter and will be included in the measurement of the corresponding piles in place.

f. When cut-backs are made below grade for the purpose of making extensions as build-ups, the length of cut-back will be measured by the linear meter and included as build-ups in the measurement for the corresponding piles in place.

g. Cut-offs, cut-backs, and extensions of test piles will be measured as specified in paragraphs a. thru f. above.

615-5 BASIS OF PAYMENT

615-5.01 The accepted quantities, determined as provided above, for each of the particular pay items listed in Article 615-5.02 below which are included in the contract, will be paid for at the respective contract unit price per unit of measurement. Such price and payment shall constitute full compensation for furnishing, placing and finishing all required materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications, except as follows:

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a. The concrete in concrete piles shall be subject to the evaluation and basis of acceptance specified in Specifications 601 and 630. Adjustments in prices for deficient concrete will be applied to the pile contract unit price.

b. The cut-off length for steel H-piles will be made on the basis of the actual cost to the Contractor of the portion of pile cut-off measured and accepted for payment as provided in paragraph 615-4.07a. Actual costs will be based on vendor's invoice and will include transportation charges for delivery to the project site.

c. The cut-off of sheet piling measured and accepted for payment will be made in the same basis as provided for steel H-pipes in paragraph b above.

d. Leftover steel piles ordered from outside Puerto Rico on the basis of plan quantity, with the Engineer's approval, will be paid for at the actual cost to the Contractor (vendor's invoice plus delivery to site costs) plus 15 percent of such cost. These piles shall then become property of the Authority.

e. When the contract does not contain a pay item for all or any portion of the work under this specification, the cost thereof shall be a subsidiary obligation of the Contractor under other contract items of work.

615-5.02 Payment will be made under:

Pay Item	Pay Unit
Precast Conventionally Reinforced Concrete Piles, ____(size).....	Linear Meter
Prestressed Concrete Piles, ____(size).....	Linear Meter

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Pay Item	Pay Unit
Cast-in-Place Concrete Piles……..	Linear Meter
Steel H-Piles, ____ (size)……	Linear Meter
Precast Conventionally Reinforced Concrete Test Piles, ____ (size)……...	Linear Meter
Prestressed Concrete Test Piles, ____ (size)……	Linear Meter
Cast-in-place Concrete Test Piles, ____ (size)……	Linear Meter
Steel Test H-Piles, ____ (size)…….	Linear Meter
Load Tests……..	Each
Timber Sheet Piling……	Square Meter
Treated Timber Sheet Piling……..…….	Square Meter
Concrete Sheet Piling…….	Square Meter
Steel Sheet Piling……...	Square Meter

SPECIFICATION 616 – STEEL STRUCTURES

616-1 DESCRIPTION

616-1.01 Scope

a. This work shall consist of steel structures and the steel structure portions of composite structures, constructed in accordance with these specifications, and in conformity with the lines, grades, dimensions and details shown on the plans or established by the Engineer.

b. The work shall include the furnishing, fabricating, erecting, and painting of structural metals called for in the contract documents. Structural metals shall include structural, welding, special, and alloy steels; metallic electrodes; steel forgings and castings; iron castings; and any incidental metal construction not otherwise provided for, all in accordance with the contract.

616-2 MATERIALS

616-2.01 Metallic materials for the fabrication and construction of steel structures shall conform to the requirements of the following articles of Specification 715 - Structural Metals:

Structural Steel……..	715-1
High-Strength Bolts……..…..	715-2
Pins, Rollers and Expansion Rockers……	715-3
Welded Stud Shear Connectors…….	715-4
Castings…….	715-5
Steel Forgings……	715-6
Copper Alloy Plates……..	715-7
Sheet Zinc…….....	715-8
Sheet Lead…….	715-9
Galvanizing……	715-10
Welding Electrodes and Fluxes…….	715-11
Stainless Steel……...	715-12

616-2.02 Wherever steel shapes, plates and miscellaneous steel items are specified, all designations shall be understood to be the

same as those in the current edition of the AISC Manual of Steel Construction. All such material shall conform to the standard dimensional requirements specified therein.

616-2.03 Elastomeric pads for bridge bearings shall meet the requirements of Specification 717 - Elastomeric Bearings for the class specified on the plans.

616-2.04 Paint shall conform to the requirements of Specification 708 - Paints for Steel Structures.

616-2.05 The Contractor shall submit manufacturers' certificates of compliance with the specification requirements for all of the metallic materials and any other of the above materials which are included in the contract. Certified mill test reports shall be submitted by the Contractor for all the structural steel items.

616-3 CONSTRUCTION REQUIREMENTS

616-3.01 General

a. The Contractor shall furnish and place all steel castings, steel forgings, structural steel and other materials as shown on the plans, or as directed by the Engineer.

b. All fabrication, erection and painting of the structural steel shall be as indicated in these specifications. Any of the work not specifically covered in this specification shall be performed in conformance with the applicable sections of the AASHTO Standard Specifications for Highway Bridges.

616-3.02 Working Drawings - The Contractor shall submit for review and approval by the Engineer, all working drawings necessary to supplement the contract plans and to adequately control the work in line with the requirements of Article 105.02 of the General Provisions.

SPECIFICATION 616 – STEEL STRUCTURES

616-3.03 Fabrication

a. General

1. All rolled structural material shall be properly straightened by methods which will not injure the metal, prior to being laid off, punched, or otherwise worked in the shop. Sharp kinks and bends shall be cause for rejection of the material.

2. The straightening of bent edges of plates, angles and other shapes, when permitted by the Engineer, shall be done by methods not likely to produce fracture or other injury. The metal shall not be heated unless permitted by the Engineer, in which case the heating shall not be done to a higher temperature than 1150ºF. After heating, the metal shall not be artificially cooled until after naturally cooling to 600ºF.

3. The workmanship and finish shall be first class and equal to the best general practice in modern bridge shops. Shearing, flame cutting and chipping shall be done accurately, and all portions of the work exposed to view shall be finished neatly.

4. All steel surfaces which will be in contact with concrete shall be cleaned of all adhering rust, scale, dirt, grease or other foreign matter.

b. Bolt Holes

1. All holes for bolts shall be either punched or drilled. Material forming parts of a member composed of not more than five thicknesses of metal may be punched 1/16 inch larger than the nominal diameter of the bolts whenever the thickness of the metal is not greater than 3/4 inch for structural steel, 5/8 inch for high strength low alloy steel, or 1/2 inch for quenched and tempered alloy steel.

2. When there are more than five thicknesses of material or when any of the main material is thicker than 3/4 inch in carbon steel, 5/8 inch in alloy steel, or 1/2 inch for quenched and tempered alloy steel, all holes shall either be subdrilled or drilled full size.

3. When required for field connections, all the holes shall be sub-punched or sub-drilled 3/16 inch smaller and, after assembling, reamed 1/16 inch larger, or drilled full size to 1/16 inch larger than the nominal diameter of the bolts.

c. Punched Holes - The diameter of the die shall not exceed the diameter of the punch by more than 1/16 inch. If any holes must be enlarged to admit the bolts, they shall be reamed. Holes must be clean cut, without torn or ragged edges. Poor matching of holes will be cause for rejection.

d. Reamed or Drilled Holes - Reamed holes shall be cylindrical, perpendicular to the member and not more than 1/16 inch larger than the nominal diameter of the bolts. Reamers and drills shall be directed by mechanical means unless otherwise specifically permitted by the Engineer. Drilled holes shall be 1/16 inch larger than the nominal diameter of the bolt. Burrs on the outside surfaces shall be removed. Poor matching of holes will be cause for rejection. Reaming and drilling shall be done with twist drills. If required by the Engineer, assembled parts shall be taken apart for removal of burrs caused by drilling. Connecting parts requiring reamed or drilled holes shall be assembled and held securely while being reamed or drilled and shall be match-marked before disassembling.

e. Subpunching, Reaming and Shop Assembly

1. Unless otherwise specified, holes in all field connections and field splices of main truss or arch members, continuous beams, girders and rigid frames shall be drilled full size, or subpunched (or sub-

drilled) and reamed, with all members assembled in proper position while laid down in the shop. If splices are to be drilled full size, one splice plate from each flange or from each web splice may be pre-drilled full size and the pre-drilled plate used as a template for drilling the flange or web and opposite splice plates, provided the resulting holes are, in the opinion of the Engineer, equal in quality to holes drilled completely from the solid or sub-drilled (or sub-punched) and reamed. The assembly, including camber, alignment, and accuracy of holes and milled joints, shall be approved by the Engineer before reaming of under size holes or drilling of full size holes is commenced.

2. All holes for floor beam and stringer field end connections shall be sub-punched and reamed to a steel template or reamed while assembled.

3. If additional sub-punching and reaming is required, it shall be specified in the special provisions or in the plans.

4. Complete shop assembly of an entire structure, including floor system, which may be necessary in the case of complicated designs, shall be done when shown on the plans or when specified in the special provisions. Such shop assembly shall be by the method specified in the contract documents and shall conform to the AASHTO bridge specifications requirements.

5. Surfaces of metal in contact shall be cleaned before assembling. The parts of a member shall be assembled, well pinned, and firmly drawn together with bolts before reaming is commenced. Assembled pieces shall be taken apart, if necessary, for the removal of burrs and shavings produced by the reaming operation. The members shall be free from twists, bends and other deformation.

6. End connection angles, stiffener angles and similar parts shall be carefully adjusted to correct positions and bolted, clamped, or otherwise held firmly in place until bolted.

f. Accuracy of Holes

1. All holes punched full size, sub-punched, or sub-drilled shall be so accurately punched that after assembling (before any reaming is done) a cylindrical pin 1/8 inch smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drifting, in at least 75 percent of the contiguous holes in the same plane. If the requirement is not fulfilled, the badly punched pieces will be rejected. If any hole will not pass a pin 3/16 inch smaller in diameter than the nominal size of the punched hole, this will be cause for rejection.

2. When holes are reamed or drilled, 85 percent of the holes in any contiguous group shall, after reaming or drilling, show no offset greater than 1/32 inch between adjacent thicknesses of metal.

g. Match-Marking - Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be match-marked, and a diagram showing such marks shall be furnished to the Engineer.

h. Bolted Connections with Unfinished, Turned and Ribbed Bolts

1. Bolts shall be unfinished, turned or an approved form of ribbed bolt conforming to the requirements for Grade A Bolts of Specification for Low-Carbon Steel Externally and Internally Threaded Standard Fasteners, ASTM A 307. Bolted connections shall be used only as indicated by the plans or special provisions. Bolts shall have single

self-locking nut or double nuts unless otherwise shown on the plans or in the special provisions. Beveled washers shall be used where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

2. Unfinished bolts shall be furnished unless other types are specified.

3. The surface of the body of turned bolts shall meet the ANSI roughness rating value of 125. Heads and nuts shall be hexagonal with standard dimensions for bolts of the nominal size specified or the next larger nominal size. Diameter of threads shall be equal to the body of the bolt of the nominal diameter of the bolt specified. Holes for turned bolts shall be carefully reamed with bolts furnished to provide for a light driving fit. Threads shall be entirely outside of the holes. A washer shall be provided under the nut.

4. The body of ribbed bolts shall be of an approved form with continuous longitudinal ribs. The diameter of the body measured on a circle through the points of the ribs shall be 5/64 inch greater than the nominal diameter specified for the bolts and they shall be furnished with round heads conforming to ANSI B 18.5 unless otherwise specified. Nuts shall be hexagonal, either recessed or with a washer of suitable thickness. Ribbed bolts shall make a driving fit with the holes. The hardness of the ribs shall be such that the ribs do not mash down enough to permit the bolts to turn in the holes during tightening. If for any reason the bolt twists before drawing tight, the hole shall be carefully reamed and an oversized bolt used as a replacement.

i. Bolted Connections with High-Strength Bolts

1. When shown on the plans, high-strength bolts shall be used for the fabrication of structural steel forming rigid joints in installations where the initial tension in the bolt body is depended upon to produce resistance to shear loads through friction at the faying surfaces.

2. The slope of surfaces of bolted parts in contact with the bolt head and nut shall not exceed 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material.

3. When assembled, all joint surfaces, including those adjacent to the bolt head, nuts, or washers, shall be free of scale, except tight mill scale, and shall also be free of burrs, dirt, and other foreign material that would prevent solid seating of the parts. Paint is permitted unconditionally in bearing-type connections.

4. In friction-type connections the Class, as defined below, indicating the condition of the contact surfaces shall be specified on the plans. Where no class is specified all joint surfaces shall be free of scale, except tight mill scale and shall not have a vinyl wash.

(a) Classes A, B, and C (uncoated) - Contact surfaces shall be free of oil, paint, lacquer, or other coatings.

(b) Class D (hot dip galvanized and roughened) - Contact surfaces shall be lightly scored by wire brushing or blasting after galvanizing and prior to assembly. The wire brushing treatment shall be a light application of manual or power brushing that marks or

scores the surface but removes relatively little of the zinc coating. The blasting treatment shall be a light "brush-off" treatment which will produce a dull gray appearance. However, neither treatment should be severe enough to produce any break or discontinuity in the zinc surface.

(c) Classes E and F (blast-cleaned, zinc rich paint) - Contact surfaces shall be coated with organic or inorganic zinc rich paint as defined in the Steel Structures Painting Council System SSPC 12.00.

(d) Classes G and H (blast-cleaned, metallized zinc or aluminum) - Contact surfaces shall be coated in accordance with AWS C2.2. Recommended Practice for Metallizing with Aluminum and Zinc for Protection of Iron and Steel, except that subsequent sealing treatments, described in Section IV therein, shall not be used.

(e) Class I (vinyl wash): Contact surfaces shall be coated in accordance with the provisions of the Steel Structures Painting Council Pretreatment Specifications SSPC PT3.

5. AASHTO M 164 (ASTM A 325) Type 2 and AASHTO M 253 (ASTM A 490) bolts shall not be galvanized nor shall they be used to connect galvanized material.

j. High-Strength Bolts Installation

1. Each bolt shall be tightened to provide, when all bolts in the joint are tight, at least the minimum

bolt tension shown in Table 616-1 for the size of bolt used.

TABLE 616-1

BOLT TENSION

Bolt Size (in.)	AASTHO M 164 (ASTM A 325) Bolts	AASHTO M 253 (ASTM A 490) Bolts
1/2	12,050	14,900
5/8	19,200	23,700
3/4	28,400	35,100
7/8	39,250	48,500
1	51,500	63,600
1-1/8	56,450	80,100
1-1/4	71,700	101,800
1-3/8	85,450	121,300
1-1/2	104,000	147,500

* Equal to 70 percent of specified minimum tensile strength of bolts.

2. Threaded bolts shall be tightened using turn-of-nut method or such other method as approved by the Engineer provided it can be demonstrated by an accurate direct measurement procedure that the bolt has been tightened in accordance with Table 616-1. If required because of bolt entering and wrench operation clearances, tightening by the selected procedure may be done by turning the bolt while the nut is prevented from rotating. Impact wrenches, if used, shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

3. AASHTO M 253 (ASTM 490) and galvanized AASHTO M 164 (ASTM A 325) bolts shall not be reused; other AASHTO M 164 (ASTM A 325) bolts may be reused, but not more than once, if approved by the Engineer. Retightening previously tightened bolts which may have been loosened by the tightening of adjacent bolts will not be considered as a reuse.

4. All bolts shall have a hardened washer under the element (nut or bolt head) turned in tightening except that AASHTO M 164 (ASTM A 325) bolts installed by the turn-of-nut method in holes which are not oversize or slotted may have the washer omitted. Hardened washers shall be used under both the head and nut, regardless of the element turned, in the case of AASHTO M 253 (ASTM A 490) bolts, if the material against which it bears has a specified yield strength less than 40 ksi.

5. When the turn-of-nut method is used to provide the bolt tension specified in paragraph (1) above, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into full contact with each other. Snug tight is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table 616-2 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

TABLE 616-2

NUT ROTATION FROM SNUG TIGHT CONDITION (1)

Bolt Length measured form underside of head to extreme end of point	Disposition of Outer Faces of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces sloped not more than 1:20 from bolt (bevel washers not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters (2)	2/3 turn	5/6 turn	1 turn

1. Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. For bolts installed by 1/2 turn and less, the tolerance should be plus or minus 30 degrees; for bolts installed by 2/3 turn and more, the tolerance should be plus or minus 45 degrees.

2. No research work has been performed by the Research Council on Riveted and Bolted Structural Joints to establish the turn-of-nut procedure when bolt lengths exceed 12 diameters. Therefore, the required rotation must be determined by actual tests in a suitable tension device simulating the actual conditions.

k. Inspection of High-Strength Bolts Connections

1. The Engineer will observe the installation and tightening of bolts to determine that the selected tightening procedure is properly used and will determine that all bolts are tightened.

2. When requested by the Engineer, verification of bolt tension produced by any method shall be conducted by the Contractor using a calibrated manual torque wrench in the presence of the engineer as follows:

(a) The manual torque wrench shall be furnished by the Contractor.

(b) Three bolts of the same grade, diameter, length and condition as those under inspection shall be placed individually in a calibration device capable of indicating bolt tension. The surface under the part to be turned in tightening each bolt shall be like that under the corresponding part in the structure, i.e., there shall be a washer under the part turned if washers are so used in the structure or, if no washer is used, the material abutting the part turned shall be of the same nature as that in the structure.

(c) Each of the three bolts shall be tightened in the calibration device by any convenient means to the minimum tension specified for its size in Table 616-1. The inspecting wrench then shall be applied to the tightened bolt and the torque necessary to turn the nut or head 5 degrees (approximately 1 inch at 12 inch radius) in the tightening direction shall be determined. The average torque measured in the tests of the three bolts

shall be determined. The average torque measured in the tests of three bolts shall be taken as the job inspecting torque to be used in the manner specified herein.

(d) Bolts represented by the sample prescribed in paragraph (b) above which have been tightened in the structure shall be inspected by applying, in the tightening direction, the inspecting wrench and its job inspecting torque to 10% of the bolts, but not less than two bolts, selected at random in each connection. If no nut or bolt head is turned by this application of the job inspecting torque, the connection shall be accepted as properly tightened. If any nut or bolt head is turned by the application of the job inspecting torque, this torque shall be applied to all bolts in the connection, and all bolts whose nut or head is turned by the job inspecting torque shall be tightened and reinspected or, alternatively, the fabricator or erector at this option may retighten all of the bolts in the connection and then resubmit the connection for the specified inspection.

l. Bearing Surfaces - The surface finish of bearing and base plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the American National Standards Institute (ANSI) surface roughness requirements as defined in ANSI B 46-1, Surface Roughness, Waviness and Lay, Part I:

Steel slabs……..	2,000
Heavy plates in contact with shoes…….	1,000
Flame cut surfaces of members carrying Calculated stress……..	1,000
Flame cut surfaces of members not Carrying calculated stress……	2,000

Mill ends of compression members……..	500
Bridge rollers and rockers…….	250
Pins and pinholes……	125
Sliding bearings……..	125

m. Abutting Joints - Abutting joints in compression members of trusses and columns shall be milled or saw-cut to give a square joint and uniform bearing. At other joints, not required to be faced, the opening shall not exceed 3/8 inch.

n. Pins and Rollers

1. Pins and rollers shall be accurately turned to detailed dimensions and shall be smooth, straight, and free from flaws. The final surface shall be produced by a finishing cut, and shall conform to the requirements of paragraph 616-3.03 l.

2. Pins and rollers more than 9 inches in diameter shall be forged and annealed. Pins and rollers 9 inches or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting. In pins larger than 9 inches in diameter, a hole not less than 2 inches in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range, under suitable conditions to prevent injury by too rapid cooling, and before being annealed.

3. Pinholes shall be bored true to detailed dimensions, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. A finishing cut shall always be made.

4. The length outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from detailed dimensions more than 1/32 inch. Boring of holes in

built-up members shall be done after the welding is completed.

5. The diameter of the pin hole shall not exceed that of the pin by more than 1/50 inch for pins five inches or less in diameter, or by 1/32 inch for larger pins.

6. Unless otherwise specified, two pilot nuts and two driving nuts shall be furnished for each size of pin.

o. Plate Cut Edges

1. Sheared edges of plate more than 5/8 inch in thickness and carrying calculated stress shall be planed, milled, ground, or thermal cut to a depth of 1/4 inch. Re-entrant corners shall be filleted to a minimum radius of 3/4 inch before cutting.

2. Flame cutting of structural steel shall conform to the requirements of the current edition of the AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

p. Bent Plates – Cold-bent load-carrying rolled-steel plates shall conform to the following:

1. They shall be so taken from the stock plates that the bending will be at right angles to the direction of rolling.

2. The radius of bends shall be such that no cracking of the plate occurs. Minimum bend radii, measured to the inside face of the metal, for all grades of structural steel in this specification shall be as follows:

	Plate Thickness (t) in Inches			
	Up to 1/2"	Over 1/2“ to 1”	Over 1” to 1 1/2"	Over 1/12” to 2 1/2"
Radius	2t	2 1/2t	3t	3 1/2t

3. If a shorter radius is essential, the plates shall be bent hot at a temperature not greater than 1125° for ASTM A 514 and A517 steels and 1200?F for other steels. Hot bent plates shall conform to the requirements of paragraph (1) of this article.

4. Before bending, the corners of the plate shall be rounded to a radius of 1/16 inch throughout that portion of the plate at which the bending is to occur.

q. Threads for Bolts and Pins - Threads for all bolts and pins for structural steel construction shall conform to the Unified Standard Series UNC - ANSI B1.1, Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded six threads to the inch.

r. Stiffeners - End stiffeners of girders and stiffeners intended as supports for concentrated loads shall have full bearing (either milled, ground or, on weldable steel in compression areas of flanges, welded as shown on the plans or specified) on the flanges to which they transmit load or from which they receive load. Stiffeners not intended to support concentrated loads shall, unless shown or specified otherwise, fit sufficiently tight to exclude water after being painted.

s. Welding

1. Welding of steel structures, when authorized, shall comply with the requirements of the current

edition of the American Welding Society (AWS)

Structural Welding Code AWS D1.1 as modified by the current AASHTO Standard Specifications for Welding of Structural Steel Highway Bridges.

2. Non-destructive testing of welds by radiography or ultrasonic testing shall be performed at the Contractor's expense and in accordance with AWS requirements.

3. All welders, operators and tackers shall be competent, trained and certified in the particular arc welding process to be used, experienced in the type of welding required, and capable of producing reliable fillet and groove welds in the positions for which they are qualified.

(a) Qualification testing is required. The applicable clauses of the AWS Code shall be the basis for qualifying for this work. The testing shall be done, at the Contractor's expense, by a laboratory recognized and accepted by the Engineer. The qualification of the welder, operator, or tacker shall be considered as remaining in effect indefinitely unless the person is not engaged in the given process of welding for which he is qualified for a period exceeding six months; or unless there is some specific reason to question the person's ability.

(b) The fabricator or Contractor shall furnish a certificate stating that the welder, operator or tacker has been doing satisfactory welding with the required process within the six month period prior to the subject work. A certification shall be submitted for each

welder, operator or tacker and for each project. The certificate shall state the name of the welder, operator or tacker, the arc welding process, the welding position, the qualification positions, whether for groove or fillet weld, whether for limited or unlimited plate thickness, the AWS Electrode and flux or electrode classification, the date and results of the test and any other pertinent information.

(c) When qualification of the welder, operator, tacker or procedure is required, it shall be the responsibility of the Contractor to make all necessary arrangements for the testing. The Contractor shall notify the Engineer as to the time and location of the test, at least 48 hours in advance of the time the testing will begin, in order that the Engineer may observe the actual qualification testing.

4. Field welding will be permitted only where specified in the plans.

616-3.04 Shop and Field Inspection

a. The Contractor shall give the Engineer ample notice of the beginning of work in the shop so that inspection may be provided. No material shall be manufactured or work done in the shop before the Engineer has been so notified.

b. The Contractor shall furnish all facilities for the inspection of material and workmanship in the shop, and inspectors shall be allowed free access to the necessary parts of the premises.

c. When structural steel is fabricated outside Puerto Rico, the Authority may, at its option, not provide shop inspection, depending on the size and importance of the order being fabricated and the time and expense required for such

inspection work. When such inspection is not provided, it is understood that the Engineer will make complete inspection of all fabricated work after delivery to the site.

d. The inspector shall have the authority to reject materials or workmanship which do not fulfill the requirements of these specifications; but in cases of dispute, the Contractor may appeal to the Engineer, whose decision shall be final.

e. Inspection at the shop is intended as a means of facilitating the work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility for imperfect material or workmanship and the necessity for replacing the same, as required by later inspection.

f. The acceptance of any material or finished members by the inspector shall not be a bar to their subsequent rejection, if found defective. Rejected material and workmanship shall be promptly repaired or replaced by the Contractor.

g. All work of field erection shall be subject to the inspection of the Engineer who shall be given all facilities required for a thorough inspection of workmanship. Material and workmanship not previously approved, particularly when steel work is fabricated outside of Puerto Rico, will be inspected for acceptance after its delivery to the site of the work.

616-3.05 Marking and Shipping

a. Each member shall be painted or marked with an erection mark for identification and an erection diagram shall be furnished with erection marks shown thereon.

b. Members weighing more than three tons shall have the weight marked thereon. Bolts of one length and diameter

and loose nuts or washers of each size, shall be packed separately. Pins, small parts, and small packages of bolts, washers, and nuts shall be shipped in boxes, crates, kegs, or barrels of convenient sizes. A list and description of the contained material shall be plainly marked on the outside of each shipping container.

c. The weight of all tools and erection material shall be kept separate.

d. Anchor bolts, washers, and other anchorage or grillage materials, shall be shipped to suit the requirements of the masonry construction.

e. The loading, transportation, unloading and storing of structural material shall be so conducted that the metal will be kept clean and free from damage.

f. The Contractor shall furnish the Engineer with as many copies of mill orders and shipping statements as the Engineer may direct. They shall be properly identified as to the project on which the material is to be used. The weights of the individual members shall be shown on the statements.

616-3.06 Storage of Material

a. All material, either plain or fabricated, shall be stored at the shop and field location above the surface of the ground upon platforms, skids, or other supports, and shall be protected from exposure to conditions producing rust. It shall be kept free of accumulation of dirt, oil and other foreign matter. Long members, such as columns and chords, shall be supported on skids near enough together to prevent injury from deflection.

b. If the contract is for erection only, the Contractor shall check the material turned over to him against the shipping lists and report promptly in writing any shortage or damages discovered. He shall be responsible for the loss of any

material while in his care, and for any damage caused to it after being received by him.

616-3.07 Erection

a. General

1. Before starting the work of erection, the Contractor shall inform the Engineer fully as to the method of erection he proposes to follow, and the quantity and character of equipment he proposes to use, which shall be subject to the approval of the Engineer. The approval of the Engineer shall not be considered as relieving the Contractor of the responsibility for the safety of his method or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done until such approval by the Engineer has been obtained.

2. The Contractor shall provide the falsework and all tools, machinery, and appliances, including drift pins and fitting-up bolts, necessary for the expeditious handling of the work, and shall erect the metal work, remove any temporary construction, and do all the work necessary to complete the structure as required by the contract and in accordance with the plans and specifications.

3. If so indicated in the contract documents, the Contractor shall dismantle any old existing structure at the site for the new structure in accordance with Specification 202 - Removal of Structures and Obstructions.

b. Falsework - The falsework shall be properly designed and substantially constructed and maintained for the loads that will come upon it. The Contractor, if required, shall prepare and submit to the Engineer for approval, plans for

falsework or for changes in an existing structure necessary for maintaining traffic. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

c. Bearing and Anchorages

1. Bridge bearings shall be set level, in exact position, and must have full and even bearing on the masonry. Bearings shall not be placed on masonry bearing areas that are irregular or improperly formed.

2. Elastomeric bearing pads, if used, shall set directly on the concrete masonry. Cast iron or steel, or rolled steel bearings shall be bedded on the masonry with a single thickness of sheet lead preformed fabric bearing pad.

3. The Contractor shall drill holes for anchor bolts and set them in portland cement grout, or preset them using a template as shown on the plans or as specified.

4. Location of anchors and setting of rockers or rollers shall take into account any variation from mean temperature at time of setting and anticipated lengthening of bottom chord or bottom flange due to dead load after setting, the intention being that, as near as practicable, at mean temperature and under dead load, the rockers and rollers shall set vertical and anchor bolts at expansion bearings will center their slots. Care shall be taken that full and free movement of the superstructure at the movable bearings is not restricted by improper setting or adjustment of bearings or anchor bolts and nuts.

d. Field Assembling

1. The parts shall be accurately assembled as shown on the plans and any match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the members shall not be done.

Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have one-half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. Splices and connections carrying traffic during erection shall have at least three-fourths of the holes so filled. Fitting-up bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1/32 inch larger.

2. The correction of minor misfits involving harmless quantities of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The correction shall be made in his presence. If the contract provides for complete fabrication and erection, the Contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacement. If the contract is for erection only, the corrective work shall be performed as extra work under Article 109.04 of the General Provisions.

616-3.08 Cleaning and Painting - All metal surfaces shall be cleaned and painted as specified in the contract documents and in accordance with Specification 653 - Painting Metal Structures.

616-3.09 Site Clean-up and Restoration - Upon completion of the erection and before final acceptance, the Contractor shall remove all falsework, excavated or useless materials, rubbish, and temporary buildings. He shall replace or renew any fences damaged and restore in an acceptable manner all property, both public and private, which may have been damaged during the prosecution of this work, and shall leave the bridge site and adjacent highway in a neat and presentable condition satisfactory to the Engineer. All excavated material or falsework placed in the stream channel during construction shall be removed by the Contractor before final acceptance.

616-4 METHOD OF MEASUREMENT

616-4.01 Structural steel will be measured by the pound of material in place and accepted in the completed structure. For purposes of measurement and payment, the term structural steel includes components fabricated from the various metals listed in paragraph "a" below. The payment quantities will be computed from the dimensions shown on the plans, except as modified in subsequent paragraphs of this section.

a. Unless otherwise provided in the contract documents, the weights of metals paid for will be computed on the basis of the following unit weights:

Metal	Lbs. Per Cu. Ft.
Aluminum, cast or wrought……	173.0
Bronze, cast……	536.0
Copper-alloy……..	536.0
Copper sheet……..	558.0

Iron, cast…….	445.0
Iron, malleable……	470.0
Iron, wrought…….	487.0
Lead, sheet…….	707.0
Steel, rolled, cast, copper bearing, silicon nickel and stainless, all grades…….	490.0
Zinc…….	450.0

b. The weights of steel shapes and plates will be computed on the basis of their nominal weights and dimensions as shown on the drawings, or listed in the steel industry handbooks, deducting for copes, cuts and open holes but not for bolt holes. The weights of all plates shall be computed on the basis of nominal dimensions with no additions for overruns.

c. The weight of castings will be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight shall be added 5 percent allowance for fillets and overrun. Scale weights may be substituted for computed weights in the case of castings or of small complex parts for which accurate computations of weight would be difficult.

d. The weight of temporary erection bolts, boxes, crates and other containers used for shipping, and materials used for supporting members during transportation and erection shall not be included in the measurement for payment.

e. The weight of heads, nuts, washers, and threaded stick-through of all high-strength field and shop bolts shall be

included in the measurement of structural steel on the basis of the following weights:

Diameter of Bolt (inches)	Weight per 100 Bolts* (pounds)
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1 1/8	165.1
1 1/4	212.0
1 3/8	280.0
1 1/2	340.0

* Includes nuts and washers

f. The weight of steel stud connectors will be computed on the basis of their nominal weights and dimensions.

g. The weight of weld metals and shop and field paint on structural steel will not be included in the pay quantities.

616-4.02 Structural steel, castings, and miscellaneous metals which are components of other construction pay items will not be included in the measurements of pay quantities under this specification.

616-4.03 Elastomeric pads for bridge bearings will not be measured for direct payment but shall be a subsidiary obligation of the Contractor under the structural steel pay items.

616-4.04 Other construction pay items included in the contract, which form part of the completed structure, will be measured for payment as provided under their respective specifications.

616-4.05 When the structural steel is to be paid for on the basis of a lump sum price, no measurement will be made of the structural steel nor of any other items which enter into the completed structure, except as noted in paragraph 4.04 above or required to determine the amount of any price adjustment as per paragraph 616-5.04b(2).

616-5 BASIS OF PAYMENT

616-5.01 The accepted quantities of structural steel determined as provided above will be paid for at the contract lump sum price or unit price per pounds for "Structural Steel, Furnished, Fabricated and Erected", or at the contract unit price per pound for "Structural Steel, Furnished and Fabricated", or "Structural Steel, Erected", whichever is called for in the contract.

616-5.02 Structural Steel, Furnished and Fabricated - The contract unit price per pound and payment shall constitute full compensation for furnishing, galvanizing, fabricating, radiographing, ultrasonic testing, magnetic particle inspection, shop painting, and delivering the structural steel and other metal free of charges at the place designated in the contract documents, and for all labor, equipment, tools and incidentals necessary to complete the work, except for erection, and except as provided in Articles 616-5.05, 5.06 and 5.07.

616-5.03 Structural Steel, Erected - The contract unit price per pound and payment shall constitute full compensation for unloading all the structural steel and other metal, payment of any demurrage charges, transporting to the bridge site, erecting, radiographing, ultrasonic testing, and magnetic particle inspection, complete ready for use, including furnishing and applying the field paint, and for all labor, equipment, tools, and incidentals necessary to complete the work under the item, except furnishing and fabrication, and except as provided in Articles 616-5.05, 5.06 and 5.07.

SPECIFICATION 616 – STEEL STRUCTURES

616-5.04 Structural Steel, Furnished, Fabricated and Erected

a. Unit Price Per Pound - The contract unit price and payment shall constitute full compensation for furnishing, galvanizing, fabricating, radiographing, ultrasonic testing, magnetic particle inspection, delivering, erecting ready for use, and painting all steel and other metal, and for all labor, equipment, tools and incidentals necessary to complete the work, except as provided in Articles 616-5.05, 5.06 and 5.07.

b. Lump Sum Price - The contract lump sum price and payment shall constitute full compensation for furnishing, fabricating and erecting the structural steel and other metals as specified in paragraph 616-5.04a. above, including all labor, tools, equipment and incidentals necessary to complete the work, except as provided in Articles 616-5.05, 5.06 and 5.07. The following conditions also apply to the lump sum price method of payment:

1. The estimate of the weight of structural steel shown on the plans is approximate only and no guarantee is made that it is the correct weight to be furnished. No adjustment in the contract price will be made if the weight furnished is more or less than the estimated weight.

2. If changes or additions in the work are ordered by the Engineer which vary the weight of steel to be furnished, fabricated and erected, the lump sum payment will be adjusted as follows: The value per pound of the increase or decrease in the weight of structural steel involved in the change will be determined by dividing the lump sum price by the estimate of weight shown on the plans. The adjusted lump sum payment will be the lump sum plus or minus the value of the steel involved in the change, and no additional compensation will be made on account of said change.

SPECIFICATION 616 – STEEL STRUCTURES

616-5.05 When certain alloy steels, forgings, castings or other specific categories of metal are called for as separate items in the contract, the weight of such selected material, determined as provided above, will be paid for at the respective contract unit prices per pound for "Structural Steel (Alloy steel forgings, castings and/or other category), Furnished, Fabricated and Erected" or "Structural Steel (Alloy steel forgings, castings, and/or other category), Furnished and Fabricated", as the case may be, and as named in the contract.

616-5.06 The quantities of all other contract items which enter into the completed and accepted structure will be paid for at the contract unit prices for the several pay items as prescribed for the items involved.

616-5.07 When the Proposal Schedule does not contain a pay item for structural steel, and unless otherwise provided, the quantities of metal drains, scuppers, conduits, and structural shapes for expansion joints and pier protection, anchor bolts, rockers, rollers, steel plates, etc., measured as provided above will be paid for as reinforcing steel under Specification 607 - Reinforcing Steel.

616-5.08 When the proposal schedule includes a pay item identified only as Structural Steel it shall be understood that it includes full compensation for structural steel furnished, fabricated and erected as defined in Article 5.04 above.

616-5.09 Payment will be made under:

Pay Item	Pay Unit
Structural Steel, Furnished, Fabricated and Erected…….….	Pound
Structural Steel, Furnished and Fabricated……	Pound
Structural Steel, Erected…….....	Pound
Structural Steel __*__, Furnished, Fabricated	Pound

SPECIFICATION 616 – STEEL STRUCTURES

Pay Item	Pay Unit
and Erected……..	
Structural Steel, __*__, Furnished and Fabricated……	Pound
Structural Steel, Furnished, Fabricated and Erected……..	Lump Sum

** Name the special alloy steel, forgings, castings or other specific category being separately identified.

SPECIFICATION 617 – PAVED WATERWAYS

617-1 DESCRIPTION

617-1.01 Scope

a. This work shall consist of paving ditches, gutters, spillways and other similar waterways with concrete or grouted stone, constructed on a prepared bed in accordance with these specifications and in conformity with the lines, grades, dimensions and details shown on the plans or established by the Engineer.

b. When shown on the plans or ordered by the Engineer, the work shall also include the construction of a bed course of granular material, immediately beneath the paving material.

617-2 MATERIALS

617-2.01 Concrete - The portland cement concrete for paving waterways shall meet the applicable requirements of Specification 601 - Structural Concrete.

617-2.02 Stone - The stone for grouted stone paving shall consist of sound, durable quarry or field stone, meeting the requirements of Articles 718-2.01 and 718-2.02 of Specification 718 - Stone Revetment Material, and shall be of the sizes indicated on the plans. If no size is indicated, each stone shall be approximately 15 centimeters thick and weigh no less than 40 pounds.

617-2.03 Filler Aggregate - Granular filler material for use in grouted stone paving shall consist of a well-graded clean sand meeting the requirements of Specification 703-1.

617-2.04 Other materials shall meet the requirements of the following specifications:

Bed Course Material……	703-5.01
Reinforcing Steel…….	709-1
Cement Grout and Mortar……	705-4

SPECIFICATION 617 – PAVED WATERWAYS

617-3 CONSTRUCTION REQUIREMENTS

617-3.01 Bedding

a. The bedding for the paving shall be formed of the required section and depth below the finished pavement surface. All soft and yielding material or other unsuitable material shall be removed and replaced with approved bed course material. The bed shall be compacted and finished to a smooth firm surface.

b. When shown on the plans, bed course material shall be placed and compacted to form a bed course of the required shape and thickness.

617-3.02 Concrete Paving - Concrete paving shall be plain or reinforced concrete of the class called for in the plans. If the class is not indicated on the plans, Class A concrete shall be provided. It shall be manufactured, placed, finished and cured in accordance with all the applicable requirements of Specification 601 and shall conform to the sections and dimensions shown on the plans.

617-3.03 Grouted Stone Paving

a. The paving stones shall be bedded in the foundation with the flat faces up and their longest dimension at right angles to the centerline of the waterway, and with joints not exceeding 2.5 centimeters in width. Each stone shall be rammed into place until the surface is firm and in reasonable conformance to the finished grade, alignment and cross section shown on the plans. Any stone having an irregular or uneven surface shall be taken up and satisfactorily relaid.

b. After the stones are firmly in place and the surface is satisfactory, the spaces or voids between and around the stones shall be filled with the approved filler aggregate to 10 centimeters below the surface. Cement grout shall then be poured and broomed into the spaces between the stones until the grout remains about one centimeter below the tops of the

stones. The grout shall be of such consistency that it will flow readily into the spaces between the stones, but it shall not be so wet that the solid matter separates from the water.

c. Special energy dissipating grouted stone pavements for waterways shall be built according to the design details shown on the plans.

617-3.04 Finishing - Any forms used shall be removed within 24 hours of placing concrete and necessary repairs made to the edges of the waterway pavement. Adjacent slopes and shoulders shall be shaped and compacted to the required cross section.

617-4 METHOD OF MEASUREMENT

617-4.01 Paved waterways will be measured by the square meters of surface of each type completed and accepted, determined from the dimensions shown on the plans or established by the Engineer.

617-4.02 Bed course material will be measured by the cubic meter of material in place and accepted, determined from the dimensions shown on the plans or established by the Engineer.

617-4.03 No measurement for direct payment will be made of any excavation required to form the bedding or for the removal of unsuitable material. Such excavation shall be a subsidiary obligation of the Contractor under the bed course material placing and the paved waterway items of the contract.

617-5 BASIS OF PAYMENT

617-5.01 The accepted quantities, determined as provided above for each of the pay items listed below which is included in the contract, will be paid for at the contract unit price per unit of measurement. Such prices and payments shall constitute full compensation for furnishing and placing all required materials, and for all labor, equipment, tools, and incidentals necessary to complete each item as required by the plans and specifications.

SPECIFICATION 617 – PAVED WATERWAYS

617-5.02 Payment will be made under:

Pay Item	Pay Unit
Concrete Paved Waterway…….	Square Meter
Grouted Stone Waterway……...	Square Meter
Bed Course Material……..	Cubic Meter

SPECIFICATION 618 – THERMOPLASTIC AND PREFORMED PLASTIC PAVEMENT MARKINGS

618-1 DESCRIPTION

618-1.01 Scope

a. This work shall consist of furnishing and applying pavement markings on the finished pavement surfaces at the locations shown on the plans, or ordered by the Engineer, and of the types, colors, patterns and dimensions called for in the contract documents, using thermoplastic compound or preformed plastic in conformance with these specifications.

b. These markings shall be of the following types:

1. Hot applied thermoplastic compounds which soften when heated and harden when cooled without changing the inherent properties of the material. These include any of the following:

(a) Reflectorized thermoplastic material that is extruded by mechanical means in a molten state onto a primed pavement surface with a surface application of glass beads.

(b) Reflectorized thermoplastic pavement marking material which is applied to the surface in a hot-spray powder form with a surface application of glass beads.

2. Reflective preformed plastic pavement marking material consisting of a polymer film with embedded glass beads, for direct application to the pavement.

SPECIFICATION 618 – THERMOPLASTIC AND PREFORMED PLASTIC PAVEMENT MARKINGS

618-2 MATERIALS

618-2.01 General

a. The materials shall be of the best quality available for the purpose in good commercial practice, and shall be free from all defects and imperfections that might affect the visibility and serviceability of the finished product.

b. Each container shall be clearly and adequately marked to indicate the color of the material, the process batch number or similar manufacturer's identification, the manufacturer's name and location of plant, and the date of manufacture.

c. The Contractor shall furnish manufacturer's certificates of the proposed materials showing that they meet the requirements of these specifications.

618-2.02 Glass Beads - The glass beads to be used to reflectorize pavement markings shall conform to Article 716-2, Glass Beads, of Specification 716.

618-2.03 Thermoplastic Pavement Markings - Shall conform to the requirements of Article 716-4, Reflectorized Thermoplastic Pavement Marking Materials, of Specification 716. Any one of the two types covered in Article 716-4 may be used by the Contractor unless otherwise specified in the contract documents.

618-2.04 Preformed Plastic Pavement Markings - Shall conform to the requirements of Article 716-5, Reflectorized Preformed Plastic Film, of Specification 716. This material may be used for pavement markings on asphaltic concrete pavements in lieu of Thermoplastic Pavement Markings, unless specifically prohibited in the contract documents.

618-2.05 Warranties - All warranties on materials that are offered by manufacturers as normal trade practices shall be turned over by the Contractor to the Highway Authority.

SPECIFICATION 618 – THERMOPLASTIC AND PREFORMED PLASTIC PAVEMENT MARKINGS

618-3 CONSTRUCTION REQUIREMENTS

618-3.01 General

a. The surface to be marked shall be completely dry and free of dirt, curing compound, grease, oil, moisture, loose particles and any other material which would adversely affect the bonding of the markings to the surface. For portland cement concrete pavements, the Contractor shall clean the surface using water blasting at 3,000 psi. For hot plant-mix bituminous pavements, surface shall be cleaned using compressed air or other effective means to the satisfaction of the Engineer.

b. The Contractor shall submit satisfactory evidence of having previously performed successful applications of the paving marking materials being used, or shall provide such evidence for his subcontractor, if one is used. He shall employ experienced technicians thoroughly familiar with the equipment to be used and the application of the pavement marking materials.

c. All markings shall be as shown on the plans or as ordered by the Engineer. Details not shown on the plans shall be in accordance with the "Manual de Dispositivos Uniformes para el Control de Tránsito en las Vías Públicas de Puerto Rico" (MDUCT) of the P. R. Department of Transportation and Public Works. All markings shall present a clear cut, uniform and workmanlike appearance. Any markings which fail to have a uniform, satisfactory appearance, either day or night, shall be corrected at the Contractor’s expense.

d. Tack points shall be painted on the pavement at appropriate intervals for use in aligning the equipment that will apply the traffic stripes and, if necessary to achieve the required accuracy, a string line will be set from such points. The tack points shall be painted prior to opening any

pavement to traffic to provide for traffic guidance until the permanent markings are applied.

e. Before any final pavement marking work is begun, a schedule of operations shall be submitted for the approval of the Engineer.

f. When pavement markings are to be applied under traffic, the Contractor shall provide all necessary flags, markers, signs, cones, etc. to protect the markings until they are thoroughly set and can be crossed without tracking. The Contractor shall take all the necessary measures to control and protect the traffic while the marking operations are in progress and shall comply with the applicable provisions of Specification 638. The application of pavement markings shall be done in the general direction of traffic; striping against traffic shall not be allowed except when marking the centerline of a two-way, two-lane road.

g. The application of thermoplastic markings shall not be initiated until at least ten (10) days after the pavement is completed but shall be started no later than 5 days thereafter. However, the application of preformed plastic marking film which is to be inlaid on a fresh asphaltic concrete surface shall be made before the final rolling of the pavement.

618-3.02 Reflectorized Thermoplastic Markings

a. Equipment - The thermoplastic material shall be applied to the surface utilizing either extrusion or spray application equipment appropriate for the type of material used and approved by the Engineer. It shall meet the following requirements:

1. The equipment shall provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the shaping die shall prevent accumulation and

clogging. All parts of the equipment which come in contact with the material shall be easily accessible and exposable for cleaning and maintenance.

2. All mixing and conveying parts up to and including the shaping die, shall maintain the material at the plastic temperature with heat transfer oil or electrical element controlled heat.

3. The equipment shall assure continuous uniformity in the dimensions of the stripe and shall provide for varying die width to produce varying widths of traffic markings.

4. The applicator shall produce straight lines and true arcs and shall provide a means for cleanly cutting off square stripe ends and a method of applying "skip" lines. The use of pans, aprons or similar appliances which the die overruns will not be permitted.

5. The equipment shall include an automatic bead dispenser attached to the liner in such manner that the glass spheres are uniformly dispensed almost instantly upon the complete line. The bead dispenser shall be equipped with an automatic cut-off control synchronized with the cut-off of the thermoplastic material.

6. A special kettle shall be provided for melting and heating the material. The kettle shall be equipped with an automatic thermostatic control device and temperature gage in order to provide uniform and positive temperature control to prevent overheating of the composition. The applicator and kettle must be so equipped and arranged as to satisfy the requirements of the National Board of Fire Underwriters.

7. All of the equipment necessary to the preheating and application of the material shall be so designed that the temperature of the material can be controlled within the limits specified by the manufacturer and necessary to its pourability for good application. It shall permit agitation of the material to prevent scorching, discoloration or excessive high temperatures of any part of the material.

8. Applicator shall consist of either hand operated portable equipment for use in marking crosswalks, stop bars, arrows, legends, and short lengths of lane, edge, and centerlines; or truck mounted, self-contained equipment machines for marking lane, edge, and centerlines.

b. Sealing Primer - Prior to the application of the thermoplastic marking, a sealing primer if required, of the type and amount recommended by the manufacturer of the thermoplastic compound shall be sprayed on the clean and dry surface using mobile spray equipment. If necessary, as determined by the Engineer, the surface of new and existing bituminous pavements shall be washed with a detergent solution followed by a water rinse to remove any clay coating or other foreign material prior to priming or to applying the markings. On new or existing PCC pavement, the surface shall be abrasive blast cleaned to remove laitance, curing seal or other foreign material prior to priming.

c. The thermoplastic material shall be applied to the pavement at a temperature within the range specified by the manufacturer, normally between 380° and 420°F.

d. Application Rates - The various materials used to complete the reflectorized thermoplastic markings shall be applied at the following rates:

1. Primer - Unless otherwise recommended by the manufacturer, the primer shall be applied at a wet film thickness of 5 $\pm$ 1 mils on asphaltic pavements and between 4 and 5 mils on PCC pavements.

2. Thermoplastic Material - Shall be applied to provide thickness ranging from a minimum of 110 mils to a maximum of 130 mils but with a minimum average of 120 mils. The Authority will measure at the edge of the pavement markings the thickness of the thermoplastic pavement marking above the pavement area and compute the average thickness. The Authority, in its judgment, may reject and require the removal and replacement, at the Contractor's expense, of pavement markings with excessive thickness or thickness variability in excess of the permissible range.

3. Glass Beads - Glass beads shall be automatically applied immediately behind the striping mechanism at a rate of one pound per 3 square meters of thermoplastic surface area.

e. The pigment shall be evenly dispersed throughout the marking and the density and character of the material shall be uniform throughout its thickness.

f. The completed marking shall maintain under traffic its original dimensions and placement. The ductility of the material shall be such as to permit normal movement with the road surface without chipping or cracking.

g. When the material is applied over an existing marking, the total thickness shall meet the requirements specified for new markings. New material applied over an old marking of compatible material shall bond itself to the old material in such a manner that no splitting or separation takes place during its useful life.

SPECIFICATION 618 – THERMOPLASTIC AND PREFORMED PLASTIC PAVEMENT MARKINGS

618-3.03 Reflective Preformed Plastic Pavement Markings

a. Reflective preformed plastic pavement marking film shall be applied using the proper mechanical applicator and procedures recommended by the manufacturer that will assure an effective performance life.

b. This material is intended for inlay markings on fresh asphaltic concrete pavements. The marking film shall be inlaid in the fresh surface during final rolling of the mat before the pavement is opened to traffic.

618-3.04 Tolerances

a. Dimensions - No marking shall be less than the specified width nor exceed it by more than 1.25 centimeters. The length of the marked segment for skip stripes and the open gap between segments may each vary plus or minus 30 centimeters, except that the over and under tolerance lengths shall approximately compensate.

b. Alignment - On tangents, and on curves of 1800 meter radius or larger, the alignment of the traffic stripes shall not deviate from the stringline line by more than 2.5 centimeters. On curves of less than 1800 meter radius, the maximum permissible variation will be 5.0 centimeters. The outer edge of pavement edge stripes shall fall uniformly at no less than 5.0 nor more than 10.0 centimeters from the edge of pavement and shall have no noticeable breaks or deviations in alignment.

c. Correction Rates - Any corrections in variations in the width or alignment of stripes shall not be made abruptly but the stripes shall be returned to the design width at the rate of at least 3.0 meters for each 1.25 centimeters of correction, and returned to the stringline alignment at the rate of at least 8 meters per 2.5 centimeters of correction.

SPECIFICATION 618 – THERMOPLASTIC AND PREFORMED PLASTIC PAVEMENT MARKINGS

618-3.05 Corrective Measures

a. All markings which fail to meet the specifications, including the tolerance and appearance requirements, or are damaged by the Contractor's equipment and operations, shall be corrected at the contractor's expense. When necessary to correct a deviation which exceeds the permissible tolerance in alignment, that portion of the marking shall be removed and replaced in accordance with these specifications at the Contractor's expense.

b. All drip and spattered markings shall be removed to the satisfaction of the Engineer. Removal of markings shall be done by means approved by the Engineer, which will not damage the underlying surface of the pavement.

618-3.06 Acceptance

a. When the work under this specification has been completed to the satisfaction of the Engineer, including any required corrective work, and the pavement is to be opened to traffic, acceptance will be made by the Engineer, independently of other remaining work under the contract, and the Contractor will be relieved of all maintenance of the markings except as covered by warranties or for damage caused by his operations.

618-4 METHOD OF MEASUREMENT

618-4.01 The accepted quantities of pavement markings will be measured as follows:

a. Stripes - Center, lane, pavement edge and other stripes or lines will be measured in lineal meters, to the nearest tenth of a meter, along their centerline as outlined below, completed and accepted.

1. Solid stripes will be measured from end to end of each continuous stripe.

2. Dashed or broken stripes will be measured end to end of each segment. No measurement will be made of the skip or open space.

3. The contract unit price of each type and color of stripe will be based on a width of 15 centimeters (6 inches). The measured length of lines or stripes wider or thinner than 15 centimeters (6 inches) will be adjusted in the ratio of their specified width to 15 centimeters (6 inches).

b. Symbols and letter markings will be measured by each unit applied and accepted. A unit will consist of one letter or one symbol.

618-5 BASIS OF PAYMENT

618-5.01 The quantities determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and placing all materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

618-5.02 Thermoplastic pavement markings found deficient in thickness but which are accepted by the Authority according to Article 618-3.02 d. (2) of this specification will be paid for at a reduced unit price.

a. The reduced unit price will be computed in accordance with the following formula:

RUP = (1 – R) * UP

Where RUP = Reduction in unit price

R = (120 – AMT) / 120

R = Percentage reduction in unit price

UP = Contract unit price

AMT = Average measured thickness of thermoplastic pavement markings measured in mils.

b. No additional payment will be made for thermoplastic pavement markings with excess thickness or thickness variability in excess of the permissible range which are accepted to remain.

618-5.03 Payments will be made under:

Pay Item	Pay Unit
Thermoplastic Pavement Markings Stripes, white or yellow……..	Linear Meter
Thermoplastic Pavement Marking Symbols and Letters, white……	Each
Preformed Plastic Pavement Markings Stripes, white or yellow……	Linear Meter
Preformed Plastic Pavement Markings Symbols and Letters, white……	Each

SPECIFICATION 619 – GALVANIZED STEEL RAILING

619-1 DESCRIPTION

619-1.01 Scope - This work shall consist of the furnishing and erection of galvanized steel pipe railing and chain-link railing on pedestrian overpasses and at other locations as indicated on the plans, in accordance with these specifications, and in conformity with the designs, dimensions, and details shown on the plans or ordered by the Engineer.

619-1.02 Galvanized Steel Pipe Railing - Shall consist of galvanized pipe railing elements supported by metal brackets or pipe posts including all required hardware and fittings as shown on the plans.

619-1.03 Chain-Link Railing - Shall consist of a metal frame covered with chain link fabric, including posts, horizontal members, posts anchorages, stretcher bars, truss rods and all other required hardware and fittings, as shown on the plans.

619-2 MATERIALS

619-2.01 Galvanized iron pipe for railings shall be hot-dipped galvanized, welded or seamless steel pipe conforming to the requirements of ASTM A 120. Pipe shall be standard weight or extra strong class as specified on the plans. If not specified, standard weight pipe shall be provided. Galvanizing shall be applied after fabrication.

619-2.02 Chain-link fabric shall be either galvanized steel fabric or vinyl coated galvanized steel fabric as called for on the plans, and shall conform to the applicable requirements of Article 710-2 of Specification 710 - Fence and Guard Rail.

619-2.03 All required hardware and fittings shall be galvanized in accordance with the applicable requirements of ASTM A 120, and AASHTO M 111 and M 232, and shall conform to the details shown on the plans.

619-2.04 After fabrication and galvanizing, all elements of the railings shall be free of fins, abrasions, rough or sharp edges, loose mill scale and other surface defects, and shall not be kinked, twisted or bent.

619-2.05 Abraded or damaged galvanized surfaces of railings, and ends of railing elements cut after galvanizing shall be cleaned and repaired by field galvanizing by applying a paste composed of approved zinc powder and flux with a minimum of water. The surfaces to be coated shall first be heated with a torch to a sufficient temperature so that all metallics in the paste are melted when applied to the heated surface. Extreme care shall be taken to see that the galvanized surfaces are not damaged by the torch. The flux in the paste will cause a black substance to appear on the surface of the coated parts, and this black substance shall be removed by wiping off with waste or by the quick application of cold water.

619-3 CONSTRUCTION REQUIREMENTS

619-3.01 Railings shall be fabricated and erected in conformance with the dimensions and details shown on the plans and in accordance with the applicable requirements of Specification 616 - Steel Structures.

619-3.02 In the case of welded railings, all exposed joints shall be finished by grinding or filing after welding to give a neat appearing job. Welds shall be field galvanized as specified in paragraph 619-2.05 above.

619-3.03 The line and grade of the railings shall be true to that shown on the plans, and shall not follow any unevenness in the superstructure.

619-3.04 Railings shall not be placed on a span until the centering or falsework has been removed and the span is self supporting.

619-3.05 Railings shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints, and correct

alignment throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at proper grade and alignment.

619-3.06 Chain-link fabric shall be carefully stretched and securely fastened to the railing frame as indicated on the plans. Where necessary to conform to curvature, either horizontal or vertical, the fabric shall be reworked and fitted so as to present a smooth, neat and workmanlike appearance.

619-3.07 Painting of galvanized railing and chain link fabric will not be required, unless otherwise shown on the plans, except for the base contact surface of posts that shall be given one coat of a rapid drying bituminous type paint.

619-4 METHOD OF MEASUREMENT

619-4.01 Galvanized steel pipe railing will be measured by the lineal meter, to the nearest tenth of a meter, along the top rail from outside to outside of end posts.

619-4.02 Chain-link railing of the single type, which is independently erected on a side of the structure, will be measured by the linear meter to the nearest tenth of a meter. Measurement will be along the top rail from outside to outside of end posts.

619-4.03 Chain-link railing of the canopy type, which extends continuously from one side of the structure to the other will be measured by the linear meter, to the nearest tenth of a meter. Measurement will be made along the top of the railing structure, along its centerline, from one end to the other.

619-5 BASIS OF PAYMENT

619-5.01 The accepted quantities, determined as provided above, of each of the types of railings listed below which are included in the contract will be paid per unit of measurement. Such price and payment shall be full compensation for furnishing and erecting all required materials and for all labor, equipment, tools and

incidentals necessary to complete each item as required by the plans and specifications.

619-5.02 Payment will be made under:

Pay Item	Pay Unit
Galvanized Steel Pipe Railing……	Linear Meter
Chain-Link Railing, Single Type……	Linear Meter
Chain-Link Railing, Canopy Type……..	Linear Meter

SPECIFICATION 620 – TRAFFIC IMPACT ATTENUATOR

620-1 DESCRIPTION

620-1.01 Scope - This work shall consist of the furnishing and installation of traffic impact attenuation devices of the sand filled drum type in accordance with these specifications and in conformity with details and at the locations shown on the plans or established by the Engineer.

620-2 MATERIALS

620-2.01 Module Type A - The Type A traffic impact attenuation module shall consist of a frangible sand filled drums meeting the following requirements:

a. The assembled cylindrical drum shall have a nominal diameter of 91.5 centimeters (36"), a height as shown on the plans. The cylinder walls shall be made of high density polyethylene structural foam or equal material.

b. The drum lid shall be of the same material as the cylinder walls but of a thinner gauge. It shall be made for a tight press and snap fit on the module.

c. The material for the drums and lids shall be durable, impervious to weather, and resistant to deterioration from ultra-violet rays.

d. The module core shall be made of polystyrene foam or equal material and shall be of the appropriate height for the required sand content. It shall be installed in accordance with the manufacturer's instructions. Cores are normally supplied in three heights - 29, 42 and 52 centimeters (11 1/2, 16 1/2 and 20 1/2 inches).

e. The module shall be provided with a circular plastic seal adequate to retain the sand filler in place without leakage.

f. The module shall be provided with a stiff plastic circular disc, of such size, weight and quality as to support and spread the sand filler. When the module is to be placed on soft ground, an additional disc shall be provided for placing on the bottom of the drum.

g. Rivets for module assembly shall be AD 612 BSLF with 1/2" diameter washers, with an approximate weight of 10 lbs. per 1,000.

h. Sand for filler shall be a washed sand conforming to the Grading A or B requirements of fine aggregate for concrete given in Table 703-1 of Specification 703 - Aggregates.

i. The color of the modules shall be highway yellow unless otherwise specified.

620-2.02 Module Type B - The Type B traffic impact attenuation module shall consist of a stabilizer drum with a wine glass shaped inner container meeting the following requirements:

a. The drum and the inner container walls shall be made of high-density expanded polyethylene structural foam or equal material. Each stabilizer drum and each inner container shall be molded in one piece.

b. The stabilizer shall be approximately 91 centimeters high (35 3/4") with an outside diameter of approximately 91.5 centimeters (36") at the top and 82.5 centimeters (32 1/2") at the bottom.

c. The wine glass shaped inner container shall be approximately 91.5 centimeters (36") high and in sizes designed generally to contain 200, 400, 700 and 1400 lb. sand masses or other amounts as indicated on the plans. The stems' heights are designed to insure that the center of gravity of each module is at the proper elevation to control the attitude of impacting vehicles.

d. Wall thickness for both stabilizer and inner container shall be 0.5 to 0.8 centimeter (3/16 to 5/16 inch). Both units shall be designed to shatter upon impact.

e. The lid shall be of the same material and of the same thickness as the walls. The lid shall be made for a tight fit and to clamp securely over the top of the inner container.

f. The material for stabilizers, inner containers and lids shall be durable and weatherproof. The stabilizers and lids shall be formulated to resist deterioration from ultra-violet rays.

g. The filler sand shall be as specified in paragraph 2.01 h. above.

h. The color of the modules shall be highway yellow unless otherwise specified.

620-3 CONSTRUCTION REQUIREMENTS

620-3.01 General

a. Any required site preparation work indicated on the plans or ordered by the Engineer shall be completed prior to the installation of the attenuator assembly.

b. The assembly of all parts of the completed modules, including filling with sand, shall be in accordance with the recommendations of the module manufacturer. The weight and height of each module shall be as called for in the plans.

c. The modules shall be installed at the locations and as indicated on the plans to form a complete impact attenuator assembly. The location and required weight of each module shall be marked on the bearing surface to facilitate future replacement. The modules shall be placed in such a manner and sequence that each module will remain in its final

position after being filled with the required amount of dry sand.

d. After each module is set and filled with sand, the lid shall be drilled at 4 equidistant points and secured in place on the drum with pop rivets.

620-3.02 Soft Ground Installation - When the modules are to be placed on soft earth or on grass, an additional disk shall be placed on the ground under the core of each Type A module.

620-3.03 Sloping Sites

a. When an impact attenuator assembly using Type A modules is to be installed at a sloping site with a slope not exceeding 5%, the cylinder and core bottoms of each module shall be adapted to the slope by sawing as required to provide a vertical module position.

b. When an impact attenuator assembly using the Type B module is to be installed at a sloping site with a slope not exceeding 5%, a $\pm$ 0.6 centimeter ($\pm$ 1/4") thick stem block with a 0.15 centimeter (6") diameter hole in the center shall be fastened to the surface to hold the stem of the inner container in place and prevent movement of the module.

c. Where an attenuator assembly is to be installed at a site with a slope exceeding $\pm$5%, the area shall be leveled as shown on the plans.

d. Where indicated in the plans, a module locator half-ring shall be installed on the side of the downward slope, in accordance with the module manufacturer's recommendations, to prevent module displacement.

620-4 METHOD OF MEASUREMENT

620-4.01 Each traffic impact attenuation module will be measured as a single unit complete in place and accepted, including

all components, hardware, sand fill, marking of bearing surface and any required locator half-ring.

620-4.02 Site preparation required at sites with slopes exceeding ±5% will be measured and paid for separately under the respective construction work items involved.

620-5 BASIS OF PAYMENT

620-5.01 The accepted quantity of traffic impact attenuation modules of each type measured as provided above will be paid for at the contract price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and installing all materials, labor, equipment, tools and incidentals necessary to complete the work as required.

620-5.02 Payment will be made under:

Pay Item	Pay Unit
Traffic Impact Attenuation Module Type ____ ……..	Each

SPECIFICATION 621 – MARKERS AND DELINEATORS

621-1 DESCRIPTION

621-1.01 Scope

a. This work shall consist of furnishing and installing kilometer and hectometer markers, right-of-way markers, traffic delineators and similar markers or posts of the dimensions and designs shown on the plans and standard drawings, in accordance with these specifications and at the locations shown on the plans or directed by the Engineer.

b. Kilometer and hectometer markers are panels with a reflective legend mounted on metal posts at 100 meter intervals along the highway to provide a numerical location reference.

c. Right-of-way markers are concrete posts installed to identify the right-of-way limits of the highway.

d. Traffic delineators are reflective panels or acrylic prismatic reflectors mounted on metal posts or other supports and placed along the highway at hazardous locations to serve as driving aids.

621-2 MATERIALS

621-2.01 Markers and delineators shall be built to the design and of the materials shown on the plans or the standard drawings.

621-2.02 Material for markers and delineators shall meet the requirements of the following specifications:

a. Concrete for precast concrete markers - Class "B" concrete as per Specification 601.

b. Reinforcing Steel - Specification 602.

c. Reflective Panels - The aluminum panels and the reflective sheeting shall conform to Specification 613 - Traffic Signs.

d. Metal Posts - Shall be of galvanized steel conforming to Specification 613 - Traffic Signs.

e. Acrylic Prismatic Reflectors for delineators shall conform to the applicable requirements of AASHTO Specification M 290.

621-3 CONSTRUCTION REQUIREMENTS

621-3.01 Fabrication

a. Precast reinforced concrete right-of-way markers shall be fabricated, finished and cured in accordance with the applicable provisions of Specification 601 - Structural Concrete.

b. Reflective panels for kilometer and hectometer markers and traffic delineators shall be fabricated in accordance with the applicable provisions of Specification 613 - Traffic Signs.

621-3.02 Installations

a. Unless otherwise shown on the plans or directed by the Engineer, markers shall be located as follows:

1. Kilometer (KM) markers shall be installed at every kilometer and hectometer (HM) markers at every 100 meters between KM markers along the highway, following the stationing of the project or as a continuation of the existing marking sequence. KM markers shall be installed on each side of the highway facing traffic. Even numbered HM markers shall be installed on the right side of the highway facing traffic and odd numbered HM markers shall be installed on

the left side. The marker posts shall be placed 0.6 meter outside the shoulder unless otherwise shown on the plans.

2. Delineators shall be installed at the locations shown on the plans, normally 15 meters apart on tangent sections and 7.5 meters apart on curved sections. The face of the delineators shall be so placed as to be most effectively visible to approaching traffic. Delineator posts shall be placed 0.6 meter outside the shoulder unless otherwise shown on the plans.

3. Right-of-way (ROW) markers shall be placed at the locations shown on the plans. If not specified on the plans, a ROW marker shall be installed at every corner where the ROW boundary changes direction and at every point where the ROW boundary crosses a property line.

b. Excavation and backfill, when required for the erection of markers, shall be made in accordance with the applicable provisions of Specification 206 - Unclassified Excavation for Structures.

c. Metal posts shall be driven straight and plumb into the ground using appropriate driving equipment and in such manner that the completed installation is firmly in place and in the correct position.

621-3.03 Field Inspection

a. An inspection of the installed markers and delineators shall be made in daylight to check for proper location, line and grade, vertical post alignment, appearance and visibility. The reflective markers and delineators shall also be inspected at night by the Engineer to check for proper orientation, specular reflection and possible defects that may be more conspicuous at night.

b. All defects disclosed by the day and night inspections shall be corrected by the Contractor, at his expense, to the satisfaction of the Engineer.

621-4 METHOD OF MEASUREMENT

621-4.01 Kilometer and Hectometer markers, Right-of-way markers and traffic delineators shall be measured as the number of complete markers or delineators furnished, installed and accepted. Each unit shall include the complete assembly including the post where applicable.

621-4.02 Any excavation and backfill that may be necessary to complete the installation of any markers and delineators will not be measured for payment but shall be a subsidiary obligation of the Contractor under this specification.

621-5 BASIS OF PAYMENT

621-5.01 The quantities, determined as provided above, shall be paid for at the contract unit price per unit of measurement for each of the particular pay items listed below that is included in the contract, which price and payment shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to satisfactorily complete the item.

621-5.02 Payment will be made under:

Pay Item	Pay Unit
Kilometer Marker……...	Each
Hectometer Marker……	Each
Right-of-way Marker……..	Each
Traffic Delineator……...	Each

SPECIFICATION 622 – RIPRAP

622-1 DESCRIPTION

622-1.01 Scope

a. This work shall consist of furnishing and placing riprap for bank and slope protection, and erosion control, in accordance with these specifications and in conformity with the lines, grades, sections and dimensions, and locations shown on the plans or established by the Engineer. The types of riprap included in this specification are:

1. Dumped riprap which consists of stone dumped in place on a filter blanket or prepared slope to form a well-graded mass with a minimum of voids.

2. Grouted riprap which consists of stone riprap with all or part of the interstices filled with portland cement mortar.

3. Concrete riprap in bags which consists of concrete in cloth cement sacks or other suitable bags.

b. This work shall also include, when called for in the plans, the furnishing and placing of one or more layers of a filter blanket on the slope before placing the riprap in order to prevent the bank material from passing through the riprap protection.

622-2 MATERIALS

622-2.01 Dumped Riprap

a. Stone used for dumped riprap shall be hard, durable, angular in shape, resistant to weather and water action, and shall meet the size distribution requirements indicated in Table 622-1 for the class specified in the contract documents.

b. The length of each stone shall not exceed three times its width or its thickness. Rounded stone or boulders will not

be accepted. Broken concrete may be substituted for stone when authorized in the contract documents. Shale and stone with shale seams are not acceptable.

c. Each load of riprap shall be reasonably well graded from the smallest to the maximum size specified.

d. The minimum density of the stone shall be 150 pounds per cubic foot as computed by multiplying the bulk specific gravity saturated - surface - dry basis, determined by AASHTO T 85, by 62.5 pounds per cubic foot.

TABLE 622-1

DUMPED RIPRAP STONE - SIZE DISTRIBUTION

Size of Stone in Pounds	Maximum Percent of Total Weight Smaller Than the Given Size Glass of Stone			
	I	II	III	IV
2,000			100	
1,400			80	
700		100	50	
500		80		
300				100
200		50		
100	100			
75				10
60	80		10	
40	50			
25		10		
2	10			

e. The stone shall have a percentage of wear of not more than 40 when tested as per AASHTO T 96. Samples of the larger size stones shall be broken down to provide the smaller (less than 1 1/2 inch) sizes required for the T96 test.

f. The stone shall be free from overburden, spoil, shale, and organic material.

g. Control of gradation will be by visual inspection. The Contractor shall provide two samples of the stone of at least 5 tons each, meeting the size distribution requirement for the class specified. One sample shall be provided at the quarry and the other at the construction site. The latter may be a part of the finished riprap covering. These samples shall be used as a frequent reference for judging the gradation of the riprap being supplied. Any difference of opinion between the Engineer and the Contractor will be resolved by dumping and checking the size distribution of two random truck loads of stone. Mechanical equipment, a sorting site, scales and labor needed to assist in checking the gradation shall be provided by the Contractor as a subsidiary obligation under this item at no additional cost to the Authority.

h. The approval of some stone from a particular quarry shall not be construed as constituting the approval of all stone taken from that quarry.

622-2.02 Grouted Riprap

a. The stones for grouted riprap shall meet the requirements of Article 622-2.01 above except for size and gradation which shall be as specified on the plans for each project. This stone shall be free of fines which prevent penetration of the grout.

b. Grout for grouted riprap shall consist of one part portland cement and three parts of sand thoroughly mixed with water to produce a grout having a thick creamy consistency. The minimum amount of water shall be used to prevent excess shrinkage of the grout after placement. The cement shall conform to the requirements of Specification 701, the sand shall conform to the requirements of Specification 703-1.

SPECIFICATION 622 – RIPRAP

622-2.03 Concrete Riprap in Bags - Concrete riprap in bags shall consist of Class B concrete conforming to Specification 601 packed in cloth cement sacks or other suitable burlap bags.

622-2.04 Filter Blanket - The filter blanket shall consist of one or more layers of gravel, crushed stone, or sand of the thickness shown on the plans. The filler material shall meet the requirements included in Section 718-1 of Specification 718, Stone Revetment Materials, and shall conform to the gradation requirements included in Table 718-1 for the type or types of filter material specified in the contract documents.

622-3 CONSTRUCTION REQUIREMENTS

622-3.01 Preparation of Slopes

a. Slopes and banks to be protected by riprap shall be free of brush, trees, stumps and other objectionable material. The slopes shall be trimmed and dressed to a smooth surface conforming to the lines and grades shown on the plans.

b. Any necessary excavation shall be completed by the Contractor as shown on the plans and in accordance with Specification 203, and shall be approved by the Engineer before any filter blanket and riprap is placed.

c. All soft, spongy and otherwise unsuitable material shall be removed to the depth shown on the plans or as directed by the Engineer and replaced with approved material. Filled areas will be compacted in accordance with Specification 203.

d. Unless otherwise shown on the plans, the riprap on banks shall extend from 60 centimeters below the bed of the stream to the apparent high water line.

SPECIFICATION 622 – RIPRAP

622-3.02 Filter Blanket

a. When required, a filter blanket shall be placed on the prepared slope or area in one or more layers of the thickness shown on the plans. Each layer shall be placed in one operation using methods which will not cause segregation of particle sizes within the bedding. The surface of each finished layer shall be reasonably even and free from mounds or windrows.

b. Additional layers of filter materials, when required, shall be placed in the same manner, using methods which will not cause the mixing of the materials in the different layers.

622-3.03 Dumped Riprap

a. The riprap stone shall be placed on the prepared slope or area in a manner that will produce a reasonably well graded mass of stone with the minimum practicable percentage of voids. The stone shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material.

b. Placing of riprap by dumping into chutes or by any other method likely to cause segregation will not be permitted. Hand placing or rearranging of individual stones by mechanical equipment or by hand will be required to the extent necessary to obtain the specified results.

622-3.04 Grouted Riprap

a. The stones shall be placed on the prepared slope substantially to the dimensions shown on the plans. Care shall be taken in placing to minimize the void spaces between adjacent stones and to keep earth or sand from filling these spaces. The stones shall be thoroughly moistened and any excess of fines shall be sluiced to the underside of the stone layer before grouting.

b. The grout may be delivered to the place of deposit by any means that will insure uniformity and prevent segregation of the grout. If penetration of the grout is obtained by gravity flow into the interstices, the grout shall be spaded or rodded unto the interstices to completely fill the voids in the stone layer. Pressure grouting may be used provided that care is taken not to unseat the stones and that, after placing, the grout is also spaded or rodded into the voids.

c. Weep holes shall be provided through the grouted riprap layer as shown on the plans or as directed by the Engineer.

d. Where the depth specified for grouting is in excess of 30 centimeters, the riprap shall be placed in equal lifts of 30 centimeters or less and each lift shall be grouted prior to placing the next lift.

e. After grouting, the surface of the stones shall be cleaned to remove accumulations of excess grout. The grouted riprap shall be kept moist for seven days or covered by a liquid membrane curing compound meeting the requirements of Specification 711-1.

622-3.05 Concrete Riprap in Bags

a. Cloth cement sacks, or approved alternate bags, about 2/3 filled with concrete and securely tied, or burlap grain sacks containing about 2/3 cubic feet of concrete and folded at the top, are placed in position on the prepared slope immediately after filling. Placing of the sacks shall follow the pattern indicated on the plans with joints between sacks staggered. Each sack shall be hand placed and pushed into firm contact with adjacent sacks.

b. Cutoffs and weep holes shall be placed as shown on the plans or as directed by the Engineer. The finished work shall present a neat appearance with the sacks in parallel rows

and no sack shall protrude more than 7.5 centimeters from the finished surface.

c. Whenever placement of concrete riprap in bags is delayed sufficiently to affect the bond between succeeding courses, a small trench about half the depth of a sack shall be excavated back of the last row of sacks in place and this trench filled with fresh Class B concrete before the next row of sacks is placed. In addition, at the start of each day's work, or when a delay of over two hours occurs during the placing of successive rows or layers of sacks, the previously placed sacks shall be moistened and dusted with cement to develop bond.

d. Pouring and curing of the concrete shall be as specified for structural concrete in Specification 601.

622-4 METHOD OF MEASUREMENT

622-4.01 The quantity of filter blanket and of each type of riprap to be paid for will be the number of cubic meters determined from the dimensions shown on the plans or established by the Engineer completed in place and accepted. Material placed in excess of these dimensions will not be included in the measurement for payment. When the depth of an in-place riprap course is less than the dimension established on the plans or ordered by the Engineer, the payment volume will be reduced accordingly or the course corrected, as determined by the Engineer.

622-4.02 Preparation of the slope, including any required excavation and the removal and replacement of unsuitable material, will not be measured for direct payment. This shall be a subsidiary obligation of the Contractor under the riprap pay items.

622-5 BASIS OF PAYMENT

622-5.01 The accepted quantities, determined as provided above, for each of the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of

measurement. Such prices and payment shall constitute full compensation for all the required work including any required excavation, the preparation of the slope, the furnishing and placing of all required material, the grouting when required, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

622-5.02 Payment will be made under:

Pay Item	Pay Unit
Filter Blanket…….	Cubic Meter
Dumped Riprap, Class ___……	Cubic Meter
Grouted Riprap, Class ___……	Cubic Meter
Concrete Riprap in Bags……...	Cubic Meter

SPECIFICATION 623 – STONE REVETMENT FOR SLOPE PROTECTION

623-1 DESCRIPTION

623-1.01 Scope - This work shall consist of constructing a protective revetment of stone over one or more layers of filter stone placed upon an embankment, cut or natural slope at the locations indicated, in accordance with these specifications, and in conformity with the lines, grades, sections and dimensions shown on the plans or established by the Engineer.

623-2 MATERIALS

623-2.01 Filter Material - The material for the filter layers shall conform to the requirements of Article 718-1 of Specification 718 - Stone Revetment Materials for the type or types in Table 718-1 called for in the contract documents.

623-2.02 Revetment Stone - The rock material for the stone revetment shall conform to the requirements of Article 718-2 of Specification 718 - Stone Revetment Materials for the type or types in Table 718-2 called for in the contract documents.

623-2.03 Sampling and Testing

a. The Contractor shall advise the Engineer as to the exact location of the sources of filter and revetment materials that he proposes to provide at least four weeks in advance of their actual use.

b. Suitable samples of the materials which the Contractor proposes to use in the work shall be furnished by the Contractor and delivered at his expense to the Engineer for approval at least four weeks prior to delivery of any such material to the site of the work, accompanied by certified test results by an approved laboratory, showing that the material meets the specified requirements. The Engineer reserves the right to witness the tests performed by the Contractor and to perform his own tests of the proposed sources of material if he deems it necessary or convenient. The Contractor shall

not deliver any of the proposed materials to the site of the work until approval of the materials and source by the Engineer has been received.

c. All tests for approval of the source shall be made by the Contractor and at his expense. Approval of the source shall not be construed as a waiver of the right of the Engineer to require the Contractor to furnish stone which complies with this specification. The stone shall be subject to approval at the site of the work for quality, gradation and placement. All stone shall be processed through grizzlies with mechanical screens if necessary to eliminate oversized and undersized material. The use of a rock crusher may be required to obtain the specified gradation.

d. During the course of construction, the stone will be regularly tested by the Engineer and the Contractor may be required to vary the source and loading operations to secure the results specified.

e. Stone not meeting the specification and plan requirements will be rejected. Rejected stone shall be promptly removed from the construction site at no expense to the Authority. Work areas containing rejected stone will be considered as incomplete work.

623-3 CONSTRUCTION REQUIREMENTS

623-3.01 Preparation of Foundations

a. Any required clearing and grubbing shall be performed in accordance with Specification 201 prior to initiating the work.

b. The slopes upon which the stone filter layers and revetment are to be placed shall be trimmed, dressed and compacted to conform to the required lines, grades and

density, and any required toe trench shall be excavated, prior to starting the placing of stone.

c. No material shall be placed in any prepared area until such area has been inspected and approved by the Engineer.

623-3.02 Filter Layers

a. When called for on the plans, specified revetment stone shall be placed in the toe ditch prior to placing the filter layers.

b. Filter material shall be spread uniformly on the prepared base to the neat lines indicated on the plans or as directed by the Engineer. Placing of material by methods which will tend to segregate particle sizes within the filter will not be permitted.

c. Filter under water shall be placed by crane, using a clam shell skip or similar equipment that will place the material in its final position without dropping it through water. Any damage to the surface of the filter base during placing of the filter shall be repaired before proceeding with the work.

d. Filter material shall be compacted to the extent necessary to present a reasonably even surface free from mounds or windrows and to hold it in place while the stone revetment is placed upon it.

e. The following tolerances from the required slope lines and grades, as measured with a 3-meter straightedge, will be allowed in each finished filter layer. However, either extreme of these tolerances shall not be continuous over an area greater than 20 square meters.

1. Types A and B - Plus or minus 3 centimeters. Individual large size stone projections above the

prescribed grade not exceeding 6 centimeters will be permitted.

2. Types C, D and E - Plus or minus 5 centimeters. Individual large size stone projections above the prescribed grade not exceeding 10 centimeters for Types C and D, and 15 centimeters for Type E will be permitted.

623-3.03 Stone Revetment

a. Stone revetment shall be placed on the prepared filter in a manner to produce a reasonably well graded mass with a minimum practicable percentage of voids, and shall be constructed to the lines and grades shown on the drawings, or as established by the Engineer. Stone shall be placed to its full course thickness in one operation and in a manner to avoid displacing the underlying material. The method of placement shall be submitted to the Engineer in writing for approval prior to commencement of placement operations.

b. Where called for on the plans the stones shall be roughly dressed to properly bed them and make them fit together so that they shall rest on their longest face. It is not intended to have a specially smooth or even appearance on the outside slope or face as long as the underlying stones are completely covered by the bigger stones. A sufficient large stock at stones of the kinds being used in the work shall be kept at the site at all times to permit adequate selection of the stones.

c. For stone revetments Type I, II and III, the rock may be placed in its final position by dumping, provided no segregation occurs, and may be adjusted in position by bulldozers or other similar equipment. Placing stone by dumping into chutes or by similar methods likely to cause segregation will not be permitted. Hand placing, barring, or

placing by crane will be required only to the extent necessary to secure the results specified.

d. Revetment consisting of large size stone, Types IV through VII, shall be keyed and set by relocating or placing with a crane, derrick or similar approved equipment. The longitudinal axis of the stones shall be normal to the alignment of the embankment with attitude horizontal or dipping slightly inward. The rocks shall have a 3-point bearing on the underlying rocks. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing such large stones by dumping will not be permitted. Dropping of rocks for any appreciable height or excessive moving with tractor bulldozers shall be avoided.

e. Local individual surface irregularities of the stone revetment, measured at right angles to the slope, shall not vary from the required slopes by more than the following limits.

1. Types I and II - Minus 0 to plus 15 cms.

2. Types III and IV - Minus 15 to plus 20 cms.

3. Types V, VI and VIII - Plus or minus 30 cms.

f. The Contractor shall maintain the stone revetment until accepted and any material displaced by any cause shall be replaced, at his expense, to the lines and grades shown on the drawings.

623-4 METHOD OF MEASUREMENT

623-4.01 Filter material and stone revetment will be measured by the cubic meter determined from the dimensions shown on the plans or the dimensions established by the Engineer. Materials placed in excess of these dimensions will not be included in the measurement for payment.

SPECIFICATION 623 – STONE REVETMENT FOR SLOPE PROTECTION

623-4.02 Any necessary clearing and grubbing will be measured for payment under the pay item for "Clearing and Grubbing" if such item is included in the contract; otherwise, it will not be measured directly for payment but shall be a subsidiary obligation of the Contractor with its cost included in the contract prices for filter stone and stone revetment pay items.

623-4.03 Any required excavation, backfill and disposal of surplus material will not be measured directly for payment. These items of work shall be a subsidiary obligation of the Contractor with their cost included in the contract prices for filter stone and stone revetment pay items.

623-5 BASIS OF PAYMENT

623-5.01 The completed and accepted quantities of filter material and stone revetment, measured as provided above, will be paid for at the contract price per unit of measurement. Such price and payment shall constitute full compensation for furnishing and placing all required material and for all excavation, labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications.

623-5.02 Payment will be made under:

Pay Item	Pay Unit
Filter Stone, Type ___ ……..	Cubic Meter
Stone Revetment, Type ___ …….	Cubic Meter

SPECIFICATION 624 – VERTICAL DRAINS

624-1 DESCRIPTION

624-1.01 Scope - This work shall consist of furnishing and installing vertical drains and drainage blankets in accordance with these specifications, at the locations indicated, and in conformity with the details, lines and grades shown on the plans or established by the Engineer.

624-1.02 Vertical drains shall be one of the following types as called for in the contract documents.

a. Vertical sand drains consist of columns of permeable sand designed to provide a vertical path for the movement of excess water from the soil being drained and as a filter for soil particles.

b. Vertical wick drains consist of plastic cores wrapped in a filter envelope made of synthetic fabric and designed to provide a vertical path for the movement of excess water from the soil to be drained.

624-1.03 Drainage blanket shall consist of permeable material placed in a thick lift to provide a working platform and a horizontal path by which the excess water coming up the vertical drains can escape laterally as the embankment is subsequently constructed.

624-2 MATERIALS

624-2.01 Sand - Material for the sand drains shall be a natural, processed or manufactured sand having a minimum coefficient of permeability of 10^{-3}cm/sec when tested in accordance with AASHTO T 215 (ASTM D 2434), and conforming to the grading requirements given below when tested in accordance with AASHTO T 27.

Sieve Designation	Percentage by Weight Passing Square Sieves
No. 10	90 – 100
No. 50	10 - 30
No. 100	0 - 3
No. 200	2 Max.

624-2.02 Drainage Blanket - Unless otherwise specified in the contract documents, material for the drainage blanket shall be a granular soil classifiable as an A-1 or A-3 under AASHTO M 145 but having all particles passing a 2-inch sieve and with a minimum coefficient of permeability of 10^{-3}cm/sec in a compacted condition.

624-2.03 Drainage Wicks

a. Drainage wicks shall consist of a prefabricated polyvinyl chloride, polyethylene, or other polymer plastic core about 10 cm. (4") wide, equipped with protruding studs or with longitudinal channels or grooves on both sides to allow for water flow. The core shall be wrapped with a fabric envelope made of non-woven filaments of polypropylene, polyester, acrylic or other chemical synthetic material. The fabric shall be inert to chemicals commonly encountered in the soil, rot proof, and dimensionally stable.

b. Drainage wicks may be any one of the following brands at the option of the Contractor.

1. Alidrain
   Vibroflotation Foundation Company
   U. S. Steel Building
   600 Grant Street
   Pittsburgh, PA 15212

2. Amerdrain
International Construction Equipment, Inc.
301 Warehouse Drive
Matthews, NC 28105

3. Castle Drain Board
Harquim International Corporation
3112 Los Feliz Boulevard
Los Angeles, CA 90039

4. Mebra Drain
L. B. Foster Company
415 Holiday Drive
Pittsburgh, PA 15220

c. The Contractor may submit other alternate brand of drainage wick for evaluation for use in lieu of the brands specified above. However, any alternate type submitted for consideration shall be comparable as to quality and performance and shall comply with all the requirements of this specification.

d. The Contractor shall submit samples of the drainage wicks he proposes to use at least four (4) weeks prior to delivery to the project for evaluation and approval by the Engineer.

e. The Contractor shall furnish a certification from the supplier with each shipment of drainage wicks stating the quantity furnished and that the material complies with the requirements of this specification.

624-2.04 Sampling and Testing

a. The Contractor shall advise the Engineer as to the exact location of the sources of sand and drainage blanket material that he proposes to provide, at least four weeks in advance of their actual use, so that samples may be obtained and tested for conformance with this specification. No

material shall be deposited on the roadway until the Engineer has approved its source.

b. Once a source is approved, it shall be the Contractor's responsibility to ascertain that the material from such source continues to meet specification requirements.

c. Throughout the construction operations, the Engineer will take random samples of the materials in place for testing. Any stockpiled or in-place material failing to meet the requirements of this specification shall be removed and replaced with acceptable material at the Contractor's expense.

624-3 CONSTRUCTION REQUIREMENTS

624-3.01 Drainage Blanket

a. Prior to the construction of the drainage blanket, the area to be treated with vertical drains shall be cleared and grubbed in accordance with the requirements of Specification 201 - Clearing and Grubbing.

b. The Contractor shall install such devices for embankment construction control under Specification 208 as are called for in the contract documents.

c. The drainage blanket shall be deposited, spread in layers and compacted to the depth and section shown on the plans or ordered by the Engineer, in accordance with the applicable provisions of Specification 203 - Excavation and Embankment.

d. Compaction of the drainage blanket may be attained by means of the passage of the spreading equipment to the satisfaction of the Engineer. No specific moisture and density control values will be required.

e. If after completion of the drainage blanket and during the installation of the vertical drains the drainage blanket

should settle in excess of 30 centimeters below the grade elevation shown on the plans, the Contractor shall place additional material meeting the requirements of paragraph 624-2.02 above to restore the grade elevation. If the settlement is 30 centimeters or less no additional material will be required, unless ordered by the Engineer.

624-3.02 Sand Drains

a. Vertical sand drains shall be located and staked out by the Contractor in accordance with the layouts shown on the plans or as directed by the Engineer. Location of drains shall not vary by more than 15 centimeters from that shown on the plans or established by the Engineer.

b. Vertical sand drains shall be installed from the top of the drainage blanket to the depths shown on the plans or ordered by the Engineer.

c. Installation of each vertical sand drain shall be made by driving, with pile driving equipment of adequate capacity, a steel pipe mandrel of the inside diameter specified on the plans and provided with a suitable closure device at the lower end. The mandrel shall be driven to the required sand drain depth. The pipe mandrel then shall be filled to the top of the blanket with the specified graded sand. The pipe mandrel shall be withdrawn while applying air pressure to the sand through a suitable device at the top of the pipe mandrel to insure that the sand remains in place in each drain and is continuous from the bottom of the drain to the top of the blanket.

d. The Contractor may submit for the Engineer's consideration other methods for installing the vertical sand drains, but no method will be approved which may result in unsatisfactory drains, differing in form and sand content from the sand drains obtained through the use of the above described method.

SPECIFICATION 624 – VERTICAL DRAINS

624-3.03 Wick Drains

a. Equipment

1. Wick drains shall be installed by either tracked or rubber-tired, power-driven equipment from the surface of the drainage blanket, as detailed on the plans. Equipment of such size or configuration as to cause destruction of the drainage blanket will not be allowed to operate on the blanket.

2. Wick drains shall be installed vertically, by means of hydraulic pressure or vibratory driving force, within a hollow sleeve (mandrel), in such a manner as to advance the drain in a continuous manner to the depths required, without any damage to the drain during advancement or retraction of the mandrel. In no case will alternate raising or lowering of the mandrel during advancement be permitted. Raising of the mandrel will only be permitted after completion of a drain installation.

3. The wick drains shall not be installed by jetting or impact methods.

4. The mandrel used for installation may be rectangular, rhombic or trapezoidal in shape, of a cross-section as close as possible to the size of the wick drain, and shall not exceed the minimum dimensions required for structural integrity.

5. The mandrel shall be equipped with a non-recoverable tip or similar device whose purpose is to hold the wick drain in place and prevent intrusion of soil into the mandrel during advancement. The dimensions of this device shall conform as closely as possible to the dimensions of the mandrel so as to minimize soil disturbance.

b. Construction Procedures

1. At least two weeks prior to the installation of drainage wicks, the Contractor shall submit to the Engineer for his review and approval, details of the sequence and method of installation. Approval by the Engineer will not relieve the Contractor of his responsibility to install drainage wicks in accordance with these specifications.

2. Prior to the installation of drainage wicks within the designated areas, the Contractor shall demonstrate that his equipment, method, and materials produce an installation in accordance with these specifications. For this purpose, the Contractor will be required to install trial wicks at locations designated by the Engineer. Payment will be at the bid price per linear meter for satisfactory trial drainage wicks; however, no payment will be made for unsatisfactory trial wicks.

3. Approval by the Engineer of the method or equipment used to install the trial wicks shall not constitute, necessarily, acceptance of the method for the remainder of the project. If, at any time, the method of installation is not producing satisfactory wick drains, the Contractor shall alter his method and/or equipment as necessary to comply with these specifications.

4. Wick drains shall be located and staked out by the Contractor in accordance with the layouts shown on the plans or as directed by the Engineer. The location of the wick drains shall not vary by more than 15 centimeters from the location shown on the plans or established by the Engineer.

5. Drainage wicks shall be installed from the surface of the drainage blanket to the depth shown on

the plans, or to such a depth where the soil resists a reasonable effort at further penetration. The Engineer may vary the depths, spacings, or the number of wicks to be installed, and may revise the plan limits for this work as necessary.

6. The Contractor will be permitted to set a temporary casing through the sand blanket, if necessary, prior to the installation of the drainage wick.

7. The Contractor will be permitted to use augering or other methods to loosen stiff upper soils prior to the installation of the drainage wick, provided such augering does not extend more than 30 centimeters into the underlying compressible soils.

8. Equipment for installing the drainage wicks shall be carefully plumbed prior to installing each wick and shall not deviate from the vertical by more than 3.0 centimeters in 1.50 meters during the installation of any wick.

9. Wicks that are out of their proper location by more than 15 centimeters, or that are out of plumb by more than the allowable tolerance, or that are damaged during construction, or that are improperly installed, will be rejected by the Engineer and no compensation will be allowed for any materials furnished or for any work performed on such wicks.

10. Rejected wicks that interfere with the installation of replacement wicks or other acceptable wicks shall be removed at no cost to the Authority. Other rejected wicks may be removed or abandoned in place at the Contractor’s option.

11. Splices or connections in the drainage wick material shall be done in a workmanlike manner so as

to insure continuity of wick material. The wick material shall be cut neatly at its upper end at a length approximately 10 to 20 centimeters above the surface of the drainage blanket.

12. The Contractor shall provide the Engineer with suitable means of making a linear determination of the quantity of wick material used at each wick location. During installation of the wick, the Contractor shall provide suitable means of determining the depth of the drain at any given time.

13. Where obstructions are encountered below the working surface which cannot be penetrated using normal and accepted procedures, the Contractor shall complete the wick drain from the elevation of the obstruction to the surface of the drainage blanket and notify the Engineer. At the direction of the Engineer, the Contractor shall then install a new drain within 50 centimeters of the obstructed drain. The Contractor will be paid for all obstructed drains for the actual length installed at the contract unit price unless the drain is improperly installed.

624-4 METHOD OF MEASUREMENT

624-4.01 Drainage Blanket - Material for the drainage blanket will be measured by one of the following methods as called for in the contract.

a. By average end area method, in cubic meters, in final position in the completed and accepted drainage blanket. The end areas will be determined by taking no less than three (3) borings at each cross section to determine the bottom of the blanket. Two borings will be at the ends of the horizontal top surface of the blanket section and the other at the center of the cross section. Additional borings may be taken at the discretion of the Engineer.

b. By the ton, weighed in the vehicle at the point of delivery utilizing suitable scales furnished by the Contractor and approved by the Engineer. The weight of water in the material in excess of the optimum moisture content will be deducted.

c. In cubic meters measured on trucks at the point of delivery.

624-4.02 Vertical Sand Drains - Vertical sand drains will be measured by the linear meter, to the nearest tenth, complete in place, from the top of the drainage blanket to the bottom of the drain. The measurement will be made immediately upon completion of each drain.

624-4.03 Vertical Wick Drains - Vertical wick drains will be measured by the linear meter, to the nearest tenth, complete in place, from the top of the drainage blanket to the bottom of the drain.

624-5 BASIS OF PAYMENT

624-5.01 The accepted quantities determined as provided above for each of the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and placing all required materials, and for all equipment, tools, labor, and incidentals necessary to complete each item as required by the plans and specifications.

624-5.02 Payments will be made under:

Pay Item	Pay Unit
Drainage Blanket……..	Cubic Meter (In Place) or Ton or Cubic Meter (Truck Measure)
Vertical Sand Drains…….....	Linear Meter
Vertical Wick Drains……	Linear Meter

SPECIFICATION 625 – TOPSOIL

625-1 DESCRIPTION

625-1.01 Scope

a. This work shall consist of furnishing, transporting and spreading topsoil in accordance with these specifications at the locations shown on the plans or as designated by the Engineer.

b. The topsoil material under this specification may be obtained from sources within the roadway areas, when available and authorized by the Engineer under the provisions of paragraph 3.02a(7)(b) of Specification 203 - Excavation and Embankment and Article 104.08 of the General Provisions, or from sources outside the project selected by the Contractor.

c. The Engineer may delete this work over areas of the project where a suitable growing medium for grass or other suitable vegetation is obtained as a result of normal grading operations or regeneration of natural growth has occurred.

625-2 MATERIALS

625-2.01 Topsoil material shall conform to the requirements of Article 713-1 - Loamy Topsoil of Specification 713 - Roadside Improvement Materials. Unsuitable material from required excavations that meets these requirements will be acceptable. Frequency of sampling for topsoil material incorporated in the project shall be as deemed necessary by the Engineer to assure the quality of the material, but not less than 3 samples per project.

625-3 CONSTRUCTION REQUIREMENTS

625-3.01 The subsoil within the areas to be covered by topsoil shall be graded so that the completed work after topsoil is placed, shall conform to the specified lines and grades. Wherever slope areas to be topsoiled are steeper than 3:1, the Contractor shall scarify or till the surface of the subsoil before the topsoil is placed to permit

bonding the topsoil with the subsoil. Tillage by disking, harrowing, raking or other approved methods shall be accomplished in such a manner that depressions and ridges formed by tillage shall be parallel to contours.

625-3.02 After the Engineer has approved the graded areas, the loamy topsoil shall be deposited and spread to the depth shown on the plans or ordered by the Engineer. The Contractor shall take all reasonable precautions to avoid injury to existing or planted growth, and to structures or surfacing on the roadway.

625-3.03 During loamy topsoil hauling and spreading operations the roadway surfacing shall be kept clean and any topsoil or other dirt which may be spilled upon the surfacing shall be removed promptly and thoroughly. The wheels of all vehicles shall be kept clean to avoid bringing any dirt upon the surfacing.

625-3.04 After the spreading of loamy topsoil, any large stones, stiff clods, hard lumps, brush, roots, stumps, litter, or other foreign material shall be raked up and removed from the topsoil areas.

625-4 METHOD OF MEASUREMENT

625-4.01 Topsoil to be paid under this specification will be measured by the cubic meter of loamy topsoil furnished, spread and accepted. Topsoil furnished by the Contractor from sources within or outside the project will be measured in the vehicles at the point of delivery.

625-4.02 When the contract does not include a pay item for "Loamy Topsoil", any topsoil ordered by the Engineer which can be obtained from the roadway excavation will be measured for payment as a second handling of roadway excavation as provided in paragraphs 203.3.02a(7)(a) of Specification 203 - Excavation and Embankment.

SPECIFICATION 625 – TOPSOIL

625-5 BASIS OF PAYMENT

625-5.01 The accepted quantity of loamy topsoil determined as provided in paragraph 625-4.01 above will be paid for at the contract unit price per cubic meter. Such price and payment shall constitute full compensation for furnishing, transporting and placing all material and for all labor, equipment, tools and incidentals necessary to complete the work as required by the plans and specifications.

625-5.02 Payment will be made under:

Pay Item	Pay Unit
Furnishing and Placing Loamy Topsoil……	Cubic Meter

SPECIFICATION 626 – PLANTING

626-1 DESCRIPTION

626-1.01 Scope - This work shall consist of furnishing and planting or removal and transplanting of trees and palms, pruning of existing trees, shrubs, vines and other ground cover plants in accordance with these specifications and the details and locations shown on the plans or established by the Engineer.

626-2 MATERIALS

626-2.01 Materials for this work shall meet the requirements of the following articles of Specification 713 - Roadside Improvement Materials.

Topsoil……	713-1
Agricultural Lime……....	713-2
Fertilizer…….....	713-3
Mulch…….....	713-6
Plant Material…….	713-7
Miscellaneous Planting Material……	713-9

626-2.02 The specific plant materials, type of fertilizer and other materials required shall be as indicated in the contract documents or ordered by the Engineer.

626-2.03 Source of plants

1. All plant materials should originate in Puerto Rico from locally available seed and cutting sources (including Vieques, Culebra and Isla de Mona). Exceptions to this requirement need to the approved by the Puerto Rico Highway and Transportation Authority (PRHTA) or Department of Natural Environmental Resources (DNER).

2. All plant material to be imported shall comply with importation dispositions of the US Department of Agriculture and the Department of Agriculture of the Commonwealth of Puerto Rico.

SPECIFICATION 626 – PLANTING

626-3 CONSTRUCTION REQUIREMENTS

626-3.01 Delivery and Inspection of Plants

a. The Contractors shall notify the Engineer in writing not less than seven (7) calendar days in advance of delivery of plants from the nursery or collecting source. The Contractor shall furnish the Engineer complete information concerning the source of supply for all plant material.

b. All plant material shall be available for inspection at the nursery or collecting fields before they are dug. Inspection of materials at the source shall be at the discretion of the Engineer. Approval to move nursery material shall not be considered as final acceptance.

626-3.02 Handling and Shipping

a. All plant material shall be handled, prepared and packed for shipment with care by experienced workmen. Digging shall be done in such manner as to retain the essential root systems and avoid damage to them. Each species or variety shall be handled or packed in an approved manner and as required by soil and climatic conditions at the time of digging and with due regard to conditions of shipment and time to be consumed in transit and delivery.

b. All broadleaf plants and conifers shall be furnished balled and burlapped (B & B) or in suitable containers, as hereinafter provided. All balled and burlapped plants shall it all times be handled by the ball and not by the top.

c. Unless otherwise specified, all plants not furnished B & B shall be supplied in the containers where the plants have been grown and established.

d. Standard and Grades of Plant Material

1. **Acceptable Trunk Structure** is one that has one central trunk. It may be straight or have a very slight bow less than 5º. The tip of the leader on the main trunk must be the highest part of the tree. The trunk may branch (fork) into two approximately equal-sized trunks in the upper ½ of the tree trunk. The tip of the leader on the main trunk must be the highest part of the tree. Unless specified in plans the trees shall have a minimum height of 1.82m (6 feet). The tree shall not include the height of the root ball or container.

2. **Non-Acceptable Trunk Structure** is one that the trunk branches into two approximately equal-sized trunks along the lower ½ of the tree or the trunk branches into three or more nearly equal-sized trunks in the upper ½ of the tree or there is one trunk, but it has a bow greater than 15º.

3. **Acceptable Branch Arrangement** is one that has several branches which some are larger in diameter (and obviously more dominant) than others. These should be spaced at least six (6") apart along the trunk. No two major branches grow from the same position on the trunk. No branches are greater than ⅔ the diameter of the trunk measured directly above the branch. No major branches are oriented nearly vertical with the trunk. There may be temporary branches on the lower trunk, but these should be no larger than 1/5 the diameter of the trunk.

4. **Non-Acceptable Branch Arrangement** is one in which most of the major branches are oriented vertically; and/or several major branches are located at the same node at two or more position on the trunk and/or one or more branches are larger than 2/3 the

diameter of the trunk measured directly above the branch. All branches are growing vertically, and they are forming narrow angles with the trunk; or most major branches are growing from the same point on the trunk. Some are less than four (4") from the ground. Major limbs are opposite each other on the trunk.

5. **Palm Root System Standards** – Container grown palms shall be sturdily established in container, without excessively root bound and no large roots growing out of container. Balled and burlapped (B&B) shall have roots sturdily established in ball which has been tightly wrapped and securely tied with twine or wire, or pinned. The root ball must contain sufficient room for continued growth without resulting shock. For palms with overall height of less than 15 feet the root ball shall have a minimum radius of 8" as measured from the base of the trunk, if the palm is solitary (single-stemmed palms) or from the base of the steem furthest from the center of the cluster (clusting palms). For palms with an overall height in excess of 15 feet, the root ball shall have a minimum radius of 10" as measured from the base of the trunk, if the palm is solitary (singe-stemmed palms) or from the base of the steem furthest from the center of the cluster (clustering palms). For palms greater than 25 feet in overall height, it is recommended that the root ball radius of a palm larger than 25 feet tall be increased by 1" for each additional 5 feet of overall height beyond 25 feet. The depth of Ball for palms up to 15 feet in overall height, shall have a minimum depth of 12" measured from the soil surface. For palms 15-25 feet in overall height, root ball will have a minimum depth of 18" measured from the soil surface. For palms in excess of 25 feet overall height, root ball will have a minimum depth of 24".

SPECIFICATION 626 – PLANTING

626-3.03 Protection and Storage

The Contractor shall keep all plant material moist and protected from drying out. The protection period shall include the time when the plants are in transit, in temporary storage, or at the project site awaiting planting. Plants delivered B & B but not scheduled for immediate planting shall have the earth balls covered with sawdust, woodchips or other suitable material and kept in a moist condition.

The Contractor shall not keep all plant material for an extended period with out planting. This period shall not be longer than five calendar days. Temporary holding areas shall be appropriate as deemed by the Engineer for live plant material.

626-3.04 Layout

a. Trees and plants shall be planted at the locations shown on the plans or established by the Engineer.

b. The Engineer reserves the right to adjust the number and location of any of the designated types and species to be used at any of the locations shown, in order to provide for any unanticipated effects which might become apparent after other phases of the project have been substantially completed, or for other causes.

626-3.05 Excavation for Planting Holes and Beds

a. Prior to excavating for planting and beds the area shall conform to the lines and grades shown on the plans. All sod, weeds, roots and other objectionable material unsuitable for backfill shall be immediately removed from the site and disposed of by the Contractor in a manner satisfactory to the Engineer.

b. The size of planting holes should be 46 to 61cm (18 to 24 inches) wider in diameter than the root ball. The planting

hole should never be deeper than the root ball of the plant. In dense clay soil the planting hole will be 8-13cm (3-5 inches) shallower than the root ball, to permit adequate gas exchange in the root zone. The exposed ball will be covered with a 3cm of soil and 5 to 8cm (2-3 inches) of much.

c. The soil at the bottom of the planting hole shall be loosened to a depth at least 15 centimeters by spading or other approved methods before setting the plants.

d. For large shade trees, flowering trees, or larges shrubs wherever the soil is sterile or wherever existing conditions in the judgement of the Engineer are unfavorable to plant growth, the holes shall be of sufficient size and depth to permit the placing of 30 centimeters of prepared topsoil around and under the root ball.

626-3.06 Plant Backfill Soil - Unless otherwise specified in the plans, the in-situ soil excavated from each planting hole shall be used to backfill the hole after the plant has been set. However, to this soil shall be added and mixed in one (1) part of peat moss or peat humus for each four parts of soil. When a prepared backfill soil is called for in the plans, the topsoil to be used must match the soil type of the site as closely as possible and it shall consist of a mixture of four (4) parts of approved topsoil and one (1) part of peat moss or peat humus.

626-3.07 Planting Order - The order of planting shall be as follows:

a. Large Trees

b. Small trees and large shrubs

c. Small shrubs

d. Other ground cover

SPECIFICATION 626 – PLANTING

626-3.08 Setting Plants

1. All plants shall be set approximately plumb and at the same level or depth at which they were grown in the nursery.

2. Balled and burlapped plants shall be carefully placed in the prepared planting holes upright at the required depth so as to rest in a firm upright position. Plants shall be handled and moved only by the ball. Backfill soil shall then be filled in around the plant ball to half the depth of the ball, then tamped and thoroughly watered. Earth saucers or water basins shall then be provided and the plant thoroughly watered.

3. Container grown stock which has become "pot-bound" or for which the top system is out of proportion (larger) to the size of the container will not be acceptable. The stock shall not be removed from the container until just before planting, and all due care shall be exercised to prevent root system damage.

626-3.09 Fertilization - A complete controlled release fertilizer will be used for planted material, at a rate 2 to 4 lbs. of N per 1000 square feet. The analysis of the complete fertilizer will be 18-8-12 or other with high N percent. The fertilizer will be broadcast prior to the application of mulch.

626-3.10 Watering - All plant shall be watered during and immediately after planting and at such intervals during the plant establishment period as determined by the Engineer. Water shall not contain elements toxic to plant life. At each watering the soil around each plant shall be thoroughly saturated.

626-3.11 Pruning - Pruning immediately after planting shall be kept to a minimum; only broken or damage limbs should be removed.

626-3.12 Guying and Staking - All trees with a caliper less then 2.54cm shall be staked using two (2) support stakes and tied with a single flexible 12 or 14 gauge wire as shown in drawings. All trees larger than 10.16cm shall be guyed with 3 or 4 wires anchored in the ground, with stakes, land anchors or deadmen. Guy wires must be passed through a section of hose to protect the tree. The wires and the section of hose are passed around the three crotches and the wire twisted to them all.

626-3.13 Mulching - Mulch material shall be furnished and placed over all planting holes or saucer areas of individual trees and shrubs and over the entire area of shrub beds as indicated on the plans. Mulch shall be placed within 24 hours after planting.

The Mulch shall be placed with a depth of 7.62cm. Mulching material shall be free of toxic trash, or objectionable material unsuitable as organic cover. Mulching material shall be "cured" no raw organic material shall be used.

626-3.14 Restoration and Cleanup - Where existing grass areas have been damaged or scarred during planting operations the Contractor shall restore the disturbed areas to their original conditions as directed by the Engineer at no additional cost to the PRHTA. The Contractor shall clean up all debris, spoil piles, containers, and other trash and leave the project in an acceptable condition.

626-3.15 Plant Establishment Period and Replacements

a. The acceptability of the plant material furnished and planted as specified shall be determined at the end of a period of establishment of 180 days calendar during which the Contractor shall employ all possible means to maintain the plant material in a healthy growing condition.

b. Care during the establishment period shall include watering, cultivating, pruning, repair and adjustment of guys and stakes, and such other work as ordered by the Engineer.

c. The Contractor shall inspect at a minimum the newly planted areas on the site, at a bi-weekly basis until the project is finished and accepted by the PRHTA. Inspector will note the presence of nuisance or weekly species general health conditions, insect or disease problems, among other. The result shall be reported to PRHTA with corrective actions taken or other recommendations.

d. During the establishment period, the Contractor shall replace all dead, dying, or other unsatisfactory plants as many times as the Engineer may deem necessary to assure that reasonable established healthy plants are in place at the end of the plant establishment period. Dead or unsatisfactory plants shall be replaced within the following 7 calendar days of the inspection.

e. A semi-final inspection by the Contractor and the Engineer will be held to determine the acceptability of the plant material 15 days before the end of the establishment period.

f. When the planting is including as part of a highway construction contract, the Contractor is responsible for the care of the plants, including replacement when required, shall extend until the completion and acceptance of the construction project or the 180 days establishment period whichever is longer.

626-3.16 TRANSPLANTING TREES

a. Inspection of Trees for Transplanting

1. The Contractor shall read and understand the Tree Removal, Pruning, Transplanting and Planting Permit issued, for the construction project by the DNER. A copy of the permit shall be kept at the construction site at all times.

2. The Contractor shall notify the Engineer in writing not less than 7 calendar days in advance of the transplanting activities.

3. The Contractor shall furnish the Engineer complete information concerning the list of equipment, procedure and labor force for use in transplanting work, a daily schedule of work and product literature of any chemicals, wetting agents or any other compound to be used.

4. All proposed transplanting work shall be performed or supervised by an Arboriculture Professional certified by the DNER.

b. Transplanting and Handling

1. The Contractor shall mark with flagging tape all trees and/or palms to be transplanted as indicated in DNER Permit. All tree saplings, shrubs, bush, vines and undergrowth occurring around select tree that may interfere with transplanting will be removed from site.

2. Before digging if necessary, the lower branches of the tree should be tied to prevent injury or breaking. No pruning shall be performed.

3. To determine the root ball diameter needed for each tree, measure the diameter of the tree twelve inches above the root crown. The root ball should be nine (9") inches in diameter per inch of truck diameter. The final depth of the root ball or each tree will be thirty six (36) inches. The root ball shall be wider at the top that at the bottom.

4. The first cut or digging to form the root ball shall be done six (6) inches away from the estimated root ball diameter. The cut must be done with a sharp

edge shovels or machinery. Every root cut must be performed with a hard saw. The ball must be formed slowly. While digging the trench standing on the rootball shall be avoided. Once the ball has been dug the desired depth, it can be shaped. The ball should taper on the sides, slanting inward toward the base. The ball should stand on a pedestal of soil for shaping and burlapping before it is undercut.

5. The root ball shall be burlapped. The burlap is placed on the side and across the top of the ball. It is pinned together using nails. Tucks may be taken to pull the burlap snug. The burlap should cover the full circumference of the root ball, with a bottom skirt of burlap hanging over the pedestal. This will be pinned to the ball later after the tree is taken out of the hole.

The root ball then shall be **drum laced** with rope. The rope generally used is ½ inch manila or double strands of 4-ply sisal. One rope is looped around the bottom of the ball and pulled snug at the top of the pedestal of soil. A second loop of rope is placed on the top of the ball and may be held in place with nails. One end of the lacing rope is tied to the top loop and placed up and down the circumference of the ball, weaving in and out of the upper and lower loops.

The bottom rope is then pulled tight. The top rope is snugged up, and securely tied. The slack is worked out of the side lacing, working around the all until each section is tight. If the soil ball is large, top lacing should also be used. A top rope is laced back and forth across the top of the ball, taking care not to let the rope into the trunk of the tree.

6. Once the ball is laced and secured, the tree can be undercut. A clean cut can be made using a cable without having to tilt the ball of soil. An anchor pin is driven into the bottom of the hole opposite a trench

where the cable is to be pulled. The cut-off cable is a ½ inch or ⅝ inch cable with an eye in end. The cable must be long enough to pass around the ball and out to where the winch is hooked to one eye. The other eye is placed over the steel anchor pin. The pulling end must pass under the anchor end to keep the cable from riding up into the ball. The cable is pulled using a winch, and the ball is undercut.

7. Trees shall be removed from the hole with a crane. Chains are place around the ball and attached to the crane book. Trees shall not be lifted by the trunk as this can cause trunk injury and serious damage to the root ball. Once out of the hole, the burlap shall fasten to the bottom of the ball. Once out of the hole, the burlap shall fasten to the bottom of the ball.

If the tree must be transported to a distant site, it shall be protected. The trunk all be we padded to protect form injury. The crown of the tree may be loosely wrapped with burlap to minimize drying and wind damage.

8. Trees or palms transplanted will be planted in their location immediately after transplanting. If proposed at the moment, transplanted trees will be kept under adequate shade and watered until the moment of planting.

626-3.17 Protection of Trees and Palms to remain

a. **Protection of existing Trees and Palms to remain** – Individual trees and palms to remain, as indicated on plans, shall be protected by installing a security fence in the perimeter of the tree or palm at a minimum distance of two (2) meter form the trunk or to the dripline zone, whichever is larger. If a series trees, like along the right of way of a road, are required to be protected, a continuous security fence, four

(4) feet high shall be installed by the Contractor at a distance of two (2) meter from the trunk of the tree. Protection fences shall be installed prior to commencement of construction.

b. No debris or combustible material shall be piled or discarded within spread of branches or dripline zone.

c. The Contractor shall read and understand the Tree Removal, Pruning, Transplanting and Planting Permit issued for the construction project by the DNER. A copy of this permit shall be kept at project site at all times.

d. All proposed tree protection work shall be performed or supervised by an Arboriculture Professional certified by the DNER.

626-3.18 Maintenance Plan

When a project calls for a maintenance plan beyond the subsidiary maintenance performed by the Contractor during Establishment Period the plan shall be implemented as describe hereafter.

The maintenance plan and schedule of work shall be presented 45 calendar days prior to the commence of work to the Engineer for approval. The Maintenance Plan shall include the following activities.

a. Watering – All plants shall be watered along the duration of the maintenance contract in the following frequency:

1. daily for the first three (3) months

2. every two days for the following three (3) months

3. weekly for the next six (6) months to the end of contract. Watering frequency at it this point may

be altered depending on the climatic conditions (rainfall) prevailing at the site. Watering shall not contain elements toxic to plant material. At each watering the soil around each plant material shall be thoroughly saturated. Care should be take so that the mulch or soil around the trees is not eroded or displaced by water stream.

b. Fertilizing – The Contractor shall furnish soil and foliar analyses of the site and trees including the following parameters:

1. essential element availability

2. soil pH and salt content

3. action exchange capacity

4. element deficiencies or toxicities

Soil samples shall be taken from representative locations of the entire area. The samples shall be dried and mixed together so that the results will averaged over the entire area. Foliar samples shall be taken from all over the tree, dried and mixed together.

A complete controlled release fertilizer shall be applied at a rate minimum 2 to 4 lbs. of N per 1000 square feet. The analysis of the complete fertilizer will be 18-8-12 or other with high N percent. The fertilizer will be applied using one of the following methods:

The drill hole method of fertilization granular fertilizer is placed below turfgrass root. Holes spaced 2-3 feet apart are drilled in the soil around the tree in concentric circles. The holes shall extend well beyond the dripline and have a depth of 8-12 inches. The recommended rate of fertilizer shall be uniformly

distributed among the holes. Fertilizing will be followed by watering.

The liquid injection method in which fertilizer dissolved or suspended in water is injected into the soil using a lance and hydraulic sprayer. The hole spacing and distribution are 8-2 inches deep and 2-3 feet on center, respectively. If this method is preferred a water soluble fertilizer will be used.

c. Pruning – Pruning shall be done whenever determined necessary by the Engineer. In any case, pruning shall be limited to the removal of dead or dying branches. All pruning shall be done by an experienced Arboriculture Professional Certified by the DNER.

d. Guying and Staking – All support stakes and guys will be periodically inspected and any adjustment of wire tension will be made at the moment.

e. Disease Insect and Weed Control – In the event of disease or insect attack on planted plant material the Contractor shall diagnose the condition in a written report to the Engineer describing the pattern of abnormality of the plant material site conditions, color, size and thickness of foliage visible symptoms and signs name of suspected pathogen or insect and proposed method of control. Weeding will be performed every two weeks or when climatic conditions favor the propagation of weedy species.

f. Restoration and Cleanup – Where existing grass areas have been damaged or scarred during maintenance operations the Contractor shall restore the disturbed areas to their original conditions as directed by the Engineer at no additional cost to the PRHTA. The Contractor shall cleanup all debris, spoil piles, containers, and other trash and maintain the project in an acceptable condition.

626-3.19 Pruning of existing areas

Pruning shall be done on existing trees indicated on plans and/or as indicated by the Engineer. All pruning shall be done by an experienced Arboriculture Professional Certified by the DNER.

626-4 METHOD OF MEASUREMENT

626-4.01 Excavation and preparation of planting holes and beds to receive and set plants will not be measured for direct payment but shall be a subsidiary obligation of the Contractor under the pay items for plants.

626-4.02 The preparation and use of in-situ soil for backfilling after setting plants will not be measured for direct payment but shall be a subsidiary obligation of the Contractor under the pay items for plants.

626-4.03 Prepared plant backfill soil for plant holes, when called for in the contract will be measured by the cubic meter of prepared soil furnished, placed and accepted. The soil will be measured in the vehicles at the point of delivery at the project.

626-4.04 Any required topsoil, other than in-situ soil or prepared plant backfill soil, will be measured and paid for under Specification 625.

626-4.05 Plants will be measured by each for healthy trees, shrubs, vines and other plant types, of the specified kinds and sizes furnished, planted and accepted. Only living plants in healthy condition at the end of the establishment period or project completion and acceptance, whichever comes later, will be accepted for payment. Furnishing and placing mulch, fertilizers, agriculture limestone, water, guying and staking materials, and other required miscellaneous planting materials will not be measured for direct payment but shall be considered as subsidiary obligations of the Contractor under the pay items for plants.

626-4.06 Pruning of existing trees will be measured by each, for any type of trees or plant pruned and accepted by the Engineer. These works include any material, equipment, and tools, necessary to complete this item.

626-4.07 Pruned and transplanted trees will be designated in relation to their height as follows:

0 to 25 feet ----------Small
over 25 feet ---------Large

626-4.08 Protection of existing trees and palms to remain will be measured by the unit for each tree or palm protected as indicated in Article 626-3.17 above. Any wooden fence damaged or stolen during the duration of the project shall be replaced by the Contractor at no extra cost to the Authority.

626-5 BASIS OF PAYMENT

626-5.01 The accepted quantities, determined as provided above, will be paid for at the contract unit price, respectively, for each of the particular pay items listed below that are shown in the bid schedule. Such prices and payment shall constitute full compensation for the furnishing, excavating, planting and maintaining of the plants and for all materials, labor, equipment, tools and incidentals necessary to complete the work as required by the plans and specifications.

626-5.02 Payment for plant materials will be made as the work progresses as follows:

a. Forty percent (40%) of the contract unit price for each tree, shrub, vine or other plant type will be paid after the initial planting is completed provided the work is accepted.

b. The remaining sixty percent (60%) due the contractor for each plant will be made at the end of the plant establishment period on the project completion and

acceptance date, whichever is later, provided the plantings have been acceptably maintained and are in place, completed and accepted.

c. The 100% of the maintenance contract unit price for each tree, shrub, vine or other plant type will be divided by the months of the maintenance contract and paid on the maintenance period, provided the planting have been acceptability maintained and is in place, completed and accepted.

626-5.03 Payment will be made under:

Pay Item	Pay Unit
Prepared Plant Backfill Soil…….	Cubic Meter
Planting _____, _____…… (Plant Name) (Size)	Each
Transplanting _____, _____……. (Plant name) (Size)	Each
Maintaining _____, _____…… (Plant name) (Size)	Each
Pruning of existing trees, _____……... (Size)	Each
Protection to Existing Trees……..	Each

SPECIFICATION 627 – TURF ESTABLISHMENT

627-1 DESCRIPTION

627-1.01 Scope - This work shall consist of soil preparation, seeding, fertilizing, liming when specified, and mulching on all areas designated for turf establishment on the plans or where directed by the Engineer and in accordance with these specifications. The work also includes the protection of seeded steep slopes from erosion by the application of soil stabilization materials or the installation of jute mesh as indicated on the plans or ordered by the Engineer, and the care and maintenance of seeded areas until the project is completed and accepted.

627-2 MATERIALS

627-2.01 Materials for turf establishment shall meet the requirements of the following articles of Specification 713 - Roadside Improvement Materials:

Agricultural Lime……..	713-2
Fertilizer…….……	713-3
Seeds…….…….	713-4
Mulch…….……	713-6
Jute Mesh…….…..	713-8
Water……..	713-9.01
Soil Stabilizer……..…	713-9.08

627-3 CONSTRUCTION REQUIREMENTS

627-3.01 General

a. When indicated on the plans, or ordered by the Engineer, topsoil shall be placed in areas scheduled for turf establishment. This work shall be performed and paid for under the requirements of Specification 203 - Excavation and Embankment and Specification 625 - Topsoil, as applicable.

b. In order to provide for erosion control, the Contractor shall provide the turf establishment in areas scheduled for such work as soon as the grading and other operations that

must be performed prior to turf establishment operations are completed in such areas. If any damage by erosion or other causes occurs after the completion of grading the Contractor shall repair such damage prior to seeding. This may include filling gullies, smoothing irregularities, and repairing other incidental damage.

627-3.02 Soil Preparation

a. The areas to be seeded shall be cultivated to provide a reasonably firm but friable seedbed. Depth of cultivation shall be as shown on the plans but with a minimum of 5 centimeters. On slopes steeper than 3.1, the depth of cultivation may be reduced as directed by the Engineer. The area shall be raked or otherwise cleared of weeds or other plant growth, stones larger than 5 centimeters, sticks, stumps and any other debris.

b. Agricultural lime, when specified, shall be applied uniformly either prior to or during soil preparation and shall be incorporated into the soil to the depth shown on the plans and at the rate specified in the contract documents or ordered by the Engineer.

c. Soil preparation operations shall be directional along the contours of the areas involved. On roadbed cut and fill slopes, the operations shall closely parallel the roadbed center line to form minor ridges and irregularities thereon to retard erosion, retain seed and favor germination of seeds.

627-3.03 Seeding Time

a. Seeding shall not be done during windy weather or when the ground is excessively wet and untillable that satisfactory results are not likely to be obtained.

b. The Contractor shall give at least 48-hours advance notice to the Engineer of the time and place of starting his seeding operations and shall not proceed with such work until

authorized by the Engineer. The Contractor shall keep the Engineer advised as to his proposed schedule of seeding.

627-3.04 Application Methods

a. General - Seed, fertilizer, agricultural lime and mulch materials shall be placed by either one of the methods described below, at the option of the Contractor unless otherwise called for in the contract documents. Seed shall be of the kind and applied at the rate indicated in the contract documents. If the kind of seed and the rate of application are not indicated, then the seed shall be a mixture of 60% Rye and 40% Bermuda grass applied at a rate of not less than 3 1/2 pounds of live seed mix per every 100 square meters of area to be seeded.

b. Hydraulic Method

1. The seed, seed and fertilizer, or the seed, fertilizer and suitable mulch materials shall be mixed in the specified amount of water to produce a slurry and then applied under pressure on the areas and at the rates indicated. When wood cellulose mulch materials are to be incorporated as an integral part of the slurry mix, they shall be added after the seed, fertilizer and any specified agricultural lime, have been thoroughly mixed.

2. When the hydraulic method is employed, seed and fertilizer may be applied in one application provided the fertilizer is added to the slurry before the seed.

3. Any area inadequately covered shall be re-treated as directed by the Engineer.

c. Dry Method

1. Power drawn seeders, seed drills, or other approved mechanical equipment may be used when seed and fertilizer are to be applied in dry form. Hand operated seeding devices may be used on areas which are inaccessible to mechanical seeders.

2. When the dry seeding method is employed, the seed and the fertilizer shall be applied separately. The fertilizer shall be incorporated into the upper portion of the seedbed prior to the seeding operation.

627-3.05 Fertilizing - Fertilizer shall be applied at the rate and of the type specified in the contract documents. If the fertilizer type and rate of application are not indicated, the fertilizer used shall be the 12-6-8 or 12-8-8 formula initially applied at the rate of not less than 10 pounds per 100 square meters followed by a second application, within 90 calendar days, of not less than 10 pounds per 100 square meters.

627-3.06 Mulching

a. Mulch, when specified, shall be spread uniformly over seeded areas at the rates shown in the contract documents within 48 hours following seeding. If no rate is indicated, a rate of not less than 25 pounds of mulch per 100 square meters of area shall be applied.

b. On steep slopes mulch shall be tied down by covering with jute mesh or by spraying with an approved soil stabilizer as shown on the plans or directed by the Engineer.

c. Care shall be exercised in the mulching operations to prevent displacement of soil, fertilizer and seed in place on the project and to prevent disfigurement or damage to the areas on which the mulching is performed. Mulch material which comes upon adjacent trees and shrubs, roadways, in drain ditches, on structures, upon areas where mulching is not

specified, or which collects at the ends of culverts or accumulates to excessive depths on mulched areas shall be removed therefrom and shall be spread lightly on specified areas, restored to thinly mulched areas or wasted as conditions warrant and as the Engineer may approve or direct. Mulch materials which are deposited in a matted condition or in clumps shall be loosened and spread uniformly over the areas.

627-3.07 Watering - The seeded areas shall be watered regularly so as to provide optimum growth conditions for the establishment of the grass cover.

627-3.08 Care and Maintenance

a. The Contractor shall care for the seeded and mulched areas until the project is completed and accepted. When, in the judgment of the Engineer, at any time prior to acceptance, any area which has been seeded fails for any reason to produce a satisfactory growth of grass after a suitable period of time has elapsed, the Contractor shall reseed, refertilize and, if necessary, remulch such areas in the same manner as specified in the contract and at his expense.

b. The Contractor shall protect seeded areas against traffic by warning signs or barricades, as approved by the Engineer.

c. The Contractor shall mow, water and otherwise maintain seeded areas in a satisfactory condition until final inspection and acceptance of the work. Such maintenance shall include the filling, leveling and repairing of any washed or eroded areas as may be necessary. If a seeded area must be reseeded due to the Contractor's negligence, carelessness, or failure to provide routine maintenance of such area, such replacement shall be at the Contractor's expense.

SPECIFICATION 627 – TURF ESTABLISHMENT

627-4 METHOD OF MEASUREMENT

627-4.01 Seeding, with and without mulch, will be measured by 100 square meter units of ground surface, measured to the nearest tenth of a unit, which has been acceptably seeded.

627-4.02 Any required seed, agricultural lime, fertilizer, mulch, water and soil stabilizer as called for in the contract documents will not be measured for separate payment but shall be included as a subsidiary obligation under the respective seeding pay items.

627-4.03 Jute mesh will be measured by number of square meters, surface measurement, of mesh furnished, placed and accepted.

627-5 BASIS OF PAYMENT

627-5.01 The accepted quantities, determined as provided above, for the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and placing all the required materials, and for all equipment, tools, labor and incidentals necessary to complete all the work for each item as required by the plans and specifications, including the care and maintenance of the turf until the project is accepted.

627-5.02 Payment will be made under:

Pay Item	Pay Unit
Seeding, (without mulch)……	100 – Square Meter Unit
Seeding, (with mulch)…..……...	100 – Square Meter Unit
Jute Mesh……..……...	Square Meter

SPECIFICATION 628 – SODDING

628-1 DESCRIPTION

628-1.01 Scope - This work shall consist of preparing the sod bed; furnishing, cutting, hauling, placing and maintaining sod of perennial turf-forming grasses; furnishing and placing fertilizer and agricultural lime, if required; all in conformance with these specifications and at the locations shown on the plans or as designated by the Engineer.

628-2 MATERIALS

628-2.01 Materials for this work shall meet the requirements of the following articles of Specification 713 - Roadside Improvement Materials:

Agricultural Lime……	713-2
Fertilizer……..	713-3
Sod…….....	713-5
Water……...	713-9.01
Pegs for Sod……	713-9.09

628-3 CONSTRUCTION REQUIREMENTS

628-3.01 Sources of Sod - The Contractor shall notify the Engineer, not less than five days prior to cutting sod, on the proposed source of the sod to be used. The sod requires the approval of the Engineer in its original position before cutting and delivery to the project.

628-3.02 Preparation for Sodding

a. Before the placing of sod, the areas to be sodded shall be brought to the required lines and grades and then plowed, disked or harrowed, or otherwise loosened, to a depth of not less than 5 centimeters. Stones larger than 5 centimeters in any diameter, sticks, stumps and other debris which might interfere with the proper laying and subsequent growth of the sod, shall be removed.

b. On slopes steeper than 3:1 the depth of tillage may be reduced as directed by the Engineer; however, the earth surface shall be loosened prior to applying fertilizer, agricultural lime or other material.

628-3.03 Topsoiling - Topsoil, when included in the contract or ordered by the Engineer, shall be placed, measured and paid for as provided in Specification 625 or Specification 203 as may be applicable.

628-3.04 Applying Fertilizer and Agricultural Lime

a. Following preparation for sodding and topsoiling, if required, fertilizer and agricultural lime shall be uniformly spread at the rates indicated in the contract documents. If no rates are indicated, the fertilizer shall be applied at a rate of not less than 10 pounds per 100 square meters of area for 20-20-20 formula and 20 pounds per 100 square meters for 10-10-10 formula.

b. Mechanical spreaders, blower equipment or other approved mechanical equipment may be used for spreading the fertilizer and lime in dry form after which such materials shall be incorporated into the soil by disking or tillage.

628-3.05 Cutting, Lifting and Storing Sod

a. The sod may be cut into rectangular blocks or in strip sections of such sizes that will permit the sod to be lifted without breaking. The sod shall be cut to a depth equal to the growth of the roots but in no case less than 5 centimeters.

b. Sod blocks or strips shall be cut away below the root line with sharp sod cutting tools or spades. Strips shall be rolled into tight rolls or laid flat on boards or planks and lifted and transported to storage piles or carried direct to the point of placing without breaking. All lifting and unloading shall be done by hand. Dumping from vehicles will not be permitted.

c. Sod shall be placed as soon after cutting as is practicable. If not laid within the first 24 hours, the sod may be temporarily stored in stacks but for not more than 3 days. Sod stored beyond this 3-day limit may be rejected by the Engineer if he determines that its survival is doubtful.

d. While in temporary storage, sod shall remain in tight rolls or shall be stacked grass to grass and roots to roots. The stored sod shall be kept moist by periodic water sprinkling. When required by the Engineer, the sod stacks shall be covered with wet burlap, straw or other acceptable material that will keep it moist and protected from the sun. Any sod that is permitted by the Contractor to dry out while in transit or storage will be rejected if in the judgment of the Engineer its survival after placing has been rendered doubtful.

628-3.06 Placing Sod

a. Sodding shall be incorporated into the project at the earliest practical time in the life of the contract. As soon as a suitable length of roadway where sodding is to be placed has been graded and is ready for sodding, the Contractor shall, unless otherwise directed by the Engineer, proceed at once with the sodding of the available areas.

b. Sodding shall not be performed when weather and soil conditions are, in the Engineer's opinion, unsuitable for proper results.

c. Before the sod is placed, the underlying soil shall be well moistened.

d. Sod shall be placed edge to edge with staggered joints. Any openings shall be plugged with sod or filled with acceptable loamy topsoil. After placing and joint filling, sod shall be rolled or tamped with approved equipment to eliminate air pockets and provide an even surface.

e. Where sodding is used in drainage channels, the setting of the pieces shall be staggered in such way as to avoid a continuous seam along the flow line.

f. Sod placed in channels, on slopes steeper than 2:1, and in other areas where the sod may slide due to height and slope, shall be pegged after tamping. The pegs shall be driven flush with the sod surface and into firm earth. Spacing shall be at approximately 60 centimeter on centers or as ordered by the Engineer.

g. Any pieces of sod which, after placing, show an appearance of extreme dryness shall be removed and replaced with living sod at the Contractor's expense.

628-3.07 Maintenance and Protection of Sod

a. Sod shall be watered when laid and shall be kept moist by watering at appropriate intervals until final acceptance. The moistened condition shall extend at least to the full depth of the rooting zone.

b. Watering shall be done in a uniform distribution pattern and in such way as to avoid erosion and prevent damage to the sodded areas by wheels or vehicles.

c. The Contractor shall erect, at his expense, necessary warning signs and barriers to protect sodded areas.

d. The Contractor shall, at his expense, periodically mow sodded areas as required to maintain a height of grass not exceeding 7.5 centimeters.

e. The Contractor shall, at his expense, remove and replace dried out or damaged sod.

SPECIFICATION 628 – SODDING

628-4 METHOD OF MEASUREMENT

628-4.01 Sodding will be measured by the square meter of surface area of healthy living sod placed and finally accepted.

628-4.02 Furnishing and placing of fertilizer, agricultural lime, and pegs, and watering will not be measured for direct payment. These shall be a subsidiary obligation of the Contractor included under the sodding pay item.

628-5 BASIS OF PAYMENT

628-5.01 The area of accepted sodding, determined as provided above, will be paid for at the contract unit price per square meter. Such price and payment shall constitute full compensation for soil preparation; furnishing and applying fertilizer and agricultural lime; furnishing, placing, pegging, watering, mowing, maintaining and protecting the sod; and for all labor, equipment, tools and incidentals necessary to complete the work as required by the plans and specifications.

628-5.02 Payment will be made under:

Pay Item	Pay Unit
Sodding……	Square Meter

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

630-1 DESCRIPTION

630-1.01 Scope

a. This work shall consist of constructing prestressed concrete structures and the prestressed concrete members of composite structures, in conformity with the lines, grades, design and dimensions shown on the plans, or established by the Engineer, and in accordance with this and other specifications involved.

b. The work shall include the furnishing and placing of all required formwork, concrete, curing materials, reinforcing steel, bearing assemblies and any appurtenant items necessary for the particular prestressing system to be used, including but not limited to ducts, anchorage assemblies, prestressing steel, and grout used for pressure grouting ducts.

c. The work shall include the manufacture, transportation and storage of beams, slabs, piling and other structural members of precast concrete, prestressed by either pretensioning or post-tensioning methods. It shall also include the installation of all precast prestressed members except piling, which shall be placed as provided for in Specification 615 - Piling.

630-1.02 Prestressing Methods

a. Unless otherwise provided for in the contract documents, the method of prestressing to be used will be optional with the Contractor, subject to all requirements hereinafter specified.

b. Prior to casting any members to be prestressed, the Contractor shall submit shop drawings to the Engineer for approval with complete details of the method, materials, and equipment he proposes to use in the prestressing operations. Such details shall outline the method and sequence of

stressing, complete specifications and details of prestressing steel and anchoring devices proposed for use, anchoring stresses, types of enclosures, and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, grouting materials and equipment.

c. In the event that the Contractor desires to use materials or methods that differ from those specifically shown on the plans and described in these specifications, he shall submit full plan details and specifications on the changes proposed. In order for any such alternate materials or methods to be considered, they shall comply with all the applicable provisions of the AASHTO Standard Specifications for Highway Bridges and the specified design criteria. The Authority shall be the sole judge on the adequacy and acceptability of any proposed alternative materials and methods.

d. Unless otherwise permitted or ordered by the Engineer, the Contractor or fabricator shall have available a technician, skilled in the prestressing method approved for use, who shall supervise and give such assistance in the use of the prestressing equipment and installation of materials as may be necessary to obtain the required results.

630-2 MATERIALS

630-2.01 Concrete and Grout

a. Concrete and Grout shall conform to all the applicable requirements of Specification 601 - Concrete.

b. Concrete in prestressed members shall be of the class and have the 28-day compressive strength specified on the plans. The concrete mix shall be designed by the Contractor, who shall be responsible for producing concrete which meets the specified strength requirements. When requested by the

Engineer, the Contractor shall submit certified test results made on standard cylinders, conforming to AASHTO T 22 and T 23, which show that the proposed mix meets the strength requirements. If no strength or class of concrete is indicated on the plans, Class D concrete shall be furnished.

c. Admixtures, if used, shall impart the properties of low water content, good flowability, minimum bleed, and expansion if desired. They shall contain no chemicals in quantities that may have harmful effect on the prestressing steel or cement. Admixtures containing chlorides in excess of 0.5 percent by weight of admixture, assuming 1 lb. of admixture per sack (94 lb. of cement), fluorides, sulphites, and nitrates shall not be used.

d. The water soluble chloride ions in concrete and grout for prestressed units shall not exceed 0.06 percent by weight of cement.

630-2.02 Reinforcing Steel - Shall conform to Specifications 602 and 709.

630-2.03 Prestressing Steel

a. Prestressing steel shall conform to the requirements of Specifications 602 and 709 for the type called for in the contract documents.

b. All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting. Material which shows injurious defects and excessive rust prior to its installation in the work will be rejected.

c. All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices. All anchoring devices for post-tensioning shall be capable of holding the prestressing steel at a load producing a

stress of not less than 95 percent of its guaranteed minimum tensile strength.

d. The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete.

630-2.04 Bearing Plates and Pads

a. Unless otherwise shown on the plans, the sole plates, bearing plates, anchor bolts and nuts shall be of chromium-nickel stainless steel meeting the requirements of Specification 715.

b. Elastomeric bearing pads shall conform to the requirements of Specification 717 and to the dimensions shown on the plans. Shop drawings shall not modify such dimensions nor the specified hardness.

630-2.05 Miscellaneous - All water used for flushing ducts shall contain 0.1 lb. per gallon of either quick lime (calcium oxide) or slaked lime (calcium hydroxide). All compressed air used to blow out ducts shall be oil free.

630-2.06 Sampling and Testing

a. Concrete will be sampled and tested in accordance with the requirements of Specification 601 - Structural Concrete.

b. Prestressing Steel and Anchorages

1. All wire, strand, anchorage assemblies, or bars to be shipped to the site shall be assigned a lot number and tagged for identification purposes.

2. All samples submitted shall be representative of the lot to be furnished and in the case of wire or strand, shall be taken from the same master roll.

3. All of the material specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use.

4. The Contractor shall furnish for testing, when requested, the following samples selected from each lot. If ordered by the Engineer, the selection of samples shall be made at the manufacturer's plant by the inspector.

(a) Pretensioning method - Samples at least 2.15 meters long shall be furnished of each strand size. A sample shall be taken from each end of every coil.

(b) Post tensioning method - Samples of the following lengths shall be furnished:

For wires requiring heading - 5.2 meters.

For wires not requiring heading - sufficient length to make up one parallel-lay cable 1.5 meters long consisting of the same number of wires as the cable to be furnished.

For strand to be furnished with fittings - 1.5 meters between near ends of fittings.

For bars to be furnished with threaded ends and nuts - 1.5 meters between thread at ends.

(c) Anchorage assemblies - Two anchorage assemblies shall be furnished,

complete with distribution plates of each size or type to be used, if anchorage assemblies are not attached to reinforcement samples.

5. Samples will be tested for yield strength, tensile strength, and elongation as per AASHTO T 244.

6. When prestressing systems have been previously tested and approved for similar projects by an agency acceptable to the Authority, complete tendon samples need not be furnished provided there is no change in the materials, design or details previously approved, and that certified test reports are submitted to the Engineer.

c. Elastomeric Bearing Pads - The Contractor shall submit certified test reports of the pads he proposes to use. He shall order, at his expense, one extra pad for each structure and furnish these to the Authority for testing.

630-2.07 Acceptability of Prestressed Concrete Units

a. Rejection of Units - Any prestressed concrete unit not fabricated in accordance with the requirements of the contract documents or displaying any of the following defects shall be subject to rejection.

1. Any unit not meeting the compressive strength requirements. In such cases, the acceptability will be subject to the provisions of Article 2.10 of Specification 601 except that each unit will be individually evaluated on the basis of the testing of cylinders made of its concrete without applying the principle of moving averages.

2. Any unit which has a prestress strand exposed.

3. Honeycomb of the unit to such an extent that chipping away from the honeycombed concrete results in a strand exposed in excess of 24 diameters.

b. Damaged Units - The Engineer will determine whether spalled, honeycombed or otherwise defective concrete in a prestressed unit is repairable or shall be rejected. For units approved for concrete repair the following applies:

1. Prior to beginning the repair, all spalled, honeycombed or disintegrated concrete shall be removed by chipping away unsuitable material until sound concrete is reached.

2. All surfaces to be repaired shall be thoroughly cleaned by sandblasting or as ordered by the Engineer.

3. Repair of the concrete shall be made with an epoxy grout composed of an epoxy resin system, meeting the appropriate requirements of AASHTO M 235, mixed with fine aggregate in an approximate ratio of one (1) part epoxy to two (2) parts fine aggregate. The exact proportion shall be determined on-site to produce a dense void-free grout.

4. The epoxy grout shall be placed against a clean and primed surface.

5. Pointing of minor honeycombs and other minor repairs may be made with a mortar of cement and fine aggregate mixed in the same proportions as the concrete being repaired.

c. Forms for prestressed units shall comply with the requirements for formwork for structural concrete specified in Specification 601. Prestressed units shall also meet the following tolerance requirements:

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

		I-Beams	Box Beams
1.	Length	± 6 mm per 10.5 m, ± 25 mm. max.	± 19 mm
2.	Width (overall)	± 13 mm., - 6mm	± 6 mm
3.	Width (web)	± 10 mm, - 6mm	± 10 mm
4.	Depth (overall)	± 13 mm, - 6mm	± 6 mm
5.	Depth (flanges)	± 6 mm	top: ± 13 mm bottom: ± 13 mm, - 3 mm
6.	Sweep (variation from straight line parallel to center-line of unit)	3 mm per 3 m	up to 12m: ± 6mm 12 to 18m: ± 10mm over 18m: ± 12mm
7.	Camber variation from design camber	± 3mm per 3m ± 13mm max. to 24 m ± 5mm max. over 24 m	± 3mm per 3m, ± 13mm max.
8.	Position of tendons	± 6mm	± 6mm
9.	Position of stirrups	± 19 mm ± 50 mm	+ 6m, - 19mm ± 25mm
10.	Position of deflection points for deflected strands	± 300 mm	± 300mm
11.	Position of plates	± 25mm	± 25mm

		I-Beams	Box Beams
12.	Position of bearing plates	± 16mm	-
13.	Position of ducts	± 6mm	± 6mm
14.	Position of inserts	± 13mm	± 13mm
15.	Position of handling devices		
	Parallel to length	± 150mm	± 150mm
	Transverse to length	± 25mm	± 25mm
16.	Variation from specified end squareness of skew		
	Horizontal	± 6mm per 300mm ± 25mm max.	± 3mm per 300mm ± 13mm max.
	Vertical	± 3mm per 300mm of depth	± 13mm

d. Prestressed precast slabs, including hollow core and void slabs, shall comply with the following dimensional tolerances:

1.	Length	± 13 mm
2.	Width	± 6mm
3.	Depth	± 6mm
4.	Flange angle	3mm per 300mm, 13mm max.

5.	Variation from specified end squareness or skew	± 13mm
6.	Sweep	± 10mm
7.	Camber	As shown on plans
8.	Top flange, bottom flange and web thickness – shall be not less than 85% of specified.	
9.	Center of gravity of strand group	± 6mm
10.	Position of individual strand	± 13mm vertical ± 18mm horizontal
11.	Position of plates	± 50mm
12.	Tipping and flushness of plates	± 6mm
13.	Local smoothness (Does not apply to deck surfaces left rough to receive a topping)	6mm in 3m

e. Other prestressed units shall meet the dimensional tolerances specified in the plans or special provisions.

f. Units which do not meet the dimensional tolerances and other plan and specification requirements, and damaged units which cannot be satisfactorily repaired, will be rejected and replaced with acceptable units at the Contractor's expense.

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

630-3 CONSTRUCTION REQUIREMENTS

630-3.01 General

a. Prestressed concrete members shall be constructed in accordance with the requirements of Specification 601 - Structural Concrete and the reinforcement steel shall be placed in accordance with Specification 602 - Reinforcement Steel, as modified and supplemented by this specification.

630-3.02 Prestressing Equipment

a. The jacking system used for stressing the tendons shall be approved by the Authority prior to use.

b. The jacking system shall be equipped with accurately reading gages to show the stressing loads and each jack shall be accompanied by a current certified calibration chart for its gage. The jacking system shall also provide an independent procedure by which the tendon elongation can be measured.

c. The jacking system used shall be capable of inducing and sustaining the required tendon loads.

d. Safety measures shall be taken by the Contractor to prevent accidents due to possible breaking of the prestressing steel or the slipping of the grips during the prestressing process.

630-3.03 Casting Yard - The precasting of prestressed concrete structural members may be done at any location selected by the Contractor, subject to approval by the Engineer.

630-3.04 Ducts for Prestressing Steel

a. Ducts for placing prestressing steel in post tensioned units shall be accurately placed, within the tolerances specified in Article 2.07 above, at the locations shown on the

plans or approved by the Engineer, and securely fastened in place to prevent displacement.

b. All ducts shall be made of galvanized ferrous metal and shall be mortar tight. However, the Contractor, at his option, may form the enclosures by means of cores or ducts made of rubber or other suitable materials which can be completely removed prior to installing the prestressing steel.

c. Ducts shall be strong enough to maintain their alignment and shape under such forces as will come upon them during the construction operations. They shall be 0.63 cm. (1/4") larger in internal diameter than the bar, cable, strand or group of wires which they will enclose.

d. Joints between sections of ducts shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at the connections.

e. All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after the prestressing has been completed.

f. Ducts shall be provided with vents as shown on the plans or ordered by the Engineer. The vents shall be mortar tight and shall provide means for ejection of grout through the vents and for sealing the vents.

g. After installation, the ends of ducts shall be covered as necessary to prevent the entry of water or debris.

630-3.05 Placing Prestressing Steel - Wires, wire groups, parallel- lay cables, and any other prestressing elements shall be straightened to insure proper position in the ducts. Suitable horizontal and vertical spacers shall be provided as required to hold the wires in place in true position in the ducts.

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

630-3.06 Pretensioning

a. The prestressing elements shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongations produced thereby. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor shall end anchorage be released, until the concrete of the members have attained a compressive strength of at least 4000 psi, or as indicated on the plans.

b. The concrete compressive strength for load transfer shall be determined by the use of standard cylinders cast and cured in the same manner and under the same condition as the structural member. In the event that these cylinders do not meet the minimum requirements for load transfer, the members in question shall be stressed at 28 days age if the results of the laboratory cured cylinders meet the minimum specified compressive strength at this age.

c. The prestressed elements shall be cut or released in such a sequence that the lateral eccentricity of the prestressed member is maintained at a minimum.

630-3.07 Placing Concrete

a. Concrete shall not be deposited in the forms until the Engineer has inspected the placing of the reinforcement, ducts, anchorages, and prestressing steel and has given his approval thereof.

b. Prior to placing concrete, the Contractor shall demonstrate to the satisfaction of the Engineer that all ducts are unobstructed.

c. The concrete shall be vibrated internally or externally, or both, as ordered by the Engineer. The vibrating shall be done with care in such a manner as to avoid displacement of reinforcing ducts or wires.

d. After completion of the concrete placing, the ducts shall be blown out with compressed air to remove any mortar before it hardens.

630-3.08 Curing of Concrete

a. The prestressed units shall be water cured or cured by low pressure steam at the Contractor's option.

b. Water curing shall be performed as provided in Specification 601.

c. Steam curing shall be performed as follows:

1. Water curing shall be used from the time the concrete is placed until steam is first applied.

2. The casting bed for any unit cured with steam shall be completely enclosed by a suitable type of housing, tightly constructed so as to prevent the escape of steam and simultaneously exclude outside atmosphere. Two to four hours after placing concrete and after the concrete has undergone initial set as determined by AASHTO T 197, the first application of steam shall be made unless retarders are used, in which case the waiting period before application of the steam shall be increased to 4 to 6 hours.

3. The steam shall be at 100 percent relative humidity to prevent loss of moisture and to provide moisture for proper hydration of the cement. Application of the steam shall not be directly on the concrete. During application of the steam, the ambient

air temperature shall increase at a rate not to exceed 40°F per hour until a maximum temperature of from 140°F to 160°F is reached. The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam application, the ambient air temperature shall not decrease at a rate to exceed 40°F per hour until a temperature has been reached 20°F above the temperature of the air to which the concrete will be exposed.

630-3.09 Post-Tensioning

a. Tensioning of the prestressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions, indicate that the concrete of the particular member to be prestressed has at least the compressive strength specified in Article 630-3.06 above.

b. After the concrete has attained the required strength the prestressing reinforcement shall be stressed by means of jacks to the desired tension and the stress transferred to the end anchorage.

c. The tensioning process shall be so conducted that the tension being applied and the elongation of the prestressing elements may be measured at all times. The friction loss in the elements shall be estimated as provided in the AASHTO Standard Specification for Highway Bridges. Elongation and jacking pressures shall make appropriate allowance for friction and all possible slippage or relaxation of the anchorage.

d. A written record shall be kept of gauge pressures and elongations at all times and submitted to the Engineer for his review and approval.

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

630-3.10 Bonding Steel

a. Prestressing steel in post-tensioned units shall be bonded to the concrete by filling the void space between the duct walls and the tendon with grout.

b. The grout shall consist of portland cement, water, fine sand passing a No. 30 sieve, and an expansive admixture such as unpolished aluminum powder. The approximate mix shall be one part cement to 0.75 parts sand and water but the proportions shall be adjusted to obtain a grout having the consistency of a thick paint. It shall also be so proportioned that free water will not separate out of the mix. Plasticizer admixtures may be used in accordance with the manufacturer's recommendations provided they contain no chlorides, nitrates, fluorides, sulphites or other ingredients that are corrosive to steel.

c. The grout shall be mixed in mechanical equipment capable of producing a thoroughly mixed uniform product. The grout shall be continuously agitated until it is pumped. Retempering of the grout will not be permitted.

d. All prestressing steel to be bonded shall be free of dirt, loose rust, grease, or other deleterious substance. Before grouting, the ducts shall be free of water, dirt or any other foreign substance. The ducts shall be blown out with compressed air until no water comes through the duct. For long members with draped strands, an open tap at the low point of the duct may be necessary.

e. Grouting equipment shall be capable of grouting at a pressure of at least 100 psi and shall be equipped with a pressure gage having a full scale reading of not more than 300 psi.

f. Grout injection pipes shall be fitted with valves, caps or other devices capable of withstanding the pumping pressure.

g. After the tendons have been stressed and the ducts blown out with compressed air, each duct shall be completely filled, starting from the low end, with grout under pressure. Grout shall be pumped continuously through the duct at moderate pressure and wasted at the outlets and vents until all entrapped air or water is forced out as evidenced by a steady stream of grout coming out for 10 seconds. All vents and openings shall then be closed and the grouting pressure increased to 100 psi and held there for a minimum of 10 seconds. Valves and caps shall not be removed or opened again until the grout has set.

630-3.11 Handling and Transporting

a. Extreme care shall be exercised in handling, hoisting and moving precast prestressed concrete members. Precast girders and slabs shall be transported in an upright position and the points of support and directions of the reactions with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position. Units damaged by improper storing, handling or moving shall be replaced by the Contractor at his expense.

b. Prestressed concrete units shall not be handled and transported until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions as the unit, indicate that the concrete has attained a compressive strength equal to the specified design compressive strength.

c. Beams placed in their final position in overpass structures open to traffic shall be securely anchored, either permanently or temporarily, to protect traffic moving under them.

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

630-4 METHOD OF MEASUREMENT

630-4.01 Prestressed concrete structural members, except piling, will be measured as individual units of the several types and sizes installed in place, completed and accepted. Each unit shall include the concrete, reinforcement and prestressing steel, ducts for prestressing steel, shear connectors, anchorages, plates, nuts and other such material contained within or attached to the member. In addition, prestressed bridge beams and girders shall include the complete bearing assemblies including shoes, rockers, rollers, pins, elastomeric pads, grout pads, canvas and any other materials used to level or support the beams and girders on the abutments, piers, or bents.

630-4.02 Precast prestressed piling will be measured and paid for as provided under Specification 615 - Piling.

630-5 BASIS OF PAYMENT

630-5.01 The quantity, determined as provided above, of prestressed structural concrete members will be paid for at the contract unit price per unit, which price and payment shall constitute full compensation for all materials, labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications, except as provided below for units with deficient strength accepted by the Authority.

630-5.02 Units found deficient in strength but accepted by the Authority under the conditions of Article 630-2.07 above will be paid for at a reduced unit price. The price reduction will be computed in accordance with the formula specified in Article 5.05 of Specification 601.

SPECIFICATION 630 – PRESTRESSED CONCRETE STRUCTURES

630-5.03 Payment will be made under:

Pay Item	Pay Unit
Prestressed Structural Concrete Member…….	Each
(Identify by type and nominal dimensions)*	

* The dimensions indicated for the bid item are nominal for identification and pay purposes. Actual dimensions for construction shall be as specified on the plans.

SPECIFICATION 631 – PNEUMATICALLY APPLIED MORTAR

631-1 DESCRIPTION

631-1.01 Scope

a. This work shall consist of lining ditches and channels, paving of slopes, constructing warped sections and similar structures, encasing steel members, and replacing unsound concrete with a pneumatically applied mortar in accordance with these specifications and in conformance with the lines, dimensions and details shown on the plans or established by the Engineer.

b. Pneumatically applied mortar shall consist of a dry mixture of sand and cement carried by compressed air to a nozzle where water is added and the resulting mixture is jetted from the nozzle at high velocity onto the surface to which it is to be applied.

631-2 MATERIALS

631-2.01 Materials shall meet the requirements of the following specifications:

Portland Cement……..	Specification 701
Sand…….……...Table 703-1,	Specification 703
Water…….……..	Specification 712
Concrete Curing Material……	Specification 711
Reinforcing Steel…….	Specification 709

631-2.02 Mortar Composition

a. The proportions of cement and sand shall be based on dry and loose volumes and shall be as follows:

- Not less than one (1) part of cement to four (4) parts of sand for encasement of steel.

- Not less than one (1) part of cement to three (3) parts of sand for concrete repair.

- Not less than one (1) part of cement to four and one half (4 1/2) parts of sand for special linings.

b. The volume of water added at the nozzle shall be maintained at a practical minimum and shall not exceed three (3) gallons per sack of cement used in the dry mix.

c. When called for in the contract documents, the air-blown mortar shall be colored by mixing a fine ground, synthetic mineral oxide, specifically manufactured for coloring concrete, into the mortar. The coloring agent shall be uniformly mixed into the air-blown mortar to produce the specified color. Trial mixes shall be prepared by the Contractor and submitted for approval by the Engineer.

631-3 CONSTRUCTION REQUIREMENTS

631-3.01 Equipment

a. The batching and mixing equipment shall be capable of storing and producing mixed materials in sufficient quantity to maintain placing continuity.

b. The compressor shall be of adequate capacity to maintain a constant nozzle velocity for all parts of the work while simultaneously operating a blow pipe for cleaning away rebound. The air hose shall be equipped with a filter to prevent any oil or grease from contaminating the mortar.

c. The delivery equipment shall be capable of delivering a continuous, smooth, uniformly mixed material to the nozzle. The nozzle shall be equipped with a water ring and valve to permit adjustment of the water flow. The water added to the dry mortar mix at the nozzle shall be maintained at a pressure at least 15 psi greater than the air pressure. The

nozzle shall be capable of delivering a conical discharge stream.

631-3.02 Preparation of Surfaces

a. The earth or crushed rock foundations of areas to receive pneumatically applied mortar lining or paving shall be evenly graded to the lines, grades and dimensions shown on the places or ordered by the Engineer. It shall be thoroughly compacted with sufficient moisture to produce a firm foundation and to prevent absorption of water from the mortar, but shall not contain free surface water.

b. When replacing unsound concrete, the unsound concrete shall be removed until there are no offsets in the cavity which would cause abrupt changes in the new mortar thickness. No square shoulders shall be left at the perimeter of the cavity and all edges shall be tapered out. The final cut surface shall be sound and properly shaped, and shall be sandblasted. Prior to placing the pneumatically applied mortar, the receiving surface shall be thoroughly cleaned, wetted and air blown.

c. Other surfaces to which pneumatically applied mortar is to be bonded shall be thoroughly cleaned of dirt, paint, grease, organic matter and loose particles. Absorptive surfaces shall be wetted before the application of the mortar.

631-3.03 Forms - Required forms shall be structurally adequate and of such design that rebound or accumulated loose sand can freely escape or be easily removed. Side forms, shooting strips, and gaging wires shall be used at corners, edges and on surfaces where necessary to obtain true lines and proper thickness.

SPECIFICATION 631 – PNEUMATICALLY APPLIED MORTAR

631-3.04 Reinforcement

a. Reinforcement, when required on linings, paving and similar work, shall be as called for in the contract documents or as ordered by the Engineer.

b. Reinforcing steel shall consist of welded wire mesh or round bars spaced not less than 5 centimeters nor more than 10 centimeters apart either way, and having a diameter of not less than that of No. 12 wire, unless otherwise shown on the plans.

The cross sectional area of reinforcement steel shall be at least 0.2 per cent of the cross sectional area of the mortar.

c. When repairing old concrete, the reinforcement may consist of the existing bars plus any additional welded galvanized wire mesh or mechanical anchors required to anchor the mortar to the old concrete. On overhead surfaces of 2.5 centimeters or greater depth, galvanized wire mesh and mechanical concrete anchors shall be used.

d. Sufficient clearance shall be provided around the reinforcement to permit its complete encasement in the applied mortar. The reinforcement shall be at least 1.2 centimeters from the unexposed surfaces of the mortar and at least 2 centimeters from exposed surfaces of the mortar.

631-3.05 Mixing

a. The sand shall be measured by means of batch boxes approved by the Engineer or in a proportioning plant. The same source of sand shall be used throughout each structure.

b. Prior to the mixing, the moisture content of the sand shall be such that the sand-cement mixture will flow at a uniform rate, without slugs, through the delivery hose. The

sand shall be dampened or dried as required to bring its moisture content to a satisfactory level, normally between 3 and 6 percent by weight. Moisture content fluctuation shall not exceed 3 percent.

c. Sand and cement that have been mixed for more than 45 minutes shall not be used unless specifically authorized by the Engineer.

631-3.06 Placing

a. The nozzle shall be held in such a position and at such a distance that the stream of mortar impinges on the surface at approximately right angles without excessive impact and with a minimum of rebound. Similarly, the velocity of the mortar as it leaves the nozzle shall be maintained uniform and at a rate determined for the given job conditions to result in a minimum of rebound.

b. Rebound sand shall be removed from the surface prior to placing the original or succeeding layers. Rebound material shall not be reused.

c. The new mortar at the end of an application operation shall be sloped off to a thin edge at the construction joint prior to initial setting. This sloped portion shall be thoroughly cleaned and wetted before applying the adjacent section.

631-3.07 Finishing

a. After the mortar has been placed to the required depth, the surface shall be checked with a straightedge and any low spots or depressions shall be corrected with additional mortar in such a manner that the finished surface will be reasonably smooth and uniform for the type of work involved.

b. The natural gun finish will be sufficient unless the plans call for one of the finishes described in Article 601-3.18 of Specification 601 - Structural Concrete.

c. Loose areas of pneumatically applied mortar shall be removed and replaced by the Contractor at his expense.

631-3.08 Curing - Pneumatically applied mortar shall be cured as specified in Article 601-3.19 of Specification 601 - Structural Concrete. The surface shall be fully protected from loss of moisture for at least 7 days when Type 1 portland cement is used and 3 days if Type 3, high-early strength cement, is used.

631-4 METHOD OF MEASUREMENT

631-4.01 Pneumatically applied mortar used in linings, slope paving, and similar structures where area coverage can be determined shall be measured by the square meters, to the nearest tenth, of mortar placed and accepted in accordance with the dimensions shown on the plans or ordered by the Engineer.

631-4.02 When so specified in the Contract documents, pneumatically applied mortar used to replace unsound concrete will be measured by the number of U. S. bags (94 lbs.) of portland cement used in the amount of mortar mix actually applied and accepted.

631-4.03 Reinforcing steel placed and incorporated into the pneumatically applied mortar will be measured and paid for as prescribed in Specification 602 - Reinforcing Steel. However, if no separate pay item for reinforcing steel is included in the contract, the furnishing and placing of any required reinforcing steel shall be a subsidiary obligation of the Contractor and its cost included in the unit price for the pneumatically applied mortar.

631-5 BASIS OF PAYMENT

631-5.01 The completed and accepted quantity of pneumatically applied mortar, measured as provided above, will be

paid for at the contract unit price per square meter or bag as called for in the contract. Such price and payment shall constitute full compensation for furnishing all materials, equipment, tools, labor and incidentals, and for doing all the work necessary to complete the item as required by the plans and specifications.

631-5.02 Payment will be made under:

Pay Item	Pay Unit
Pneumatically Applied Mortar……	Square Meter or Bag

SPECIFICATION 632 – CLEANING AND REPAIR OF EXISTING CULVERTS AND STORM SEWERS

632-1 DESCRIPTION

632-1.01 Scope

a. This work shall consist of the cleaning and minor repairs of existing culverts and storm sewers in accordance with these specifications and in conformance with the details and locations shown on the plans or established by the Engineer.

b. The work under this specification does not include major repairs such as replacement of pipe sections; reconstruction of manholes, inlets and catch basins and relining with pneumatically applied concrete. The reconstruction or repaving of eroded concrete or metal pipe culvert inverts is also not included except for those culverts specifically indicated on the plans. Major repairs will be separately identified on the plans and will be performed and paid for under the appropriate specifications.

632-2 MATERIALS

632-2.01 Mortar for concrete pipe joint repairs shall conform to Article 705-5, Pipe Joint Mortar, of Specification 705.

632-2.02 Mortar for minor repairs of concrete surfaces shall conform to Article 705-6, Masonry Mortar, of Specification 705.

632-2.03 Epoxy grout for repairing cracks in PC concrete shall consist of a commercial epoxy resin adhesive system suitable for injection and meeting the requirements of AASHTO M 235.

632-2.04 Epoxy mortar for repairing eroded inverts of RC pipe culverts shall consist of a mixture of portland cement, fine aggregate, water and epoxy resin adhesive meeting the requirements of AASHTO M 235, Class II or III. The type and grading of the aggregate and the preparation of the mix shall be in accordance with the recommendations of the manufacturer of the epoxy resin.

SPECIFICATION 632 – CLEANING AND REPAIR OF EXISTING CULVERTS AND STORM SEWERS

632-2.05 Asphalt coating material for repairing and field coating corrugated metal pipe culverts shall consist of asphalt mastic meeting the requirements of AASHTO M 243.

632-2.06 Corrugated metal for the repair of inverts of CM pipes shall be zinc coated (galvanized) corrugated steel meeting the requirements of AASHTO M 36 and M 218 for the CM pipe culverts indicated on the plans.

632-3 CONSTRUCTION REQUIREMENTS

632-3.01 Cleaning

a. The cleaning of culverts and storm sewers shall consist of the removal of all rubbish, detritus and soil deposits accumulated within the conduits, manholes, inlets, catch basins and at the inlet and outlet ends of culverts. It also includes the cleaning and shaping of the inlet and outlet ditches to the right-of-way limits.

b. Pipes and other water conduits shall be cleaned by water jetting or by other acceptable mechanical or manual means that will remove all the accumulated objectionable material.

c. The Contractor shall dispose of all the removed material, at his expense, at the locations within the project designated on the plans or by the Engineer, or at locations outside the project limits selected and obtained by him which comply with all applicable legal and regulatory requirements.

632-3.02 Minor Repairs - The Contractor shall perform all minor repairs of pipes and other conduits, manholes, inlets and catch basins indicated on the plans. Minor repairs include:

a. The sealing with joint mortar or epoxy grout, as called for in the plans, of open joints and cracks in concrete pipe culverts, manholes, inlets and catch basins.

b. The repair with masonry mortar of spalled or disintegrated concrete surfaces, other than inverts, in pipes and other conduits, manholes, inlets and catch basins.

c. The repair of eroded inverts of concrete culverts specifically indicated on the plans with epoxy mortar.

d. The repair of eroded CM pipe inverts specifically indicated on the plans with new corrugated steel sheets.

e. The recoating of eroded bituminous coating in CM pipes, specifically indicated in the plans, with asphalt coating material. Also the field coating of CM pipe inverts repaired with new steel CM sheeting.

f. The removal, cleaning and repair of metal grates of inlets and catch basins, and the replacement with new ones of such grates specifically indicated in the plans.

632-4 METHOD OF MEASUREMENT

632-4.01 The cleaning and minor repair of existing culverts and storm sewers will be measured as follows:

a. Pipe and box culverts will be measured by the number of units, satisfactory cleaned and repaired, and accepted by the Engineer. Each culvert which is identified on the plans for repair and cleaning will be considered as an individual unit regardless of type, size and length.

b. Storm sewers will be measured by the linear meter of sewer line, regardless of type and size, satisfactorily cleaned and repaired, and accepted by the Engineer. Measurement will not include manhole and inlet structures.

c. Manholes, inlets and catch basins will be measured by the number of units, satisfactorily cleaned and repaired,

including the grates, and accepted by the Engineer. Each manhole, inlet and catch basin which is identified on the plans for repair and cleaning, or is a component of a storm sewer system which is scheduled for repair and cleaning, will be considered as an individual unit regardless of type and size.

d. The cleaning and repair of metal grates of inlets and catch basins will be a subsidiary obligation of the Contractor under the item of cleaning and repair of manholes, inlets and catch basins. However, those grates identified on the plans for replacement by new ones or the installation of new frames and grates where none existed, will be measured for payment as an individual unit each regardless of type or size.

e. Where a lump sum method of payment is specified in the contract, the cleaning and repair of all pipe and box culverts, and all catch basins and inlets will be considered as a single unit and no separate payment will be made for individual components.

632-5 BASIS OF PAYMENT

632-5.01 The accepted quantities, determined as provided above, for the pay items listed in Article 5.02 below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such price and payment shall constitute full compensation for all materials, equipment, tools, labor, and incidentals necessary to complete the work as required by the plans and specifications.

SPECIFICATION 632 – CLEANING AND REPAIR OF EXISTING CULVERTS AND STORM SEWERS

632-5.02 Payment will be made under:

Pay Item	Pay Unit
Cleaning and Repair of Culverts…….	Each
Cleaning and Repair of Storm Sewers…….	Linear Meter
Cleaning and Repair of Manholes, Inlets and Catch Basins…….	Each
Replacement Grates, New Frames and Grates……	Each
Cleaning and Repair of Pipe and Box Culverts, Catch Basins and Inlets……	Lump Sum

SPECIFICATION 634 – ADJUSTMENT OF UTILITIES

634-1 DESCRIPTION

634-1.01 Scope

a. This work shall consist of the adjustment by the Contractor of privately or publicly owned utility facilities occupying the project right-of-way, or adjacent thereto, which interfere with or are affected by the project construction. The work shall be performed in accordance with this specification, the latest applicable standards and specifications of the respective utilities, and in conformity with the lines, dimensions and details shown on the plans or established by the Engineer.

b. The adjustment work includes any required relocation, removal, replacement, rearrangement, reconstruction, improvement, disconnection, connection, shifting or altering of an existing utility facility in any manner as shown on the plans, described in the contract documents or ordered by the Engineer.

634-1.02 The work under this specification will cover the adjustment of facilities of the Puerto Rico Telephone Company (PRTC) when included in the contract. The adjustment of the facilities of the Puerto Rico Electric Power Authority (PREPA) and of the Puerto Rico Aqueduct and Sewer Authority (PRASA) are covered under separate specifications. Other utilities that occupy highway rights-of-way such as Pipeline of Puerto Rico, San Juan Gas Company, and the cable television companies perform their own utility adjustment work unless otherwise specifically provided in the contract.

634-1.03 The specific utility work to be performed by the Contractor is as indicated in the plans and other contract documents. Contractor's utility work is normally limited to the installation of the required new conduit runs including necessary excavation and backfill, and indicated pull, splice and junction boxes, and manholes. However, the contract may include other utility work items as specified in the plans and contract documents.

SPECIFICATION 634 – ADJUSTMENT OF UTILITIES

634-1.04 It shall be understood that the latest technical specifications and standards of a utility referred to or included in the contract documents to cover contract pay items apply to the materials and construction requirements of the work but that the measurement and payment for such item will be governed by the provisions of this specification.

634-1.05 When utility adjustment work is included for performance as part of the highway contract, the Contractor shall save harmless the utility owner from any claims for injuries and otherwise, sustained by the Contractor or his employees as a result of his utility adjustment operations.

634-1.06 The provisions of Article 105.06 of the General Provisions concerning the Contractor's responsibility for and cooperation with utilities are applicable, as appropriate, for all utility adjustment work, whether performed by the Contractor or by the utility.

634-2 MATERIALS

634-2.01 All materials required for utility adjustment work to be performed under the contract shall be furnished by the Contractor unless otherwise specified. These materials shall be new and shall meet the standards and specifications of the utility owner and the requirements of these specifications. However, sound salvaged materials obtained from the removal of existing facilities may be used in the adjustment work if acceptable to the utility owner.

634-2.02 Concrete used in utility adjustment work shall meet the applicable requirements of Specification 601 - Structural Concrete. Unless otherwise specified in the contract documents, concrete shall be Class A except for encasement of PVC conduits which shall be Class B.

634-2.03 Reinforcing steel shall be of the grade and class indicated on the plans and shall meet the requirements of Specification 602 - Reinforcing Steel. When not shown on the plans, Grade 60 shall be provided.

634-2.04 Conduits shall be of the types and sizes indicated on the plans or in the utility standards. Unless otherwise specified, galvanized steel conduit shall meet the requirements of Specification 714-9 and rigid plastic conduit the requirements of Specification 714-10.

634-3 CONSTRUCTION REQUIREMENTS

634-3.01 General

a. The Contractor shall give the owner of any utility facility to be adjusted at least two (2) weeks advance notice before beginning work in connection with the adjustment, to permit the utility to make arrangements to have a representative to supervise the work present at the site of the work. The Contractor shall not perform adjustment work without the presence of the owner's representative except when the right to have a representative present at the work is waived in writing by the owner.

b. The utility representative shall have free access, at all times to all parts of the work and to all material intended for use in the work concerning the owner's facilities. The Contractor shall coordinate with the owner's representative his proposed construction schedule and procedures.

c. The Contractor shall be responsible for maintaining the continuity of service of the existing utility installations when in operation and shall not interrupt the service, except with the written approval of the owner, for the purpose of making actual necessary final connections to the adjusted installations or otherwise, in which case the construction operations shall be arranged by the Contractor and duly coordinated with the owner's representative, to take the minimum possible time and assure the maximum safety of the operations.

d. The location of the adjusted facilities shown on the plans are approximate only and the exact location will be established by the utilities and the Engineer in the field. It shall be understood that any changes made by the Engineer in the vertical or horizontal locations shown in the plans, which do not materially affect the character and scope of the adjustment work, will be made by Contractor at no extra cost to the Authority.

e. Salvageable existing utility items identified in the contract documents, which are not to be used in the utility adjustment work shall be removed by the Contractor from the project site and delivered to the utility owner at the locations indicated in the contract documents, at the Contractor's expense.

f. Existing underground facilities which are not to be incorporated in the adjusted utility may be abandoned in place, if authorized by the Engineer, unless they interfere with the project construction or otherwise shown on the plans. However, such abandonment in place shall be subject to providing, at the Contractor's expense, any necessary protective measures such as plugging or filling of conduits, manhole and boxes as may be specified in the contract documents or required by the Engineer.

634-3.02 Excavation and Backfill - Excavation and backfilling shall be performed in accordance with the applicable requirements of Specification 205 - Trench Excavation and Specification 206 - Excavation for Structures, supplemented as follows:

a. Excavation for locating existing underground pipes and conduits shall be done by hand tools, unless otherwise authorized by the Engineer, and exercising the utmost care to avoid damage to the existing facility and the interruption of service. Power tools and picks shall be used only on the hard top surface with the excavation in the underlying soil material performed with hand shovels.

b. In making excavations in paved surfaces to remain, cuts shall be made with an abrasive type power saw along the neat boundaries of the area to be removed as specified in paragraph 3.03b below.

c. Backfill shall be placed as soon as practicable but not later than 3 days after the underground utility work has been completed and accepted. Backfill shall consist of material approved by the Engineer, placed in layers nor exceeding 20 centimeters in thickness, and compacted by mechanical tamping tools.

d. Unless otherwise authorized by the Engineer, all surplus excavated material shall be removed and disposed of outside the right-of-way or at locations within the project approved by the Engineer. The excavation site shall be cleaned up and left in a neat condition satisfactory to the Engineer.

634-3.03 Removing and Replacing Improvements

a. Existing improvements such as sidewalks, curbs, gutters, P.C. concrete and asphaltic concrete pavements, underlying materials, lawn and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of material as found in the work or with materials of equal quality acceptable to the Engineer. Replacement and repair of such improvements shall be undertaken as soon as practicable, but not later than 3 days, after the backfilling of the excavations has been completed and accepted.

b. The outline of all areas to be removed in pavements, sidewalks, curbs, gutters and driveways shall be cut to a minimum depth of five (5) centimeters with an abrasive type saw, prior to removing the existing material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

634-3.04 Conduit Runs

a. Conduit runs, including conduits, pull, splice and junction boxes, and manholes shall be constructed in accordance with the details shown on the plans and with the utility standards and specifications which are made part of the contract.

b. Conduit runs shown on the plans may be changed as to location only, with the approval of the utility representative and the Engineer, to avoid obstructions.

c. The use of the same trench for conduit runs of more than one utility will not be permitted unless specifically shown on the plans or authorized in writing by the utilities concerned.

d. All open conduit ends shall be capped or plugged until wiring is started.

e. Conduits in structures shall be provided with hangers as required and with expansion joints of an approved type at every expansion joint in the structure that the conduit crosses.

f. All conduits installed shall be tested for clear bore and correct installation by the Contractor using an appropriate snake before the installation will be accepted. Snaking of the conduits shall be done by the Contractor in the presence of the utility representative. Any obstructed conduit shall be cleared by the Contractor and he shall replace any defective conduit at his expense. A record shall be kept as the conduits are tested and, after testing, all the empty conduits and duct openings shall be capped or plugged by the Contractor as directed.

g. The tops of pull, splice and junction boxes installed in sidewalk or paved areas shall be flush with the surrounding grade or top of adjacent curb. Those installed in the ground shall have the tops projecting 5 cm. above the adjacent grade.

All conduit entrances into pull or junction boxes shall be made watertight.

634-3.05 Wiring - The furnishing and installation of all necessary wiring will be performed by the respective utility owners unless otherwise provided in the contract.

635-3.06 As-Built Plans - Upon completion of the utilities adjustment work, the Contractor shall submit to the Engineer "As-Built" plans of the adjustment work incorporating all the changes made, if any, in the original plans.

634-4 METHOD OF MEASUREMENT

634-4.01 When a lump sum method of payment is specified in the contract, the complete utility adjustment work shown on the plans will be considered a single unit and no separate measurement will be made of any of its individual components.

634-4.02 When components of the utility adjustment work are included as separate pay items in the contract these will be measured as follows:

a. Conduit will be measured by the linear meter of each type and size specified, installed according to the plans or as ordered by the Engineer, and accepted, and with all fittings, hangers, expansion devices, concrete encasement, warning ribbons and any other items required to provide a completed installation. Where a cluster of parallel conduits is installed in a conduit run, the length of each size of conduit will be determined by the product of the length of the cluster by the times the conduit occurs in the cluster.

b. Junction, splice and pull boxes, and manholes will be measured by the number of each type and size installed in accordance with the plans or as ordered by the Engineer, and accepted. Each unit shall be complete and include frames, covers and all necessary hardware.

c. The measurement of any other utility adjustment items of work which are not subsidiary and which are included as contract pay items for performance by the Contractor will be made as specified in the contract documents.

634-4.03 Excavation, bedding and backfill required for manholes, pull, splice and junction boxes, and conduit installations will not be measured directly for payment. These items shall be a subsidiary obligation of the Contractor with their cost included under the respective utility adjustment pay items.

634-4.04 Concrete and reinforcing steel for manholes, pull, splice and junction boxes, conduit encasement and other utility adjustment units will not be measured directly for payment but shall be a subsidiary obligation of the Contractor with their cost included under the respective utility adjustment pay items.

634-4.05 The connections of new utility installations to existing utility facilities to remain will not be measured for separate payment but shall be a subsidiary obligation of the Contractor with their cost included under the various utility adjustment pay items.

634-4.06 The removal and replacement of existing improvements required for the construction of the utility adjustments, covered under Article 634-3.03, will not be measured for direct payment but shall be a subsidiary obligation of the Contractor with the cost included under the utility adjustment pay items.

634-4.07 The required removal and disposition of any existing utility facility that is indicated in the plans and contract documents, and the salvaging and delivery to the designated sites of any utility items specified in the contract documents, will be measured for payment as a lump sum item. When no pay item is included in the contract, such removal and salvaging work shall a subsidiary obligation of the Contractor.

SPECIFICATION 634 – ADJUSTMENT OF UTILITIES

634-5 BASIS OF PAYMENT

634-5.01 The accepted quantities, determined as provided above for the pay items listed in Article 5.03 below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such price and payment shall constitute full compensation for furnishing and installing all required equipment and materials, and for all labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications.

634-5.02 When utility adjustment pay items not listed in Article 5.03 below are included in the contract, the basis of payment will be as specified in the contract documents.

634-5.03 Payment will be made under:

Pay Item	Pay Unit
Adjustment of Facilities of the P.R. Telephone Company……..	Lump Sum
Adjustment of Facilities of _____ (1)……	Lump Sum
_____ (2) Conduit……...	Linear Meter
Pull Box _____ (3)……...	Each
Splice Box _____ (3)……	Each
Junction Box _____ (3)……	Each

SPECIFICATION 634 – ADJUSTMENT OF UTILITIES

Pay Item	Pay Unit
Manhole _____ (3)…….	Each
Removal of Existing _____ (1) Facilities…….	Lump Sum

(1) Indicate the name of the utility.
(2) Indicate the type and size of the conduit.
(3) Indicate the type and size of the pull box, splice box, junction box or manhole.

SPECIFICATION 635 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO ELECTRIC POWER AUTHORITY

635-1 DESCRIPTION

635-1.01 Scope

a. This work shall consist of the adjustment by the Contractor of facilities of the Puerto Rico Electric Power Authority (PREPA) occupying the project right-of-way or adjacent thereto which interfere with or are affected by the project construction. The work shall be performed in accordance with these specifications, the applicable standards and specifications of PREPA, and in conformity with the lines, dimensions and details shown on the plans or established by the Engineer.

b. The work by the Contractor consists of the furnishing of all necessary materials and the installation of complete electrical distribution lines (primary and/or secondary) and/or transmission lines including, but not limited to, poles, distribution and transmission standards, conduits, conductors, transformers, fixtures, fittings and all other appurtenances and hardware required to complete the adjustments. The work also includes the removal of existing distribution and/or transmission lines indicated on the plans, and the relocation, removal, replacement, rearrangement or reconstruction of any other PREPA facilities shown on the plans or described in the contract documents.

635-1.02 Definitions

a. Distribution lines include overhead or underground lines of 2.40, 4.16, 4.8, 7.62, 8.32 and 13.20 KV. It also includes secondary lines of 120/240V, 120/208V, 120/277V and 240/480V.

b. Transmission lines include overhead or underground lines of 38, 115 and 230KV.

c. Transmission and distribution line standards refer to construction standards and details included in PREPA's Construction Standards Handbooks.

635-1.03 It shall be understood that PREPA technical specifications and standards referred to or included in the contract documents to cover contract pay items apply to the materials and construction requirements of the work but that measurement and payment for such items will be governed by the provisions of this specification. The latest PREPA standards and regulations shall prevail during the construction no matter the Standards Drawings and Specifications shown in plans.

635-1.04 When PREPA adjustment work is included for performance as part of the highway contract, the Contractor shall save PREPA harmless from any claims for injuries and otherwise, sustained by the Contractor or his employees as a result of his adjustment operations.

635-1.05 The provisions of Article 105.06 of the General Provisions concerning the Contractor's responsibility for and cooperation with utilities are applicable, as appropriate, for all PREPA adjustment work, whether performed by the Contractor or by PREPA.

635-2 MATERIALS

635-2.01 All materials required for the PREPA adjustment work to be performed under the contract shall be furnished by the Contractor unless otherwise specified. These materials shall be new and shall meet the requirements of the plans and these specifications. However, sound salvaged materials obtained from the removal of existing facilities may be used in the adjustment work if acceptable to PREPA.

SPECIFICATION 635 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO ELECTRIC POWER AUTHORITY

635-2.02 All electrical equipment and materials shall conform to the latest appropriate standards and specifications of PREPA, the Underwriters Laboratories (UL), the National Electrical Code (NEC), and other building codes and regulations applicable to the work.

635-2.03 Promptly following the execution of the contract but not later than 60 calendar days after receipt of notice of the contract award, the Contractor shall submit to PREPA and the Engineer for review and approval a complete list of all equipment and materials which he proposes to install in the adjustment work. The list shall include all the materials required by the plans and other contract documents indicating for each item the manufacturers' name, size and other descriptive data which is necessary and customarily used in the trade to identify such materials.

635-3 CONSTRUCTION REQUIREMENTS

635-3.01 General

a. The Contractor shall give PREPA at least two (2) weeks advance notice before beginning work on the utility adjustments, to permit PREPA to make arrangements to have a representative present at the site of the work. The Contractor shall not perform adjustment work without the presence of PREPA representative to supervise the work except when the right to have a representative present at the work is waived in writing by PREPA.

b. The PREPA representative shall have free access at all times to all parts of the work and to all material intended for use in the work concerning the PREPA facilities. The Contractor shall coordinate with the PREPA and the Authority representatives his proposed construction schedule and procedures.

c. The Contractor shall be responsible for protecting the existing PREPA installations from damage by his construction operations to insure the continuity of the utility service.

d. Any work involving disconnecting existing live lines, connection to live lines, and crossing of or working in close proximity to existing live lines shall be performed by PREPA personnel. The Contractor shall pay PREPA for the cost of such work. Upon receipt of a certified invoice or other acceptable evidence of payment by the Contractor, the Authority will reimburse the Contractor by an extra work order. The reimbursement will include the amount paid to PREPA, any additional municipal excise taxes, and insurance payments related to these work. No payment will be made for mark-up, administrative and incidental expenses, profit surcharges and any similar charge.

e. The Contractor shall be responsible for obtaining, at his expense, all permits and inspections required by PREPA and by applicable laws and regulations.

f. All adjusted facilities shall be completely installed, inspected, tested and left in operating condition to the satisfaction of PREPA and the Authority.

g. Construction shall be performed in accordance with the latest standard practices of PREPA and shall conform as to quality of materials used, tests and workmanship with the requirements of PREPA and all the applicable standards of the National Electrical Manufacturers' Association (NEMA), the Electronics Industries Association (EIA), the Institute of Electronic and Electrical Engineers (IEEE), the National Electrical Code (NEC) and the American National Standards Institute (ANSI). Any changes in the plans and specifications that may be considered necessary to meet the applicable requirements of any of these standards and codes shall be

submitted to PREPA and the Authority for written approval prior to being made.

h. Wherever reference is made in these specifications to any national or local code or standard it shall be construed to mean the code or standard which is in effect on the date the project is advertised for bids.

i. The locations of the adjusted facilities shown on the plans are approximate only and the exact location will be established by PREPA and the Engineer in the field. It shall be understood that any changes made by the Engineer in the vertical or horizontal locations shown in the plans, which do not materially affect the character and scope of the adjustment work, will be made by Contractor at no extra cost to the Authority.

j. Any changes proposed by the PREPA District Engineer and/or the Contractor that materially affect the character and scope of the adjustment work require the prior written approval of the PREPA central office and the Design Area of the Highway Authority.

k. Existing salvageable items identified on the plans, which are not to be used in the utility adjustment work, shall be removed by the Contractor from the project site and delivered to PREPA at the locations indicated in the contract documents, at the Contractor's expense.

l. Existing underground facilities which are not to be incorporated in the adjusted utility may be abandoned in place, if authorized by the Engineer, unless they interfere with the project construction or otherwise shown on the plans. However, such abandonment in place shall be subject to providing, at the Contractor's expense, any necessary protective measures such as plugging or filling of conduits, manholes and boxes as may be specified in the contract documents or required by the Engineer.

SPECIFICATION 635 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO ELECTRIC POWER AUTHORITY

635-3.02 PREPA Standards - For construction details not shown on the plans, reference shall be made to the PREPA Construction Standards Handbooks. These cover such items as typical pole construction, conductor separations and clearances, neutral conductor position, transformers details and installation, interconnections and grounding, and other applicable installation details.

635-3.03 Excavation and Backfill

a. Before beginning excavations for any underground work, the Contractor shall notify the utilities concerned, the Engineer and the Demolitions and Excavations Center, a minimum of two weeks in advance of the proposed excavation work, so that the location of all underground installations in the project area may be determined. It will be the responsibility of the Contractor to make the necessary contacts with utilities and others who have underground installations in the project area. Any damage to existing facilities, shown on the plans or identified by the utilities prior to excavations caused by negligence by the Contractor shall be repaired of the Contractor at no expense to the Authority.

b. Unless otherwise indicated in the contract documents, the Contractor shall do all excavation, backfilling and resurfacing work, including removal and replacement of curbs, sidewalks, paved surfaces and other materials necessary to complete the work in accordance with the plans and specifications.

c. Excavation and backfilling shall conform to the applicable requirements of Specification 205 - Trench Excavation and Specification 206 - Excavation for Structures, supplemented as follows:

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1. Excavations for locating existing underground conduits shall be done by hand tools, unless otherwise authorized by the Engineer, and exercising the utmost care to avoid damage to the existing facility and the interruption of service. Power tools and picks shall be used only on the hard top surface with the excavation in the underlying soil material performed with hand shovels.

2. The location of conduit trenches are shown approximately on the plans and will be located in the field by the Engineer. All conduit trenches shall be dug to the depth required by the PREPA construction standards.

3. In making excavations in paved surfaces, cuts shall be made with an abrasive type power saw along the neat boundaries of the area to be removed as specified in paragraph 3.04b below.

4. Foundation and backfill material for conduits shall comply with applicable PREPA requirements. Backfill shall be placed in layers not exceeding 20 centimeters in thickness and compacted by mechanical tamping tools. Backfill shall be placed as soon as practicable but not later than 3 days after the underground utility work has been completed and accepted.

5. All excavations for pole or pedestal concrete foundations shall be made to the neat lines of the foundations. No backfilling will be permitted as the concrete must be placed directly against the sides of the excavation. On completion of the work, the top surfaces shall be replaced and finished to correspond with the existing surrounding surfaces.

6. Unless otherwise authorized by the Engineer, all surplus excavated material shall be removed and disposed of outside the right-of-way or at locations within the project approved by the Engineer. The excavation site shall be cleaned up and left in a neat condition satisfactory to the Engineer.

635-3.04 Removing and Replacing Improvements

a. Existing improvements such as sidewalks, curbs, gutters, P.C. concrete and asphaltic concrete pavements, underlying materials, lawn and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of materials as found in the work or with materials of equal quality acceptable to the Engineer. Replacement and repair of such improvements shall be undertaken as soon as practicable but not later than 3 days after backfilling of the excavations has been completed and accepted.

b. The outline of all areas to be removed in pavements sidewalks, curbs, gutters and driveways shall be cut to a minimum depth of five (5) centimeters with an abrasive type saw, prior to removing the existing material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

635-3.05 As-Built Plans - Upon completion of the PREPA adjustment work, the Contractor shall submit to the Engineer "As-Built" plans of the adjustment work incorporating all the changes made, if any, in the original plans.

635-3.06 Partial Certifications and Final Acceptance - For the adjustment works of PREPA facilities, the Contractor shall obtain partial certifications every three months for the work executed. These certifications shall be performed and duly signed by a Puerto Rico licensed Electrical Engineer according to PREPA requirements

and submitted to PREPA for acceptance. When all adjustment works are completed, a final certification shall be submitted to PREPA for final acceptance and the Contractor shall furnish to the Authority PREPA's certification accepting the works.

635-4 METHOD OF MEASUREMENT

635-4.01 When a lump sum method of payment is specified in the contract, the complete PREPA adjustment work shown on the plans will be considered a single unit and no separate measurement will be made of any of its individual components.

635-4.02 When components of the PREPA adjustment work are included as separate pay items in the contract these will be measured as follows:

a. Poles of each material, class and size specified in the contract documents, installed complete and accepted, will be measured by the unit.

b. Transmission and distribution standards of each type specified in the contract documents, installed complete with all hardware and appurtenances and accepted, in conformity with PREPA requirements, will be measured by the unit.

c. Electrical conduit will be measured by the linear meter of each type and size specified, installed according to the plans or as ordered by the Engineer and accepted, and including all fittings, hangers, spacers, expansion devices, concrete encasement, warning ribbon and any other items required to provide a complete installation. Where a cluster of parallel conduits is installed in a conduit run, the length of each size of conduit will be determined by the product of the length of the cluster by the times the conduit occurs in the cluster.

d. Junction boxes, pull boxes and manholes will be measured by the number of each type and size installed in accordance with the plans or as ordered by the Engineer, and accepted. Each unit shall be complete and include frames, covers and all necessary hardware.

e. Conductors for transmission and distribution lines will be measured by the linear meter of each class and size specified in the contract documents, including spacers and messenger cables, installed complete and accepted according to the plans or as ordered by the Engineer.

f. Substations of each specified type and size furnished, installed and accepted will be measured as a unit. Each substation unit shall consist of the complete installation conforming to PREPA standards, ready for operation, including foundation, concrete pad (when required), specified pole and cross arms (when required), transformer, fuses, breakers, risers, connectors, fuse cutouts, lightning arresters, insulators, grounds, enclosures and cabinets (as required), and all necessary hardware and appurtenances.

g. The removal of existing electrical lines, including poles, conductors and all hardware and appurtenances, and including also the storing and delivery to PREPA of any salvageable materials specified in the contract documents which are not used in the adjustment work, will be measured as a lump sum item. When no pay item is included in the contract, such removal and salvaging work shall be a subsidiary obligation of the Contractor under the PREPA adjustment work.

635-4.03 The removal and replacement of existing improvements required for the adjustment of PREPA facilities, covered under Article 635-3.04, will not be measured for direct payment but shall be a subsidiary obligation of the contractor under the PREPA adjustment pay items.

635-4.04 Excavation, bedding and backfill required for foundations, poles, pull and junction boxes, and conduit installations will not be measured directly for payment. These items shall be a subsidiary obligation of the Contractor with their cost included under the respective utility adjustment pay items, except when a PREPA Standard pay item covering such work is included in the contract.

635-4.05 Concrete and reinforcing steel for foundations, conduit encasement, manholes, pole and junction boxes and other system units, will not be measured directly for payment but shall be a subsidiary obligation of the Contractor with their cost included under the respective utility adjustment pay items, except when a PREPA Standard pay item covering such work is included in the contract.

635-4.06 Any piles required for foundations will be measured and paid for under Specification 615 - Piling.

635-4.07 When the PREPA adjustment work is paid for by separate component pay units rather than as a lump sum item, it shall be understood that the combination of all component pay units shall provide for the complete adjustment ready for operation and that any miscellaneous fees, work, equipment, and materials necessary to complete the adjustment work shall be furnished and installed by the Contractor at no extra cost to the Authority. The cost of any of these miscellaneous items shall be considered as included under the contract pay items.

635-4.08 The costs for obtaining PREPA's certifications and acceptance of the performed works according to article 635-3.05 shall be considered a subsidiary obligation of the Contractor under the pay items of this specification included in the proposal schedule.

635-5 BASIS OF PAYMENT

635-5.01 The accepted quantities, determined as provided above for the pay items listed in Article 5.04 below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such price and payment shall constitute full

compensation for furnishing and installing all required equipment and materials, and for all labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications, and to the satisfaction of PREPA.

635-5.02 When PREPA adjustment pay items not listed in Article 5.04 below are included in the contract, the basis of payment will be as specified in the contract documents.

635-5.03 When the Contractor installs materials furnished by PREPA at no cost to the Contractor in exchange for similar materials salvaged from the existing PREPA facility, and for which payment is being made by the Highway Authority to the Contractor under a contract pay item, the value of such material will be deducted by the Authority from the payments due the Contractor.

635-5.04 Payment for works under this specification will be made according to the following schedule:

a. Eighty percent (80%) of the contract unit price for each pay item will be paid after the initial installation is completed and accepted by the Engineer.

b. The remaining twenty percent (20%) due to the Contractor will be paid to the Contractor after the submittal to the Authority of the certification of final acceptance of the works by PREPA.

635-5.05 Payment will be made under:

Pay Item	Pay Unit
Adjustment of PREPA Facilities……..…	Lump Sum
Wood Poles _____…… (Class, Size)	Each

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Pay Item	Pay Unit
Concrete Poles _____ (Class, Size)…….	Each
PREPA Transmission Standard _____ (Type)….	Each
PREPA Distribution Standards _____ (Type)…..	Each
Conductor _____ (Type, Size)……	Linear Meter
Conduit _____ (Type, Size)……	Linear Meter
PREPA Pull Box Standard _____ (Type, Size)……..	Each
PREPA Junction Box Standard _____ (Type, Size)….	Each
PREPA Manhole Standard _____ (Type, Size)……	Each
Substation _____ (Type, Size)……	Each
Removal of Existing PREPA Facilities……	Lump Sum

SPECIFICATION 636 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

636-1 DESCRIPTION

636-1.01 Scope

a. This work shall consist of the adjustment by the Contractor of privately or publicly owned utility facilities occupying the project right-of-way or adjacent thereto which interfere with or are affected by the project construction. The work shall be performed in accordance with these specifications, the latest applicable standards and specifications of the respective utilities, and in conformity with the lines, dimensions and details shown on the plans or established by the Engineer.

b. The adjustment work includes any required relocation, removal, replacement, rearrangement, reconstruction, improvement, disconnection, connection, shifting or altering of an existing utility in any manner described in the contract documents or ordered by the Engineer.

636-1.02 Where reference is made in this specification to the PRASA specifications, it shall be understood to refer to PRASA's Standard Specification for Water Works and Standard Specification for Sanitary Sewerage System, the editions in effect at the time the project is advertised for bids.

636-1.03 It shall be understood that PRASA technical specifications and standards referred to or included in the contract documents to cover contract pay items apply to the materials and construction requirements of the work but that measurement and payment for such items will be governed by the provisions of this specification.

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636-1.04 When PRASA adjustment work is included for performance as part of the highway contract, the Contractor shall save PRASA harmless from any claims for injuries and otherwise, sustained by the Contractor or his employees as a result of his adjustment operations.

636-1.05 The provisions of Article 105.06 of the General Provisions concerning the Contractor's responsibility for and cooperation with utilities are applicable, as appropriate, for all PRASA adjustment work, whether performed by the Contractor or by PRASA.

636-2 MATERIALS

636-2.01 General - All materials required for the PRASA adjustment work to be performed under the contract shall be furnished by the Contractor unless otherwise specified. These materials shall be new and shall meet the requirements of the plans and these specifications. However, sound salvaged materials obtained from the removal of existing facilities may be used in the adjustment work if acceptable to PRASA. The Contractor should obtain PRASA's approval of the proposed materials prior to purchasing them.

636-2.02 Portland Cement Concrete - Shall conform to the requirements of Specification 601 - Structural Concrete. All concrete shall be Class A (3,000 psi) unless otherwise indicated in the contract documents.

636-2.03 Reinforcing Steel - Shall be of the class, grade and size indicated on the plans and shall meet the requirement of Specification 602 - Reinforcing Steel. When the grade is not indicated on the plans, Grade 60 shall be furnished.

636-2.04 Manholes - Materials for manholes shall conform to the requirements of Specification 604 - Manholes, Inlets and Catch Basins.

SPECIFICATION 636 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

636-2.05 Concrete Pipe - Shall be of the types, classes and sizes indicated in the contract documents and shall conform to:

Plain Concrete Sewer Pipe…….	ASTM C-14 (AASHTO M 86)
Reinforced Concrete Sewer.Pipe…	ASTM C-76 (AASHTO M 170)

Acceptance shall be as specified in paragraph 706-1.05 of Specification 706 – Concrete and Plastic Pipe.

636-2.06 Other Materials - Metal pipes and pipes of other materials, fittings, valves, valve boxes, hydrants, meters and all other materials indicated in the contract documents and needed to complete the work shall conform to the requirements indicated on the plans and the applicable PRASA specifications.

636-3 CONSTRUCTION REQUIREMENTS

636-3.01 General

a. The Contractor shall give PRASA at least two (2) weeks advance notice before beginning work on the utility adjustments, to permit PRASA to make arrangements to have a representative present at the site of the work. The Contractor shall not perform adjustment work without the presence of PRASA's representative to supervise the work except when the right to have a representative present at the work is waived in writing by PRASA.

b. The PRASA representative shall have free access at all times to all parts of the work and to all material intended for use in the work concerning the PRASA facilities. The Contractor shall coordinate with the Authority and PRASA representatives his proposed construction schedule and procedures.

c. The Contractor shall be responsible for protecting the existing PRASA installations from damage by his construction operations to insure the continuity of the utility service.

d. Any work involving disconnecting existing lines in service and connecting to such lines and the tapping for service connections shall be performed by PRASA personnel unless otherwise specifically authorized by PRASA. The Contractor shall pay PRASA for the cost of such work and the Puerto Rico Highway and Transportation Authority will then reimburse the Contractor for such costs with no surcharges added. The Contractor shall not interrupt the service, except with the written approval of PRASA, for the purpose of making actual necessary final connections to the adjusted installations or otherwise, in which case the construction operations shall be arranged by the Contractor and duly coordinated with the PRASA representative, to take the minimum possible time.

e. All adjusted facilities shall be completely installed, inspected, cleaned, tested and left in operating condition to the satisfaction of PRASA and the Authority.

f. Construction, including construction details not shown on the plans, shall be performed in accordance with, and shall conform as to quality of materials, workmanship and tests with the applicable PRASA standards and specifications as amended and supplemented by this specification.

g. The locations of the existing and adjusted facilities shown on the plans are approximate only and the exact location will be established by PRASA and the Engineer in the field. It shall be understood that any changes made by the Engineer in the vertical or horizontal locations shown in the plans, which do not materially affect the character and scope

of the character and scope of the adjustment work, will be made by the Contractor at no extra cost to the Authority.

h. Existing salvageable items identified on the plans, which are not to be used in the utility adjustment work, shall be removed by the Contractor from the project site and delivered to PRASA at the locations indicated in the contract documents, at the Contractor's expense.

i. Existing underground PRASA facilities which are not to be incorporated in the adjusted utility may be abandoned in place, if authorized by the Engineer, unless they interfere with the project construction or otherwise shown on the plans. However, such abandonment in place shall be subject to providing, at the Contractor's expense, any necessary protective measures such as plugging or filling of conduits, manholes and boxes as may be specified in the contract documents or required by the Engineer.

636-3.02 Excavation and Backfill

a. Before beginning excavations for any underground work, the Contractor shall notify the utilities concerned, the Engineer and the Demolitions and Excavation Center a minimum of two weeks in advance of the proposed excavation work, so that the location of all underground installations in the project area may be determined. It will be the responsibility of the Contractor to make the necessary contacts with utilities and others who have underground installations in the project area. Any damage to existing facilities, shown on the plans or identified by the utilities prior to excavation, caused by negligence of the Contractor shall be repaired by the Contractor at no expense to the Authority.

b. Unless otherwise indicated in the contract documents, the Contractor shall do all excavation, backfilling and resurfacing work, including removal and replacement of curbs, sidewalks, paved surfaces and other materials necessary to complete the work in accordance with the plans and specifications.

c. Excavation and backfilling shall conform to the applicable requirements of Specification 205 - Trench Excavation supplemented as follows:

1. Excavation for locating existing underground pipes shall be done by hand tools, unless otherwise authorized by the Engineer, and exercising the utmost care to avoid damage to the existing facility and the interruption of service. Power tools and picks shall be used only on the hard top surface with the excavation in the underlying soil material performed with hand shovels.

2. In making excavations in paved surfaces to remain, cuts shall be made with an abrasive type power saw along the neat boundaries of the area to be removed as specified in paragraph 3.03b. below.

3. Backfill shall be placed as soon as practicable but not later than 3 days after the underground utility work has been completed and accepted. Backfill shall consist of material approved by the Engineer, placed in layers not exceeding 20 centimeters in thickness, and compacted by mechanical tamping tools.

4. Unless otherwise authorized by the Engineer, all surplus excavated material shall be removed and disposed of, outside the right-of- way or at locations within the project approved by the Engineer. The

excavation site shall be cleaned up and left in a neat condition satisfactory to the Engineer.

636-3.03 Removing and Replacing Improvements

a. Existing improvements such as sidewalks, curbs, gutters, P.C. concrete and asphaltic concrete pavements, underlying materials, lawn and plants, and any other improvements removed, broken or damaged by the Contractor's operations, shall be replaced or reconstructed with the same kind of materials as found in the work or with materials of equal quality acceptable to the Engineer. Replacement and repair of such improvements shall be undertaken as soon as practicable but not later than 3 days after the backfilling of the excavations has been completed and accepted.

b. The outline of all areas to be removed in pavements, sidewalks, curbs, gutters and driveways shall be cut to a minimum depth of five (5) centimeters with an abrasive type saw, prior to removing the existing material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

636-3.04 Pipe Installation

a. Concrete sanitary sewer pipe shall be bedded and laid in accordance with the requirements of Specification 603 - Pipe Culverts and Storm Drains. Joints, cleaning and testing shall be in conformance with the PRASA specification for concrete sewer pipe.

b. Cast and Ductile iron pipe shall be installed, cleaned and tested in accordance with all the requirements of the PRASA specifications on cast and ductile iron pipe, fittings and valves.

c. PVC pipe shall be laid on a bed of sand or other approved selected material. A metallic ribbon to facilitate locating it with a metal detector shall be placed over the pipe approximately 30 cm. below the ground surface as shown on the plans.

d. Other types of pipes shall be installed in accordance with the applicable PRASA specifications and plan details.

636-3.05 Manholes and Valve Boxes

a. Concrete manholes and valve boxes shall be constructed in accordance with the details shown on the plans and in conformance with the requirements of Specification 604 - Manholes, Inlets and Catch Basins.

b. Frame and covers, ladder rungs and miscellaneous metal work for manholes and concrete valve boxes shall conform to the applicable PRASA specifications.

c. Metallic valve boxes shall be installed in conformance with the applicable PRASA specification.

636-3.06 Water Service Connections - Water service connections shall be made in accordance with the details shown on the plans and the PRASA specifications. The work shall include, when applicable:

a. Providing temporary service connections including the relocation of the existing water meter.

b. Providing the final service connection including relocating the water meter again to its final location.

636-3.07 Other items of the PRASA facilities adjustment work shall be constructed as shown on the plans and in accordance with the applicable PRASA specifications.

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636-3.08 **Acceptance** - Prior to acceptance by the Authority of the utility adjustment work, the Contractor shall furnish to the Authority a certification by PRASA that it has accepted the work.

636-3.09 **As Built Plans** – Upon completion of the PRASA adjustment work, the Contractor shall submit to the Engineer "As Built" plans of the adjustment work all change made, if any, in the original plans.

636-4 METHOD OF MEASUREMENT

636-4.01 When a lump sum method of payment is specified in the contract, the complete adjustment work shown on the plans will be considered a single unit and no separate measurement will be made of any of its individual components.

636-4.02 When component of the PRASA adjustment work are included as separate pay items in the contract these will be measured as follows:

a. Trench excavation will be measured and paid for separately as provided under Specification 205 - Trench Excavation. Any required sheet piling and bracing will be a subsidiary obligation of the Contractor under the pay item for trench excavation unless such sheet piling is identified on the plans and a separate pay item under Specification 615 is included in the contract.

b. Foundation fill, if required, will be measured and paid for separately under Specification 207 - Foundation Fill.

c. Water and sewer pipes of the different types, classes and sizes will be measured along the invert by the linear meter, to the nearest tenth of a meter, in place and accepted including all fittings, hangers and thrust blocks.

d. Valves, air vents, fire hydrants and metallic valve boxes will be measured by the number of units of each type, class and size installed and accepted.

e. Service connections to water and sewer lines will be measured by the number of each type, regardless of size, completed in final location and accepted. Temporary service connections will not be measured for separate payment but are a subsidiary obligation of the Contractor under the final service connections measured for payment.

f. Concrete manholes and concrete boxes shall be measured by the number of each type and size completed and accepted. Frames and covers, ladder rungs and miscellaneous items incorporated to these units will not be measured for separate payment but shall be a subsidiary obligation of the Contractor under the manhole and concrete box pay items.

g. Concrete and reinforcing steel, other than that included as part of separate pay units such as concrete manholes and boxes; and thrust blocks included under pipes, will be measured and paid for as provided under Specification 601 - Structural Concrete and Specification 602 - Reinforcing Steel respectively.

h. The removal of existing PRASA facilities, including the storing and delivery to PRASA of any salvageable materials specified in the contract documents which are not used in the adjustment work, will be measured as a lump sum item. When no pay item is included in the contract, such removal and salvage work shall be a subsidiary obligation of the Contractor under the PRASA adjustment work.

636-4.03 Backfill, other than Foundation Fill, and granular material required for pipe bedding will not be measured for separate payment as these materials are a subsidiary obligation of the Contractor under the trench excavation and pipe pay items.

SPECIFICATION 636 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

636-4.04 The removal and replacement of existing improvements required by the adjustment of PRASA facilities, covered under Article 636-3.03, will not be measured for direct payment but shall be a subsidiary obligation of the Contractor under the PRASA adjustment pay items.

636-4.05 When the PRASA adjustment work is paid for by separate component pay units rather than as a lump sum item, it shall be understood that the combination of all component pay units shall provide for the complete adjustment ready for operation and that any miscellaneous fees, work, equipment and materials necessary to complete the adjustment work shall be furnished and installed by the Contractor at no extra cost to the Authority. The cost of any of these miscellaneous items shall be considered as included under the contract pay items.

636-5 BASIS OF PAYMENT

636-5.01 The accepted quantities, determined as provided above for the pay items listed in Article 5.04 below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such price and payment shall constitute full compensation for furnishing and installing all required equipment and materials, and for all labor, equipment, tools and incidentals necessary to complete each item as required by the plans and specifications, and to the satisfaction of PRASA.

636-5.02 When PRASA adjustment pay items not listed in Article 5.04 below are included in the contract, the basis of payment will be as specified in the contract documents.

636-5.03 When the Contractor installs materials furnished by PRASA at no cost to the Contractor in exchange for similar materials salvaged from the existing PRASA facility, and for which payment is being made by the Highway Authority to the Contractor under a contract pay item, the value of such material will be deducted by the Authority from the payments due the Contractor.

SPECIFICATION 636 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

636-5.04 Payment will be made under:

Pay Item	Pay Unit
Adjustment of PRASA Facilities……..	Lump Sum
Concrete Sanitary Sewer Pipe _____…… (Type, Class, Size)	Linear Meter
Cast Iron Pipe _____……... (Type, Class, Size)	Linear Meter
Ductile Iron Pipe _____…… (Type, Class, Size)	Linear Meter
PVC Type _____……. (Class, Size)	Linear Meter
Air Vent _____…… (Size)	Each
Valve _____…… (Type, Class, Size)	Each
Blow-off Valve _____……. (Size)	Each
Fire Hydrant……..	Each
PRASA Manhole _____…….. (Type, Size)	Each
PRASA Concrete Box _____…… (Sizes)	Each

SPECIFICATION 636 – ADJUSTMENT OF FACILITIES OF THE PUERTO RICO AQUEDUCT AND SEWER AUTHORITY

Pay Item	Pay Unit
Water Service Connection _____……..	Each
Sanitary Sewer Service Connection _____……..…	Each
Removal of Existing PRASA Facilities……	Lump Sum

SPECIFICATION 638 – MAINTENANCE AND PROTECTION OF TRAFFIC

638-1 DESCRIPTION

638-1.01 Scope

a. This work shall consist of maintaining traffic and protecting the public from damage to persons and property throughout the project construction area for the duration of the contract. The contractor shall be required to maintain and protect through and local traffic within the limits of the project, including traffic on all existing roads and streets which intersect the project within the project limits, and access driveways, except as otherwise provided on the plans or other contract documents. Traffic shall be maintained from the time the contractor begins work at the project site until final acceptance of the project.

b. All work to be performed shall be as shown on the plans and contract documents, as specified herein and as directed by the Engineer.

c. The work includes furnishing, installing, moving, removing, and maintaining temporary construction signs, barricades, cone, drums, pavement marking, guard rails, concrete barriers, impact attenuators, traffic signals, highway lighting and other traffic control devices as may be required for the maintenance and protection of traffic. It includes providing the necessary flag persons with appropriate equipment for adequate traffic control on the traveled way during construction operations. It also includes making any necessary repairs and maintaining the existing and temporary roadways within the project limits as required providing a reasonably safe and smooth traveled way.

d. All traffic control devices and traffic control operations shall be in accordance with the "Manual de Dispositivos Uniformes para el Control del Tránsito en las Vías Públicas de Puerto Rico" adopted by the Puerto Rico Department of Transportation and Public Works (DTPW) and

in particular with Part VI- "Controles de Tránsito para Operaciones de Construcción y Conservación en Calles y Carreteras"of this manual and/or with the Manual on Uniform Traffic Control Devices (MUTCD- FHWA) – Edition 2000.

e. The contractor is placed in notice that maintenance and protection of traffic over a highway during construction is considered as important as the construction itself. The contractor shall at all times conduct his operations in a manner to insure the convenience and safety of all travelers and abutting property owners as well as the safety of his own employees.

f. The contractor is also put in notice that he has the primary responsibility for providing the necessary traffic control devices and taking other appropriate measures for the protection of the public and his personnel. The fact that provisions may be included in the plans and other contract documents, or may be ordered by the Engineer, for the maintenance and protection of traffic during construction, including the payment for certain items under this specification, does not relieve the contractor of his responsibility under Articles 104.07, 107.08, 107.11 and 107.15 of the General Provisions. In the absence of specific provisions in the contract plans and specification, or instructions from the Engineer, the Contractor shall provide at his expense such additional devices and operational measures as may be necessary for the protection of the public and his employees.

638-2 MATERIALS

638-2.01 General

a. All traffic control devices shall conform to the design, dimensions, materials, color, fabrication and installation requirements specified on the plans, the "Manual de Dispositivos Uniformes para el Control del

Tránsito"(MUTCD), the Manual de Señales de Tránsito (MST) of the DTPW, the standard drawings of the Authority, and the applicable standard specifications as may be modified by the specification and/or with the Manual on Uniform Traffic Control Devices (MUTCD- FHWA) – Edition 2000.

b. All traffic control devices, whether new or used, shall be in good working condition and shall be subject to approval by the Engineer.

c. Reflecting sheeting of the high intensity type, meeting the requirements of Article 613-2.02 of Specification 613 shall be used on all devices requiring reflectorization.

d. All other materials whether paid under this specification or under other contract items, shall meet the requirements of their respective specifications.

638-2.02 Construction Signs

Sign panels may be made of aluminum, galvanized steel or marine plywood. Sign posts shall be metallic as shown on the standard drawings but wood supports may be used when so designed as to yield if impacted by moving vehicle. Nothing larger than 2"x 2" nominal size timber shall be used, except that 2"x 4" may be used with a 2" bored drilled 4"above level on the 4"side.

638-2.03 Barricades, Drums and Cones (limited use)

Barricades shall be constructed of wood or plastic. Drums shall be plastic with conic, round or square section, approximately 36 inches high and a minimum of 18 inches in diameter. Cones shall be used on low-volume, low-speed (40MPH or less) roadways only. Never shall be used on expressway, freeway or toll roads. They shall be a minimum of 28 inches in height with a broadened base, orange colored and shall be made of a material that can be struck without causing damage to the impacting vehicle. Barricades, drums and cones shall be marked and reflectorized in accordance with the

requirements of Part VI of the MDUCT. The name and the telephone number of the Contractor shall be shown on the non-retro reflective surface of all types of channelizing devices. Both, the letters and numbers shall be non-retro reflective and not over 50 mm (2 in.) in height.

638-2.04 Temporary Pavement Markings

Temporary pavement markings shall comply with the following requirements:

a. When placed on temporary pavement surfaces or on a layer of the pavement, which is to be subsequently covered, by another layer, reflectorized traffic paint or removable reflectorized traffic tape shall be used at the option of the Contractor.

b. When placed on the final finished pavement surface, only removable reflectorized traffic tape shall be used.

c. Reflectorized traffic paint shall be conforms to the appropriate requirements of Specification 639 - Painted Pavement Markings.

d. Removable reflectorized traffic tape shall be consist of glass spheres of a high optical quality imbedded into a polymeric bonder film on a suitable backing that is precoated with a pressure sensitive adhesive and conforming to the following requirements:

1. The glass spheres shall be uniform graduation and distributed evenly over the surface of the tape. The spheres adhesion shall be such that the spheres are not easily removed when the tape surface is scratched with the thumbnail.

2. The color of the tape shall conform to the standard colors for pavement markings and shall be readily visible when viewed under vehicular headlights a night.

3. The tape shall be precoated with a pressure sensitive adhesive and shall be capable of being adhered to bituminous concrete or Portland cement concrete pavement surfaces without the use of heat, solvents or other additional adhesive means. It shall be immediately ready for traffic after application and shall be capable of being removed intact or in large strips either manually or with a recommended roll-up device upon completion of service. A non-metallic medium shall be incorporated to facilitate removal.

4. The tape, when applied in accordance with the manufacturer's recommended procedure, shall be o good appearance, free of cracks, and its edges shall be true, straight and unbroken. The tape shall be weather resistant, and shall show no appreciated fading, lifting or shrinkage during its useful life.

638-2.05 Temporary Post Mounted Guard Rail

Temporary post-mounted guard rail shall be of the corrugated steel beam type conforming to the requirements shown on the plans and Specification 606.

638-2.06 Temporary Concrete Barrier

Temporary concrete barrier sections shall be portable, shall be not less than 3 meters in length, and shall conform to the shape and dimensions shown on the plans, he Standard Drawings, MPT 3 to MPT 8 and to the applicable requirements of the Specification 610 – Concrete Barrier. Lifting devices shall no protrude from the sides of the barrier.

SPECIFICATION 638 – MAINTENANCE AND PROTECTION OF TRAFFIC

638-2.07 Temporary Impact Attenuators

Temporary impact attenuators shall be the sand-filled plastic drum type conforming to Specification 620. They shall be installed as indicated on the plans or as ordered by the Engineer.

638-2.08 Temporary Traffic Signals

Temporary traffic signals shall conform to the requirements shown on the plans and to the appropriate sections of Specification 654 and 723. Used equipment such as signal heads controllers, poles and mast arms may be furnished, subject to approval by the Engineer, provided it is in good operating condition.

638-2.09 Temporary Highway Lighting

Temporary highway lighting shall conform to the requirements specified in the contract documents and to the appropriate sections of Specification 612 and 714.

638-2.10 Flashing Arrow Signs

Flashing arrow signs shall conform to the details shown on the plan and shall comply with the following requirements:

a. Sign boards shall be rectangular in shape and finished in flat black enamel. They shall be either 4 feet high by 8 feet wide or 3 feet high by 6 feet wide as indicated in the contract documents. When no size is specified, the 4'x 8'size shall be approved.

b. Lamps shall be mounted on the sign board in such a way as to be capable of forming each of the following patterns:

Pattern 1 – Flashing arrow left
Pattern 2 – Flashing arrow right
Pattern 3 - Sequential arrow left

Pattern 4 – Sequential arrow right
Pattern 5 – Simultaneous mode
Pattern 6 – Caution mode

c. In the flashing arrow patterns all lamps forming the arrowhead and shaft shall flash on and off simultaneously. In the sequential arrow patterns, either arrowheads or arrow shall flash sequentially in the direction indicated or the arrow shall be formed sequentially from the shaft to the head in three steps. In the simultaneous mode, the lamps forming both left and right arrowheads and the lamps of the arrow shaft shall flash on and off simultaneously. The first light on the shaft next to the light on the arrowhead point shall remain unlit when that arrow head lights up. In the caution mode, a combination of four or more lamps shall flash on and off in a pattern that will not indicate direction.

d. There shall be no less than fifteen (15) lamps on the sign. These shall be either recess-mounted or each lamp provided with a hood or visor surrounding the upper half.

e. Lamps shall be 12 volt, sealed-beam units, yellow or amber color. Lamps shall be type PAR 46 but on the 3’ x 6’ size signs PAR 36 may be used. The lamps shall provide a minimum candlepower at design voltage of 8,800 on the 4’x 8’ sign and 7,000 on the 3’x 6’signs.

f. Lamps shall be controlled by an electronic o electromechanical circuit that will provide between 30 and 45 complete operating cycles per minutes in each of the patterns specified. A dimmer control capable of varying the lamps voltage from 6 to 12 volts shall also be provided. The dimmer shall automatically dim the arrow board at night. The control switch box shall be lockable.

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638-2.11 Warning Lights

Warnings lights shall be of the steady burning type meeting the requirements of Part VI of the MUTCD.

638-2.12 Roadway Maintenance

Existing and temporary pavements shall be kept free of trash and debris and in good repair using materials compatible with the pavement.

638-3 CONSTRUCTION REQUIREMENTS

638-3.01 General

a. The Contractor shall notify the Engineer before starting any work that might inconvenience or endanger traffic. Arrangements shall be made by the Contractor for closing the road, if required, and providing detours, signs barricades and other necessary appurtenances for the maintenance and protection of traffic prior to beginning the work.

b. The Contractor shall follow the provisions for traffic maintenance indicated on the plans or ordered by the Engineer. The Contractor may submit alternative traffic maintenance plans for approval by the Engineer.

c. The Contractor shall provide a traveled way suitable for two lanes of moving traffic, or more lanes when specified in the contract documents. The traveled way shall be kept reasonably smooth and hard at all times, and shall be well drained and free of potholes, bumps, irregularities and depressions that hold or retain water. The Contractor shall devote particular attention to all drainage facilities, keeping them fully operative at all times. This work will be paid for as maintenance as per paragraph 638-5.01g. except for damage caused by the Contractor.

d. Construction operations shall be conducted in such way as to insure a minimum of delay to traffic. Construction operations on high volume highways may be restricted to off-peak periods of the day. Stopping traffic for more than five minutes shall not be permitted unless specifically authorized by the Engineer.

e. The Contractor shall keep the traveled way free of foreign objects such as spilled earth, rocks, timber, and other items that may fall from transporting vehicles.

f. Dusty conditions resulting from the Contractor's operations shall be corrected by the used of calcium chloride, water, or other mans acceptable to the Engineer, at the Contractor's expense.

g. The Contractor shall provide and maintain at all times, safe and adequate pedestrian and vehicular ingress and egress to and from intersecting highways, houses, businesses, and other establishment at existing or new access points, consistent with the work, unless otherwise shown on the plans or authorized by the Engineer. This work shall be at the Contractor's expense.

h. Existing traffic signs and other traffic control devices within the project limits that are to remain shall be protected from damage by construction operations. Any such items lost or damaged because of negligence on the part of the Contractor shall be replaced at the Contractor's expense. Should temporary relocation of any such items be required because of construction operations, they shall be placed as directed by the Engineer at the Contractors expense.

i. In the event of an unauthorized suspension of work by the Contractor or when a temporary suspension of work is ordered by the Engineer because of failure of the Contractor to comply with any of the contract provisions or to carry out any legitimate order of the Engineer, it shall be the

Contractor's responsibility to maintain the traffic in accordance with the requirements of this specification. During the days on which such suspension is in effect, the cost of maintenance of traffic will be borne by the Contractor at no extra cost to the Highway Authority. Maintenance of traffic during any authorized suspension of work for reasons not attributable to the Contractor's fault or negligence will be paid for in accordance with this specification.

j. The Contractor shall not permit his employees to park their vehicles nor shall he store equipment or materials adjacent to the traveled way where it may be a hazard to traffic. A clear distance from the edge of the pavement consistent with the type of highway and space available shall be kept free of any such obstacles.

k. Whenever construction operations near the traveled way result in a hazardous condition to the traveling public, such as excavation and replacement or shoulders, the extent of such operations should be limited to work that can be replaced within a reasonable period of time. Once started, such work should progress continuously to completion within a reasonable extent of time.

l. Temporary traffic control devices shall remain in operation only as long as they are needed for traffic guidance and safety. Only those devices shall be in place as apply to conditions and operations in existence at a particular time.

m. All traffic control devices shall be cleaned, repainted, reflectorized or replaced as necessary to provide adequate visibility and legibility at all times. This work shall be at the Contractor's expense.

n. Any materials in good condition recovered from existing or temporary installations of guard rail, impact attenuators, traffic signals and highway lighting within the project limits may be incorporated into the final project

location by the Contractor as called for in the plans and the Contractor will be compensated under the corresponding pay item. The use of the such materials shall be subject to approval by the Engineer.

o. The items for the maintenance and protection of traffic furnished by the Contractor under this specification are his property. The items shall be promptly removed from the project after they are no longer required except those items specifically indicated in the contract to remain after completion of construction.

638-3.02 Construction Signs

a. The Contractor shall furnish, erect, maintain, move and remove construction signs as required and as directed by the Engineer to adequately and safely inform and direct the traveling public.

b. The number of signs indicated in the MDUCT and the plans area a minimum and the Engineer may require additional signs. The Contractor shall have an adequate quantity of these signs on hand prior to starting construction operations for use as required.

c. All signs and markers shall be appropriate for actual existing conditions and shall be covered, moved removed, relocated or changed as required by changed conditions or as directed by the Engineer.

d. All signs shall be kept clean and in good condition for the duration of the contract. They shall be mounted at the required height on adequate supports and placed in proper position and alignment so as to give maximum visibility both day and night.

e. During non-working hours and following the completion of a particular construction operation, all warning signs, except those required to remain for the safety of the public, shall be removed or covered as indicated in the standard drawings.

638-3.03 Barricades, Drums and Cones

a. The Contractor shall furnish, erect, maintain, move, replace and remove construction barricades, drums and cones where and as indicated on the plans, in the MDUCT, Part VI, or as directed by the Engineer.

b. Where indicated on the plans or proposal, or directed by the Engineer, construction barricades shall be supplemented by approved steady burning lights as appropriate. The operation and maintenance of such lights shall be at the Contractor's expense.

c. Whenever construction work results in a long-term stationary operation, temporary concrete barriers shall be used instead of plastic drums.

638-3.04 Temporary Pavement Markings

a. The Contractor shall furnish, apply and, when so ordered, remove temporary payment markings when shown on the plans or as ordered by the Engineer. Unless otherwise indicated in the contract documents, or ordered by the Engineer, any course of asphaltic concrete, including base courses, upon which traffic will be maintained shall be properly delineated as soon as completed. Concrete surfaces shall be marked prior to opening to traffic.

b. Paint used for pavement delineation shall be applied in accordance with Specification 639. Traffic tape shall be applied in accordance with the manufacturer's recommendations. Any tape that fails to adhere to the

pavement surface during the period of shall be replaced by the Contractor at no additional cost to the Highway Authority.

638-3.05 Removal of Pavement Markings

The Contractor shall remove existing and temporary pavement markings as shown on the plans or ordered by the Engineer. The existing pavement markings may be removed by grinding, sandblasting, scraping or any other method approved by the Engineer provided that it is conducted in such a manner that the pavement surface is not damaged or left in a pattern that will mislead or misdirect the motorist. Painting out pavement markings is not an acceptable method.

638-3.06 Temporary Guard Rail and Temporary Concrete Barrier

a. The Contractor shall furnish, install and maintain temporary guard rails or concrete barriers of the types indicated and at the locations shown on the plans, the Standard Drawings, volumen I (sheets MPT 3-8) or ordered by the Engineer prior to diverting traffic or prior to beginning the construction work necessitating the use of such barriers.

b. Temporary strong post type guard rail or concrete barrier shall be used when it is necessary to provide a barrier that will deflect or stop an impacting vehicle. They shall be moved and relocated as required by the construction operations and shall be removed when ordered by the Engineer. The sequence of removal shall be in the direction opposite to the traffic flow.

638-3.07 Temporary Impact Attenuator

a. The contractor shall furnish, install and maintain temporary traffic impact attenuators of the inertial barrier type at the location shown on the plans or as ordered by the Engineer.

The impact attenuator for each particular location shall be designed and erected in accordance with the manufacturer's recommendations. It shall not be removed until ordered by the Engineer.

b. Any impact attenuator modules damaged by impacting vehicles shall be promptly replaced. If the damage is caused by the Contractor's forces, the replacement shall be at the Contractor's expense.

638-3.08 Temporary Traffic Signals

a. The Contractor shall furnish and install temporary traffic signals as shown on the plans or as directed by the Engineer and shall maintain them in proper operation until their removal is approved. He shall be responsible for their continuous operation except for reasonable shut down during relocation and transfer operations if such are required.

b. The Contractor shall paint on each signal controller cabinet a sign indicating the telephone to be called for repairs in case of malfunctioning of the signal system.

c. If for any reason a signal is not functioning as required, the Contractor shall commerce repair work on this signal within 4 hours after he has been notified of a malfunction. The Contractor shall provide adequate traffic control acceptable to the Engineer, at his own expense, during repair work and until the temporary traffic signal is restored to proper operation. If the Contractor fails complete the repair of a malfunctioning signal within a reasonable time, normally considered to be 24 hours, the Authority may opt to complete the necessary repairs and deduct the expenses incurred in such repairs from any monies due the Contractor.

d. The electric power consumption and the maintenance of the temporary traffic signals shall be at the Contractor's expense.

e. Any installed temporary traffic signal that is not in operation shall be bagged and have the power turned off.

638-3.09 Temporary Highway Lighting

a. The Contractor shall furnish, install, operate and maintain temporary highway lighting as shown on the plans or as ordered by the Engineer and it shall remain in place and operation until its removal is ordered by the Engineer.

b. The electric power consumption and the maintenance of the temporary highway lighting shall be a subsidiary obligation of the Contractor under the temporary highway lighting pay items.

638-3.10 Flashing Arrow Signs

a. Each flashing arrow sign shall be mounted on a truck or on a trailer and shall be capable of operating while the vehicle is moving. It shall also be capable of being placed and maintained in operation at stationary locations as shown on the plans or as directed by the Engineer.

b. Signs shall be mounted to provide a minimum of 7 feet between the bottom of the sign and the roadway.

c. The electrical power to operate the sign shall be obtained from the vehicle on which the sign is mounted, from a generating plant mounted on the vehicle, or from self-contained batteries. Regardless of the source, the supply of electrical energy shall be capable of operating the sign in the manner specified.

d. Where batteries are used as the primary source of power they shall be of sufficient capacity to provide, between chargings, 11 volts or more to each of the lamps for a period of at least 72 continuous hours of operation at full daylight intensity. Units that operate on battery power shall have a

permanently mounted voltmeter which shall be wired so as to measure the voltage available to the lamps.

e. Trailer mounted units utilizing generators shall be equipped with storage batteries wired so that the units shall automatically switch to battery operation in the event of a generator failure. The standby batteries shall be of sufficient capacity to operate the units for a minimum of three hours in any pattern at 11 volts or greater.

638-3.11 Flag persons

a. The Contractor shall provide a sufficient number of competent flaggers in areas where construction equipment is operating in potential conflict with public traffic, regardless of the volume of traffic and the sight distances.

b. Whenever it becomes necessary to maintain traffic in two directions alternating in only one lane, the Contractor shall provide a sufficient number of flaggers of continuously control the alternating traffic and, if possible, provide two-way radio communication between the flaggers.

c. For daytime work, the flagger's vest, shirt, or jacket shall be orange, yellow, yellow-green, or a fluorescent version of these colors. For nighttime work, similar outside garments shall be retro reflective. The flagmen operate in conformance with the procedures and requirements of Part VI of the MUTCD.

638-4 METHOD OF MEASUREMENT

638-4.01 Individual Basis –The various devices required for the maintenance and protection of traffic will be measured as follows:

a. Construction signs will be measured by the square meter of area, computed to the nearest hundredth, for signs

furnished, installed and accepted by the Engineer. Both fixed and portable signs will be measured for payment one time only, at the time of initial installation, except as provided under basis of payment. The relocation, removal, reinstallation and maintenance of temporary signs required for the maintenance of traffic during construction shall be a subsidiary obligation of the Contractor included in the contract unit price for this item.

b. Barricades (all types), cones drums and warning lights will be measured by the individual unit for the actual quantity of each furnished, installed and accepted by the Engineer. They will be measured one time only except as provided under the basis of payment. Their relocation, removal, reinstallation and maintenance as required for the maintenance of traffic should be a subsidiary obligation of the Contractor included in the contract unit price for this item.

c. Each construction sign, barricade, drum and cone accepted and certified for payment by the Engineer shall be identified as directed by the Engineer for inventory and control purposes.

d. The quantity of temporary pavement markings to be paid for will be the actual marking s placed as shown on the plans or ordered by the Engineer, measured as follows:

1. Pavement lines or stripes will be measured in linear meters, to the nearest tenth of a meter, along their centerline and shall be based on a 4-inch width. The linear measurement of lines or stripes specified to be wider than 4 inches shall be adjusted in the ratio of the specified width to 4 inches.

2. For dashed lines, the skip or open space between dashes will not be measured for payment.

3. Double lines will be measured separately as for single lines.

4. Symbols and letters will be measured by each unit applied. A unit will consist of one letter or one symbol.

5. The maintenance of temporary pavement markings throughout their period of need and use shall be an obligation of the contractor included in the contract unit price for this item.

6. The removal of temporary pavement markings will be an obligation of the Contractor under this pay item and no separate measurement and payment will be made.

e. The pay item for removal of pavement markings applies only on the removal of permanent markings existing prior to construction. The quantity to be paid for will be measured in liner meters to the nearest tenth of a meter. Measurement will be made as provided for temporary pavement markings in paragraph "d" above except that symbols and letters will also be measured linearly along their longest dimensions and not as units.

f. The quantity of temporary guard rail to be paid for will be the linear meters, measured to the nearest tenth of a meter, of guard rail of each type installed as shown on the plans or ordered by the Engineer. Required end anchorages, including connections at structures, will not be measured separately, but shall be a subsidiary obligation included in the contract unit price for this item. Terminal sections will be measured as for regular rail sections.

g. The quantity of temporary concrete barrier to be paid for will be the linear meters, measured to the nearest tenth of a meter, of barrier installed as shown on the plans or ordered

by the Engineer. Required temporary end sections will be included in the linear measurement. Temporary concrete barrier will be measured for payment only once, at the time of initial installation, except as provided under basis of payment. The relocation, removal and reinstallation of temporary concrete barriers as may be required during construction shall be a subsidiary obligation of the Contractor included in the contract unit price for this item.

h. Temporary impact attenuators installed as shown on the plans or ordered by the Engineer, other than those which are a subsidiary obligation of concrete barrier under Specification 610, will be measured by each inertial barrier module required. Each module will be measured for payment only once, at the time of initial installation, except as provided under basis of payment. The relocation, removal and reinstallation of modules as may be required shall be a subsidiary obligation of the Contractor included in the contract unit price for this item.

i. Each temporary traffic signal installation shown on the plans will be measured as a unit. Each unit will include all the necessary components to provide a complete operating installation including the signal heads, controller, standards, wiring, hardware, detectors, other appurtenances and power consumption.

j. Temporary highway lighting will be measured and paid for as provided in Specification 612-Highway Lighting System.

k. Flashing arrow signs will be measured by full days (24 hours) of actual operation of each unit required by the Engineer and furnished by the Contractor, and accepted by the Engineer.

l. Flagpersons will not be measured for direct payment but shall be a subsidiary obligation of the Contractor covered under other contract items.

m. Roadway maintenance items not covered by contract unit prices will be measured as required for force account work under Article 109.04 of the General Provisions.

638-5 BASIS OF PAYMENT

638-5.01 Payment

a. The quantities determined as provided above for construction signs, barricades (all types), cones, drums, warning lights, flashing arrow signs, temporary pavement markings, removal of pavement markings, temporary guard rail, temporary concrete barrier, temporary impact attenuators and temporary traffic signals will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items included in the bid schedule. The unit price shall be full compensation for all material, tools, equipment and labor necessary to complete each item as required by the plans and specifications, including erection, relocation, maintenance, operating costs, electric power costs, storage and removal.

b. Traffic control devices required for the maintenance of traffic that are removed from the project without the prior approval of the Engineer will not be considered for payment.

c. Any traffic control device that is damaged by traffic, vandalism or other cause attributable to negligence on the part of the Contractor will be repaired by force account or by agreed unit price, or will be replaced at the contract unit price when so ordered by the Engineer. However, no payment will be made for required repair or replacement of traffic control devices damaged by the Contractor’s personnel or equipment,

or as a result of negligence on his part, or for normal maintenance.

d. No payment will be made for the repair and maintenance of temporary traffic signals and highway lighting required because of malfunctioning, normal wear and tear, or damage caused by the Contractor's personnel or equipment. However, repairs to these items required by damage due to traffic accidents or other cause not attributable to the Contractor will be paid for on a force account or agreed price basis as may be agreed upon with the Engineer.

e. Items necessary for the construction of temporary detours shown on the plans or ordered by the Engineer will be paid for on the basis of the contract unit prices of the appropriate items included in the contract.

f. Roadway maintenance items ordered and accepted by the Engineer as per paragraph 638-3.01c will be paid for in accordance with the provisions of Article 109.04 of the General Provisions. However, roadway maintenance required because of construction deficiencies, or because of damage caused by the Contractor's operations or equipment, shall be undertaken by the Contractor at this expense.

g. When the contract does not include any maintenance of traffic pay items, any construction signs, barricades, cones, drums, temporary pavement markings, temporary guard rail, temporary concrete barrier, temporary impact attenuators, temporary traffic signals and any other traffic protection devices required to comply with Article 107.11 of the General Provisions shall be furnished, installed and maintained by the Contractor and will not be paid for directly but this work shall be a subsidiary obligation of the Contractor covered under other contract items.

h. In the event that the Contractor fails to maintain traffic in a satisfactory manner in accordance with the requirements of Articles 104.7, 104.8 and 107.11 of the General Provisions and of this specification, and with the Violation Citation emitted by the Safety Office of the Authority, he will be assessed liquidated damages at the rate specified in the Article 108.09 of the General Provisions for each day for the violations indicated in the citation. The Engineer will notify the Contractor in writing of the effective date of the application of the penalty.

These fines or penalties are not reimbursable and are in addition to non-payment for items that the Contractor failed to provide and maintain under the requirements of this specification.

i. If the Contractor fails to maintain and project traffic adequately and safely for a period of 24 hours or more, the Engineer will correct the adverse conditions by any means he deems appropriate and will deduct the cost of such corrective work from any monies due the Contractor. The cost of this work shall be in addition to the liquidated damages and nonpayment for items specified above.

638-5.02 Pay Items

Payment will be made under:

Pay Item	Pay Unit
Construction Signs…….	Square Meter
Barricades (All Types)……...	Each
Cones…….….	Each
Drums…….	Each
Temporary Pavement Markings – Stripes…….….	Linear Meter
Temporary Pavement Markings – Symbols and Letters…….….	Each
Removal of Pavement Marking……..	Linear Meter

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Temporary Guard Rail…..……..	Linear Meter
Temporary Concrete Barrier…….….	Linear Meter
Temporary Impact Attenuators…….….	Each Module
Temporary Traffic Signals…….	Each
Flashing Arrow Signs…….	Full Days (24 hours)
Warning Lights……...	Each

SPECIFICATION 639 – PAINTED PAVEMENT MARKINGS

639-1 DESCRIPTION

639-1.01 Scope - This work shall consist of painting reflectorized pavement markings on the pavement surfaces at the locations shown on the plans, or ordered by the Engineer, and of the types, colors, patterns and dimensions shown on the plans, and in accordance with these specifications.

639-2 MATERIALS

639-2.01 General

a. The materials shall be of the best quality available for the purpose in good commercial practice, and shall be free from all defects and imperfections that might affect the serviceability of the finished product.

b. Each container shall be clearly and adequately marked to indicate the color of the material, the process batch number or similar manufacturer's identification, the manufacturer's name and location of plant, and the date of manufacture.

c. The Contractor shall furnish manufacturer's certificates of the proposed materials showing that they meet the requirements of these specifications.

639-2.02 Traffic Paint - White or yellow paint shall conform to the requirements of Article 716-1, Pavement Marking Paint, of Specification 716. The reflectorized paints shall also conform to the requirements of Article 716-3, Reflectorized Pavement Marking Paints, of Specification 716.

639-2.03 Glass Beads - The glass beads to be used to reflectorize pavement markings shall conform to Article 716-2, Glass Beads, of Specification 716.

639-2.04 Warranties - All warranties on materials that are offered by manufacturers as normal trade practices shall be turned over by the Contractor to the Highway Authority.

SPECIFICATION 639 – PAINTED PAVEMENT MARKINGS

639-3 CONSTRUCTION REQUIREMENTS

639-3.01 General

a. The surface to be painted shall be free of dirt, curing compound, grease, oil, moisture, loose particles and any other material which would adversely affect the bonding of the paint to the surface. The Contractor shall clean the surface using compressed air or other effective means to the satisfaction of the Engineer.

b. The Contractor shall submit satisfactory evidence of having previously performed successful applications of the paving marking materials being used or shall provide such evidence for his subcontractor, if one is used. He shall employ experienced technicians thoroughly familiar with the equipment to be used and the application of the pavement marking materials.

c. All markings shall be as shown on the plans or ordered by the Engineer. Details not shown on the plans shall be in accordance with the "Manual de Dispositivos Uniformes para el Control de Tránsito en las Vías Públicas de Puerto Rico" (MDUCT) of the P. R. Department of Transportation and Public Works. All markings shall present a clear cut, uniform and workmanlike appearance. Any markings which fail to have a uniform, satisfactory appearance, either day or night, shall be corrected at the Contractor’s expense.

d. Tack points shall be painted on the pavement at appropriate intervals for use in aligning the equipment that will apply the traffic stripes and, if necessary to achieve the required accuracy, a string line will be set from such points. The tack points shall be painted prior to opening any pavement to traffic to provide for traffic guidance until the final markings are painted.

e. Before any final pavement marking work is begun, a schedule of operations shall be submitted for the approval of the Engineer.

f. When pavement markings are to be applied under traffic, the Contractor shall provide all necessary flags, markers, signs, cones, etc. to protect the paint until it is thoroughly dry and can be crossed without tracking. The Contractor shall take all the necessary measures to control and protect the traffic while the marking operations are in progress and shall comply with the applicable provisions of Specification 638. The application of pavement markings shall be done in the general direction of traffic; striping against traffic shall not be allowed except when marking the centerline of a two-way, two-lane road.

g. The application of painted pavement markings shall not be initiated until at least ten (10) days after the pavement is completed but shall be started no later than 5 days thereafter.

639-3.02 Application of Paint and Beads

a. Equipment - Painted pavement markings shall, unless otherwise noted herein, be applied with an atomizing spray type stripping machine suitable for the type of paint being used. The traveling unit shall be capable of traveling at a uniform, predetermined rate of speed, in order to produce a uniform application of paint. The machine shall be capable of applying two separate stripes, either solid or skip at the same time. The paint tank shall be equipped with a mechanical agitator. The nozzles shall have cut-off valves which will apply broken or skip lines automatically. The nozzles shall be equipped with a mechanical bead dispenser that will operate simultaneously with the spray nozzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle shall also be provided with suitable line guides, either metallic shrouds or air blasts.

b. The Engineer may authorize hand application of the paint using rollers or brushes for special areas and markings that are not adaptable to machine application such as turn arrows. When rollers or brushes are allowed, then glass beads shall be applied to the wet paint film at the specified rate in a manner acceptable to the Engineer. Roller or brushes shall not be used for painting lane, edge, and centerlines.

c. The paint shall be thoroughly mixed before it is poured into the painting machine and no thinning of the paint in the machine will be permitted. No paint shall be applied when any moisture is present in the surface to be painted.

d. The rate of application shall be such as to provide a coverage of not less than 9 square meters nor more than 10 square meters per gallon of paint and a minimum film thickness of 15 mils. Glass beads shall be applied uniformly over and into the wet paint film at a rate of not less than 5.75 pounds nor more than 6.25 pounds per gallon of paint.

639-3.03 Tolerances

a. Dimensions - No marking shall be less than the specified width nor exceed it by more than 1.25 centimeters. The length of the marked segment for skip stripes and the open gap between segments may each vary plus or minus 30 centimeters, except that the over and under tolerance length shall approximately compensate.

b. Alignment - On tangents, and on curves of 1800 meter radius or larger, the alignment of the traffic stripes shall not deviate from the stringline line by more than 2.5 centimeters. On curves of less than 1800 meter radius, the maximum permissible variation will be 5.0 centimeters. The outer edge of pavement edge stripes shall fall uniformly at no less than 5.0 nor more than 10.0 centimeters from the edge of pavement and shall have no noticeable breaks or deviations in alignment.

c. Correction Rates - Any corrections in variations in the width or alignment of stripes shall not be made abruptly but the stripes shall be returned to the design width at the rate of at least 3.0 meters for each 1.25 centimeters of correction, and returned to the stringline alignment at the rate of at least 8 meters per 2.5 centimeters of correction.

639-3.04 Corrective Measures

a. All markings which fail to meet the specifications, including the tolerance and appearance requirements, or are damaged by the Contractor's equipment and operations, shall be corrected at the Contractor's expense. When necessary to correct a deviation which exceeds the permissible tolerance in alignment, that portion of the marking shall be removed and replaced in accordance with these specifications at the Contractor's expense.

b. All drip and spattered markings shall be removed to the satisfaction of the Engineer. Removal of markings shall be done by means approved by the Engineer, which will not damage the underlying surface of the pavement.

639-3.05 Acceptance

When the work under this specification has been completed to the satisfaction of the Engineer, including any required corrective work, and the pavement is to be opened to traffic, acceptance will be made by the Engineer, independently of other remaining work under the contract, and the Contractor will be relieved of maintenance of the markings except as covered by warranties or for damage caused by his operations.

639-4 METHOD OF MEASUREMENT

639-4.01 The accepted quantities of painted pavement markings will be measured as follows:

a. Stripes - Center, lane, pavement edge and other stripes or lines will be measured in lineal meters, to the nearest tenth of a meter, along their center line as outlined below, completed and accepted.

1. Solid stripes will be measured from end to end of each continuous stripe.

2. Dashed or broken stripes will be measured end to end of each segment. No measurement will be made of the skip or open space.

3. The contract unit price of each type and color of stripe will be based on a width of 10 centimeters

4. The measured length of lines or stripes wider than 10 centimeters will be adjusted in the ratio of their specified width to 10 centimeters.

b. Symbols and letter markings will be measured by each unit applied and accepted. A unit will consist of one letter or one symbol.

c. Reflective and non-reflective raised pavement markers will be measured as units of the types and colors specified, determined from actual count in place and accepted.

639-5 BASIS OF PAYMENT

639-5.01 The quantities determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and placing all materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

SPECIFICATION 639 – PAINTED PAVEMENT MARKINGS

639-5.02 Payments will be made under:

Pay Item	Pay Unit
Reflectorized Painted Pavement Markings Stripes, white or yellow……	Linear Meter
Reflectorized Painted Pavement Markings Symbols and Letters, white……..	Each

SPECIFICATION 640 – RAISED PAVEMENT MARKINGS

640-1 DESCRIPTION

640-1.01 Scope

a. This work shall consist of furnishing and installing raised pavement markings on the finished pavement surfaces at the locations shown on the plans, or ordered by the Engineer, and of the types, materials, colors, patterns and dimensions called for in the contract documents, and in accordance with these specifications.

b. Raised pavement markings shall be of the following types:

1. Non-reflective raised pavement markers consisting of a heatfired, vitreous, ceramic base with a heat-fired, opaque, white or yellow glazed surface.

2. Reflective raised pavement markers consisting of an acrylic plastic shell filled with a tightly adherent potting compound.

640-2 MATERIALS

640-2.01 General

a. The materials shall be of the best quality available for the purpose in good commercial practice, and shall be free from all defects and imperfections that might affect the visibility and serviceability of the finished product.

b. The Contractor shall furnish manufacturer's certificates of the proposed materials showing that they meet the requirements of these specifications.

640-2.02 Non-Reflective Raised Pavement Markers - Shall conform to the requirements of Article 716-6 of Specification 716.

SPECIFICATION 640 – RAISED PAVEMENT MARKINGS

640-2.03 Reflectorized Raised Pavement Markers - Shall conform to the requirements of Article 716-7 of Specification 716.

640-2.04 Warranties - All warranties on materials that are offered by manufacturers as normal trade practices shall be turned over by the Contractor to the Highway Authority.

640-3 CONSTRUCTION REQUIREMENTS

640-3.01 Application of Markings

a. The surface to be marked shall be free of dirt, curing compound, grease, oil, moisture, loose particles and any other material which would adversely affect the bonding of the markings to the surface. The Contractor shall clean the surface using compressed air or other effective means to the satisfaction of the Engineer.

b. All markings shall be as shown on the plans or ordered by the Engineer. Details not shown on the plans shall be in accordance with the "Manual de Dispositivos Uniformes para el Control de Tránsito en las Vías Públicas de Puerto Rico" (MDUCT) of the P.R. Department of Transportation and Public Works. All markings shall present a clear cut, uniform and workmanlike appearance. Any markings which fail to have a uniform, satisfactory appearance, either day or night, shall be corrected at the Contractor’s expense.

c. Tack points shall be painted on the pavement at appropriate intervals for use in aligning the markers when delineating traffic stripes and, if necessary to achieve the required accuracy, a string line will be set from such points. The tack points shall be painted prior to opening any pavement to traffic to provide for traffic guidance until the final markings are applied.

d. Before any final pavement marking work is begun, a schedule of operations shall be submitted for the approval of the Engineer.

e. When pavement markers are to be applied under traffic, the Contractor shall provide all necessary flags, markers, signs, cones, etc. to protect the markers until they are thoroughly set and can be crossed without damaging them. The Contractor shall take all the necessary measures to control and protect the traffic while the marking operations are in progress and shall comply with the applicable provisions of Specification 638. The application of pavement markers shall be done in the general direction of traffic; marking against traffic shall not be allowed except when marking the center line of a two-way, two-lane road.

f. The application of raised pavement markings shall not be initiated until at least ten (10) days after the pavement is completed but shall be started no later than 5 days thereafter.

g. Markers shall be bonded to the pavement using the adhesive specified in paragraph 716-6.03 of Specification 716. However, standard set type adhesive shall only be used when the installation will not be exposed to traffic for at least six hours.

h. No marker shall be placed over longitudinal or transverse joints of the pavement surface.

i. The adhesive shall be placed uniformly on the pavement surface or on the bottom of the marker in sufficient quantity to completely cover the base of the marker with no voids present and with a slight excess after the marker has been pressed in place. The marker shall be placed in position and pressure applied until firm contact is made with the pavement. Excess adhesive around the edge of the marker, excess adhesive on the pavement, and any adhesive on the surface of the marker shall be immediately removed. Soft rags moistened with mineral spirits conforming to Federal

Specification TT-T 291, or kerosene, may be used to remove adhesive from the exposed surface of the marker. The marker shall be protected against impact until the adhesive has hardened to the degree designated by the Engineer.

640-3.02 Tolerances

a. Dimensions - The length of the segment for skip stripes delineated by raised markers and the open gap between segments may each vary plus or minus 30 centimeters, except that the over and under tolerance length shall approximately compensate.

b. Alignment - On tangents, and on curves of 1800 meter radius or larger, the alignment of the traffic stripes delineated by markers shall not deviate from the stringline line by more than 2.5 centimeters. On curves of less than 1800 meter radius, the maximum permissible variation will be 5.0 centimeters. The outer edge of pavement edge markings shall fall uniformly at no less than 5.0 nor more than 10.0 centimeters from the edge of pavement and shall have no noticeable deviations in alignment.

c. Correction Rates - Any corrections in variations in the alignment of markers shall not be made abruptly but the markers shall be returned to the stringline alignment at the rate of at least 8 meters per 2.5 centimeters of correction.

640-3.03 Corrective Measures

a. All markings which fail to meet the specifications, including the tolerance and appearance requirements, or are damaged by the Contractor’s equipment and operations, shall be corrected at the Contractor’s expense. When necessary to correct a deviation which exceeds the permissible tolerance in alignment, that portion of the marking shall be removed and replaced in accordance with these specifications at the Contractor’s expense.

b. Removal of markers shall be done by means approved by the Engineer, which will not damage the underlying surface of the pavement.

640-3.04 Acceptance

When the work under this specification has been completed to the satisfaction of the Engineer, including any required corrective work, and the pavement is to be opened to traffic, acceptance will be made by the Engineer, independently of other remaining work under the contract, and the Contractor will be relieved of maintenance of the markings after 3 months of service under traffic, except as covered by warranties or for damage caused by his operations.

640-4 METHOD OF MEASUREMENT

640-4.01 Reflective and non-reflective raised pavement markers will be measured as units of the types and colors specified, determined from actual count in place and accepted.

640-5 BASIS OF PAYMENT

640-5.01 The quantities determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such prices and payment shall constitute full compensation for furnishing and placing all materials, and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

SPECIFICATION 640 – RAISED PAVEMENT MARKINGS

640-5.02 Payment will be made under:

Pay Item	Pay Unit
Non-reflective Raised Pavement Markers White or Yellow……..	Each
Reflective Raised Pavement Markers One way or two-way, clear, yellow or red……	Each

SPECIFICATION 650 – SLOPE PAVING

650-1 DESCRIPTION

650-1.01 Scope - This work shall consist of constructing grouted stone or portland cement concrete slope paving of the designs called for in the contract, in accordance with these specifications, and in conformity with the lines, grades and dimensions shown on the plans or ordered by the Engineer.

650-2 MATERIALS

650-2.01 Portland cement concrete shall meet the requirements of Specification 601 - Structural Concrete for the class of concrete specified on the plans. When the class of concrete is not specified on the plans, Class A concrete shall be provided.

650-2.02 Stone for grouted stone paving shall consist of sound, hard, durable, flat quarry or field stone of the sizes indicated on the plans. If the sizes are not shown, the stones shall be between 4" and 6" thick and weigh about 30 pounds each. Aggregate for filling the interstices between the stones shall consist of clean gravel, or crushed stone all passing the 3/8 inch sieve but with no more than 10 percent passing the No. 40 sieve. Contractor shall submit samples of both the stone and filler aggregate for approval by the Engineer prior to use.

650-2.03 Other materials shall conform to the requirements of the specifications indicated below:

Material	Specification
Bed Course Material……	703-5.02
Concrete Joint Filler……	705-1
Masonry Mortar……...	705-4
Reinforcing Steel…….	709-1

SPECIFICATION 650 – SLOPE PAVING

650-3 CONSTRUCTION REQUIREMENTS

650-3.01 Foundation Bed

a. The foundation bed for the slope paving shall be constructed to the required elevation below the finished surface of the paving and shall be shaped and compacted to a smooth, uniform surface.

b. Where indicated on the plans a bedding of compacted bed course material shall be provided. In addition, all soft and yielding material, or other unsuitable material, shall be removed and replaced with compacted bed course material at the locations indicated by the Engineer.

650-3.02 Concrete Paving

a. The manufacture, placing, finishing and curing of concrete for slope paving shall be in accordance with the requirements of Specification 601 - Structural Concrete.

b. Placing of reinforcing steel, when such steel is called for in the plans, shall be in accordance with the requirements of Specification 602 - Reinforcing Steel.

c. Concrete slope paving shall be constructed in uniform sections approximately five (5) meters in length and two (2) meters in width except where shorter sections are necessary for closures, but no section shall be less than one meter long. The concrete shall be placed in the forms to the depth specified and tamped and spaded until mortar entirely covers the surface. The concrete surface shall be floated smooth. Before the concrete is given the final finishing, the paving shall be checked and any irregularities of more than 13 mm. in 3 meters shall be eliminated.

d. Contraction or construction joints shall be formed as shown on the plans but the spacing between joints shall not exceed 6 meters.

SPECIFICATION 650 – SLOPE PAVING

650-3.03 Grouted Stone Paving

a. The stones shall be placed on the foundation bed with the flatter faces up and with close joints not exceeding 2.5 centimeters in width. Each stone shall be thoroughly rammed until the surface is firm and conforms to the finished grade, alignment and cross section shown on the plans.

b. After each stone has been rammed into place and the surface is satisfactory, the spaces or voids between and around the stone shall be filled with broken stones, or gravel to within seven (7) centimeters of the surface.

c. After the placing of stones is completed, masonry mortar grout shall be poured and broomed into the spaces between the stones. These operations shall continue until the grout remains about one centimeter below the top of the stone. The grout shall be of a creamy consistency which will flow readily into the spaces between the stones.

d. The grouted stone paving shall be kept moist for four (4) days after pouring the grout.

650-4 METHOD OF MEASUREMENT

650-4.01 Grouted stone and concrete slope paving will be measured by the square meter, surface measurement, of slope paving completed and accepted.

650-4.02 No separate measurement for direct payment will be made of any excavation and backfilling that may be required in preparing the foundation nor for any bed course material required to complete the bedding. This work and materials shall be a subsidiary obligation of the Contractor with their cost included in the unit price for the slope paving items.

650-4.03 Reinforcing steel, when specified for concrete slope paving, will not be measured for separate payment but shall be a subsidiary obligation of the Contractor with its cost included in the price of the concrete slope paving item.

650-5 BASIS OF PAYMENT

650-5.01 The accepted quantities of slope paving, determined as provided above for the pay items listed below which are included in the contract, will be paid for at the corresponding contract unit price per square meter. Such price and payment shall constitute full compensation for preparing the bedding, furnishing and placing all materials, and for all labor, equipment, tools and incidentals necessary to complete the work as required by the plans and specifications.

650-5.02 Payment will be made under:

Pay Item	Pay Unit
Concrete Slope Paving……	Square Meter
Grouted Stone Paving……..……..	Square Meter
Grouted Stone or Concrete Slope Paving*…….	Square Meter

* When this pay item is included in the proposal, it shall be understood that the Contractor has the option of selecting the type of slope paving, concrete or grouted stone, to be used. However, only one type shall be used throughout the project unless otherwise authorized by the Engineer.

SPECIFICATION 652 – EPOXY ADHESIVE

652-1 DESCRIPTION

652-1.01 Scope - This work shall consist of furnishing and applying an epoxy resin adhesive for bonding fresh portland cement concrete to old portland cement concrete at the locations shown on the plans, in accordance with these specifications and as directed by the Engineer.

652-2 MATERIALS

652-2.01 The epoxy adhesive shall be two-component, flexible, polysulfide modified epoxy binder meeting the requirements of Class I or Class III of AASHTO M 235, as called for in the contract documents.

652-2.02 The epoxy adhesive will be accepted on the basis of manufacturer's certificates that the materials proposed to be furnished meet all specification requirements. Such certificates shall be accompanied by certified laboratory reports showing the results of the tests performed on the materials.

652-2.03 The Authority may, at its discretion, sample and inspect the epoxy materials either at the place of manufacture, from warehouse lots, or from containers delivered at the project, for testing by the Authority.

652-2.04 The materials shall be packaged and delivered in strong substantial containers. The containers shall be identified as "Part A - Epoxy Resin" and "Part B - Hardener". Each container shall be clearly marked with the following information:

a. Name of product.
b. Name and address of manufacturer.
c. Lot and batch number.
d. Date of manufacture.
e. Date of expiration of acceptance.
f. Quantity.
g. Mixing proportions and instructions.

SPECIFICATION 652 – EPOXY ADHESIVE

652-3 CONSTRUCTION REQUIREMENTS

652-3.01 Preparation of Adhesive

a. Immediately prior to use, each component shall be thoroughly mixed with a clean paddle. The paddle shall be of a type that does not induce air into the material. Separate paddles must be used for each component.

b. The two components shall be thoroughly mixed at the site just before using. The mixing ratios, mixing time and procedures shall be in strict accordance with the manufacturer's recommendations. When mixed, all adhesives with different color components shall have a uniform color without streaks.

c. No more material shall be mixed than can be spread within eight minutes from the time operations are started.

652-3.02 Preparation of Surfaces - The concrete surfaces upon which the epoxy adhesive is to be spread shall be completely free of rust, paint, grease, oil, asphalt, laitance, unsound concrete, loose material, dust and any other deleterious substance. The concrete surface shall be dry before any epoxy is applied except when epoxy specifically formulated and recommended by the manufacturer for use on damp concrete surfaces is used.

652-3.03 Application of Adhesive - The mixed epoxy adhesive shall be spread over the prepared surface with a brush at a rate sufficient to thoroughly and uniformly coat the surface. Spreading rate will normally vary from 25 square feet per gallon for very rough surfaces to 40 square feet per gallon on sand blasted concrete.

652-3.04 Placing of New Concrete - The new concrete shall be placed against the epoxy adhesive coating within 15 minutes at temperatures below 90°F and 10 minutes at temperatures above 90°F, and before thickening of the epoxy has begun.

SPECIFICATION 652 – EPOXY ADHESIVE

652-3.05 **Safety Measures** - The epoxy resin adhesives can cause severe dermatitis. The Contractor shall provide and insure that the workmen handling and applying these materials wear appropriate boots, gloves, safety glasses, protective creams and clothing to prevent contact with the skin and eyes.

652-4 METHOD OF MEASUREMENT

652-4.01 No measurement will be made of this item as it will not be paid for directly.

652-5 BASIS OF PAYMENT

652-5.01 The furnishing and application of epoxy adhesive will not be paid for directly but shall be a subsidiary obligation of the Contractor with its cost included under the corresponding pay items of concrete.

SPECIFICATION 653 – PAINTING STEEL STRUCTURES

653-1 DESCRIPTION

653-1.01 Scope - This work shall consist of painting steel structures and includes the furnishing of all the required paints; the preparation of the metal surfaces to be painted; the application, protection and drying of the paint coatings; and the protection of all traffic or underneath the structure. The work shall be performed in accordance with this specification and in conformity with the details shown on the plans or established by the Engineer.

653-2 MATERIALS

653-2.01 Paints and paint materials shall conform to the requirements of Specification 708 - Paints for Steel Structures and shall be in accordance with the systems set forth in Table 653-1. The paint system or systems to be applied and the finish color shall be as indicated on the plans. When the paint system is not specified in the contract documents, the Alkyd-Oil Basic Lead Silico-Chromate System (Spec. 708-3) will be used and the finish color shall be a green conforming to Federal Color Standard 595-1427-2.

TABLE 653-1

PAINT SYSTEMS

System/Specification	Coating	Dry Film Thickness (mils)
Vinyl Paint System Specification 708-2	Wash Primer	0.5
	2nd. Coat	1.5 – 2.5
	3rd. Coat	1.5 – 2.5
	4th. Coat	1.5 – 2.5
	Finish Coat	1.5 – 2.5
	Total Thickness	6.5 – 10.5

SPECIFICATION 653 – PAINTING STEEL STRUCTURES

System/Specification	Coating	Dry Film Thickness (mils)
Alkyd-Oil Basic Lead	Prime Coat	2.0 - 3.0
Silico-Chromate	Second Coat	1.5 – 2.5
Paint	Third Coat	1.5 - 2.5
System	Finish Coat	2.0 - 3.0
Specification 708-3	Total Thickness	7.0 – 11.0

653-3 CONSTRUCTION REQUIREMENTS

653-3.01 Surface Preparation

a. Except for weathering steel, the surfaces of structural steel and welds shall be thoroughly cleaned prior to the application of any paint. All oil, grease, dirt, rust, weld slag, mill scale, old paint and other deleterious substances shall be removed from the surface.

b. Methods of cleaning described below shall be in accordance with the provisions, unless otherwise specified, of the Steel Structures Painting Council (SSPC) - Surface Preparation Specifications. The SSPC is located at Mellon Institute, 4400 Fifth Avenue, Pittsburgh, PA 15213.

1. Solvent Cleaning (SSCP-SP1) - may be used for the removal of dirt oil, grease, drawing and cutting compounds and detrimental weld fume deposits.

2. Hand Tool Cleaning (SSCP-SP2) - may be used for the removal of loose rust, loose mill scale and loose paint. Hand tool cleaning includes the use of hand sanding, brushing, chipping and other hand impact tools.

3. Power Tool Cleaning (SSCP-SP3) - Includes the removal of loose rust, loose mill scale, loose paint and slag with power sanders, power impact tools,

power wire brushes, power grinders and other appropriate power tools.

4. Brush-off Blast Cleaning (SSPC-SP7) - May be used for rapid removal of oil grease, dirt, loose rust, loose mill scale, loose paint and slag. Tight rust, mill scale and old paint may be sufficiently abraded by this method to provide adhesion for the new paint.

5. Commercial Blast Cleaning (SSPC-SP6) - Used for the removal of all dirt, grease, rust scale, foreign material, mill scale, rust, old paint and slag. The cleaned surface shall show only slight evidence of shadows streaks or discoloration and shall be free of all rust, mill scale and old paint.

c. Unless otherwise noted in the contract documents, all new and existing structural steel to be painted shall receive a final surface preparation by the Commercial Blast Cleaning method. The other methods may be used to supplement the blast cleaning as necessary.

d. Surfaces that will be inaccessible after fabrication shall be blast cleaned and painted before assembly.

e. Following blast cleaning, all surfaces shall be brushed clean with bristle or wood fiber brushes, blown clean with compressed air which is free of oil or water, or cleaned by vacuum to remove any trace of blast products from the surface, pockets or corners, and the final surface condition shall be approved by the Engineer before painting commences.

f. Blast cleaned surfaces shall receive the prime coat of paint within 24 hours after cleaning, unless otherwise authorized by the Engineer. Any new rust or surface contamination occurring before painting shall be recleaned at the Contractor's expense. However, a dry surface upon

which very light rusting may have formed after cleaning may be considered acceptable.

g. Where touch-up of an initial or shop coat is required, cleaning of small areas may be accomplished by the use of a needle gun or coarse sandpaper. Larger areas shall be blast cleaned.

653-3.02 Paint Preparation

a. Before paint is applied, it shall be thoroughly mixed so the pigment is completely in suspension and the consistency is uniform. It shall be kept in this uniform condition while being applied.

b. No thinner shall be added to the paint unless authorized by the Engineer as essential for proper application. When authorized, the type and amount of thinner used shall be in strict accordance with the paint manufacturer's specifications and shall be added during the mixing process. No further thinner shall be added after the paint has been thinned to the correct consistency.

c. Tinting pastes or color, when required, shall be added to the original paint containers and shall be thoroughly mixed by mechanical means until the paint color is uniform throughout.

653-3.03 Application of Paint

a. No painting shall be applied until cleaned steel surfaces have been inspected and approved by the Engineer.

b. No paint shall be applied upon wet or damp surfaces. No paint shall be applied in the field during adverse weather such as rainy conditions or when the relative humidity exceeds 85%, or other conditions which in the opinion of the Engineer are unsatisfactory for painting.

c. Material painted under cover in damp weather shall remain under cover until the paint is dry or until weather conditions permit its exposure in the open. Any wet paint exposed to excessive humidity, rain or condensation shall be permitted to dry, and damaged paint shall then be removed and the surface recleaned and repainted. Painting in open yards or upon erected structures shall not be done, when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

d. All paint shall be applied in a neat and workmanlike manner. Paint shall be applied uniformly in the specified number of coatings with each coating having the wet film thickness necessary to meet the specified dry film thickness. The requirements shown in Table 653-1 for the paint system used shall apply unless otherwise called for in the contract documents.

e. Paint may be applied by brushes, rollers or air-less spray, or a combination of these methods, in such way that coating shall be free of runs, sags, drips, ridges or other defects. Each coat of paint shall be in proper state of cure or dryness, as recommended by the paint manufacturer, before the application of the succeeding coat.

1. Hand Brushing - The paint, when applied with brushes, shall be so manipulated by the brush as to produce a uniform even coating. When applying a coating to a previously painted surface, strokes should be made perpendicular to those of the previous coat to insure adequate anchorage. Brushes shall be of good quality and the length of the exposed bristle shall be equal to or greater than the width of the brush. On those areas which are inaccessible to brushes, the paint shall be applied by the use of rollers, or air-less spray equipment, or daubers.

2. Rolling - Rollers for the application of paint shall be of such a quality as to produce a smooth

uniform coating. Roller covers shall be "all mohair" made from Angora goat wool; "mohair" made from blends of mohair, wool and/or rayon or as approved by the Engineer. Roller nap lengths shall be from 1/2 – 1-1/2 inches. The roller cover shall be uniformly loaded with paint by rolling on the slanted surface of a tray, framed screen wire or other suitable device. Roller application shall be done at such a pace that no spinning of the roller or throwing off of paint occurs when the roller is lifted from the surface. The paint shall be feathered out by using light pressure at the end of the stroke to promote uniformity. On those areas which are inaccessible to roller application, the paint shall be applied by brushes, or air-less equipment, or daubers.

3. Air-less Spraying - Air-less spray equipment shall be capable of applying paint in a fine, even spray so as to produce a uniform coating. Air-less spray equipment shall consist of a hydraulic pump (air or electric power) mounted over a paint tank, high pressure hoses, spray gun, valves, gages, regulators, screens, traps and other equipment necessary to satisfactorily complete the work. Spray painting shall be done by experienced and qualified painters. Painters shall determine the best distance between the spray gun and receiving surface so as to promote uniform coverage and prevent discontinuity of the applied paint film. The spray gun shall be moved uniformly across and perpendicular to the receiving surface. To insure a uniform coating each spray pass should lap the other by 50%. Any sags, drips, air holes or other film defects shall be immediately corrected by hand brushing. On those areas that are inaccessible to air-less spray application, the paint shall be applied by brushes, or rollers, or daubers.

SPECIFICATION 653 – PAINTING STEEL STRUCTURES

653-3.04 Shop Painting

a. All new structural steel specified to be painted shall receive at least the prime coat of paint in the shop after the fabrication work is completed and accepted. Unless otherwise specified, the second coat of paint may also be applied in the shop.

b. Surfaces, against which plastic concrete is to be placed, shall not be painted. Bolts, nuts and washers shall not be shop painted. Shop contact surfaces shall not be painted unless specified.

c. Surfaces, which are not be in contact, but which will be inaccessible after erection shall be painted in the shop with the full paint system required on the completed structure.

d. If paint would be harmful to a welding operator or would be detrimental to the welding operation or the finished welds, the steel shall not be painted within a suitable distance from the edges to be welded.

e. Antiweld spatter coatings shall be removed before painting. Weld slag and flux shall be removed by methods at least as effective as those specified for the cleaning.

f. Machine-finished or similar surfaces that are not to be painted shall be coated with a rust inhibitive petroleum.

g. Erection marks and weight marks shall be copied on areas that have been previously painted with the shop coats. The manufacturer or fabricator shall not paint his name upon any structural members.

653-3.05 Field Painting

a. Steel structures shall be painted as soon as practicable after erection.

b. Metal which has been shop coated shall be touched up with the same type of paint as the shop coat. This touch-up shall include cleaning and painting of field connections, welds, rivets, and all damaged or defective paint and rusted areas. The Contractor may apply an overall coat of primer in place of touch-up or spot painting.

c. Surfaces (other than contact surfaces) that are accessible before erection but which will not be accessible after erection shall receive all field coats of paint before erection.

d. The final coat of paint shall not be applied until all concrete work is finished. If concreting or other operations damage any paint, the surface shall be cleaned and repainted. All cement or concrete spatter and drippings shall be removed before any paint is applied.

e. Wet paint shall be protected against damage from rain, dust or other detrimental foreign matter to the fullest extent practicable.

f. The contractor shall protect pedestrian, vehicular and other traffic upon or underneath the structure, and also all portions of the superstructure and the substructure against damage or disfigurement by splatters, splashes and smirches of paint or paint materials.

g. All metal coated with paint which is not acceptable, shall be thoroughly blast-cleaned and repainted by the Contractor at his expense, to the satisfaction of the Engineer.

653-3.06 Handling of Painted Steel

a. Painted steel shall not be handled nor loaded for shipment until the paint has dried, except for necessary handling in turning for painting or stacking for drying. Precautions shall be taken to minimize damage to paint films resulting from stacking members.

b. Paint that is damaged in handling shall be scraped off and touched up with the same number of coats and kinds of paint as were previously applied to the steel.

653-3.07 Measurement of Dry Film Thickness of Paints

a. Equipment - The Contractor shall furnish to the Engineer at least one Type 1 Magnetic Gauge for measuring dry paint film thicknesses. This may be a Tinsley, Elcometer, Microtest, Positactor or Inspector model. The Contractor shall also furnish the basic calibrating standards, preferably the chrome plated steel panels available from the National Bureau of Standards in coating thicknesses from 0.5 to 8 mils. Plastic skims of certified thicknesses in the appropriate range may also be used in lieu of the NBS standards.

b. Calibration - The Contractor shall calibrate the gauges and furnish the calibration correction factors to the Engineer, who will recheck these as often as he may determine.

c. Measurement Procedures

1. Three gauge readings shall be made for each spot measurement of either the substrate or the paint. The probe shall be moved a short distance for each new gauge reading. Any unusually high or low gauge reading that cannot be repeated consistently shall be discarded. The average of the three gauge readings will be taken as the spot measurement.

2. The base substrate shall be measured at a number of spots to obtain a representative average value. The dry paint film shall also be measured at the specified number of spots. The readings shall be corrected as per the gauge calibration factors. The corrected base substrate average value shall be subtracted from the corrected average dry film readings to obtain the thickness of the dry paint film above the peaks of the surface.

d. Special Notes

1. All of the above magnetic gauges, if properly adjusted and in good condition, are inherently accurate to within + 15% of the true thickness of the coating.

2. Much larger, external errors may be caused by variations in method of use of the gauges or by unevenness of the surface of the substrate or of the coating. Also, any other films present on the steel (rust of mill scale or even a blast cleaned profile zone) will add to the apparent thickness of the applied paint film.

3. The surface of the paint and the probe of the gauge must be free from dust, grease and other foreign matter in order to obtain close contact of the probe with the paint and also to avoid adhesion of the magnet. The accuracy of the measurement will be affected if the coating is tacky or excessively soft.

4. The magnetic gauges are sensitive to geometrical discontinuities of the steel, as at holes, corners or edges. The sensitivity to edge effects and discontinuities varies from gauge to gauge. Measurements closer than 2.5 cm. from the discontinuity may not be valid unless the gauge is calibrated specifically for that location.

5. Magnetic gauge readings also may be affected by proximity to another mass of steel close to the body of the gauge, by surface curvature, and by presence of other magnetic fields.

6. All of the magnets or probes must be held perpendicular to the painted surface to produce valid measurements.

653-3.08 Cleaning Weathering Steel - Unless otherwise provided in the contract documents, weathering steel structures shall not be painted but shall be cleaned as follows:

a. Exterior surfaces of all fascia girders and bottom surfaces of all bottom flanges (including splice plates) of all girders shall be blast cleaned to the finish commonly known as commercial blast cleaned surface. Such cleaning shall remove all rust, mill scale, paint and other markings, dirt and all other foreign materials and shall produce a uniformly cleaned, bare metal surface, with only slight shadows, streaks, discolorations from rust and mill scale oxides remaining. Grease, oil and paint shall first be removed by suitable solvents.

b. All other weathering steel surfaces shall be cleaned only to the extent necessary to remove oil, grease, dirt, weld slag and spatter, paint, crayon or chalk markings and other foreign material. All rust and mill scale may remain.

c. All blast cleaned surfaces shall be protected against contamination by oil, grease, paint or other markings during transportation, storage and erection, and against form marks and mortar leaks and spatters during decking and concrete placement. Oil and grease shall be removed with suitable solvents. Dirt, mortar leaks and spatters shall be removed by appropriate methods.

d. All cleaned surfaces shall present a uniform surface appearance in the completed structure and shall be free of any substance which will affect the natural oxidation of the steel.

653-4 METHOD OF MEASUREMENT

653-4.01 Unless otherwise provided in the contract documents, no measurement will be made of the surface preparation and the painting of structural steel or the cleaning of weathering steel of new structures. This work on new structures will not be paid for directly

but shall be a subsidiary obligation of the Contractor under the work and pay items included under Specification 616 - Steel Structures.

653-4.02 For the surface preparation and field painting of existing steel structures, when called for in the contract, each structure will be measured as a separate unit for payment as a lump sum item.

653-5 BASIS OF PAYMENT

653-5.01 All the work required under this specification for new structures shall be a subsidiary obligation of the Contractor under the pay items of Specification 616 - Steel Structures.

653-5.02 For each existing steel structure, to be painted, the contract lump sum price and its payment shall constitute full compensation for all required surface preparation and painting, or cleaning in the case of weathering steel, and for all materials, labor, tools and incidentals necessary to satisfactorily complete the work specified.

653-5.03 For existing structures payment will be made under:

Pay Item	Pay Unit
Painting Structure at Sta. _____……	Lump Sum

SPECIFICATION 654 – TRAFFIC SIGNAL SYSTEMS

654-1 DESCRIPTION

654-1.01 Scope

a. This work shall consist of furnishing, installing, adjusting and fine tuning new traffic signal systems in accordance with these specifications and in conformity with the locations, dimensions and details shown on the plans or established by the Engineer.

b. Each traffic signal system shall include the traffic and pedestrian signal heads, the signal support structures, the detector units, the local and master controllers, conduits, pull boxes, handholes, electrical conductors, telecommunications cables, and all hardware, fittings, appurtenances, materials and equipment required to provide a complete operational system as specified and as shown on the plans.

c. When so indicated in the contract documents, this work shall also include the maintenance, modification, replacement or removal of existing traffic signal systems as shown on the plans and as directed by the Engineer.

654-1.02 Definitions - The following definitions pertain to work, equipment and materials used in traffic signal systems. Terms not included herein but pertaining to detectors, controllers, signals, signal supports and mounting hardware are as defined in NEMA Standards Publication TS-1 - Traffic Control Systems.

Actuation - The operation of any type of detector.

Controller Assembly - A complete assembly for controlling the operation of a traffic signal, consisting of a controller unit and all auxiliary equipment housed in a weatherproof cabinet or cabinets.

Controller Unit - That part of the controller assembly which performs the basic timing and logic functions.

SPECIFICATION 654 – TRAFFIC SIGNAL SYSTEMS

Cycle - A complete sequence of signal indications.

Cycle Length - The time in seconds required for one complete cycle.

Detector - A device for indicating the passage or presence of vehicles or pedestrians.

Flasher - A device used to open and close signal circuits at a repetitive rate.

Induction Loop Detector System - A detector consisting of a wire loop embedded in a precast concrete slab placed in the roadway surface, or embedded in the deck of a structure, and connected to an electronic device that is capable of sensing the passage or presence of either moving or stationary vehicles by the change in the electrical inductance characteristics of the wire loop.

Interval - The part or parts of a signal cycle during which signal indications do not change.

Interval Sequence - The order of appearance of signal indications.

Master Controller Assembly - A controller assembly for supervising a system of secondary controller assemblies.

Pedestrian Detector - A detector, usually of the push button type, capable of being operated by hand.

Phase Sections - That electrical portion or program of the controller unit with its manually variable program controls which provides control of right of way and clearance interval timing and other functions for a particular phase.

Recall Switch - A manual switch on a traffic-actuated controller unit which will place a recurring demand for service on the phase when that phase is not in its green interval.

Right of Way - The right of a vehicle or pedestrian to proceed in a lawful manner.

SPECIFICATION 654 – TRAFFIC SIGNAL SYSTEMS

Signal Face - That part of a signal head provided for controlling traffic in a single direction and consisting of one or more signal sections.

Signal Head - An assembly containing one or more signal faces.

Signal Indication - The illumination of a signal section or other device, or of a combination of sections or other devices at the same time.

Signal Section - A complete unit for providing a signal indication consisting of a housing, lens, reflector, lamp receptacle and lamp.

Split - A division of the signal cycle length allocated to each of the various phases. (Normally expressed in percent).

Traffic-Actuated Controller Assembly - A controller assembly for operating traffic signals in accordance with the varying demands of traffic as registered with the controller unit by detectors.

Traffic Phase - The right of way, change and clearance intervals assigned to a traffic movement or combination of movements.

654-2 MATERIALS

654-2.01 General

a. All electrical equipment shall conform to the applicable standards of the National Electrical Manufacturers Association (NEMA), the Underwriters Laboratories, Inc. (UL), and the Electronics Industries Association (EIA). In addition to the requirements of the plans, these specifications and the special provisions, all materials and workmanship shall conform to the applicable requirements and standards of the P.R. Electric Power Authority (PREPA), the National Electrical Code (NEC), the American National Standards Institute (ANSI), the Institute of Electronic and Electrical Engineers (IEEE) and the ASTM.

b. Wherever reference is made to any of the standards or codes mentioned above, the reference shall be construed to mean the standard or code that is in effect on the date the contract is advertised for bids. Differences in standards or code requirements shall be resolved by applying the more restrictive unless otherwise approved by the Engineer.

c. Where a criterion specification is designated for any material or equipment to be installed by the name or catalog number of a specific manufacturer, such designation is intended only for the purpose of establishing the style, quality, and performance characteristics, and is not intended to limit the acceptability of competitive products. Products of other manufacturers which meet the specification requirements and which are approved as equal or better will be acceptable.

654-2.02 Traffic Signals Equipment and Materials - The specific components used in the construction of new traffic signal systems shall meet the requirements of the specifications indicated below:

Material	Specification
Traffic Signal Heads…….	723-1
Optically Programmed Signal Heads……...	723-2
Pedestrian Signal Heads……...	723-3
Traffic Signal Supports……	723-4
Inductive Loop Vehicle Detector Systems……...	723-5
Pedestrian Push Button Detector……..	723-6
Local Traffic Signal Controller Assembly……...	723-7
Traffic Signal System Master Controller Assembly……...	723-8
Rigid Plastic Conduit……	723-9
Galvanized Steel Conduit…….	723-10
Pull Boxes and Junction Boxes……	723-11
Electrical Conductors……...	723-12

SPECIFICATION 654 – TRAFFIC SIGNAL SYSTEMS

Material	Specification
Telecommunication Cable……	723-13
Grounding Materials…….	714-14
Sealant for Loop Detectors……..	705-1

654-2.03 Concrete - Concrete shall conform to the requirements of Specification 601 - Structural Concrete and shall be Class A unless otherwise specified in the plans. Reinforcing steel shall conform to the requirements of Specification 602 - Reinforcing Steel.

654-2.04 Equipment Lists and Shop Drawings

a. The Contractor shall submit to the Engineer for review, within 30 days following the award of contract and before purchasing materials or equipment for this work, a list of the equipment and materials which he proposes to install. The list (five copies) shall include the name of manufacturers, size, and identifying number of each item, descriptive literature, drawings, specifications, manuals and such other data as may be required to evaluate it.

b. The Contractor shall also submit to the Engineer for review and approval, five copies of manufacturer's shop drawings, structural design computations, schematic wiring diagrams, and scale drawings of cabinets showing location and spacing of shelves, terminal blocks and equipment. The drawings shall show the location of the installation and shall list all the equipment to be installed in each cabinet.

c. The submittals for the traffic signal support structures, traffic and pedestrian signal heads, loop detector units, pedestrian detectors, and the local and master traffic controller assemblies shall be accompanied by a certification from each manufacturer to the effect that the equipment meets all the requirements of the plans and specifications. In the event that any item is not exactly in accordance with the

plans and specifications requirements, the certificate shall identify and explain each such difference.

d. All equipment operation and maintenance manuals, detailed parts lists, and diagrams required under Specification 723 shall be submitted at the time that the previously approved equipment is delivered to the project.

e. The approval of shop drawings and diagrams by the Engineer shall not relieve the Contractor of his responsibility for correcting any deficiencies due to erroneous or inconsistent dimensions, notations, omissions or other errors, or for the proper functioning of the completed installation, at his expense.

654-2.05 Warranties and Guarantees

a. All the traffic signal system equipment and devices shall be guaranteed against defective parts and workmanship under manufacturers warranties. The warranties shall be in accordance with customary trade practice but shall be for a period of not less than one year from the date of satisfactory initial start-up and placing in operation at the project site, and shall cover the full costs of materials necessary to repair or replace the defective component.

b. The Contractor shall guarantee the satisfactory installation and in-service operation of all the traffic signal system and related components for a period of six months following the acceptance of the project by the Authority. During the warranty period the Contractor shall repair or replace, at no expense to the Authority, any equipment, materials or work that does not provide satisfactory operation due to equipment, materials and/or installation deficiencies.

c. Any items repaired or replaced within the above guarantee periods shall be guaranteed for an additional period, meeting the requirements specified above, from the

date of acceptance of the repaired or replaced item by the Authority.

d. The Contractor shall deliver to the Engineer, prior to the acceptance of the project, the manufacturers and his warranties and guarantees required above.

654-3 CONSTRUCTION REQUIREMENTS

654-3.01 General

a. The Contractor shall obtain all necessary permits and inspections required by PREPA and any other applicable laws and regulations, and shall pay all required fees as subsidiary obligation under the contract pay items.

b. Construction shall conform to the details shown on the plans; however, the location of support structures, signals, detectors, controllers, conduits and other appurtenances shown on the plans are approximate only and the exact location will be established by the Engineer in the field.

c. Upon completion of the work the Contractor shall submit "As Built" plans incorporating any changes in the original plans.

d. All systems shall be complete, fine tuned and in operating conditions at the time acceptance of the project is requested.

654-3.02 Maintenance of Existing Signal Systems

a. The Contractor shall be responsible for maintaining in effective operation any traffic signal systems existing within the project limits during the progress of the work and until such time as the new signals are in operation and removal of the existing ones is authorized by the Engineer.

b. If during the course of construction of the new signal systems, part of the existing systems need to be relocated or modified to accommodate the new work, the Contractor shall perform such work as part of his obligations under this contract item.

c. When ordered by the Engineer, the Contractor shall remove all those portions of the existing signal systems scheduled for removal including, but not limited to, controllers, signal heads, support structures, cables, conductors and associated hardware and appurtenance. The removed equipment and materials shall be delivered to the Authority at the locations specified. Care shall be exercised in the removal and storage of existing equipment to prevent damage. The Contractor shall be responsible for the safekeeping of such equipment until delivery to the Authority.

d. For existing signal systems to be maintained in operation by the Contractor, the Authority will continue providing the following services:

1. Operating and maintaining the existing electrical facilities, signal heads and controllers except when such facilities are damaged or affected by the Contractor, who shall then be responsible for any required repairs.

2. Repairing or replacing existing facilities damaged by public traffic.

3. Providing electrical energy for the operation of the existing facilities.

e. Work under this item does not include the furnishing, installation, operation, maintenance and eventual removal of temporary traffic signals to be erected as called for in the contract documents. Such work is to be covered and paid for

under the provisions of Specification 638 - Maintenance and Protection of Traffic.

654-3.03 Excavation and Backfilling

a. It will be the responsibility of the Contractor to make the necessary contacts with utilities and others who have underground installations in the project area. Any damage to existing facilities caused by failure of the Contractor to notify utilities in advance of the work or other negligence by the Contractor shall be repaired by the Contractor at no expense to the Authority.

b. The Contractor shall do all excavation, backfilling and resurfacing work, including removal and replacement of curbs, sidewalks, paved surfaces and other materials necessary to complete the work in accordance with the plans and specifications.

c. Excavation and backfilling shall conform to the applicable requirements of Specification 205 - Trench Excavation and Specification 206 - Excavation for Structures, supplemented as follows:

1. Trenches for conduits will be excavated to the lines, grades, widths and depths shown on the plans or established by the Engineer. Unless otherwise specified, conduit trenches shall be dug to a minimum depth of 60 centimeters.

2. In making excavations in paved surfaces, cuts shall be made with an abrasive type power saw along the neat boundaries of the area to be removed as specified in paragraph 3.04b below.

3. All conduit trenches shall be backfilled with portland cement concrete meeting the requirements of Specification 305 - Lean Concrete Base or of Class B

Concrete under Specification 601 to the depth shown on the plans.

4. The remainder of the trench above the concrete backfill shall be backfilled with material meeting the requirements of paragraph 205-3.07 a. of Specification 205 - Trench Excavation. However, when a selected backfill material is called for in the plans, the backfill used shall meet such requirements.

5. The soil backfill above the concrete shall be placed in 15 centimeter layers and compacted by mechanical tamping tools.

6. All excavations for pole or pedestal concrete foundations shall be made to the neat lines of the foundations and the concrete must be placed directly against the sides of the excavation except where otherwise required or authorized by the Engineer. On completion of work, the adjacent surfaces shall be restored and finished to correspond with the existing surrounding surfaces.

7. Unless otherwise authorized by the Engineer, all backfilling and the removal of surplus excavated material shall be completed within 48 hours, after the opening of the excavation. Surplus material shall be disposed of outside the right-of-way or at locations within the project approved by the Engineer. The excavation site shall be cleaned up and left in a neat condition satisfactory to the Engineer.

654-3.04 Removing and Replacing Improvements

a. Improvements such as sidewalks, curbs, gutters, P.C. concrete and asphaltic concrete pavements, underlying materials, lawn and plants, and any other improvements required to be removed by the construction of the signal system, or broken or damaged by the Contractor's operations,

shall be replaced or reconstructed with the same kind of materials as found in the existing work or with materials of equal quality acceptable to the Engineer, and in accordance with the applicable specification.

b. The outline of all areas to be removed in pavements, sidewalks, curbs, gutters and driveways shall be cut to a minimum depth of five (5) centimeters with an abrasive type saw, prior to removing the existing material. Cuts shall be neat and true along score lines, with no shatter outside the removal area.

654-3.05 Foundations

a. Foundations for signal support structures and controller cabinets shall be of reinforced concrete conforming to the details shown on the plans.

b. The concrete foundations shall rest on solid ground. Forms, where required or authorized, shall be true to line and grade. Tops of foundations shall be finished as shown on the plans or as directed by the Engineer. Forms shall be rigid and securely braced and shall be held in place until the concrete has set up. Conduit ends and anchor bolts shall be placed in proper position and to proper height, and shall be held in place by means of a template until the concrete has set up.

c. All exposed portions of concrete structures shall be given a Class I finish in accordance with Specification 601. Exposed corners shall be finished with a 2.5 cm. chamfer. The projection of foundations above adjacent surfaces shall be as shown on the plans or as ordered by the Engineer.

d. Where obstructions prevent the construction of planned foundations, the Contractor shall construct an effective foundation satisfactory to the Engineer or relocate the foundations to a location designated by the Engineer. Minor modification or relocation of a designed foundation will not be considered as a changed condition.

e. Foundations for signal support structures and controller bases shall be provided with conduits for the conductor systems and for the ground connection as shown on the plans.

f. Special foundations shall conform to the applicable portions of the specifications listed herein, to the details shown on the plans and to any special requirements.

654-3.06 Fabrication and Erection of Signal Supports

a. The signal support structures shall be fabricated and installed in accordance with the details and dimensions shown on the plans, or as directed by the Engineer, including all necessary hardware and appurtenances.

b. Mast arms shall be fastened to the pole or shaft prior to erection unless otherwise approved.

c. The protective wrapping shall not be removed from any of the aluminum shafts or mast arms until authorized by the Engineer. The Contractor shall be responsible for repairing any defects or damage to the posts and arms due to rough handling during loading, shipping, unloading, storage and erection. The Contractor shall satisfactorily repair or replace, at his expense, any component so damaged prior to its acceptance.

d. Poles shall stand plumb under dead load. Before erection of the poles, the areas of concrete upon which the bases are to be set shall be dressed to provide for proper seating.

e. Mast arm signal poles shall be leveled by the use of shims or leveling nuts supplied with the pole. Before the pole is loaded it shall be raked back in excess of the calculated deflection and then plumbed after the loads are applied by adjustment of the shims or leveling nuts. When the pole is in its final position, the bottom of the signal head mounted at the

end of the mast arm shall be 17 to 19 feet above the pavement surface unless otherwise shown on the plans.

f. After the poles are leveled the voids, if any, between the base and the foundation shall be filled with grout or silicon sealant. Each pole shall be grounded in accordance with Article 654-3.07 below.

g. The length of poles for post top mounts shall be such that the bottom of the standard traffic signal head shall be not less than 10 feet above the curb. For optically programmed signal heads, the height shall be 12 feet above the curb and for pedestrian signals it shall be 7 feet.

h. The 4 inch galvanized steel post for pedestrian push button units shall be coupled to a reducer in the concrete foundation. The reducer shall in turn be coupled to a 2-inch elbow which shall extend one inch outside the concrete base for connection to the underground PVC conduit. The steel post shall extend at least 12 inches into the concrete base and shall be of such length that its top is 4 feet above the adjacent surface. The top of the post shall be closed with a galvanized steel cap. The post shall be painted federal highway yellow in accordance with Specification 653.

i. For span wire assemblies the Contractor shall determine the length of suspension, messenger and other wires required for the span including sufficient allowance for fastenings and required sag after adjustments. All the necessary hardware for attaching the suspension and messenger wires shall be capable of developing the full strength of the corresponding wires. Unless otherwise shown on the plans, the bottom of the signal heads suspended from the span wire shall be 17 to 19 feet above the pavement surface.

654-3.07 Grounding

a. Grounding shall be in accordance with and the requirements of the NEC and PREPA.

b. Grounding for all signal support structures and controller installations shall be as shown on the plans or as directed by the Engineer. The ground system shall be electrically connected to the grounding terminal on the pole or support structure, or on the controller cabinet.

654-3.08 Conduits

a. General

1. All conductors shall be run in conduit except overhead on span wires and in temporary installations, and where conductors are run inside poles and bracket arms.

2. Conduits shall be of the types and sizes shown on the plans. The Contractor may, at his option and expense, use conduit of a larger size than specified provided the larger size is used for the entire length of the run from outlet to outlet. No reducer couplings shall be permitted except where specifically indicated on the plans.

3. Conduit runs shown on the plans may be changed as to location only, with the approval of the Engineer, to avoid obstructions.

4. All conduit bends shall be standard factory bends. Where factory conduit bends are not commercially available, or for locations requiring special bends, conduit may be bent in the shop or field provided that:

(a) Radius of bends shall be the longest practicable but not less than six times the inside diameter of the conduit.

(b) The bends are made without any crimping, flattening or appreciably reducing the internal diameter of the conduit.

(c) No bends will be accepted for galvanized steel conduit which show any evidence of destruction of the protective coating.

5. The ends of conduits whether field or shop cut shall be made square and true so that the ends will butt or come together for the full circumference thereof. When a standard coupling cannot be used for coupling steel conduit, an approved threaded union coupling shall be used. All couplings for steel conduit shall be tightened until the end of the conduits are brought together, providing a good mechanical connection throughout the entire length of the run.

6. All steel conduit ends shall be threaded and capped with standard pipe caps until wiring is started. When caps are removed, the threaded ends of the conduit, including conduit nipples in cabinets, shall be provided with a metallic conduit ground bushing having a smoothly rounded molded insulated insert. Grounding type bushings shall always be used for steel conduits unless otherwise specified. When an open conduit ends below ground, the Contractor shall furnish and install a non-hardening pipe compound that will prevent the entrance of moisture.

7. Underground conduit runs and conduit risers in poles shall be installed as needed even though not shown on plans.

8. Non-metallic type conduit shall be cut with a hacksaw or other approved tool and connections shall be of the solvent weld type. The ends of these conduits shall be capped until wiring is started.

9. All spare conduits for future use shall be capped at both ends.

b. Underground Conduit

1. Conduit shall be installed as shown on the plans within the required excavation. Unless otherwise specified, the conduit trench shall be 20 centimeters wide and a minimum of 60 centimeters deep.

2. Conduit shall be seated on metal chairs or PVC spacers in the trench that will raise it 7.5 centimeters above the trench bottom with no sagging between supports.

c. Conduit in Structures

1. Conduit which is to be embedded in structural concrete shall be either rigid galvanized steel or rigid PVC unless otherwise specified. An expansion joint of an approved type shall be installed at every expansion joint in the structure that the conduit crosses.

2. For exposed installation on structures, the conduit shall be rigid galvanized steel and shall be attached with approved clamps or straps.

d. Testing

1. All conduits installed shall be tested for clear bore and correct installation by the Contractor using an appropriate snake before the installation will be

accepted. Snaking of the conduits shall be done by the Contractor in the presence of the Engineer or his representative. Any obstructed conduit shall be cleared by the Contractor and he shall replace any defective conduit at his expense.

2. A record shall be kept as the conduits are tested and, after testing, all the empty conduits and duct openings shall be capped or plugged by the Contractor in accordance with Article 654-3.08 above.

654-3.09 Pull Boxes and Junction Boxes

a. Pull boxes and junction boxes shall be installed at the approximate locations shown on the plans but pillboxes shall be spaced at not more than 45 meters from each other. The Contractor may, at his expense, install additional junction or pull boxes to facilitate his work.

b. The tops of pull boxes and handholes installed in sidewalk or paved areas shall be flush with the surrounding grade or top of adjacent curb. Those installed in the ground shall have the tops projecting 5 cm. above the adjacent grade.

c. All conduit entrances into pull boxes and handholes shall be made watertight.

654-3.10 Electrical and Telecommunication Wiring

a. No cables shall be installed in the conduits until after the conduit system is completed, tested and accepted.

b. Cables shall be pulled through the conduits by hand using care so as not to damage them. A cable grip designed to provide a firm hold upon the exterior covering of the cable may be employed but the use of winches or other mechanical pulling equipment will not be permitted. If required, the cables shall be treated with a UL approved lubricant suitable for the type of cable being pulled.

c. Electrical cables shall contain the required number of conductors as shown on the plans and required by the system. The substitution of several cables to attain the required number of conductors in one cable will not be permitted except for service installation cable.

d. Telecommunication cables shall be of the gauge and number of pairs called for in the plans and shall conform to the requirements of the controller manufacturer. A minimum of 4 spare pairs shall be provided.

e. Cables shall be installed to form a continuous circuit between the designated equipment terminals. All cable runs from the controller to the traffic signal heads shall be continuous without splices except for the required splice at the base of the support structure. Interconnection of signal heads with the same cable shall be in the signal head terminal block.

f. Where long runs of cable are required such as for interconnect circuits, splices may be made but shall be constructed with a standard manufactured, epoxy or approved equal, splicing kit. Splices shall be constructed only at a handhole, pull box, junction box or access opening. All splices shall be insulated to provide a watertight connection capable of satisfactory operation under continuous submersion in water.

g. The cables shall be neatly routed to their destinations in cabinets, pole bases, pull boxes, and all other terminations. Cable connections at the control cabinet shall be made at the terminal boards provided for this purpose. All stranded wires inserted under a binder screw shall be equipped with a solderless, pressure type spade connector. Only one stranded wire shall be used with each spade connector. Spade connectors shall not be used on solid non-stranded wire.

h. One meter of cable slack shall be provided at pull boxes and handholes and 0.5 meter at cabinets and foundations. Cable in pull boxes, handholes, junction boxes

and cabinets shall be identified as to functions by the use of aluminum, brass or plastic cable markers. If a wire numbering system is used for identification, the key to the system shall be placed along with the wiring diagram in the controller cabinet.

i. Cables coming out of mast arms or along a messenger cable and going into a signal head shall be provided with adequate drip loops.

j. Conductors entering the controller cabinets shall be dressed neatly with tie wraps and trained along the base and back of the cabinet to the terminal board. Spare conductors shall be taped and neatly coiled in the bottom of the cabinet. Ends of spare conductors shall be taped.

k. Conductors installed on span or messenger cables shall be tied with non-corrosive metal lashing or messenger rings, or weather resistant plastic cable bands, at intervals not greater than 30 centimeters. Taping will not be permitted.

l. Each circuit shall be tested for continuity.

654-3.11 Signal Heads

a. The specified standard and optically programmed traffic signal heads and pedestrian signal heads shall be installed as shown on the plans and on the signal support structures indicated.

b. Each signal head shall be assembled with the size, type and number of faces, sections, brackets, trunions, adapters, backplate, louvers and hardware necessary to meet the configuration specified on the plans.

c. Each signal head shall be erected so that it is plumb, correctly aligned with respect to the traffic direction served, with all fittings tight, and presenting a neat appearance.

d. Optically programmed signal heads shall be installed, directed and veiled in accordance with the manufacturer's instructions, the plans, and the Engineer's visibility requirements.

e. Signal heads shall be bagged and maintained in bagged condition to the satisfaction of the Engineer until placed in operation. The bagging material shall be burlap or similar opaque material, and shall be adequately and neatly secured so that it is not blown away.

654-3.12 Inductive Loop Vehicle Detector Systems

a. A complete system installation shall include one (LC-1), two (LC-2) or four (LC-4) sensor wire loops embedded in precast PC concrete slabs or in slots sawed in a bridge deck or PCC pavement, the loop detector unit (4-channel type) installed in the traffic signal controller cabinet or in its own cabinet, and the conduit and lead-in wiring from nearest pull box indicated on the plans to the loop detector units.

b. Sensor loops for inductive vehicle detector systems shall be installed at the locations and in accordance with the details and dimensions shown on the plans.

c. Pull boxes, conduits and curb cuts shall be completed before beginning the wire loop installation.

d. On existing PCC pavements and bridge decks, the configuration of the loop shall be outlined at the specified locations and the loop slot cut in the pavement with a power saw to a width of 1.25 centimeters (1/2") and a depth of 5.0 centimeters (2"), or as otherwise specified in the plans.

e. For precast slab installations, a 1" diameter flexible liquid-tight metallic conduit, commercial grade, unless other type conduit is shown on the plans, shall be installed between the loop slot and the nearest pull box as shown on the plans.

This conduit shall be placed in a 30 centimeter (12”) deep trench which shall be backfilled with PC concrete.

f. Prior to installing the wire loop, the slot shall be flushed with clean water to remove all traces of slurry and debris. The slot shall be cleaned and dried with compressed air immediately before placing the loop wire.

g. The loop wire shall be installed starting at the pull box, through the conduit, in the loop slot for the specified number of turns, and back through the conduit to the pull box. No splices outside the pull box shall be permitted in the loop circuit. The single conductor loop wire shall be spliced with an approved waterproof epoxy type splice, at the pull box, to the two-conductor cable leading to the loop detector unit.

h. The loop wire shall be depressed in the slot, using a blunt tool to avoid damaging the wire insulation, and the slot filled with the specified nylon rope and sealant.

654-3.13 Pedestrian Push Button Detector Assembly

a. The pedestrian push button detector assemblies, including the signs, shall be installed at the locations and in accordance with the details and dimensions shown on the plans. Each push button assembly shall be installed on an existing pole, a newly installed traffic signal pole or on its own post as specified on the plans.

b. The push button unit shall be installed 1.05 meters (3.5 feet) above the existing sidewalk or pedestrian grade with the sign immediately above or below it. The orientation of the push button shall be convenient to the pedestrians intending to cross the street at the marked crosswalk.

654-3.14 Traffic Signal Controllers

a. Local Traffic Signal Controllers

1. Each traffic signal controller assembly shall be installed on a PC concrete base at the location and in accordance with the details and dimensions shown on the plans.

2. The concrete base shall be dimensioned to fit the dimensions of the controller cabinet being furnished. The base shall be provided with all the conduits required for the wiring of the signal system. It shall also be provided, except when the controller operates under a central power system, with a power meter base and circuit breaker box as shown on the plans and meeting the requirements of PREPA. Where the concrete base is located in an unpaved area, a PC concrete pad 0.60-meter wide by 0.90-meter long by 0.10-meter thick shall be constructed in front of the cabinet door.

3. The controller assembly shall include all the basic controller equipment plus all auxiliary equipment and accessories necessary to provide the sequence of operations and timing coordination shown on the plans and required by the traffic signal system being installed.

b. Master Traffic Signal Controllers

1. Independent master traffic signal control assemblies for interconnected traffic signal systems shall be installed in their own master control room which shall be constructed under the provisions of Specification 655 - Traffic Signals Master Control Room, unless otherwise provided in the contract documents.

2. Where the master control functions are performed by a local controller provided with a secondary coordination unit the latter shall be

installed as a component part of the local controller assembly.

654-3.15 Intersection Power Centers - When a local signal controller at an intersection operates as part of an interconnected traffic signal system and receives its electrical power from a central power system, a dry type transformer housed in its own separate cabinet shall be provided and erected on the same concrete pedestal base as the intersection controller. These intersection power center transformers shall be furnished and erected as part of the central power system under Specification 656.

654-3.16 Traffic Counts, Adjustment and Fine Tuning

a. After placing the new traffic signals in operation, the Contractor shall conduct traffic counts at each signal controlled intersection to obtain the necessary data for adjusting and fine tuning the system. These traffic counts shall follow the format furnished by the Authority and shall:

1. Cover 14 hour periods from 6:00 AM to 8:00 PM on a weekday, a Saturday and a Sunday.

2. Be summarized by 15-minute periods.

b. The signal controller's programs shall be adjusted or new programs developed as needed to provide an efficient handling of all movements at the intersection. For interconnected systems, the programs shall be adapted to the traffic and progression requirements for the various time periods to cover daily and weekly variations in traffic flow.

c. For coordinated systems that are to operate in a traffic responsive mode, the number of programs to be developed shall be not less than 5 but will vary depending upon the capacity of the controller and the need of the intersections and/or system. The Contractor shall submit a listing of the programs he proposes to prepare for review by the Authority.

654-3.17 Functional Test

a. After all the traffic signal equipment has been installed, tested, adjusted and fine tuned, a functional test of the completed system shall be performed to demonstrate that every part of the system operates in accordance with the plans and specifications, and to the satisfaction of the Engineer.

b. The functional test for each signal system shall consist of not less than ten days of continuous satisfactory operation. If unsatisfactory performance of any of the system components is discovered during the test period, the condition shall be corrected by the Contractor and the test repeated until ten days of continuous satisfactory operations are obtained.

654-3.18 Traffic Signals Operational Support Package - Prior to final acceptance of the project, the Contractor shall deliver to the Authority all the items of equipment and spare parts listed in the contract documents as the traffic signals operational support package.

a. The spare parts delivered shall be in new condition and shall be completely interchangeable with and of the same quality as the corresponding parts in the installed equipment.

b. Equipment furnished shall be in new condition and shall meet all the applicable requirements of Specification 723 - Traffic Signal Materials. Each unit of equipment supplied shall be of the same model as, produced by the same manufacturer, and be fully interchangeable with the corresponding unit of equipment installed in the project.

c. When traffic signal controller units are included in the package, these shall be furnished with a cabinet meeting the requirements of Specification 723 and equal in size and details to the corresponding installed cabinets.

d. In case of a failure in the traffic signal system occurring during the adjustment, fine tuning or functional test periods, the Contractor will be allowed to borrow and use any

spare parts or equipment units already delivered to and accepted by the Authority for the repair and correction of the failure. However, prior to final acceptance of the project, the Contractor shall deliver to the Authority the replacement for the parts and/or equipment borrowed by him.

e. The Contractor shall provide for the parts and equipment furnished in the package the same manufacturer's warranties as required for installed equipment in paragraph 654-2.05a of this specification, except that the one-year warranty period shall begin on the date the particular item delivered is accepted by the Authority.

654-3.19 Pre-Formed Inductive Loop Vehicle Detector Systems - A complete system installation shall consist of the pre-formed inductive sensor loop, the loop detector unit installed in the traffic signal controller cabinet or on its own cabinet, and the conduit and lead-in wiring from nearest pull box indicated on the plans to the loop detector units.

a. Pre-formed sensor loops for inductive vehicle detector systems shall be installed at the locations and in accordance with the details and dimensions shown on the plans and in accordance with the requirements of this specifications.

b. Install pre-formed inductive loop vehicle detectors according to the following general requirements:

1. The pre-formed loops shall be installed to a minimum depth below final grade of 5 inches on hot plant mix bituminous pavements and 3 inches minimum on Portland cement concrete pavements.

2. Secure with a knot the splice between the loop conductor and the lead-in no. 4 cable with two (2) conductors shielded, welded and covered with heat shrink tube.

3. The Contractor shall comply with PRHTA standard installation procedures from the pavement edge to the pull box.

4. The distance from the stop line to the quadrupole pre-formed loop shall be at least 6 inches and 12 inch maximum.

c. The installation procedure for pre-formed inductive loop vehicle detectors on new Portland cement concrete pavement or new hot plant mix bituminous pavement shall be as follows:

1. Test pre-formed loop for continuity and resistance.

2. Lay out the pre-formed loop to its full size at the location and geometry as specified on plans.

3. Position bend supports on loop where corners should be formed according to details on figures 654-1 and 654-2.

4. Use loop support clamps to hold down the bend supports at the corners of the square or rectangular loop according to details on figures 654-1 and 654-2.

5. Route the feeder cable/outer tubing to the desired termination point. Loop support clamps shall be used to secure the outer tubing.

6. Only for asphalt pavements; secure the loop in position using a thin layer of asphalt.

7. Pour Portland cement concrete or hot plant mix bituminous pavement directly over the pre-formed loop.

d. The installation procedure for pre-formed inductive loop vehicle detectors on existing Portland cement concrete pavement or new hot plant mix bituminous pavement shall be as follows:

1. Test pre-formed loop for continuity and resistance.

2. Lay out the pre-formed loop its full size at the location and geometry as specified on plans.

3. Position bend supports on loop where corners should be formed.

4. Use loop support clamps to hold down the bend supports at the corners of the square or rectangular loop.

5. Mark the loop outline on the pavement surface using either a string or aerosol spray paint.

6. Remove the pre-formed loop and proceed to saw cut the pavement with a ½ inch saw blade.

7. Drill a 1½ inch diameter hole on each corner as shown on figure 654-3.

8. Clean debris from saw slot with oil free compressed air and allow surface and slot to dry completely.

9. Confirm that the required depth has been reached.

10. Lay out the pre-formed loop over the slot.

11. Use a wood stick or roller to insure the pre-formed loop is in the bottom of the slot. **Do not use metal objects for this purpose.**

12. Apply traffic detector loop sealant approved by the Engineer over the installed loop. The sealant shall be applied and cured according to the manufacturer's recommendations. The sealant shall be filled no more than ¼ inch of the roadway surface as shown on figure 654-3. Do not overflow the slot.

e. The installation procedure for pre-formed inductive loop vehicle detectors on new bridge decks shall be as follows:

1. Test pre-formed loop for continuity and resistance.

2. The pre-formed loop shall be tied directly to the reinforcing steel using plastic (non-metallic) ty-raps prior to pouring the Portland cement concrete for the bridge slab.

f. The installation procedure for pre-formed inductive loop vehicle detectors on existing bridge decks shall be as follows:

1. Test pre-formed loops for continuity and resistance.

2. Mark the loop outline on the pavement surface using either a string or aerosol spray paint.

3. Saw-cut pavement with a ½ inch saw blade to a 2 inch depth.

4. Clean debris from saw slot with oil free compressed air and allow surface and slot to dry completely.

5. Use a wood stick or roller to insure the pre-formed loop is in the bottom of the slot. **Do not use metal objects for this purpose.**

SPECIFICATION 654 – TRAFFIC SIGNAL SYSTEMS

654-4 METHOD OF MEASUREMENT

654-4.01 The maintenance, modification, relocation, replacement or removal and delivery to the Authority of all existing traffic signal systems and equipment within the project limits as described in Article 654-3.02 will be measured as a single lump sum item.

The components of each pre-formed inductive loop vehicle detector system will be measured as follows:

a. Each pre-formed sensor loop installation completed and accepted of the size specified on plans will be measured as a unit. The complete pay unit includes all the loop wiring to the nearest pull box, and all the necessary excavation, backfill, conduit, concrete, reinforcing steel, nylon rope, sealant and miscellaneous items required to complete the installation as shown on plans or as ordered by the Engineer, and covered under article 654-3.18.

b. Each loop detector unit, 4-channel type, furnished, installed and accepted will be measured as a unit. The complete unit shall include its own cabinet and concrete base, if required, and all necessary hardware and accessories.

c. The loop detector lead-in cable will be measured as specified in Article 654-4.06.

654-4.02 The following items of materials and work will not be measured for direct payment but shall be a subsidiary obligation of the Contractor with their costs included under the various traffic signal system pay items where they occur:

a. All excavation, bedding and backfill required for foundations, poles, controller bases, conduits, pull boxes, induction loops and cables as described under Article 654-3.03.

b. The removal and replacing of existing improvements required for the construction of the traffic signal system as described under Article 654-3.04.

c. PC concrete and reinforcing steel required for foundations of poles and other signal support structures, pull boxes, conduit trench backfill, controller bases, and other traffic signal system structures.

d. Metallic pull and junction boxes in conduit lines.

654-4.03 Traffic signal supports of each specified type furnished, installed and accepted will be measured as a unit. Each traffic signal support unit shall consist of the complete installation, including foundations, poles, bases, anchor bolts, mast arms, conduits, wiring, ground, span and messenger wires and all necessary hardware and appurtenances required to provide a complete installation except those specifically identified as separate pay items, such as signal heads and pedestrian push buttons.

654-4.04 Conduit will be measured by the linear meter of each type and size specified, installed complete according to the plans or as ordered by the Engineer and accepted. The work includes all excavation, bedding, concrete backfill, other backfill, expansion joints, clamps, fittings, hangers, and other required installation hardware. Conduits within foundations, pull boxes, concrete bases and included within signal support structures, except when used as an exposed riser, will not be measured for payment as these are subsidiary to the respective pay items.

654-4.05 Concrete pull boxes will each be measured as a unit of the type and size specified, complete, installed and accepted. Each complete unit includes the required excavation, bedding, drainage well, concrete foundation, backfill, conduit, hooks, frames, covers and all necessary miscellaneous hardware.

654-4.06 Electrical conductors, telecommunication cable and loop detector lead-in cable, will be measured by the linear meter of

each class, size and number of conductors or pairs specified and actually installed and accepted.

a. The work includes all required connectors, approved splices, testing, cable identification markers and any necessary hardware and fittings. Measurement will be made to the bases of signal support structures and traffic controller bases. All wiring within signal support structures (including span wire system), controller cabinets and sensor loops will not be measured for payment as this wiring is a subsidiary obligation with its cost included in the respective pay unit.

b. In the event that the traffic control coordination or communication equipment proposed by the Contractor and approved by the Engineer requires a different class, size or larger quantity of cable than that called for in the contract documents, the approved substitute cables shall be installed but measurement for payment shall not exceed the amount required if the specified cable had been installed.

654-4.07 Signal heads will be measured on the basis of each unit of each type furnished, installed and accepted. Basic types include standard traffic heads, optically programmed traffic heads, lane signals and pedestrian signal heads. These are further identified by the number and sizes of faces included in each unit. The completed installation includes all the equipment and hardware necessary, mounted on its traffic signal support structure and integrated into the traffic signal system.

654-4.08 The components of each inductive loop vehicle detector system will be measured as follows:

a. Each sensor loop installation completed and accepted of the type (precast slab, or saw cut) and of the number of sensor loops (LC-1, LC-2 or LC-4) specified will be measured as a unit. The complete pay unit includes all the loop wiring to the nearest pull box. and all the necessary excavation, backfill, conduit, concrete, reinforcing steel, nylon rope, sealant and miscellaneous items required to

complete the installation as shown on the plans and covered under Article 654-3.12.

b. Each loop detector unit, 4-channel type, furnished, installed and accepted will be measured as a unit. The complete unit shall include its own cabinet and concrete base, if required, and all necessary hardware and accessories.

c. The loop detector lead-in cable will be measured as specified in Article 654-4.06 above.

654-4.09 Each pedestrian push button detector installed and accepted will be measured as a unit. The complete unit includes the push button, the sign and all necessary mounting hardware and fittings.

654-4.10 Each local traffic signal controller assembly of the type specified furnished, installed and accepted will be measured as a unit. The complete unit shall include the concrete base, the cabinet, and all the basic and auxiliary electrical and electronic equipment and accessories required to provide the traffic control operations specified in the contract documents. Any required secondary coordination units, either self-contained modules installed in the controller cabinet or provided as a built-in feature of the controller, shall be considered as part of the local controller assembly and will not be measured separately.

654-4.11 Each independent master traffic controller assembly furnished, installed and accepted will be measured as a unit.

a. The complete unit shall include all the electrical and electronic equipment and accessories required to provide the supervision scheme to the system of local traffic controllers in a traffic responsible manner as specified in the contract document. The assembly also includes the weekly program unit time switch and all telemetry equipment installed in the master and in the local controllers to provide for communication within the system.

b. The master control room to house the unit will be measured and paid for separately under Specification 655 - Traffic Signals Master Control Room.

654-4.12 The traffic counts and the adjustment and fine tuning of the traffic signal system required under Article 654-3.16 will be measured as a lump sum item.

654-4.13 The functional test required under Article 654-3.17 will not be measured for direct payment but shall be a subsidiary obligation of the Contractor under the various traffic signal system pay items.

654-4.14 The traffic signals operational support package will be measured as a lump sum item including all the required spare parts and equipment furnished and accepted.

654-4.15 Traffic signal self support concrete poles for span wire installed and accepted will be measured as a single unit. Foundations, wiring, grounding, span wires, messenger wires and all necessary hardware and appurtenances required to provide a complete installation as required by standard specifications, standard drawings and details shown on plans shall be considered as a subsidiary obligation under the traffic signal self support concrete pole pay item.

654-4.16 Traffic signal self support concrete poles for span wire installed and accepted will be measured as a single unit. Foundations, wiring, grounding, span wires, messenger wires and all necessary hardware and appurtenances required to provide a complete installation as required by standard specifications, standard drawings and details shown on plans shall be considered as a subsidiary obligation under the traffic signal self support concrete pole pay item.

a. Each pre-formed sensor loop installation completed and accepted of the size specified on plans will be measured as a unit. The complete pay unit includes all the loop wiring to the nearest pull box, and all the necessary excavation,

backfill, conduit, concrete, reinforcing steel, nylon rope, sealant and miscellaneous items required to complete the installation as shown on plans or as ordered by the Engineer, and covered under article 654-3.19.

b. Each loop detector unit, 4-channel type, furnished, installed and accepted will be measured as a unit. The complete unit shall include its own cabinet and concrete base, if required, and all necessary hardware and accessories.

c. The loop detector lead-in cable will be measured as specified in Article 654-4.06.

654-4.17 Traffic signal self support concrete poles for span wire installed and accepted will be measured as a single unit. Foundations, wiring, grounding, span wires, messenger wires and all necessary hardware and appurtenances required to provide a complete installation as required by standard specifications, standard drawings and details shown on plans shall be considered as a subsidiary obligation under the traffic signal self support concrete pole pay item.

654-5 BASIS OF PAYMENT

654-5.01 Although the various components of the traffic signal system for a project are measured and paid for as separate pay units, it shall be understood that the combination of all component pay units shall provide for a complete traffic signal system ready for operation and that any miscellaneous fees, work, equipment, hardware, software and materials necessary to complete the system, whether or not they are specifically mentioned in the contract documents, shall be furnished and installed by the Contractor at no extra cost to the Authority. The cost of all such miscellaneous items shall be considered as a subsidiary obligation of the Contractor under the various contract pay items.

654-5.02 The accepted quantities, determined as provided in Section 654-4 above for the pay items listed below which are included in the contract, will be paid for at the contract unit price per

unit of measurement. Such price and payment shall constitute full compensation for furnishing, installing, adjusting and testing all required equipment and materials, and for all labor, equipment, tools, materials and incidentals necessary to complete each item and to provide a complete traffic signal system as required by the plans and specifications.

654-5.03 Payment will be made under:

Pay Item	Pay Unit
Maintenance and Removal of Existing Traffic Signal System……...	Lump Sum
Traffic Signal Support – Post Top Mount Type..	Each
Traffic Signal Support – Single Mast Arm Type (Length)……...	Each
Traffic Signal Support – Double Mast Arm Type (Lengths)…….……	Each
Traffic Signal Support – Overhead Bridge Type……..	Each
Pedestrian Push Button Post……	Each
PVC Conduit – (Diameter)……..	Linear Meter
Galvanized Steel Conduit – (Diameter)……..	Linear Meter
Concrete Pull Box – (Size)……..	Each
Electrical Conductor (Class, Size, No. Conductors)……..	Linear Meter
Standard Traffic Signal Head – (Type)……...	Each
Optically Programmed Signal Head – (Type)….	Each
Lane Control Signal Face – (Type)…….	Each
Pedestrian Signal Head – (Size)……..	Each
Inductive Sensor Loop.(Type)*……...	Each
Inductive Loop Detector Unit…….	Each
Inductive Sensor Loop Pre-formed _____ (Size)……	Each
Loop Detector Lead-In Cable……..	Linear Meter
Pedestrian Push Button Detector…….	Each
Local Traffic Signal Controller Assembly……..	Each
Master Traffic Controller Assembly……...	Lump Sum
Telecommunication Cable (Type, No. Pairs)…..	Linear Meter

SPECIFICATION 654 – TRAFFIC SIGNAL SYSTEMS

Pay Item	Pay Unit
Traffic Counts, Adjustment and Fine Tuning….	Lump Sum
Traffic Signal Operational Support Package…..	Lump Sum
Traffic Signal Self Support Concrete Pole for Span Wire…….	Each

SPECIFICATION 655 – TRAFFIC SIGNALS MASTER CONTROLLER BUILDING

655-1 DESCRIPTION

655-1.01 Scope - This work shall consist of the construction of a reinforced concrete and concrete blocks building to house a traffic signals master controller and, when called for in the plans, the central power system for the signals system. The building shall be constructed in accordance with these specifications and in conformity with the location, dimensions, details and all requirements shown on the plans.

655-2 MATERIALS

655-2.01 Structural Concrete - Shall conform to the requirements of Specification 601 - Structural Concrete and shall be Class "A", except where otherwise specified in the plans.

655-2.02 Reinforcing Steel - Shall conform to the requirements of Specification 602 - Reinforcing Steel.

655-2.03 Concrete Blocks - Shall be hollow type concrete blocks conforming to the requirements of ASTM C 90, Grade N, Type I.

655-2.04 Masonry Mortar - The mortar for setting concrete blocks shall be made by mixing, by volume, one part of portland cement, 1/10 part of hydrated lime and 3 parts of sand, or as otherwise approved by the Engineer, and adding water as necessary to obtain the required consistency.

655-2.05 Cement Plaster - Shall consist of a mix of one part portland cement, 3 parts of sand and 1/10 part of hydrated lime, by weight, to which sufficient water is added to produce a workable mix.

655-2.06 Doors - Shall be hollow metal doors of the full flush type conforming to the applicable standards of the National Association of Architectural Metal Manufacturers.

a. Doors and frames shall be manufactured of cold rolled steel conforming to ASTM A-366. The doors shall be made with face sheets of not less than 16 gage and the frames of not less than 14 gage steel.

b. All steel shall be provided with a zinc coating of not less than 0.10 ounces per square foot.

c. After fabrication, doors and frames shall have all exposed surfaces coated at the factory with a rust-inhibitive prime paint which shall be fully cured before shipment.

d. Doors and frames shall be in accordance with the dimensions, details and other requirements shown on the plans.

e. Finish hardware shall be as specified on the plans.

655-2.07 Windows - Shall be standard aluminum jalousie type windows equal or similar to those manufactured by Lausell Aluminum Jalousies Inc., Tropicair Manufacturing Corporation, or Metallic Industries Corporation.

a. Extruded aluminum for the window frames shall conform to alloy 6063-T5.

b. Minimum wall thickness shall be 0.062 inches.

c. Standard crank handle type operators shall be equal or similar to Caribbean Die Casting Corp. Model SD-400 or Anderson Model No. 2044.

d. After fabrication all windows shall be finished with two coats of baked on enamel paint at the factory of the color indicated on the plans.

e. Windows shall conform to the dimensions, details and other requirements shown on the plans.

f. Windows shall be furnished with aluminum mesh insect screens or such other screens as specified on the plans.

655-2.08 Architectural Woodwork - Wood for interior architectural woodwork such as shelves shall be Douglas Fir lumber and plywood pressure treated or treated by immersion for termite protection.

655-2.09 Roof Sealer - Shall be as specified on the plans. If not indicated, a commercial mildew resistant, vinyl acrylic based roof coating, or similar acceptable product to the Authority, shall be used.

655-2.10 Metal Grilles - Metal for the grillwork shall be galvanized steel conforming to the requirements of Specification 715 - Structural Metals and to the dimensions and details shown on the plans.

655-2.11 Chain-Link Fence - Materials for chain-link fencing shall conform to the applicable requirements of Specification 607 - Fences and Gates, and Specification 710.

655-2.12 Paints - In the following schedule, paints formulated to prevent fungus infection shall be used, such as produced by the Glidden Co. and the Sherwin Williams Co. However, top quality paints produced by other manufacturers will also be allowed when they have been shown to have fungus prevention properties.

a. Exterior Concrete and Masonry - A top quality, durable, acrylic latex paint for exterior use.

b. Interior Concrete and Masonry - A top quality, durable, washable, latex paint.

c. Interior Woodwork - Urethane stains and spar varnishes.

d. Metal Doors and Grille Work – Alkyd-oil basic lead, silico-chromate paint system meeting the requirements of Specification 653 - Painting Steel Structures and Specification 708 - Paints for Steel Structures.

655-2.13 Electrical - All equipment and materials for the electrical installation shall be as shown on the plans and shall conform to the standards and Specification of PREPA, the Underwriters Laboratories (UL), The National Electrical Manufacturers Association (NEMA) and other codes and standards applicable to this work.

a. The Contractor shall submit to the Engineer a list of all the electrical equipment and materials to be used prior to their purchase and installation. The list shall identify the items by manufacturer, catalog numbers, drawings and specifications.

b. All materials and equipment shall be new, free from defects and equal or similar to the makes and types specified.

655-2.14 Air Conditioning Unit - Shall be a window type unit with a cooling capacity of 10-12,000 Btuh, 208/230 V operation, and an EER of 7.5 or greater.

655-2.15 Telephone - The telephone conduit system shall be made of PVC Schedule 40 or DB-120 pipe of the sizes specified in the plans and including all necessary galvanized steel junction boxes.

655-2.16 Miscellaneous materials shall be as indicated on the plans and as required to complete the construction of the master controller building.

SPECIFICATION 655 – TRAFFIC SIGNALS MASTER CONTROLLER BUILDING

655-3 CONSTRUCTION REQUIREMENTS

655-3.01 Site Work

a. Clearing and grubbing of the site shall be performed in conformance with the applicable requirements of Specification 201.

b. Any required earthwork shall be performed in conformance with the applicable requirements of Specification 203 - Excavation and Embankment. Borrow material, when required, and the top 10 centimeters of material directly under the floor slab shall meet the requirements of Borrow Class B.

c. The excavation for foundations shall be in conformance with the requirements of Specification 206 - Excavation for Structures.

655-3.02 Concrete and Masonry Work

a. Reinforced concrete work shall be performed in conformance with the requirements of Specification 601 - Structural Concrete, and Specification 602 - Reinforcing Steel.

b. Masonry work shall be performed by qualified masons. Concrete block walls shall be carried up level and plumb all around. Where a masonry wall abuts or adjoins the concrete framework, provide 1” wide, 14 gauge, galvanized steel dovetail hook type anchors every two block courses for anchorage. Excess mortar shall be wiped off as the work progresses.

c. Concrete and masonry finishes shall be as follows unless otherwise indicated on the plans:

1. Concrete floor shall be given a smooth trowel finish.

2. Exterior and interior faces of walls, columns and beams shall have a cement plaster finish.

3. The bottom surface of the roof slab shall have a cement plaster finish.

4. The top surface of the roof slab shall have a Class 3 Float Finish as per Specification 601. After curing, the roof surface shall be treated with the specified waterproofing material which shall be applied in accordance with the manufacturer's instructions.

655-3.03 Doors and Windows

a. Install the hollow metal door units and the aluminum windows in accordance with the manufacturer's shop drawings and instructions, and the details shown on the plans.

b. Door and window frames shall be anchored to the concrete with machine screws and masonry anchorage devices.

c. All operating and finish hardware shall be installed in accordance with the manufacturer's instructions. Door hardware items shall be mounted, checked and adjusted prior to field painting, then removed for painting and reinstalled after final paint finish has been completed.

d. Door and window frames shall be caulked at all intersections with concrete and masonry surfaces to provide completely watertight joints.

SPECIFICATION 655 – TRAFFIC SIGNALS MASTER CONTROLLER BUILDING

655-3.04 Electrical Work

a. All electrical work shall conform to the details and requirements shown on the plans and the standards and regulations of PREPA and the NEC.

b. The contractor shall obtain all necessary permits and inspections required by PREPA and shall pay all required fees which shall be a subsidiary obligation under the contract price.

c. The electrical system shall be complete, connected to the PREPA system, or the central power system, and fully operational prior to final inspection and acceptance.

655-3.05 Telephone Work

a. The Contractor shall furnish and install a complete telephone conduit system as shown on the plans, including the connecting line to the telephone service pole, meeting the P.R. Telephone Co. requirements and ready for wiring and connection to the telephone system.

b. All conduits, cabinets and boxes shall be cleaned and provided with fish wires.

655-3.06 Metal Grille Work

a. Metal grilles shall be furnished and installed in accordance with the dimensions and details shown on the plans.

b. Welding shall be in accordance with the AWS Welding Code. All welds shall be wire brushed and painted with two coats of zinc-dust, zinc-oxide paint conforming to Federal Specification TT-P-461.

SPECIFICATION 655 – TRAFFIC SIGNALS MASTER CONTROLLER BUILDING

655-3.07 Painting

a. All hardware, hardware accessories, plates, lighting fixtures and similar items in place which are not to be finish painted shall be removed prior to surface preparation and paint operations or otherwise fully protected to the satisfaction of the Engineer. The removed items shall be reinstalled following the completion of painting operations in each space or area.

b. All surfaces to be painted shall be clean and free of oil, grease, dirt, mill scale, efflorescence and other contaminants. Imperfections in the surfaces shall be filled or obliterated as required.

c. All exterior and interior concrete and masonry surfaces, except the waterproofed roof surface, and all woodwork shall receive a prime coat and two finish coats of the specified paints of the colors indicated on the plans or selected by the Engineer.

d. Metal doors and frames shall receive over the factory prime coat, two coats of the specified paint of the color indicated on the plans or selected by the Engineer.

e. Metal grilles shall receive a shop or field coat of the specified primer and two coats of flat enamel paint of the specified type and color.

655-3.08 Fence

a. A galvanized steel chain link fence and gate of the type indicated and in accordance with the location and details shown on the plans and standard drawings shall be furnished and erected.

b. Construction of the fence and gate shall be in accordance with the requirements of Specification 607 -

Fences and Gates, including the installation of electrical grounds and the furnishing of shop drawings for prior approval by the Engineer.

c. When no particular type of fence is specified, Type A chain-link fence in accordance with Specification 607 shall be furnished and erected.

655-3.09 Driveway and Pavement - A driveway from the street to the building shall be built and paved as shown on the plans. In addition, the area around the building and within the fence shall also be paved as shown on the plans.

655-4 METHOD OF MEASUREMENT

655-4.01 The building to house the traffic signals master controller will be measured as a lump sum item complete with all the required components, including fencing and paving, as shown on the plans and as specified.

655-5 BASIS OF PAYMENT

655-5.01 The accepted building will be paid for at the contract lump sum price, such price and payment shall be full compensation for furnishing and placing all materials, equipment, labor, tools and incidentals necessary to complete the building, including the site work and fencing, as required by the plans and specifications.

655-5.02 Payment will be made under:

Pay Item	Pay Unit
Master Controller Building…….	Lump Sum

SPECIFICATION 656 – CENTRAL POWER SYSTEM FOR TRAFFIC SIGNALS

656-1 DESCRIPTION

656-1.01 Scope - This work shall consist of furnishing and installing a complete central power and electrical distribution system for the continuous operation of traffic signals at several intersections in accordance with these specifications and in conformity with the locations, dimensions and details shown on the plans or established by the Engineer. The power system shall be connected to the PREPA power distribution system and shall be fully operational when completed. The complete system shall consist of:

a. A primary service entrance from the PREPA service lines to the substation.

b. A central power substation, housed in a structure as indicated on the plans, including the specified number and size of transformers.

c. A main secondary feeder.

d. A main distribution panelboard at the master signal controller room.

e. An underground electrical power radial distribution system from the main distribution panel to the power centers at each intersection controller.

f. A power center with a dry type transformer next to each intersection traffic signal controller included in the system.

g. A standby power generation system, housed as indicated on the plans, fully capable of providing all the electrical power necessary to maintain in operation during a PREPA power failure all the traffic signals and controllers included in the system.

h. All necessary appurtenances, hardware, fittings, materials and miscellaneous equipment required to provide a complete central power and distribution system as specified and as shown on the plans.

656-2 MATERIALS

656-2.01 General

a. All equipment and materials for the central power system, in addition to meeting the requirements of the plans and other contract documents, shall conform to the applicable sections of the codes and standards listed below.

1. American National Standards Institute (ANSI) - including the Safety Standards for Mechanical Power Transmission Apparatus, Requirements of Electric Analog Indicating Instruments, General Requirements for Synchronous Machines, and Salient Pole Synchronous Generators and Condensers.

2. National Electrical Manufacturers Association (NEMA) - including the General Standards for Industrial Control Systems; Industrial Control Devices, Controllers and Assemblies; Industrial Systems; Terminal Blocks for Industrial Controls and Systems; enclosures for Industrial Controls and Systems; and Motors and Generators.

3. Institute of Electrical and Electronic Engineers (IEEE) - Test Procedures for Synchronous Machines, and Recommended Specifications for Speed Governing of Internal Combustion Engine - Generator Sets.

4. American Society of Mechanical Engineers (ASME) – Speed-Governing Systems for Internal Combustion Engine-Generator Units.

5. National Fire Protection Association (NFPA) - including the National Electrical Code, the Life Safety Code, the Flammable and Combustible Liquids Code, the Automotive and Marine Service Station Code, and the Oil Burning Equipment.

6. Underwriters Laboratories (UL) - including Automatic Transfer Switches, Battery Chargers, Steel Above Ground Tanks for Flammable and Combustible Liquids, Glass Fiber Plastic Underground Storage Tanks, and Storage of Flammable Liquids.

7. Insulated Power Cable Engineers Association (IPCEA).

8. Occupational Safety and Health Act Standards (OSHA).

9. Puerto Rico Electric Power Authority (PREPA) standards and regulations.

10. American Society for Testing Materials (ASTM) - including Glass Fiber Reinforced Polyester Underground Petroleum Storage Tank.

11. American Petroleum Institute (API) - including the Installation of Underground Storage Systems.

b. Wherever reference is made to any of the standards or codes mentioned above, the reference shall be construed to mean the standard or code that is in effect on the date the contract is advertised for bids. Differences in standards or code requirements shall be resolved as determined by the Engineer.

c. Where a criterion specification is designated for any material or equipment to be installed by the name or catalog number of a specific manufacturer, such designation is intended only for the purpose of establishing the style, quality, and performance characteristics, and is not intended to limit the acceptability of competitive products. Products of other manufacturers which meet the plan and specification requirements and which are approved as similar and equal will be acceptable.

d. All materials, equipment, and parts comprising the units specified herein shall be new and unused, of current manufacture, of highest grade and assembled in a workmanlike manner.

e. All materials subject to UL standards shall bear the UL label. Other materials not covered under UL testing standards shall be subject to testing by the Authority, or other government agency, or, at the Contractor's expense, by an independent laboratory acceptable to the Authority.

f. All materials, equipment and accessories required for the work shall be delivered, received, unloaded and stored by the Contractor until they are installed. All items shall be inspected as soon as they are received to determine if any damage has occurred in transit. Damaged items shall be repaired or replaced immediately to prevent delay in the construction schedule.

g. All items shall be properly protected during all phases of the work. Materials, equipment and accessories which are not weatherproof shall be protected against weather damage during storage. The Contractor shall be responsible for the safekeeping of all items during receiving, storing and installation.

h. Defective equipment or equipment damaged in the course of relocation, installation or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer.

656-2.02 Equipment and Materials Identification

a. All equipment and materials shall be clearly identified to indicate the loads served or the function of each item of equipment installed under this work.

b. Labels shall be provided as follows:

1. Conductors - Black on yellow or white, pre-printed material with adhesive backing.

2. Panelboards and equipment - Engraved laminated plastic, black with white letters. Minimum size for nameplates shall be 1.0 inch by 2.5 inches. Lettering shall be a minimum of 0.25 inch high normal block style.

3. Substation - In accordance with PREPA standards.

c. On panelboards - Indicate panel designation, voltage and feeder source. Provide a complete directory, in engraved laminated plastic plates, accurately accounting for every breaker installed, including spares.

d. On equipment - Label all disconnect switches, relays, contactors, indicating amperage, voltage and equipment served.

SPECIFICATION 656 – CENTRAL POWER SYSTEM FOR TRAFFIC SIGNALS

656-2.03 Primary Service Entrance

a. Conductors

1. Primary line conductors shall be of the sizes indicated on the plans. They shall be single conductor stranded copper cables, 15 KV and 90 C rated, with cross-linked polyethylene insulation 175 mils thick, and shielded with a polyvinyl chloride jacket.

2. Grounding conductors shall be single conductor stranded copper, 600V rated, THW insulation, and of the size indicated on the plans.

3. All conductors shall conform to the current PREPA regulations and standards.

b. Conduits

1. Conduit for underground installation shall be UL approved non-sparking polyvinyl chloride (PVC) conduit DB-120 designed for direct burial in the ground of the sizes indicated on the plans. PVC Schedule 40 conduit may be used as a substitute. Solvent cement for joining conduits and fittings shall meet the requirements of ASTM D 2564.

2. The riser conduit at the pole for connecting the service entrance to PREPA overhead lines shall be galvanized steel conduit and fittings conforming to all requirements of the NEC and PREPA.

656-2.04 Substation

a. The substation shall consist of three single-phase transformers connected to integrate a three-phase transformer bank of the size indicated on the plans. The substation shall be housed in a building or in a pad mounted enclosure as

called for in the contract documents. The substation housing shall provide compartments for four sections: Incoming Line, Metering, Transforming and Outgoing.

b. Primary voltage shall be 13.2 kV (Delta), 8.32 kV (Delta) or 4.16 kV (Delta) as indicated on the plans and as required by PREPA. Secondary voltage shall be 480Y/277 volts.

c. The incoming line section shall provide:

1. Air interruptor, three-pole, group operated, 15 kV, 600 amperes, continuous and minimum load interrupting rating 25,000 amperes symmetrical momentary. It shall consist of a two-position open-close air switch with quick-make, quick-break mechanism to assure positive opening and closing independent of handle operation.

2. Three power fuses, of interrupting rating 12,500 RMS amperes, symmetrical at 15 kV, 110 kV BIL. Size of fuse links shall be as indicated on drawings. Three spare fuse links shall be provided.

3. Three lightning arresters, of distribution class, 10 kV in 13.2 kV system, or 6 kV in 8.32 kV and 4.16 kV systems.

d. The metering section shall comply with PREPA requirements. The Contractor provides the mounting base and appurtenances and shall coordinate with PREPA the installation of the metering equipment that will be provided by PREPA.

e. Transformers

1. Three transformers shall be provided. They shall be single phase, self cooled, 65ºC continuous

temperature, mineral oil-immersed (non PCB) type. Size of transformers shall be as indicated on the plans. Transformers shall be designed, manufactured and tested in accordance with ANSI C57-12-20.

2. BIL transformer rating shall be 75 kV in 4.16 kV systems, or 95 kV on 8.32 kV or 13.2kV systems.

3. Transformers shall have four 2 1/2 percent taps below rated primary voltage in 4.16 kV and 8.32 kV systems, or four 2 1/2 percent taps, 2 below and 2 above rated primary voltage, in 13.2 kV systems.

f. The outgoing line section shall provide a main circuit breaker, three poles, 480 volts, thermal magnetic type, with 25,000 RMS symmetrical amperes minimum interrupting capacity. The size of the breaker shall be as indicated on the plans.

g. Bus bars shall be provided as follows:

1. Secondary copper bus bars braced for 25,000 RMS symmetrical amperes interrupting capacity.

2. Ground bus in all the length and in the lower part of the transformer housing, when the transformers are housed in a pad mounted enclosure, or a ground conductor loop inside the substation, when the transformers are housed in a building. Easily accessible, PREPA approved, ground connectors shall be provided.

656-2.05 Main Distribution Panelboard

a. The main distribution panelboard and separate terminal board, if required, shall be surface mounted, NEMA I enclosure, with thermal magnetic molded case breakers. Sizes of breakers as indicated on the plans. The minimum

interrupting capacity shall be 25,000 RMS amperes symmetrical unless otherwise indicated on the plans.

b. Voltage shall be 480Y/277 volts, 3-phase, 4-wires. Ground bus with terminal lugs for each feeder shall be provided.

c. The panelboard shall be mounted in the Master Controller Room with center of top circuit breaker handle no higher than 6 feet 6 inches above finished floor.

d. The panelboard shall have at least 25 percent extra spaces for future breakers and shall be provided with a complete directory in engraved laminated plastic plates indicating the names of all the intersections protected by the breakers.

e. Individual breakers must have terminal lugs to accommodate the size of wire to be installed. In case this is not possible at the breakers, a separate terminal board shall be provided in the panelboard to allow proper connections. Panel must have extra size gutters.

656-2.06 Distribution System

a. Conductors for the distribution system shall be single conductor, stranded copper wire, 600 volts rated, with cross-linked polyethylene insulation, and of the sizes indicated on the plans. Conductors shall be labeled with the branch feeder designation at the main distribution panelboard in the Master Control Room and at the power center at each intersection.

b. Conduits for underground distribution system shall be of the size indicated on the plans and meet the requirements specified in paragraph 2.03b(1) of this specification.

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656-2.07 Intersection Power Centers

a. Transformers for the power centers at individual intersections shall be of the dry type UL listed. They shall be 5 kVA size unless otherwise specified in the plans.

b. Transformers shall be of the totally enclosed hard shell type, impervious to water, dust, dirt and corrosive atmospheres. They shall be designed for mounting free standing on the same concrete pedestal as the intersection controller, unless otherwise indicated on the plans.

c. Transformers shall be provided with 185ºC insulation system meeting NEMA standards and shall have a maximum sound level in decibels conforming to ANSI and NEMA standards (40 decibels for 5 kVA).

656-2.08 Standby Power Generation System

a. The standby power generation system shall include a diesel engine generator set, of the capacity specified in the plans, complete with automatic transfer switch and all necessary controls and accessories to provide an electrical power standby source which will be activated automatically in the event of a PREPA power failure.

b. The generator set shall consist of a diesel engine connected to an alternating current generator with brushless excitation system mounted on a steel subbase and provided with all necessary accessories, auxiliaries, and control equipment resulting in a complete self-contained unit. In addition:

1. The set must be capable of providing full rated power within 10 seconds after failure of the normal PREPA power.

2. The rated kW and kVA (Steady and Surge conditions), voltage, power factor and frequency of the set shall be as indicated on the plans.

3. The power rating on the set shall be based on operation at rated rpm when equipped with all necessary operating accessories such as air cleaners, lubricating oil pump, fuel transfer pump, fuel injection pumps, jacket water pump, radiator fan, governor, alternating current generator and exciter regulator. Rating shall apply at conditions of 100 feet above sea level and 104°F (40°C) ambient air temperature unless otherwise indicated in the plans.

4. The set shall be mounted on a fabricated steel skid base suitable for supporting, lifting, transporting, and skidding the engine and generator without damage to the equipment or its alignment.

5. Vibration isolators shall be provided to isolate the set from the building floor. At least four isolators as recommended by the isolator manufacturer are required. The isolators shall be manufactured by a firm specializing in this product, and the unit shall be specifically listed for this application and have a maximum deflection of one inch.

6. All parts, including engine, subject to high temperature shall be treated and painted in accordance with manufacturer's standards. The generator and all associated electrical equipment shall be thoroughly cleaned and treated prior to painting. Color shall be the manufacturer's standard.

c. The generator set shall be a manufacturer's standard commercial product with any added features needed to comply with the requirements of the plans and this specification. Additional or better features which are not

specifically prohibited by this specification, but which are a part of the manufacturer's standard commercial product shall be included in the generator set being furnished. Standard commercial product is a product which has been or will be sold on the commercial market through manufacturer's catalogs and represents the latest production model available at the time of opening of bids. In addition:

1. The engine, generator, and all required auxiliary equipment and accessories shall be manufactured by manufacturers currently engaged in the production of such equipment. The unit shall be factory assembled, tested by the manufacturer and shipped to the job site by an authorized dealer or other authorized representative so there is a single source of supply and responsibility for warranty, parts and service.

2. It is essential that the engine-generator supplier maintain a local parts and service facility in Puerto Rico. The supplier must carry sufficient inventory to cover no less than 80% parts service within 24 hours and 95% within 48 hours. Further, the supplier shall have factory-trained service representatives to furnish all installation, test and start-up supervision necessary for final approval and acceptance as well as perform maintenance and repairs on all components as required.

656-2.09 Generator Set Engine

a. The generator set engine shall be stationary, watercooled, in-line or Vee type, four-stroke cycle compression ignition diesel, turbocharged and intercooled where required by engine manufacturer. It shall meet specifications when operating on No. 2 domestic burner oil. Engines requiring premium fuels will not be accepted.

1. The engine shall be equipped with filters for fuel, fuel transfer pump, fuel priming pump, lube oil cooler, intake air filters, and gear-driven water pump.

2. Certified engine horsepower curves shall be submitted showing the manufacturer's approval of the engine rating for generator set standby and prime power application. Special ratings or maximum ratings will not be acceptable.

3. The engine shall not exceed 1800 rpm at normal full load operation.

b. The engine governing system shall be suitable for controlling the speed of the generator set within the requirements specified herein without intermediate adjustment and shall maintain the specified stability without hunting or cycling.

1. The engine governor shall maintain isochronous frequency regulation from no load to full rated load. Steady-state operating band shall be $\pm$0.25%. The governor shall be capable of remote speed adjustment.

2. An overspeed shutdown device shall be provided which shall be entirely independent of the engine speed governor. It shall consist of a solid state overspeed device positively engaged so that the engine speed shall not exceed 110% of synchronous speed, by reacting to shutoff the engine's air or fuel supply and trip the set output circuit breaker. The overspeed device shall require manual resetting after emergency tripping.

c. The engine cooling system shall have sufficient capacity for cooling the engine when the engine-generator set is continuously delivering full-rated load at sea level at an

ambient temperature of 104°F (40°C) unless otherwise called for in the plans.

1. The engine shall be equipped with an engine driven, centrifugal-type water circulating pump and thermostatic valve to maintain the engine at recommended temperature level.

2. An engine-mounted radiator with blower-type fan shall be provided to maintain safe operation at 110°F ambient temperature as measured at rear of engine prior to engine radiation effects. The radiator shall be equipped with a duct adapter flange permitting the attachment of an air discharge duct directing the discharge of radiator air through the wall. Air flow restriction from the radiator shall not exceed 0.5 inches of water. Fans shall be equipped with protective shrouds in compliance with OSHA requirements.

3. The Contractor shall provide duct work with flexible connecting sections between the radiator duct flange and the exhaust damper.

4. The engine cooling system shall be pretreated by the engine manufacturer or supplier for the inhibition of internal corrosion.

d. The engine shall have a full pressure lubricating system arranged to distribute oil to all moving parts of the engine and to cool the pistons. System shall include an engine-driven positive displacement pump, pressure regulating valves, oil filter, oil pressure indicator, and the necessary piping and fittings.

1. Lubricating oil filters shall be the full flow type and shall be capable of filtering the full rate of oil flow of the oil pump at maximum engine speed.

Filters shall be conveniently located for servicing and shall be equipped with a spring loaded bypass valve to insure oil circulation if filters are clogged.

e. An engine exhaust system shall be provided to include a residential type exhaust silencer, muffler companion flanges and stainless steel bellows-type exhaust of the fitting properly sized. The size of the exhaust pipe shall be sufficient to insure that exhaust back pressure does not exceed the maximum limits specified by the engine manufacturer.

1. The silencer shall be mounted so that its weight is not supported by the engine nor will exhaust system growth, due to thermal expansion, be imposed on the engine.

2. The muffler and all indoor exhaust piping shall be lagged by the contractor to maintain a surface temperature not to exceed 150°F. The insulation shall be installed so that it does not interfere with the functioning of the flexible exhaust fitting. Insulation shall not be asbestos type.

3. A raincap shall be provided at the stack outlet.

f. The engine fuel system shall include an underground storage tank, with a fuel leak detection system, a day tank, fuel transfer pumps, fuel filters and all piping, valves, fittings and accessories to complete the fuel flow between the storage tank, the day tank and the engine.

g. The underground storage tank shall be fully double walled (360°) including a primary (inner) tank and a secondary (outer) tank. The primary tank shall have a storage capacity adequate for the operation of the generator set for 36 hours at rated load or 550 gallons, whichever is larger, unless otherwise shown on the plans. A UL certification shall be attached to each tank.

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1. The primary and secondary tanks shall be manufactured of 100% isophthalic resin and glass fiber reinforcement with no sand fillers.

2. The tank outside diameter and approximate length shall be as indicated on the plans.

3. The annular space between the primary and secondary tank shall allow for the free flow and containment of all leaked products from the primary tank. The space shall also allow for the insertion of the fluid leak monitoring device through an appropriate fitting.

4. The tank shall comply with the following structural design criteria:

(a) Internal Load - The primary and secondary tanks shall withstand 5 psi air pressure test with 5 to 1 safety factor. Contractor shall individually test tanks prior to installation as this is to test for leakage. Maximum test pressure shall be 5 psi.

(b) Vacuum Test - Every tank shall be mercury vacuum tested by the tank manufacturer to assure structural integrity. Primary tank shall be tested to 11.5 inches and secondary tank tested to 9.5 inches mercury vacuum.

(c) Surface Loads - Tank shall withstand surface H-20 axles loads when properly installed according to the manufacturer's installation instructions.

(d) External Hydrostatic Pressure - Tank shall withstand 4 feet of overburden with the

hole fully flooded with a 3:1 safety factor against buckling.

(e) Tanks shall support all required accessory equipment such as drop tubes, submersible pumps, ladders when installed according to tank manufacturer's recommendations and limitations.

5. The tank shall be capable of storing diesel fuel and other petroleum products with specific gravity up to 1.1 at ambient underground temperatures.

6. Both the primary and secondary tanks shall be individually vented to atmospheric pressure.

7. The tank shall be provided with one manway, as shown on the plans, when the capacity does not exceed 1,000 gallons. Tanks larger than 1000 gallons shall be provided with two manways.

(a) Manways shall be a minimum 22-inch inside diameter, flanged and complete with UL listed gaskets, bolts and covers. Each steel cover shall have three 4-inch nominal pipe thread (NPT) fittings welded in place.

(b) Manway extension tubes shall be fiber glass reinforced plastic (FRP) and 24 inches long for manways shown on the plans.

8. FRP anchor straps shall be provided by the tank manufacturer. The number and location of the straps shall be as specified in the manufacturer's installation instructions.

9. The tank fill tubes shall be FRP, 4-inch diameter with a 6-inch by 4-inch double topped reductor bushing, factory installed by the manufacturer at the location shown on the plans.

10. All NPT fittings shall be of materials and construction meeting UL requirements. All standard threaded fittings shall be half couplings and shall be 4 inches in diameter including the fill, gauge, inlet, outlet and vent fittings. Reducers shall be provided by the Contractor for smaller sizes where shown on the plans.

11. The suction and return lines shall be installed by the Contractor on site. Pipes shall terminate a minimum of 4 inches from the bottom of the tank.

12. A gauge plate shall be installed as shown on the plans.

13. The tank shall have test monitor fittings consisting of a 2-inch NPT fitting on the primary tank and a 6-inch NPT fitting directly above on the secondary tank.

14. The tank shall have two monitor fittings, one near each end of the tank, for tanks larger than 1000 gallons, and one monitor fitting for smaller tanks.

15. A low level fuel supply sensing device shall be installed on the main fuel tank. The sensing device shall be adjusted to signal low fuel level when the tank contains less than a three-hour supply. The three-hour supply level shall be as recommended by the manufacturer of the engine-generator set.

16. The underground tank shall be equipped with a complete electronic leak detection system which shall

provide a continuous indication of the status between the primary and secondary tanks in three modes - dry, hydrocarbon, water.

(a) The system shall include probes to be installed in the annular space between the primary and secondary tanks, a remote master control panel and all required electrical interconnections between elements.

(b) The complete installation shall be suitable for NEC Class I, Division 1, Group D hazardous locations.

(c) The master control-alarm station shall be a NEMA 4 enclosure suitable for outdoor or indoor installation. It shall be located inside the Master Control Room unless otherwise shown on the plans.

(d) Visual and audible alarms shall be provided at the panel location and provisions for future transmission of alarm signal to a remote location by phone or an equivalent media shall also be included.

h. The day tank shall meet all applicable requirements of NFPA 30 and UL 142, and shall include fittings, vents and other accessories required for installation. Storage capacity of the tank shall be adequate for operation of the engine-generator set at rated load for at least 8 hours.

i. The fuel transfer pump shall be horizontal, positive displacement, rotary pump, direct-connected to an electric motor. The motor shall be a drip-proof, single phase motor and rated for 120 volts, 60 Hz. The pump shall be capable of delivering fuel in excess of the maximum fuel consumption rate of the engine from the main storage tank to the day tank.

The float switch at the day tank shall activate the storage tank fuel pump to transfer fuel to the day tank. The fuel transfer system shall also have a positive shutoff so that when the day tank is full, no fuel can flow into the day tank even though the external fuel supply system is pressurized. Contractor shall provide necessary items to assure proper priming of fuel pumps.

j. Engine suction, injection, injector return and fuel supply lines shall be single wire braid flexible hose of the size specified by the manufacturer of the generator set. Fuel line from the underground tank to the fuel transfer pump shall be PVC of the schedule specified and the size required to match and connect to the fuel hoses. All hose fittings shall be of the reusable type.

k. The engine shall be equipped with a 24 volt DC electric starting system with positive engagement drive and of sufficient capacity to crank the engine at a speed which will allow full diesel starting of the engine. The starting pinion will disengage automatically when the engine starts. The system shall be arranged to permit starting of the engine automatically upon signal from the automatic transfer switch. It shall include:

1. A nickel-cadmium storage battery to be used in conjunction with the electric starting system. The battery shall be of sufficient size and capacity in a fully charged condition to be capable of starting the engine-generator set at least six consecutive times. A battery rack, necessary cables, and clamps shall be provided.

2. A battery charger which shall be enclosed, wall mounted, fully automatic, two rate type (fast and trickle charge), solid-state, constant voltage type having AC voltage compensation, DC voltage regulation and current limitation. The charger shall

use transistor-controlled magnetic amplifier circuits to provide continuous taper charging and shall maintain rated output voltage within ±1% from no load to full rated load. It shall have automatic surge suppressors, DC ammeter, DC voltmeter, fused inputs and outputs, and shall have a continuous rated output of not less than 10 amperes.

l. Automatic controls shall be provided that will immediately shut off delivery of fuel to the engine cylinders when actuated by a condition of low lubricating oil pressure, high water temperature, overspeed or low water level. The values at which the controls for low lubricating oil pressure and high water temperature are actuated shall be as recommended by the manufacturer, and the overspeed governor shall be set to actuate at the value specified in paragraph 2.09b(2) above. The low lubricating oil pressure shutdown control shall be provided with a means to make it inoperative during the period of low oil pressure when the engine is being started. Each shutdown shall initiate its individual light and alarm within the control panel, and shall require manual reset to release each indicating light. Normal start-up and shut-down shall not actuate the manual reset indicator system.

656-2.10 Generator

a. The generator shall be a brushless, synchronous type, coupled directly to the engine flywheel through a flexible driving disc for positive alignment. The generator rotor shall by dynamically balanced within 0.005 in. peak-to-peak amplitude displacements at both ends of the shaft and shall be capable of sustaining 25% overspeed.

b. Insulation shall be NEMA Class F and temperature rise shall be in accordance with NEMA standard MG1-22.40 for standby operation. The field shall be equipped with full amortisseur windings.

c. The excitation system shall be of the integral brushless-type, consisting of a rotating AC exciter and rectifier diode assembly together with a static type voltage regulating system, and including surge protection and the required accessories. The excitation system shall have a continuous current rating of not less than the generator excitation current required when the generator operates at 105% rated voltage under the condition of continuous rating requiring maximum field current.

d. The exciter shall be a rotating AC generator having a rotating armature on the rotor spider and a stationary field on the stator frame.

e. Rectifiers shall be of the full-wave silicon diode type with each diode protected by individual fuses. Connections shall be provided between the exciter, rectifiers, and generator field without the use of brushes or slip rings.

f. The voltage regulator shall be a completely solid state type for control of generator voltage by control of the exciter field. It shall be mounted inside the generator terminal box or in the control cabinet. Voltage regulation shall be $\pm$ 0.5% from no load to full rated load. Readily accessible voltage drop, voltage level, and voltage gain controls shall be included in the module. Voltage level adjustment shall be a minimum of $\pm$ 10%.

656-2.11 Control Equipment for Generator Set

a. The control panel for the engine-generator set shall be provided by the same manufacturer as the set and shall be mounted either on the engine or the generator. It shall be a NEMA 1 type, vibration isolated, dead front, 14 gauge steel minimum.

b. The following engine controls, instruments, switches and indicators shall be provided and clearly identified:

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1. Fully automatic engine-generator set start-stop controls. Operation shall be initiated by the closing of contacts in the automatic transfer switch. Controls shall provide automatic shutdown for low lubricating oil pressure, high water temperature, low water level, overspeed, overcrank as required in paragraph 2.09 h above, and one auxiliary contact for activating accessory items. Controls shall include one 30 second cranking cycle with lockout and manual reset feature.

2. Lubricating oil pressure gauge and coolant temperature indicator, both of the indicating dial type.

3. A running time meter.

4. A four-position function switch marked auto, manual, off/reset, and stop.

5. Indicator lamps, lamps test switch, and common external alarm contact covering the following conditions:

(a) Run (green light)
(b) Overcrank shutdown (red light)
(c) Overspeed shutdown (red light)
(d) High coolant temperature shutdown (red light)
(e) Low oil pressure shutdown (red light)
(f) Pre-warning for high coolant temperature (yellow light)
(g) Pre-warning for low oil pressure (yellow light)
(h) Switch off (flashing red light, indicating gen-set not on automatic start mode)
(i) Low fuel (yellow light)
(j) Two additional fault conditions (red lights)

6. A fault reset switch to clear fault indications and allow restarting of the engine after shut down faults have been corrected. The controls design shall be such that the fault indication shall remain until reset.

c. The following generator controls and instruments shall be provided and clearly identified:

1. A voltage adjustment rheostat and exciter circuit breaker.

2. An AC voltmeter and an AC ammeter both of the semiflush mounted, direct indicating dial type. They shall be no less than 3 1/2 inches nominal round or square in size, with 180 degree arc and with an accuracy of 2% of full scale.

3. A frequency meter of the semiflush mounted dial type (45-65 Hz). It shall be no less than 3 1/2 inches nominal round or square in size and have an accuracy of 2% of span.

4. A four position AC meters phase selector switch to read line current and voltage in each phase with off position.

d. A main line, molded case generator output breaker shall be provided as a load circuit interrupting and protection device. It shall operate both manually for normal switching function and automatically during overload or short circuit conditions.

1. The frame size, trip, voltage and interrupting capacity shall be as indicated on the plans.

2. The trip unit for each pole shall have elements providing inverse time delay during overload

conditions and instantaneous magnetic tripping for short circuit protection.

3. The circuit breaker shall have a battery voltage operated shunt trip wired to safety shutdowns to open the breaker in the event of an engine failure.

4. The circuit breaker shall meet standards established by Underwriters Laboratories, NEMA, and National Electric Code.

5. Circuit breakers which sense exciter field current do not meet the above electrical standards and are unacceptable for line protection.

656-2.12 Automatic Transfer Switch

a. The automatic transfer switch shall include a manual bypass isolation switch, and the accessories and capabilities described below. It shall have the number of poles and the amperage, voltage and withstand rating indicated on the plans. The transfer switch shall be listed, as per UL 1008, as a recognized component for emergency systems and rated for all classes of loads when installed in an unventilated enclosure. It shall be housed in a NEMA 1 enclosure.

b. The automatic transfer switch shall be of the contactor type, mechanically held and electrically operated.

1. Electrical operation shall be accomplished by a non-fused momentarily energized solenoid, direct operating mechanism or stored energy operator. Operation shall be inherently double throw and mechanically interlocked to ensure one of two possible positions: normal or emergency.

2. Main pole structure shall be designed so that fault currents result in increased main contact

pressure. An overload or short circuit shall not cause the switch to go to a neutral position. Main contacts shall be designed for automatic transfer switch service.

3. Inspection and replacement of all main and separate arcing contacts moving and stationary, shall be possible from the front of the switch without any disassembly of operating linkages or power conductors.

c. The manual bypass isolation switch shall be arranged to bypass the emergency or the normal source of power directly to the load in one operation, isolating the automatic transfer switch from the load and both the normal and emergency power sources to allow for the maintenance of the transfer switch.

1. The bypass isolation switch shall be lockable in the "isolated" position. The arrangement shall permit electrical testing of the transfer switch before the load is reconnected. Interlocks shall prevent operation of the transfer switch, except for testing purposes, when the switch is in the "isolated" position.

2. The enclosure shall be designed so that the automatic transfer switch and the bypass isolation switch shall be accessible through individual door openings and installed in separate barriered compartments to eliminate any exposure to the operator when servicing the automatic transfer switch while the bypass isolation switch is in the bypass isolation position.

3. The bypass isolation switch compartment shall include a pilot light arranged to indicate when the switch is in the bypass isolation position. Bypassing

the automatic transfer switch shall not cause any interruption of power on the load.

4. The current, voltage, phase, pole (with switched neutral) shall be at least equal to the transfer switch ratings. The bypass isolation switch may be a non-loadbreak device but shall have at least equal short circuit withstand rating as the transfer switch. Its contact temperature shall not exceed the limitations designed for the transfer switch.

d. The following accessories and capabilities shall be provided with the transfer switch:

1. Three-phase relay for full phase protection. Relay shall be field adjustable, close differential type with 92 to 95% pickup and 82 to 85% dropout. Relays are to be connected to proper output parameters.

2. Full rated neutral transfer contacts driven by the main contact shaft.

3. Isolated (ungrounded) neutral bus.

4. Four position mode selector switch marked "test-auto-off-engine start".

5. Voltage and frequency monitor on generator output to prevent transfer prior to proper output parameters.

6. Adjustable 0.5 to 6 second time delay on engine starting to override momentary outages and nuisance voltage dips.

7. Adjustable 2 to 30 minute time delay on retransfer to normal power surface.

8. Adjustable 5 to 10 minute time delay on shutdown of engine-generator after retransfer of the load to normal.

9 Plant exerciser to start and run the engine-generator set without load each 168 hours for a 30-minute interval.

10. Engine starting control contacts - one normally open, one normally closed.

11. One auxiliary single pole double throw contact on emergency contactor and another on normal contactor.

12. Three pilot lights to indicate the normal and emergency position of the transfer switch and the mode selector switch in "off" position.

656-2.13 Housing for Central Power System

The components of the central power system shall be housed in a single structure or in separate structures as called for in the plans. The materials and equipment for these housing structures shall comply with all the requirements indicated on the plans and in the special provisions for this work.

656-2.14 Equipment Lists, Drawings and Manuals

a. The Contractor shall submit to the Engineer for review, within 60 days following the award of contract and before purchasing the items, a complete list of all the equipment and materials which he proposes to install. This list (five copies) shall include the name of the manufacturer, size and identification for each item. In addition, the list shall be supplemented with descriptive literature, shop drawings, specifications and such other data as may be needed to evaluate the submittal.

b. Complete shop drawings, including wiring diagrams, shall be submitted for the primary service entrance, the central power substation, the primary disconnect and protective devices, the main distribution panel, the power distribution system, the intersection power centers and the standby power generation system.

c. The submittals for the major items of equipment shall be accompanied by a certification from each manufacturer to the effect that the equipment meets all the requirements of the plans and specifications. In the event that any item is not in exact accordance with the plans and specifications requirements, the certificate shall identify and explain each such difference. Major items of equipment include the substation transformers, the main distribution panel, the dry type power center transformers, the engine-generator set for the standby power system with all its components, and such other equipment as may be determined by the Engineer.

d. The shop drawings and product information submittals for the standby power generation system shall include:

1. Make and model of engine and generator

2. Makes and models of other major auxiliary equipment such as fuel oil day tank, fuel oil tank, fuel line strainers, engine muffler, vibration isolators, automatic transfer switch, batteries and battery charger.

3. Certified outline, general arrangements, and anchor bolt details of the complete engine-generator set clearly showing entrance points for each of the interconnections required.

4. Drawings showing day fuel tank connection points.

5. Piping schematics for fuel oil.

6. Drawings for the transfer switch, including certified outline, electrical ratings, general arrangement, and detail drawings.

7. Electrical elements, schematics and wiring diagrams, including details of the safety shutdown systems and main generator circuit breaker trip system.

8. Manufacturer-published kilowatt output curve and published fuel consumption curve.

9. Unit ventilation and combustion air requirements.

10. Manufacturer-published transient response data of the complete engine-generator at 1.0 power factor. Data shall include voltage dips, maximum frequency dips, and recovery time periods.

11. Generator motor starting curves showing the voltage dips versus starting kVA.

12. Engine altitude duration curve.

13. Underground fuel tank including the location of all fittings, accessories and critical dimensions.

14. Underground fuel tank manufacturer's literature including installation instructions.

15. Fuel leak detection system for underground tanks.

e. When required by the plans and/or special provisions, detailed shop drawings shall be submitted for the structures to house the substation and the standby power generation set.

f. The approval of shop drawings and diagrams by the Engineer shall not relieve the Contractor of his responsibility for any erroneous or inconsistent dimensions, notations, omissions or other errors, or for the proper functioning of the completed installation.

g. Five copies each of the operation and maintenance manuals, detailed parts lists, and diagrams for the major items of equipment for the substation and the standby power generation system shall be submitted to the Engineer prior to final acceptance of such items. Information submitted shall be comprehensive and specific.

656-2.15 Shop Tests

a. Performance tests shall be run at the manufacturer's shop of the diesel engine, the generator, the engine-generator set and the automatic transfer switch. Certified test reports (3 copies) shall be submitted to the Engineer.

b. The generator set tests shall show that the equipment to be furnished is within the following tolerance limits:

		Limits	
Item	Units	Percent Values Shown Are Percent of Nominal Specs	Number of Places Required After Decimal Points
Corrected Power	kW	± 3%	1
Test Speed	rpm	+ 0	0
Test Power	kW	± 1%	1

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Item	Units	Limits: Percent Values Shown Are Percent of Nominal Specs	Limits: Number of Places Required After Decimal Points
Frequency Stability	Hz	± 0.2	1
Line to line Voltage	Volts	± 4%	0
Test Voltage	Volts	± 1%	0
Line Current	Amps	± 3%	0
Overshoot	Percent	107% High Idle rpm Maximun	0
Speed Drop Isochronous Governors (% Nominal)	rpm	± 10	0
Voltage Stability	Percent	- 0.5	1
Voltage Drop (*)	rpm	± 50	0

(*) Nominal voltage drop equals 0%. The drop is set to zero value.

c. Certified copies (3) of the routine shop tests performed by the manufacturer on the transformers in accordance with ANSI C 57.12.90 standards shall be submitted to the Engineer.

d. The primary disconnect switch shall be tested by a high power laboratory for applicable ANSI and NEMA standards and certified test reports submitted to the Engineer. The tests shall include the performance of the switch assembly as well as the suitability of the enclosure venting, rigidity and bus bracing. The tests may be performed on a

similar factory assembled unit in lieu of the one to be delivered to the project.

e. All shop and independent laboratory tests shall be performed at no extra expense to the Authority. The costs of these shop tests are considered by the Authority as included in the contract unit price.

f. The required certified test reports shall be submitted to the Engineer prior to delivery of the equipment to the project site.

656-2.16 Warranties and Guarantees

a. All equipment and other components of the Central Power System including the substation, main distribution panel, intersection power centers, and the standby power generation system shall be guaranteed against defective parts and workmanship under manufacturers warranties. The warranties shall be in accordance with customary trade practice but shall be for a period of not less than one year from the date of satisfactory initial start-up and placing in operation at the project site, and shall cover the full costs of materials necessary to repair or replace the defective component.

b. The Contractor shall provide for and guarantee the satisfactory installation and in-service operation of all the electrical and mechanical equipment, and all related components, of the Central Power System for a period of six months following the acceptance of the project by the Authority. During the warranty period the Contractor shall repair or replace, at no expense to the Authority, any equipment, materials or work that does not provide satisfactory operation due to equipment, materials and/or installation deficiencies.

c. Any items repaired or replaced within the above warranty periods shall be guaranteed for an additional period, meeting the requirements specified above, from the date of acceptance of the repaired or replaced item by the Authority.

656-3 CONSTRUCTION REQUIREMENTS

656-3.01 General

a. The Contractor shall obtain all necessary permits and inspections required by PREPA and other laws and regulations, and all required fees shall be included in the contract price.

b. Construction shall conform to the details shown on the plans; however, the location of housing structures, power lines, conduits and other appurtenances shown on the plans are approximate only and the exact location will be established by the Engineer in the field.

c. Upon completion of the work the Contractor shall submit "As Built" plans incorporating any changes in the original plans.

d. All systems shall be complete, satisfactorily field tested and in operating conditions at the time acceptance of the project is requested.

e. Where the specifications call for an installation to be made in accordance with an equipment or materials manufacturer recommendations, a copy of such recommendations shall be kept at all times in the Contractor’s project office and shall be available to the Engineer at his request.

f. Pulling tensions on conductors during installation shall in no case exceed the maximum values specified by the cable manufacturer.

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656-3.02 Primary Service Entrance

a. The underground service entrance from the point of connection with the PREPA lines to the substation shall be built as shown on the plans and in accordance with PREPA requirements. However, the Contractor shall verify with PREPA the point of connection and primary voltage prior to initiating construction of the service entrance.

b. Prefabricated stress relief terminators approved by PREPA shall be provided at both ends of the service entrance conductors.

c. The underground PVC conduits for the service entrance shall be encased in Class A concrete as per PREPA standards to provide a minimum of at least 3 inches of concrete cover around each conduit. The top of any conduit shall be not less than 36" below finished grade.

d. When the project is served from an overhead line provide rigid galvanized steel pipe conduit above grade for riser at the pole, with appropriate fittings to connect to the underground PVC conduit, and protected at the base of the pole with a concrete cover 18 inches high by 3 inches thick, in accordance with PREPA standards.

e. Provide an empty spare conduit with plugs on each end. Provide a plastic pull rope having an extra 3 feet at each end of empty conduit.

656-3.03 Distribution System

a. The distribution system shall be radial from the main distribution panelboard at the master signal controller room to the power center at each intersection traffic signal controller.

b. Excavation and backfilling shall be performed in conformance with the requirements of Section 654-3.03 of Specification 654 - Traffic Signal Systems.

c. The removal and replacing of existing improvements shall be performed in conformance with the requirements of Section 654-3.04 of Specification 654.

d. The installation and testing of conduits shall be performed in conformance with the requirements of Section 654-3.08 of Specification 654.

e. Pull boxes and handholes shall be furnished and installed in accordance with Section 654-3.09 of Specification 654.

f. Electrical conductors shall be installed in conformance with the applicable requirements of Section 654-3.10 of Specification 654. Conductors shall be labeled with the branch feeder designation the main distribution panelboard in the master control room and in the power center at each intersection.

656-3.04 Substation, Main Distribution Panelboard and Standby Power Generation System

a. Shall be installed, including all accessories and appurtenances, as shown on the plans and approved shop drawings, and in accordance with the manufacturers recommendations.

b. The underground tank and piping systems shall be installed in accordance with the manufacturers' recommendations, with applicable NFPA requirements and with API Publication 1615 - Installation of Underground Storage Systems.

1. The piping must be installed at a minimum of 18 inches below grade and slope at a minimum of 1/8 inch per foot downward to the tank.

2. The Contractor shall notify the Engineer at least two working days in advance of placing the tank in the hole, anchoring the tank and backfilling the excavation. None of these operations shall be performed unless a representative of the Engineer is present.

656-3.05 Intersection Power Centers

a. The dry transformers for the intersection power centers shall be installed as shown on the plans. An engraved laminated plastic nameplate shall be provided for each transformer indicating the traffic intersection designation, the location of the central power center, and the designation of the branch circuit that feeds the intersection.

b. The Contractor will be responsible for attaining a voltage regulation of 10 percent for each transformer. If this is not possible through the use of transformer taps, a buck and boost transformer may be used to attain this requirement.

656-3.06 Field Testing

a. All the components of the central power installation shall be field tested by the Contractor, at his expense, to insure that the system meets all plans, specifications and PREPA requirements. The Contractor shall include all the tests specified below in his testing program.

b. Conductors below 600 volts shall be tested for insulation resistance on all feeders and circuits over 100 amperes, 480 volts and below with 1,000 volt megger. A written report detailing the results of the test shall be

submitted to the Engineer. Equipment which may be damaged by this test shall be disconnected prior to the test.

c. High potential tests shall be performed on all conductors above 600 volts after installation. Tests shall be in accordance with PREPA procedures. A written report on the results of the tests shall be submitted to the Engineer.

d. All grounding systems shall be tested to assure minimum resistance to ground.

e. The primary (inner) tank of the underground fuel tank shall be tested with 5 psig air pressure for a minimum of 30 minutes. After verifying the integrity of the inner tank, maintain it under pressure and test the outer tank with a minimum of 5 psig pressure while soaping the skin of the tank to detect any possible leaks. An air gauge with 0.25 pound increments shall be used.

f. All piping for the underground tank fuel system, except for the fill piping, shall be tested at 150 percent of maximum operating pressure or 50 psig air pressure, whichever is greater, for a period of one hour while all joints are soaped. If lines have held product or after backfilling, test all lines hydrostatically at 110 percent of maximum operating pressure, but not less than 50 psig. Pipes must be isolated from tanks and dispensers prior to testing.

g. The completed standby power generation set shall be tested at start-up by a laboratory, approved by the Authority at full rated load through the use of a resistive load bank. The tests must prove that the generator set is free of defects and will perform as required by the plans and specifications. Block loading at 50%, 75% and 100% loads shall be used for four-hour periods each. Transient responses, including voltage dips, frequency dips, and recovery time period, shall be measured and agree with the data submitted with the equipment.

h. After the complete central power system has been installed, tested and adjusted as necessary, a functional test of the complete system shall be performed in conjunction with the functional testing of the traffic signal system performed under Specification 654. The functional testing shall meet the requirements specified in Section 654-3.16.

i. All field testing shall be witnessed by representatives of the Authority. It shall be the responsibility of the Contractor to make all arrangements with PREPA for the necessary power connections for the testing and for their attendance at the testing when required.

656-4 METHOD OF MEASUREMENT

656-4.01 Except for the items included in paragraphs 4.02, 4.03 and 4.04 below, traffic signals central power system furnished, installed and accepted will be measured as a single lump sum unit. The complete unit shall include the substation, main secondary feeder, the main distribution panelboard, all intersection power centers, the standby power generation set, and all necessary appurtenances, wiring, hardware, fittings, miscellaneous equipment and materials necessary to provide a complete power system as specified and as shown on the plans.

656-4.02 Each structure to house the major components of the power system, of the type specified and shown on the plans will be measured as a separate lump sum unit. Each structure shall be furnished and installed complete. However, when the central power substation and the standby power generation system are to be housed in a single structure with the traffic signals master controller, the structure will be measured and paid for under Specification 655 - Traffic Signal Master Controller Building.

656-4.03 The completed and PREPA accepted primary service entrance from the connection to the PREPA service lines to the incoming line sections at the substation will be measured as a

separate lump sum unit. However, the cost charged by PREPA for connecting to its lines will be paid by the Authority.

656-4.04 The completed power distribution system from the main distribution panelboard to the power center in each intersection included in the system will be measured and paid for separately as follows:

a. Conduits - Will be measured and paid for as specified for conduits under Specification 654 - Traffic Signals Systems.

b. Pull boxes and hand-holes of the class and sizes specified will each be measured and paid for as specified for these units under Specification 654.

c. Electrical conductors will be measured and paid for by the linear meter of each class and size as specified for electrical cable under Specification 654.

656-5 BASIS OF PAYMENT

656-5.01 The accepted quantities, determined as provided above for the pay items listed below which are included in the contract, will be paid for at the contract unit price per unit of measurement. Such price and payment shall constitute full compensation for furnishing, installing, adjusting and testing all required equipment and materials, and for all labor, equipment, tools, materials and incidentals necessary to complete each item and to provide a complete central power system as required by the plans and specifications.

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656-5.02 Payment will be made under:

Pay Item	Pay Unit
Central Power System……	Lump Sum
Central Power System Housing Structure, Type ___.	Lump Sum
Primary Service Entrance……..	Lump Sum

SPECIFICATION 660 – NAME PLATES

660-1 DESCRIPTION

660-1.01 **Scope** - This work shall consist of furnishing and installing nameplates in accordance with these specifications and in conformity with the design, dimensions, materials and locations shown on the plans.

660-2 MATERIALS

660-2.01 The materials for the nameplates shall be as specified on the plans.

660-3 CONSTRUCTION REQUIREMENTS

660-3.01 Name plates shall be manufactured in accordance with the design and inscription shown on the plans.

660-3.02 The nameplates shall be installed at the locations shown on the plans or indicated by the Engineer.

660-4 METHOD OF MEASUREMENT

660-4.01 Name plates will be measured by the number of individual units installed in place and accepted.

660-5 BASIS OF PAYMENT

660-5.01 The quantity of nameplates, determined as provided above will be paid for at the contract unit price per unit. Such price and payment shall be full compensation for furnishing and installing each nameplate and for all equipment, tools, labor and incidentals necessary to complete each item as required by the plans and specifications.

SPECIFICATION 660 – NAME PLATES

660-5.02 Payment will be made under:

Pay Item	Pay Unit
Name Plate……	Each

SPECIFICATION 680 - BRIDGE SMOOTHNESS

680-1 DESCRIPTION

680-1.01 Scope - This work shall consist in measuring the roughness for bridge lots acceptance. The work shall be performed at the locations shown in the plans or indicated by the Engineer, in accordance with these specifications, and in conformance with the lines, grades and details shown on the plans or established by the Engineer.

a. The Contractor will accomplish roughness test during the construction in process to evaluate the performed work and to ease the correction procedures.

b. The Authority will perform the final measurements of surface roughness for the acceptance or rejection of the bridge lots.

680-1.02 Equipment

a. Bridge smoothness will be measured based upon the Profile Index (PI) as determined by the 25 feet computerized California type profilograph (non-uniformly spaced wheels), or a compatible device that correlates its results with the California type profilograph. The provided equipment shall comply with the ASTM E-1274, or the ASTM E-950 (Class I) in case the compatible device is selected. All bridges lanes including the bridge approach slabs shall be tested.

b. The PI will be determined using the equipment's software. The PI units will be setup in inches per mile and will be carried out to one decimal point. The profilogram is the graph that presents the roughness profile and it will be recorded using a vertical scale of one inch equal one inch, or full scale, vertically. The equipment will be setup using a blanking band of 0.2 inches and a "must correct" bump or depression limit of 0.4 inches in a length of 25 feet for the purpose of the PI computations. Motive power may be manual or by a propulsion unit attached to the assembly. The equipment will be moved longitudinally at the right wheel

path along the bridge lanes, in the direction of traffic, at a speed no greater than 3 MPH.

c. A bridge lot is defined as 528 feet (0.1 mile) of a bridge lane. The profilograph measurements will be initiated, and ended, with the profile wheel located at the beginning, or end, of the bridge decks. For lanes with 12-feet width or less, the wheel path will be located at 3 feet from and parallel to the right edge of pavement. For lane width greater than 12 feet, the profile will be taken on the right edge from the approximate lane marking.

680-1.03 Surface and Tolerances Requirements

a. The Contractor shall furnish equipment and employ methods that produce a riding surface having a Profile Index (PI) within the acceptance zone presented in Table 1. During construction, the Contractor shall verify its PI production. The profilograph will be calibrated and operated by qualified technical personnel in compliance with the equipment's manufacturer recommendations and protocols. On bridge lots, the Contractor may fill the transverse joints with an appropriated material, flush with the surface, to minimize the influence of the joint in the PI computations. The final profilograph evaluation will be made with the Authority's equipment after the bridge and approaches have been completed.

b. At the construction phase, the Contractor may submit correction proposal for those lots with PI falling in the penalties zone stated in Table 1. If the Contractor proposes correction by diamond grinding, the Authority will require phactometer measurements by the Contractor to assure that reinforcement cover is maintained. The maximum grinding depth shall be equal to ¼ inch. The Authority may require the drilling of ¼ inch holes to verify the phacometer depth readings to the top of the reinforcement. The Authority may reject the Contractor's correction proposal and the bridge deck lots will remain with the penalty. If the Authority

accepts the correction to take place, the affected lot will be measured and a new PI will be calculated for acceptance. If the corrected bridge deck lot results in damages, the full computed damage would be applied. Only one corrective effort will be permitted on the bridge deck lots. For bridge deck lots less than 0.10 miles in length, the penalties will be reduced proportionally with the actual length of the lot. Segments shorter than 15 feet will not be considered for penalties computations. No penalties will be applied to the Contractor until the corrections and the final evaluation takes place.

c. Lots with a PI falling in the rejected zone stated in Table 1, will be immediately submitted to a major slab reconstruction, at the Contractor's expense, prior to continuing the paving operation.

d. The final smoothness evaluation will be made with the Authority's profilograph. The Contractor will be responsible to clean the pavement and mark the wheel path of the areas to be tested. Also, traffic control will be the Contractor's responsibility during the testing operations and to provide survey services and reference points tied to the stationing system of the project. No compensation will be provided for these services.

e. All bridge's access will be evaluated for smoothness compliance as per the specification for PCC Pavement or Hot Plant-Mix Bituminous Pavement Smoothness, as applicable.

SPECIFICATION 680 - BRIDGE SMOOTHNESS

Table 1
Acceptance Criteria for Bridge Deck Lots

Type of Facility	Acceptance				Rejected	
	PI	Penalty	PI	Penalty	PI	Penalty
New Construc -tion	$\leq$ 30	None	30< PI $\leq$ 60	Penalty of $500 per every PI above	> 60	Major Slab Recons- truction