SECTION 7 STRUCTURES

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SECTION 7
STRUCTURES

1.0 STRUCTURAL EXCAVATION

1.1 DESCRIPTION. This section covers structural excavation which consists of the removal of material for the construction of foundations for bridges, retaining walls, head walls for culverts, or other structures, and other excavation designated on the plans or in these specifications or in the special provisions as structural excavation, and the subsequent backfill of these same structures.

1.1.1 Structural backfill shall consist of furnish material, if necessary, and placing and compacting backfill material around structures to the lines designated on the plans as specified or directed by the Engineer.

1.1.2 Structural excavation and structural backfill shall include the furnishing of all materials and equipment; the construction or installation of all cofferdams and other facilities which may be necessary to perform the excavations and place and compact the backfill; and the subsequent removal of such facilities, except where they are required or permitted by the plans or specifications to remain in place.

1.2 CONSTRUCTION METHODS

1.2.1 Excavation.

- When footing concrete or masonry is to rest upon rock, the rock shall be removed to a depth sufficient to expose sound rock. The rock shall be roughly leveled off or cut to approximate horizontal and vertical steps, and shall be roughened. Seams in the rock shall be grouted under pressure or treated as the Engineer may direct and the cost thereof will be included for payment in the quantities for the unit of the structure for which the excavation is made. When footing concrete or masonry is to rest on an excavated surface other than rock, care shall be taken not to disturb the bottom of the excavation and final removal of the foundation material to grade shall not be made until just before the concrete or masonry is placed. Except when overexcavation is directed by the Engineer, excavation below grade shall be replaced at the Contractor's expense with the same class of concrete specified for the structure and at the time the concrete for the structure is being placed.
- Excavated material required to be used for backfill may be deposited by the Contractor in storage piles at points convenient for rehandling of the material during the backfilling operations. The location of storage piles shall, however, be subject to the approval of the Engineer who may require that the survey centerline of the structure and the transverse or hub line of any unit of the structure be kept free of any obstruction.
- Excavated material required to be wasted shall be disposed of as directed by the Engineer, and the disposal shall be in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure or other part of the work.
- For all single and multiple box culverts, pipe culverts, and pipe arch culverts where the soil encountered at established footing grade is a quicksand, muck, or similar unstable material, the following procedure shall be used unless other methods are called for on the plans. All unstable soil shall be removed to a depth of 2 feet below bottom of culvert for culverts 2

feet or more in height, and to a depth equal to the height of culvert for culverts less than 2 feet in height. Such excavation shall be carried at least 1 foot beyond the horizontal limits of the structure on all sides. All unstable soil so removed shall be replaced with suitable stable material, placed in uniform layers of suitable depth for compaction as directed by the Engineer, and each layer shall be wetted if necessary, and compacted by rolling or tamping as required to provide a stable foundation for the structure. Soil which is considered to be of sufficient stability to sustain properly the adjacent sections of the roadway embankment will be considered a suitable foundation material for the culvert.

- When the material encountered at footing grade of a culvert is found to be partially rock or incompressible material, and partially a soil or material that is compressible but otherwise satisfactory for the foundation, the incompressible material shall be removed for a depth of 6-inches below the footing grade and backfilled with a material similar to the compressible foundation used for the rest of the structure.

- When the material encountered at footing grade of a bridge bent or pier is found to be partially of rock or incompressible material, and partially of a compressible material, the foundation shall not be placed until the Engineer has inspected the footing and authorized such changes found necessary to provide an adequate foundation.

1.2.2 Backfill. Structural backfill shall not be placed until the structure footings or other portions of the structure or facility have been inspected by the Engineer and approved for backfilling. As soon as practicable all spaces excavated under this item and not occupied by the permanent structure shall be backfilled, except that no backfill shall be placed against any abutment or retaining wall until such structure has been in place at least 7 days. No backfill shall be placed adjacent to box culverts until the top slab has been in place at least 4 days. When called for on the plans, special backfill material, such as pit run gravel, shall be placed at the locations and in the manner called for on the plans. All other backfill material shall be earth, free of any appreciable amount of stone or gravel particles more than 4-inches in greatest dimension, large or frozen lumps, wood or other extraneous material, and shall be of such gradation as to permit thorough compaction.

- That portion of backfill which will support any portion of the roadway or embankment shall be placed in uniform layers not to exceed 6-inches in depth (loose measurement) and compacted to that each layer and the completed backfill has a density of not less than 95% of the maximum density as determined by ASTM Designation D698.

- That portion of backfill which will not support any portion of the completed roadway or embankment shall be placed in layers not more than ten (10) inches in depth and compacted to a density comparable with the adjacent, undisturbed material. The compacted layers of backfill shall be brought up uniformly on all sides of the structure or facility. Care shall be taken to prevent any wedging action when placing backfill around abutments or wingwalls.

- Compaction of structural backfill by ponding and jetting, while not preferred, will be permitted when, as determined by the Engineer, the backfill material is of such character that it will be self-draining when compacted and that foundation materials will not soften or be otherwise damaged by the applied water, and no damage to the structure from hydrostatic pressure will result. Ponding and jetting of the upper 2 feet below finished subgrade will not be permitted in roadway areas. When ponding and jetting is permitted, material for use as structural backfill shall be placed and compacted in layers not

exceeding 4 feet in thickness. The work shall be performed without damage to the structure or softening of the embankment, and in such a manner that excess water will not be impounded. Ponding and jetting methods shall be supplemented by the use of vibratory or other compaction equipment when necessary to obtain the required compaction.

1.3 METHOD OF MEASUREMENT. Measurement for payment will be for material excavated within the limits shown on the plans or as directed by the Engineer. Unless otherwise provided in the special provisions or proposals, no payment will be made for structural excavation or backfill as such; the cost thereof under normal circumstances being considered as included in the price bid for the construction or installation of the items to which such excavation or backfill is incidental or appurtenant. Payment for such excavation or backfill will be made only when the special specifications, plans or proposal provide. When provided for, payment for work performed under these specifications will be made at the unit price bid per cubic yard for Unclassified Excavation which price shall be full compensation for all excavation and backfill and for all materials, labor, tools, and incidentals necessary to complete the work.

1.4 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

STRUCTURAL EXCAVATION CY

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

2.0. DRILLED SHAFT FOUNDATIONS

2.1 DESCRIPTION. This section covers the construction of foundations consisting of reinforced concrete shafts with or without bell type concrete footings. Concrete shafts shall be placed in drilled excavation when the shafts are without bell type footings and in drilled and underreamed excavation when shafts are with bell type footings. Such foundations shall be constructed in accordance with this item and in conformance with the details and governing dimensions shown on the plans.

2.2 MATERIALS. All concrete materials and their preparations shall be in accordance with the requirements of these specifications and the Materials Section re "Portland Cement Concrete". When Casing of the shaft is required, the following shall apply:

- The maximum size coarse aggregate shall be one and one-half (1 1/2) inches.

- The elapsed time from beginning of placement of concrete in the cased portion of the shaft until extraction of the casing is begun, shall not exceed 30 minutes. If a set retarding admixture is used, this time shall not exceed 1 hour. If nonagitating equipment is used to haul the concrete from a central mixing plant the elapsed time from discharge of concrete from the mixer to placement in the shaft shall not exceed 10 minutes. If a set retarding admixture is used, this time shall not exceed 30 minutes. When the temperature of the air or concrete is above 85°F, an approved set retarding admixture will be required in all drilled shaft concrete.

- Reinforcing steel shall conform to the requirements of Materials Section, "Reinforcing Steel". The sizes and dimensions shall be as shown on the plans.

2.3 CONSTRUCTION METHODS. The Contractor shall do all excavation required for the

shafts and bell footings through whatever materials are encountered, and to the dimensions and elevations shown on the plans or required by the site conditions. Unless otherwise shown on the plans, all shafts shall be bored plumb to a tolerance of 1-1/2-inches for depths up to and including 10 feet plus an additional tolerance of 0.05-inches per foot for depths in excess of the first 10 feet. When bells are required, they shall be excavated so as to form a bearing area of the size and shape shown on the plans. Shafts and bells may be excavated either by hand or by mechanical methods. Blasting methods shall be used only with permission of the Engineer and when used shall be so conducted as to avoid disturbance of the formations below or outside the limits of the proposed shaft concrete.

2.3.1 The plans indicate the expected depths and elevations at which satisfactory bearing material will be encountered, and this information will be used as a basis for the contract. If satisfactory foundation materials are not encountered at plan elevations, the footings may be raised or lowered as determined by the Engineer. Alterations in plan depths shall be made as judged proper to satisfactorily comply with the design requirements.

2.3.2 Casings will be required for shaft excavations when such provision is necessary to prevent caving of the material or when necessary to shut off seepage water. Casings shall be of metal and of ample strength to withstand handling stresses, the pressure of concrete and of the surrounding earth or backfill materials, and shall be watertight. The inside diameter of the casing shall not be less than the nominal size of the shaft. No extra compensation will be allowed for the concrete required to fill an oversize casing or oversize excavation.

2.3.3 When the drilling operation reaches a point where caving conditions and/or excess groundwater is encountered, no further drilling will be allowed until a construction method is employed which will prevent any caving that tends to make the excavation appreciably larger than the size of casings to be used. Drilling in a mud slurry without the removal of cuttings, or other construction methods which will control the size of excavation, will be permitted.

2.3.4 If the elevation of the top of the shaft is below ground level at the time of concrete placement, an oversize casing from ground elevation to a point below the top of the shaft shall be required to control caving of any material into the freshly placed concrete. Any excavation for the footing bells or shafts beyond the lines required, shall be backfilled with concrete at the Contractor's expense. Where casings are used, the Contractor will be permitted to backfill around the upper portion of the casing with pea gravel or other granular material. Where a double casing is required for a portion of the shaft, no material shall be placed between the casings but this area will be filled with concrete.

2.3.5 Under normal operations when the casing is to be removed, the removal shall not be started until all concrete placement is completed in the shaft. Movement of the casing for short pulls of a few inches, or rotating of the casing to insure the breaking of bond of the concrete to the casing will be permitted. When unusual conditions warrant, the casing may be pulled in partial stages. In all cases a sufficient head of concrete shall be maintained at all times above the bottom of the casing to overcome hydrostatic pressure. Extraction of the casing shall be at a slow, uniform rate and the pull shall be in a truly vertical direction. If any upward movement of the concrete and/or steel inside the casing occurs at any time during the pulling operation, the following criteria shall govern:

- If the upward movement is 1-inch or less, the casing may be left in place and the shaft used if the concrete is vibrated or rodded to reconsolidate the concrete. Vibration or rodding shall not be used to attempt to break the casing loose for extraction unless the entire shaft

is to be replaced. If the upward movement is greater than 1-inch, all of the material shall be removed and the entire drilled shaft operation shall be redone.

- Placing of drilled shaft concrete under water shall not be done without the permission of the Engineer.

2.3.6 Material excavated from shafts and bells and not used in the backfill around the completed bents or piers shall be disposed of as directed by the Engineer. The disposal of such material shall be in such manner as not to obstruct the stream or otherwise impair the efficiency or appearance of the structure or other parts of the works. At the time concrete is placed, the excavation shall be free from accumulated seepage water and all loose material shall be removed from the base area.

2.3.7 The Contractor shall provide suitable access and lighting for the Engineer to inspect the completed foundation excavation and check the dimensions and alignment of drilled shafts and the underreamed excavation when underreaming is required. At any time when a person is in the hole, provisions shall be made for pumping fresh air to the workman. Any required lighting shall be by electric lights. Any mechanical equipment used in the excavation shall be operated by air or electricity. The use of gasoline driven engines placed in the excavation for pumping or drilling will not be permitted. In order that the Engineer may judge the adequacy of a proposed foundation, the Contractor, if requested, shall make soundings or take cores at his expense to determine the character of the supporting materials. It is the intent of this provision that soundings shall be made or cores taken at the time the excavation in each foundation is approximately complete. When the plans require drilled shafts in the end bents, the embankment at the bridge ends shall be made to grade shown and thoroughly compacted as provided in the governing specifications prior to drilling for end bent shafts.

2.3.8 Reinforcing Steel. The reinforcing steel cage for the shaft consisting of longitudinal bars and spiral hooping or lateral ties shall be completely assembled and placed into the shaft as a unit. Generally, the reinforcing steel unit shall not be placed until immediately before concreting operations are to be started.

- The longitudinal bars shall be tied to the spiral hooping at intervals not to exceed 12-inches on centers to provide a rigid unit. For cased shafts where the reinforcing steel cage is over 30 feet in length, the longitudinal bars shall be tied at each intersection of the spiral hooping for a distance of 1/5 of the depth of shaft from the bottom of the cage. The cage of reinforcing steel shall be supported from the top by some positive method to prevent slumping downward during extraction of the casing.

- In uncased shafts, side spacer blocks of concrete shall be used at intervals along the shaft to insure concentric spacing for the entire length of shaft. In cased shafts, concrete spacer blocks shall not be used, but metal "chair" type spacers shall be placed vertically at intervals around the steel cage to insure concentric spacing inside the casing.

2.3.9 Concrete. The work shall be performed in accordance with these specifications. Preferably, concrete shall be placed immediately after all excavation is complete and reinforcing steel placed.

- Concrete placing shall be continuous from the beginning of placing in the shaft or footing bell to the top of shaft or to construction joint as may be indicated on the plans. Time intervals will be allowed for pulling casings, for placing forms, and other operations

necessarily carried on in sequence with the placing operations. The reinforcing steel cage shall be held vertical in some manner to restrain the steel from slumping during the concrete placement operation.

- Concrete shall be placed through a suitable tube to prevent segregation of concrete materials and unnecessary splashing on the reinforcing steel cage. The tube shall be made in sections to permit the discharge and raising as the placement progresses. A nonjointed pipe may be used if sufficient openings of the proper size are provided to allow for the flow of concrete into the shaft.

- Wherever a casing is used, the casing shall be smooth and well oiled and shall extend sufficiently above the grade of the finished shaft to provide excess concrete to be placed for the anticipated slump due to the casing removal. Where a casing is to be pulled, the concrete placed in casing shall be of such workability as to require no vibrating or rodding.

- Where a cap block or groundline strut is shown on the plans to be placed at the top of the drilled shaft, and the cap or strut is shown to be placed monolithic with the drilled shaft, a time interval will be allowed for placing the required form and reinforcing after any necessary casing removal.

2.3.10 Test Holes and Test Bells. When shown on the plans, or when ordered by the Engineer in writing, test holes will be required to establish elevations for "belling" to determine elevation of groundwater, or to determine other soil characteristics. The diameter and depth of test hole or holes shall be as shown on the plans or as directed by the Engineer. When shown on the plans, or when ordered by the Engineer in writing, the underreaming of bells, on specified test holes, will be required to establish the ability to underream in the soil strata present. The diameter and shape of the test bell shall be as shown on the plans or as directed by the Engineer.

2.4 METHOD OF MEASUREMENT. Acceptable drilled shaft in place of the specified diameter will be measured by the linear foot. The length shall be based on the plan elevation or elevation as approved by the Engineer. Drilled shaft length would be measured by the linear foot from the shaft base elevation to the top of the shaft elevation.

- Footing bells, constructed to the specified dimensions, or to the altered dimensions as authorized by the Engineer will be measured by the cubic yard of concrete in the acceptable footings placed. The bell shall consist of the authorized footing volume outside the dimensions of the drilled shaft, which for the purpose of measurement, will be considered as extending to the bottom of the bell.

- Test holes of the specified diameter will be measured from the elevation of the ground at the time drilling begins, by the linear foot of acceptable test hole drilled.

- Test bells of the specified diameter and shape will be measured by each test bell acceptably under reamed.

- Drilled shafts will be paid for at the unit price bid per linear foot of the specified diameter of "Drilled Shafts", measurements being made as outlined above. Where vertical and spiral reinforcing bars from the shaft extend into footings, caps, columns, or other concrete members, the cost of such reinforcing shall be included with and paid for as a part of "Drilled Shafts".
- Drilled Shaft will be paid for the completed length per the plan quantity or authorized by the

Engineer.

- Footing bells, constructed to the specified dimensions or to the altered dimensions as authorized by the Engineer, will be paid for at the contract unit price bid per cubic yard for "Bell Footings".

- Test holes, of the specified diameter, will be paid for at the contract unit price bid each for "Test Hole".

- Test bells, of the specified diameter, will be paid for at the contract unit price bid for each "Test Bells".

The foregoing unit prices shall be full compensation for making all excavations, for drilling all test holes and test bells, pumping, placing and removing any required casings, furnishing and placing all concrete and reinforcing steel, all backfilling, and furnishing all tools, labor, equipment, materials, and incidentals necessary to complete the work. No extra payment will be made for casings left in place.

2.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

DRILLED SHAFT (DIAMETER)	LF
BELL FOOTING	CY
TEST HOLE	EA
TEST BELL	EA

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

3.0 CONCRETE STRUCTURES

3.1 DESCRIPTION. Before starting work, the Contractor shall inform the Engineer fully of the methods of construction he proposes to follow and the amount and character of equipment he proposes to use, the adequacy of which shall be subject to the approval of the Engineer. Plans for forms and falsework for concrete piers and concrete superstructure spans over 20 feet in length and for all widening details shall be submitted to the Engineer for review and approval. Similar plans shall be submitted for other units of structure if requested by the Engineer. They shall show all essential details of the proposed forms, falsework, and bracing so that a structural analysis may be made. Four (4) sets of such plans will be required. Concurrence on the part of the Engineer in any proposed construction methods, approval of equipment, or approval of form and falsework plans does not relieve the Contractor of the responsibility for the safety or correctness of his methods and adequacy of his equipment or from carrying out the work in full accordance with the contract. Unless otherwise provided, the following requirements shall govern for the time sequence in which construction operations may be carried on and for the opening of completed structures to traffic.

3.1.1 No superstructure members, forms, falsework, or erection equipment shall be placed on the substructure before the substructure concrete has attained 80% of the 28-day specified compressive strength. The use of completed portions of a structure for storage of materials will not be permitted until all curing requirements for that particular part of the structure have been met. Forms for walls or columns shall not be erected on concrete footings until the concrete in the

footing has cured at least 2 days. Concrete may be placed in the wall or column as soon as the forms and reinforcing steel placement are approved. The support of tie beams and/or cap forms by falsework placed on previously placed tie beams is permissible provided such supporting beams have attained 80% of the 28-day compressive strength, curing requirements completed, and are properly supported to eliminate stresses not provided for in the design. Structures shall not be opened to construction traffic or to the traveling public until authorized by the Engineer.

3.1.2 Authorization may be given after the last slab concrete has been in place at least 14 days for light construction traffic not to exceed a 3/4-ton vehicle.Authorization may be given after the last slab concrete has been in place 30 days or as authorized by the Engineer for the structures to be opened for normal construction traffic and to the traveling public. Construction vehicles with a minimum of 3 axles may be operated across structures if the total gross load does not 50,000 pounds. Because of possible damage to the new structures, care shall be exercised to reduce impact on the new structures by limiting the speed of such vehicles to 10 miles per hour or less. Where a detour is not readily available or is not economically feasible, and an occasional crossing of a structure with overweight construction-equipment such as a concrete paving machine is necessary, the Engineer may permit such crossing after a structural analysis is made giving consideration to the dimensions of the equipment axle spacing and axle loads. Unless otherwise shown on the plans, the placement of roadway slabs may be by the sequence shown on the plans, using a longitudinal screed or a self-propelled transverse mechanical finishing machine; or by continuous placement using a transverse mechanical finishing machine only. The screed shall be adequately supported on a header or rail system which shall have sufficient stability to withstand the longitudinal or lateral thrust of the equipment. Supports for a transverse finishing machine shall be installed so that they may be removed without damage to the slab. Bond between the removable supports and the concrete shall be prevented in a manner acceptable to the Engineer. Portions of the rail support system which remain embedded in the slab shall not project above the upper mat of reinforcing steel. Attachment of the rail support system by welding to I-beams or girders will be permitted subject to the following requirements:

- Welds shall be parallel to the web of the member. Circular or transverse welds will not be permitted.

- Welds will not be permitted on the tension flange of the members in that area where the stress exceeds 75% percent of the allowable stress.

- Welds shall be made with low hydrogen electrodes.

- Welding shall be done by a certified welder.

3.1.3 Drains. Weep hole drains and roadway drains shall be installed and constructed as shown on the plans in the designated locations. Unless otherwise shown on the plans, the size of the weep holes will be 3-inches in diameter. A neat pocket shall be excavated at each weep hole for placing the indicated volume of gravel. Washed gravel from 3/8-inch to 1-1/2-inches in size shall be placed in the excavated pocket. When the concrete is not formed at the weep hole location, a sheet of building paper shall be placed over the gravel to prevent the entrance of concrete into the pocket during operations.

3.1.4 Expansion Joints. Expansion joints and devices to provide for expansion and contraction shall be constructed where and as indicated herein or on the plans. The bearing area under the expansion ends of concrete slabs, Pre-stressed concrete beams, girders and slab and girder

spans, shall be given a steel trowel finish. These areas shall be finished to the exact grades required. The material used to separate expansion surfaces shall be that shown on the plans and shall be placed carefully so that concrete or mortar cannot be subsequently worked around or under the material.

- Concrete adjacent to armor joints and finger joints shall be placed carefully in order to avoid defective anchorage and to avoid porous or honeycombed concrete adjacent to same.

- All open joints, and joints to be filled with joint sealing material, shall be constructed using forms adaptable to loosening or early removal. To avoid damage to the adjacent concrete caused by expansion or contraction, these forms shall be loosened as soon as possible after final concrete set to permit free movement of the span without the necessity for full form removal.

- Prior to placing the joint sealing material, the vertical faces of the joint shall be cleaned of all laitance by sandblasting or by mechanical routing. Care shall be taken to prevent spalling of adjacent surfaces. Edges which are cracked or spalled shall be removed. The joint shall be blown clean of all foreign material and sealed.

- Preformed fiber joint material, whichever used, shall be anchored to the concrete on one side of the joint by means of light wire or nails sufficient to preclude the tendency of the material to fall out of the joint.

- Careful workmanship shall be exercised in the construction of all joints. The finished joint shall conform to the indicated outline and the concrete sections shall be completely separated by the specified opening or joint material.

- Immediately after the removal of forms and again where necessary after surface finishing, all projecting concrete shall be removed along exposed edges in order to secure full effectiveness of the expansion joints.

3.1.5 Construction Joints. The joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set shall be deemed a construction joint. When concrete is to be placed monolithic, the term monolithic shall be interpreted to mean that the manner and sequence of concrete placing shall be such that construction joints will not be created. Construction joints will be of the type and at the locations shown on the plans. Additional joints will not be permitted without written authorization from the Engineer. Any additional construction joints shall have details equivalent to those shown on the plans for joints in similar locations.

- Unless otherwise provided, construction joints shall be square and normal to the forms. Bulkheads shall be provided in the forms for all joints except horizontal joints.

- Construction joints requiring the use of joint sealing material shall be as detailed on the plans. The material will be specified on the plans without reference to joint type.

- The top surface of a concrete placement which terminates at a horizontal construction joint shall have the surface roughened thoroughly as soon as practicable after the concrete has attained initial set. The surfaces at bulkheads shall be roughened as soon as the forms are removed.

- Before joining plastic concrete to concrete that has already set, the surface of the concrete in place shall be free from all loose material, laitance, dirt, or foreign matter, shall be washed, scrubbed clean and drenched thoroughly with water until saturated, and shall be kept moist until the plastic concrete has been placed. Immediately prior to the placing of additional concrete, all forms shall be drawn tight against the existing concrete and the existing joint surface shall be flushed with a coating of grout mixed in the proportions of 1 part cement to 2 parts sand, or painted with an approved bonding agent.

3.1.6 Falsework. All falsework shall be designed and constructed to safely carry the maximum anticipated loads and to provide the necessary rigidity. When the falsework is no longer required, it shall be removed. Falsework piling shall be pulled or cut off a minimum of 6-inches below finished ground level. Falsework and piling in a stream or lake shall be removed completely to a point specified by the Engineer to prevent any obstruction to the waterway.

3.1.7 Forms. Forms shall be of suitable material and of a type, size, shape, quality, and strength to insure construction as designed. The forms shall be true to line and grade, mortar tight, and sufficiently rigid to resist deflection during placing of the concrete. The responsibility for their adequacy shall rest with the Contractor. All dirt, chips, sawdust, nails, and other foreign matter shall be completely removed from forms before any concrete is deposited therein. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes that would deface the finished surfaces. Forms previously used shall be thoroughly cleaned of all dirt, mortar, and foreign matter before being reused. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly treated with an approved releasing agent which will leave no objectionable film on the surface of the forms that can be absorbed by the concrete. Care shall be exercised that no releasing agent is deposited on previously placed concrete.

- Forms for all surfaces that will not be completely enclosed or hidden below the permanent surface of the ground shall be made of surfaced lumber, or material which will provide a surface at least equal to surfaced lumber or plywood.

- Forms for all exposed surfaces of bridges, viaducts, overcrossings, and similar structures shall be constructed of plywood or an approved equal. Plywood for forms shall be Exterior Type, of the grade "Concrete Form Exterior", conforming to the specifications of the US Department of Commerce, National Bureau of Standards, Commercial Standards, latest edition. Plywood shall be placed with the grain of the outer plies in the direction of the span.

- Molding specified for chamfer strips and other uses shall be made of material of such grade that will not split when nailed and which can be maintained to a true line without warping. The molding shall be mill cut and dressed on all faces.

- Form Ties and Spreaders - Metal form ties of an approved type or an approved substitute shall be used to hold forms in place. Pipe spreaders will not be permitted. Metal and wooden spreaders which are separate from the forms shall be entirely removed as the concrete is being placed. All metal ties, wire, or other appliances used inside the forms to hold them in correct alignment shall be removed to a depth of at least 1/2-inch from the surface of the concrete. Burning off of rods, bolts, or ties will not be permitted. The cavities produced shall be carefully cleaned and completely filled with retempered sand cement mortar mixed in proportions of 1 to 3, and the concrete shall be left smooth and even.

- Form Supports for Overhanging Slabs - Form supports which transmit a horizontal force to a steel girder or beam or to a Pre-stressed concrete beam will be permitted, but shall not be used unless a structural analysis has been made of the effect on the girder or beam and approval is granted by the Engineer.

- Holes in steel members for support of overhanging brackets may be punched or drilled full size or may be torch cut to 1/4-inch under size and reamed full size. In no case shall the holes be burned full size. Holes shall be left open unless specified on the plans to be filled with a button head bolt. In no case shall the holes be filled by welding.

3.2 MATERIALS

3.2.1 Concrete. All concrete shall conform to the provisions of Materials Section, "Portland Cement Concrete". The class of concrete for each type of structure or unit shall be as specified on the plans, or by pertinent governing specifications.

3.2.2 Expansion Joint Material. Preformed fiber expansion joint material shall be of the dimensions shown on the plans. Joint sealing material shall conform to the provisions of the Materials Section. Asphalt board shall consist of 2 liners of 0.016 asphalt impregnated paper, filled with a mastic of asphalt and vegetable fiber and/or mineral filler. Boards shall be smooth, flat, and sufficiently rigid to permit installation. When tested in accordance with ASTM Designation D944, the asphalt board shall not deflect from the horizontal more than 1-inch in 3-1/2) inches. Waterstop

- Unless otherwise designated on the plans, copper waterstop shall be sixteen (16) ounce material.

- Rubber waterstop or PVC waterstop per Materials Section "Elastomeric Materials".

- Other types as specified on the plans.

3.3 CONSTRUCTION METHODS

3.3.1 Placing Reinforcement. Reinforcement in concrete structures shall be placed carefully and accurately and rigidly supported as provided in Materials Section "Reinforcing Steel".

3.3.2 Placing Concrete. The minimum temperature of concrete at the time of placement shall be not less than 50°F. The maximum temperature of cast-in-place concrete used in bridge superstructure shall not be more than 85°F, at the time of placement. Concrete diaphragms, parapets, concrete portions of railing, curbs and sidewalks, unless monolithically placed with the slab, shall not be subject to the above control. Other portions of structures, when so noted on the plans, shall require the temperature control specified thereon. A retarding admixture shall be used when the continuous placing method is used in the deck of continuous units. The initial set of the concrete shall be retarded sufficiently to insure that the concrete remains plastic in not less than 3 spans immediately preceding the one being placed. For simple spans retardation shall be required only if necessary to complete finishing operations. The retarding admixture shall be in accordance with the requirements of Materials Section, "Concrete. Admixtures".

- The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When conditions are such that additional moisture is needed for finishing, the required water shall be applied to the

surface by fog spray only, and shall be held to a minimum amount. The maximum time interval between the addition of cement to the batch, and the placing of concrete in the forms shall not exceed the following:

- The Contractor shall give the Engineer sufficient advance notice before starting to place concrete in any unit of the structure to permit the inspection of forms, the reinforcing steel placement, and preparations for casting. No concrete shall be placed in any unit prior to the completion of the formwork and the placement of the reinforcement.

- Concrete mixing, placing, and finishing shall be done in daylight hours, unless adequate provisions are made to light the entire site of all operations. Concrete placement will not be permitted when impending weather conditions may result in rainfall or low temperatures which impair the quality of the finished work. In case rainfall should occur after placing operations are started the Contractor shall provide ample covering to protect the work.

- The method of handling, placing, and consolidation of concrete shall minimize segregation or the displacement of the reinforcement, and shall produce a compact mass of uniform texture. Concrete shall not have a free fall of more than three (3) feet except in the case of thin walls such as culvert walls. The spattering of forms or reinforcement bars shall be prevented if the concrete so spattered will dry or harden before being incorporated in the mass. Any hardened concrete spatter ahead of the plastic concrete shall promptly be removed from the work.

- Each part of the forms shall be filled by depositing concrete as near its final position as possible. The coarse aggregate shall be worked back from the face and the concrete forced under and around the reinforcement bars without displacing them. Depositing large quantities at one point in the forms and running or working it along the forms will not be allowed. Chutes, troughs, conveyors, or pipes used in placing concrete shall be arranged and used so that the ingredients of the concrete will not be separated. When steep slopes are necessary, the chutes shall be equipped with baffle boards or made in short lengths that reverse the direction of movement, or the ends of such chutes shall terminate in vertical down spouts. Open troughs and chutes shall extend, if necessary, down inside the forms or through holes left in the forms. All chutes, troughs, conveyors, and pipes shall be kept clean and free from coatings of hardened concrete by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged clear of the concrete.

- Successive layers or adjacent portions of concrete shall be placed in a sequence so that they can be vibrated into a homogeneous mass with the previously placed concrete without a cold joint. Not more than 1 hour shall elapse between adjacent or successive placement of concrete. Unauthorized construction joints shall be avoided by placing required portions of abutments, piers, walls, or superstructure in one continuous operation.

- For mass placements, placements on falsework where differential setting time may induce stress cracking, placement in deep girder stems, etc., and approved retarder (cement dispersing agent) shall be used to control stress cracks and/or unauthorized cold joints.

- All concrete shall be well consolidated and the mortar flushed to the surface of the forms by continuous working with mechanical vibrators of an approved type. Vibrators of the type which operate by attachment to forms or reinforcement will not be permitted, except that

external vibration will be allowed when the forms are of steel. At least 1 standby vibrator shall be provided for emergency use in addition to the ones required for placement.

- The vibrators shall be applied to the concrete immediately after deposit. Prior to the beginning of work, a systematic spacing of the points of vibration shall be established to insure complete consolidation of the concrete being placed and the thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Immersion type vibrators shall be inserted vertically, at points 18-inches apart, and slowly withdrawn. For shallow slabs or for concrete inaccessible to vertical insertion of the vibrator, the vibrator may be inserted in a sloping or horizontal position.

- The entire depth of each lift of concrete shall be vibrated, and the vibrator shall be allowed to penetrate several inches into the preceding lift of plastic concrete. New concrete placed against hardened concrete or against fresh concrete that is not plastic shall be thoroughly consolidated along the joint surface. The vibration shall be of sufficient duration to produce thorough consolidation, and complete embedment of reinforcement and fixtures, but shall not be done to an extent that will cause segregation. Vibration may be supplemented by hand spading or rodding, if necessary, to insure the flushing of mortar to the surface of all forms.

- Holes for anchor bolts in piers, abutments, bents, or pedestals may be drilled or may be formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. The plugs or sleeves shall be withdrawn after the concrete has set. Formed holes shall be of such diameter to permit horizontal adjustments of the bolts. The bolts shall be set carefully in mortar. In lieu of the above methods of placing, anchor bolts may be set to exact locations in concrete when it is placed.

- The placing of concrete for deck slabs shall be done from a mixing plant located off the structure. Carting or wheeling concrete batches over a completed slab will not be permitted until the slab has aged at least four (4) full curing days. If carts are used, timber planking will be required for the remainder of the curing period. Carts shall be equipped with pneumatic tires. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

- The storing of reinforcing or structural steel on completed roadway slabs generally shall be avoided and, when permitted, such storage shall be limited to quantities and distribution that will not induce excessive stresses.

3.3.3 Placing Concrete under Adverse Weather Conditions. Concrete for structures shall not be placed on frozen ground nor shall it be mixed or placed while the atmospheric temperature is below 35°F or when conditions indicate that the temperature may fall to same within 24 hours. Concrete shall be effectively protected from freezing or frost for a period of 5 days after placing. When the temperature of the air is above 85°F, an approved retarding mixture will be required in all concrete used in superstructures, top slabs of direct traffic culverts and cased drilled shafts.

3.3.4 Placing Concrete in Water. Concrete shall be deposited in water only when specified on the plans or with written permission of the Engineer. The forms, cofferdams, or caissons shall be sufficiently tight to prevent any water current passing through the space in which the concrete is being deposited. Pumping will not be permitted while the Concrete is being placed, nor until it has set for at least thirty-six (36) hours. The concrete shall be placed carefully in a compact mass by

means of a tremie, closed bottom dumping bucket, or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. Depositing shall be regulated to maintain approximately horizontal surfaces at all times.

- When a tremie is used, it shall consist of a tube having a diameter of not more than ten (10) inches constructed in sections having water tight connection. The tremie shall be equipped with a device for sealing the bottom of the tube, the positive opening thereof, and for the placing of the tremie through the water to the point of placement. The means of supporting the tremie shall permit the movement of the discharge over the entire surface of the work and shall permit the tremie to be lowered rapidly when necessary to choke off or retard the flow.

- Shifting the location of the tremie, for any continuous placement of concrete, shall be held to a minimum. During the placing of concrete, the tremie shall be kept full. When a batch is dumped into the hopper, the tremie shall be raised slightly, but not out of the concrete at the bottom, until the batch discharges to the level of the bottom of the hopper, then the flow shall be stopped by lowering the tremie. The placing operations shall be continuous until the work is complete. If the placement is confined to a small area requiring very little movement, the tremie diameter may be increased.

- When concrete is placed by means of a bottom dump bucket, the bucket shall have a capacity of not less than 1/2-cubic yard. The bucket shall be lowered gradually and carefully until it rests upon the concrete already placed. Then it shall be raised very slowly during the upward travel, the intent being to maintain still water at the point of discharge and to avoid agitating the mixture.

3.3.5 Placing Concrete in Superstructure. To insure proper operation and maintenance of grades and clearances, one or more passes of the screed shall be made over the section of bridge spans to be placed prior to the placement of concrete.

- For longitudinal screeding concrete shall be placed in longitudinal strips. Placing, preferably, shall be started at a point in the center of the section adjacent to one curb, and the strip thus started shall be completed by depositing concrete uniformly in both directions toward the ends except that for spans on a grade of 1-1/2% or more, the placing shall start at the lowest end. The width of strips shall be such that the concrete therein will remain plastic until the adjacent strip is placed.

- The forms for the bottom surface of concrete slabs, girders, and overhangs shall be maintained true to the required vertical alignment during the concrete placing. For convenience in checking the vertical alignment, an approved system of "tell-tales" attached to the forms shall be installed and maintained by the Contractor. They shall provide a convenient means of matchmarking with reference to points set on stakes or other suitable reference points set independent of the forms and falsework for the span being placed. Unless otherwise provided, the girders, slab, and curbs of deck girder spans shall be placed in one continuous operation.

- The filling of girder stems ahead of placing the concrete in the slab will be permitted provided the slab concrete is placed in the time as specified in Section 403.04.02. The location of construction joints and the sequence of placements of the slab on steel and Pre-stressed concrete beams shall be as shown on the plans. Where plans do not specify a particular sequence, any logical placing sequence which will not result in the overstressing

of any of the supporting members will be permitted subject to the approval of the Engineer.

- On steel truss spans the falsework under the span shall be released and the span swung free on its permanent supports before placing any concrete in the floor slab.
- As soon as concrete is placed in a section of the slab of sufficient width to permit finishing operations, the slab shall be finished. When the surface of the slab is to receive an additional wearing surface or level-up (widening), the slab shall be given a reasonably smooth float or screed finish and shall not be finished as stated above.

3.3.6 Placing Concrete in Box Culverts. In general, construction joints will be permitted only at the points shown on the plans. Where the top slabs and sidewalls are placed monolithic in culverts more than 4 feet in clear height, an interval of not less than 1 hour nor more than 2 hours shall elapse between the placing of the concrete in the walls and that in the top slab; such interval is to allow for shrinkage in the wall concrete. The top surface of the base slab shall be finished accurately at the proper time to provide a smooth uniform surface. The upper surface of the top slab which will carry direct traffic shall be finished as specified for finishing roadway slabs. On a fill type culvert which does not carry direct traffic, the top slab shall be given a reasonably smooth finish.

3.3.7 Placing Concrete in Foundations and Substructures. Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the Engineer and permission has been given to proceed. The placing of concrete bases above seal courses will be permitted after the caissons or cofferdams are free from water and the seal course cleaned. Any necessary pumping or bailing during the concreting operation shall be done from a suitable sump located outside the forms. All temporary wales or braces on the inside of cofferdams or caissons shall be constructed or adjusted as the work proceeds to prevent unauthorized construction joints in bases or shafts. When footings can be placed in dry foundation pits without the use of cofferdams or caissons, forms may be omitted if desired by the Contractor and approved by the Engineer, and the entire excavation filled with concrete to the elevation of the top of footing. Where this procedure is followed, no measurement for payment will be made for concrete placed outside of the footing dimensions shown on the plans. Concrete in columns shall be placed monolithically unless otherwise provided. Columns and caps and/or tie beams supported thereon may be placed in the same operation. To allow for shrinkage of the column concrete, it shall be placed to the lower level of the cap or each tie beam and placement delayed for not less than 1 hour nor more than 2 hours before proceeding.

3.3.8 Treatment and Finishing of Horizontal Surfaces. All upper surfaces not covered by forms shall be struck off to grade and finished. The use of mortar topping for surfaces under this classification will not be permitted. After the concrete has been struck off as described above, the surface shall be floated with a suitable float. Bridge sidewalks shall be given a wood float or broom finish or may be striped with a brush. Unless otherwise specified, top of caps and piers shall be given a smooth finish with a steel trowel. Other surfaces shall be wood float finished and striped with a fine brush leaving a fine grained texture.

3.3.9 Finish of Roadway Slabs. As soon as the concrete has been placed and vibrated in a section of a sufficient width to permit working, the surface shall be approximately leveled, struck off and screeded, carrying a slight excess of concrete ahead of the screed to insure filling of all low spots. The screed shall be designed to provide the rigidity necessary to hold true to shape and shall have sufficient adjustments to provide for the required camber. A vibrating screed may be used if it is sufficiently heavy to withstand distortion. The screeds shall be provided with a metal

edge.

- Longitudinal screeds shall be moved forward across the concrete with a combined longitudinal and transverse motion with ends resting on headers or templates, set true to the roadway grade or on the adjacent finished slab. The surface of the concrete shall be screeded a sufficient number of times but not less than 3 times and at such intervals to produce a uniform surface true to grade and free of voids.

- Spans over 50 feet in length may be screeded in 2 or more sections if suitable intermediate templates are installed and if adequate equipment is provided. Unless otherwise provided, the templates shall be designed to permit early removal in order to avoid construction joints and to permit satisfactory finishing at the template site. If necessary, the screeded surface shall be worked to a smooth finish with a long handled wood or metal float of the proper size, or hand floated from bridges over the slab.

- While the concrete is still plastic, the Contractor shall have the surface checked with a long handled 10-foot straightedge. The check shall be made with the straightedge parallel to the centerline. Each pass of the straightedge shall lap half of the preceding pass. All high spots shall be removed and all depressions over 1/16-inch in depth shall be filled with fresh concrete and floated. The checking and floating shall be continued until the surface is true to grade and free of depressions, high spots, voids, or rough spots.

- The surface shall be given a burlap drag, wood float, broom, tine or a belt finish. If a burlap drag is used, it shall consist of layers of continuous burlap fabric, free of seams, dirt or hardened concrete. The burlap drag shall be kept wet when in use. The drag shall be attached to a work bridge and drawn over the surface of the slab as necessary to obtain the desired surface texture. After the final set of the concrete, the roadway surface shall be tested again with a standard straightedge for irregularities and the surface shall be corrected, if necessary.

3.3.10 Curing Concrete. Careful attention shall be given to the proper curing of all concrete. The Contractor shall inform the Engineer fully of the methods and procedures proposed for curing; shall provide the proper equipment and material in adequate amounts; and shall have approval of the proposed method, equipment, and material prior to placing concrete. Inadequate curing facilities or lack of attention to the proper curing of concrete shall be cause for the Engineer to stop all construction on the job until approved curing is provided. All concrete shall be cured for a period of 4 days except for upper surfaces of bridge roadways and the top slab of direct traffic slabs. In continuous placement of concrete, the required curing period shall begin when all concrete has been placed and attained its initial set. The following methods are permitted for curing concrete subject to the requirements of these specifications for each method of curing:

- Form Curing. When forms are left in contact with the concrete, other curing methods will not be required except for cold weather protection.

- Water Curing. All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. Curing will be started immediately as soon as finishing is completed. When concrete temperature is above ninety (90) degrees F, water spray or ponding will not be allowed.

- Wet Mat Curing. Cotton mats shall be used for this curing method. The mats shall not be

placed in contact with the concrete until such time that damage will not occur to the surfaces. Damp burlap blankets may be placed on the damp concrete surface for temporary protection prior to the application of the cotton mats. The mats may be placed dry and wetted down after placement. Mat curing, except for continuous placements, shall commence not later than 3 hours after finishing of the roadway slab.

- Water Spray. This method will be accomplished by overlapping sprays or sprinklers so that all unformed surfaces are kept continuously wet.

- Ponding. This method requires the covering of the surfaces with a minimum of two (2) inches of clean granular material kept wet at all times, or a minimum of one (1) inch depth of water. Satisfactory provisions shall be made to provide a dam to retain the water or saturated sand.

- Membrane Curing. Type 2 membrane curing compound may be used where permitted. Membrane shall be applied in a single, uniform coating at the rate of coverage recommended by the manufacturer and as approved by the Engineer, but not less than 1 gallon per 200 square feet.

3.3.11 Removal of Forms and Falsework. Forms for vertical surfaces may be removed when the concrete has aged not less than 1 day for normal concrete and not less than 12 hours for High Early Strength Concrete, provided the forms can be removed without damage to the concrete.

- Forms for inside curb faces may be removed in approximately three (3) hours provided the concrete has set sufficiently to permit form removal without damage to the curb.

- Weight supporting forms and falsework for all bridge components and culvert slabs shall remain in place a minimum of 4 curing days. Forms may then be removed if the concrete has attained a 80% of the 28-day specified compressive strength as evidenced by strength tests using specimens made from the same concrete and cured under the same conditions as the portion of the structure involved. Forms for other structural components may be removed as specified by the Engineer.

3.3.12 Finishing Exposed Surfaces. All top surfaces, such as the top of retaining walls, curbs, abutments, rails, etc., shall be treated by tamping and floating with a wooden float in such a manner as to flush the mortar to the surface and provide a uniform surface, free from pits or porous places. The surface thus obtained shall be troweled to produce a smooth surface and brushed lightly with a damp brush to remove the glazed surface.

- Transverse Groove Final Finish for Overlays. Do not tine finish overlays within 2 inches of a construction joint.

- High Density Concrete. After completing the finishing and before applying the transverse groove final finish, seal all vertical joints with adjacent concrete by painting with thinned grout. After joint painting, apply the transverse groove final finish. Grooving passes shall not be overlapped but shall be within 1 inch of the preceding pass.

- Latex Modified Concrete. After completing the finishing, apply the transverse groove final finish. Grooving passes shall not be overlapped but shall be within 1 inch of the preceding pass. This must be done before the plastic film forms on the surface, approximately 25

minutes in hot, dry weather. Separate screed rails and construction dams from the newly placed material by passing a point trowel along their inside face. Exercise care to insure that this trowel cut is made for the entire depth and length of rails or dams after the concrete has stiffened sufficiently to not flow back.

3.4 TESTING. Testing to be performed by a laboratory approved by the City. Any defective work discovered after the forms have been removed shall be repaired as soon as possible. If the surface of the concrete is bulged, uneven, or shows excess honeycombing or form marks, which in the opinion of the Engineer cannot be repaired satisfactorily, the entire section shall be removed and replaced. In repairing honeycombed areas, all loose material shall be removed before the repair work is started. No extra compensation will be allowed for the extra work or materials involved in repairing or replacing defective concrete.

3.5 METHOD OF MEASUREMENT. Concrete Structures will be measured by each, cubic yard, linear foot or square foot in accordance with the dimensions shown on the plans or directed by the Engineer.

3.6 BASIS OF PAYMENT. No direct measurement or payment will be made for the work to be done or the equipment to be furnished under this item, but it shall be considered an integral part of other pay items required by the plans and the contract.

4.0 STRUCTURAL CONCRETE

4.1 DESCRIPTION. This section covers the furnishing and placing of Portland Cement Concrete for structures and incidental construction in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions as shown on the plans or established by the Engineer.

4.2 MATERIALS. Materials shall meet the requirements specified in the Materials Section.

4.3 CONSTRUCTION METHODS. Handling, Measuring, Batching and Mixing shall be in accordance with other relevant paragraphs of these specifications.

4.3.1 Forms. Forms shall be so designated and constructed that they will hold reasonably true to lines and grades as shown on the plans and may be removed without injuring the concrete.

- The material to be used in the forms for exposed surface shall be sized and dressed lumber, masonite, plywood or equal, or metal in which all bolt and rivet heads are countersunk, so that in any case a plain, smooth surface is obtained. The forms shall be built reasonably true to line and grade and braced in a substantial and unyielding manner. They shall be mortar tight.

- All corners, except at tops of footings or bases, shall be chamfered. Chamfer or molding strips shall be finished lumber, cut with true edges, and shall not be warped, cracked or frayed. No. 2 pieces of chamfer strips of unequal width shall be used in the same chamfer line. Chamfer shall be held true to line and kept securely nailed to forms while placing concrete.

- Form lumber for all curbs on bridges and culverts shall have a nominal thickness of 2-inches or more. Studding on all forms shall be spaced so that no bulge or deflection is

apparent between the studs. For lumber which is to be used a second time, shall be free from bulge or warp and shall be thoroughly cleaned. The forms shall be inspected immediately preceding the placing of concrete and any bulging, warping or offset in adjacent boards shall be remedied. All dimensions shall be carefully checked by the Contractor after the forms are erected and before any concrete is placed. The Contractor will be held responsible for the accuracy of all construction. The interior surfaces of the forms shall be adequately oiled or greased to insure the non-adhesion of mortar.

4.3.2 Handling, Placing and Vibrating Concrete. In preparation for the placing of concrete, all sawdust, chips, and other debris shall be removed from the interior of forms. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. All temporary wood members shall be removed from the forms and not buried in the concrete.

- Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The Engineer may order the discontinuance of any type of conveyance or method of placing if the concrete is not being satisfactorily placed.

- Open troughs and chutes shall be mortar tight. Where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that change the direction of movement.

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

- When placing operations would involve dropping the concrete more than 5 feet, it shall be deposited through approved sheet metal chutes, pipes, or flexible tubing. As far as practicable, the pipes shall maintain an even flow of concrete during the placing and their lower ends shall be kept level with the newly placed concrete. After the initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcing bars which project.

- Concrete, during and immediately after depositing, shall be thoroughly consolidated by mechanical vibration subject to the following provisions. The vibration for concrete shall be internal unless special authorization of other methods is given by the Engineer or as provided herein. Vibrators shall be of a type and design approved by the Engineer. The manufacturer's rated capacity shall be not less than four thousand (4000) impulses per minute. The Contractor shall provide a sufficient number of vibrators to properly consolidate each batch of concrete immediately after it is placed in the forms. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures and into the corners and angles of the forms. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Application of vibrators shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective, Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration. Vibration shall be supplemented by such spading as is necessary to insure smooth surfaces and dense concrete along form surfaces and in corners and

locations impossible to reach with the vibrators.

- The provisions of this article shall apply to the filler concrete for steel grid floor, except that the vibrator shall be applied to the steel. The provisions of this article shall apply to pre-cast piling, concrete cribbing and other pre-cast members except that, if approved by the Engineer, the manufacturer's methods of consolidation may be used.

- Concrete shall be placed in horizontal layers no more than 12-inches thick. Each layer shall be placed and compacted before the preceding batch has taken initial set. Each layer shall be compacted, so as to avoid the formation of a construction joint with a preceding layer, before it has taken initial set.Immediately following the discontinuance of placing concrete, all accumulation of mortar splashed upon the exposed reinforcing steel and surfaces of the forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. 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.

4.3.3 Reinforced Concrete Boxes. In general, the base slab or footings of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. Provisions shall be made for bonding the sidewalls to the culvert base by means of longitudinal keys so constructed as to prevent the percolation of water through the construction joint. Before concrete is placed in the sidewalls, the culvert footings shall be thoroughly cleaned and the surface carefully chipped and roughened in accordance with the method of bonding construction joints. In the construction of box culverts 4 feet or less in height, the sidewalls and top slab may be constructed as a monolith. When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert. In the construction of box culverts more than 4 feet in height, the concrete in the walls shall be placed and allowed to set before the top slab is placed. Appropriate keys shall be left in the sidewalls for anchoring the cover slab.

4.3.4 Girders, Slabs and Columns. Concrete shall be deposited by beginning at the center of the span and working from the center toward the ends. Concrete in girders shall be deposited uniformly for the full length of the girder and brought up evenly in horizontal layers not more than 12-inches thick.

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

- The floors and girders of through girder superstructures shall be placed in one continuous operation unless otherwise specified. When placement is not continuous, special shear anchorage shall be provided to insure monolithic action between girder and floor.

- Concrete in T-beam or deck girder spans may be placed in one continuous operation or may be placed in 2 separate operations. Each separate operation shall be continuous; the first, to the top of the girder stems; and the second, to completion. The bond between stem and slab shall be positive and mechanical, and shall be secured by means of suitable shear keys in the top of the girder stem unless other methods are approved by the Engineer. The size and location of these keys shall be computed.

- Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least 2 hours before the caps are placed.
- Concrete shall not be placed in the superstructure until the column forms have been

stripped sufficiently to determine the character of the concrete in the column. The load of the superstructure shall not be allowed to come upon the bents until they have been in place at least 5 days.

4.5 TESTING. Slump will be determined using AASHTO T119, and air content using AASHTO T152 for gravel and stone aggregate and AASHTO T196 for slag and other highly porous coarse aggregate. Test specimens will be made and cured in accordance with AASHTO T23 except that after the initial curing, quality control specimens will be cured in a medium maintained at 40°F to 85°F until they are delivered to the laboratory. Unless otherwise provided, the minimum modulus of rupture when test beams are permitted as a criteria for removal of forms, placing a structure in service, driving piling, etc., shall be 550 psi when tested with the third point method or 650 psi when tested with the midpoint method and the minimum compressive strength of cylinders shall be 4000 psi.

4.6 METHOD OF MEASUREMENT. Structural concrete will be measured by the cubic yard in accordance with the dimensions shown on the plans or directed by the Engineer.

4.7 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

STRUCTURAL CONCRETE CY

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

5.0 To Be Published.

6.0 HIGH EARLY STRENGTH CONCRETE

6.1 DESCRIPTION. High Early Strength Concrete shall be composed of High Early Strength Portland Cement, fine and coarse aggregate, and water, each measured separately and mixed as provided in the Materials Section. It shall be used for structures or portions of structures only when approved by the Engineer or called for on the plans or in the special provisions.

6.2 MATERIALS. See Materials Section.

6.3 CONSTRUCTION METHODS. Refer to ACI publications. All methods applicable to normal concrete shall apply with respect to care, workmanship, finishing, joints and curing.

6.4 METHOD OF MEASUREMENT. Measurement of the various structures when High Early Strength Concrete is used will be in the same manner as elsewhere provided in these specifications for items of the same kind. Payment for the various items in which High Early Strength Concrete is used shall be made on the same basis as provided elsewhere in these specifications for items of the same kind. No additional compensation will be allowed when the Contractor uses High Early Strength Concrete at his own option.

6.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

HIGH EARLY STRENGTH CONCRETE CY

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

7.0 PNEUMATICALLY PLACED CONCRETE. To be published.

8.0 STEEL STRUCTURES

8.1 DESCRIPTION. This section covers the fabrication and erection of structural steel and other metals, except reinforcing steel, which are used for steel structures or steel portions of structures.

8.2 MATERIALS.

8.2.1 The metal used for the various portions of the structure shall be as specified and shall conform to the requirements of the applicable sections of Parts 1 through 12 of the ASTM Specifications.

8.2.2 Unless otherwise provided on the plans, the Contractor shall prepare and submit detailed shop drawings for each detail of the general plans requiring the use of structural steel, forgings, wrought iron, castings, or bearings. Camber and erection diagrams will be required. All shop drawings shall be checked by the fabricator before being submitted for approval by the Engineer. The Contractor shall furnish to the City as many prints of the drawings as are necessary for carrying out the work. The Contractor shall be responsible for the correctness and completeness of the drawings and for shop fit and field connections, although the drawings have been approved by the Engineer.

8.3 EQUIPMENT. Before starting work, the Contractor shall inform the Engineer fully as to the method of erection he proposes. Follow and as to the amount and character of the equipment he proposes to use; the adequacy of 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 or adequacy of his methods or equipment or from carrying out the work in full accordance with the plans and specifications. No work shall be done without the sanction of the Engineer.

- The Contractor shall prepare and submit erection plans for the erection of plate girders (riveted, bolted, or welded), trusses, and for all railroad underpass structures. Field erection plans for I-beam units will not be required unless specified on the plans. The plans shall be complete in all details of procedure, sequence of work, equipment to be used, etc., so that a check can be made of the adequacy of the proposed erection procedure.

- Spot welding for the purpose of eliminating field erection bolts or for holding steel parts together while riveting will not be permitted.

- 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. Drift pins sufficient to fill at least one-fourth (1/4) of the field holes for main connections shall be provided.

8.4 CONSTRUCTION METHODS

8.4.1 Workmanship. Workmanship and finish shall be equal to the best general practice in modern steel fabricating shops. Rolling tolerances for rolled shapes, plates, and bars shall conform to the requirements of ASTM Designation A6. Before being laid out or worked, rolled material shall be straight. If straightening is necessary, it shall be done by methods approved by the Engineer. Kinks and bends in the material will be cause for rejection. Heat shrinking of low alloy structural steels will not be permitted. If straightening is necessary in the field, only methods approved by the Engineer shall be used. Following the straightening of a bend or buckle, the surface of the metal shall be carefully inspected for evidence of fracture. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping will be done carefully and accurately. Undercut gusset plates will not be accepted. All sharp corners and edges, and edges that are marred, cut, or roughened in handling or erection, shall be slightly rounded by grinding or other suitable means.

8.4.2 Riveted and Bolted Structures. High strength bolts may be used where rivets are designated. In these specifications where reference is made to pitch, edge distance, preparation of holes, etc., for rivets, the same criteria shall govern for high strength bolts. Pitch and edge distance not shown on the plans shall be in accordance with AASHTO Standard Specifications for Highway Bridges. Unless otherwise specified or shown on the plans, fabrication of riveted structures shall conform to the current edition of AASHTO Standard Specifications for Highway Bridges.

8.4.3 Holes for Bolts or Rivets. Holes shall be either punched full size, punched and reamed, or drilled. The finished hole shall be 1/16-inch larger than the nominal diameter of the rivet. Holes punched full size shall have all burrs and sharp edges removed. The diameter of the die shall not exceed that of the punch by more than 3/32-inch. Holes for Shop Rivets shall be subpunched, or subdrilled at the fabricator's option, 1/4-inch less in diameter than that of the finished holes and shall be reamed to size with the parts assembled, with the following exceptions. Holes in material thicker than 7/8-inch shall not be punched; however, at the fabricator's option, they may be subdrilled to the diameter specified for subpunching or may be drilled full size with the parts assembled, provided that the parts are adequately bolted or clamped together. Holes in rolled beams and plate girders, including stiffeners and active fillers at bearing points, may be subpunched 1/8-inch less in diameter than that of the finished holes and reamed to size (after assembly) in material not thicker than the nominal diameter of the rivet less 1/8-inch. Holes in material not more than 7/8-inch thick, for rivets which do not transfer stress caused by external vertical loading, may be punched full size or, at the fabricator's option, may be subpunched 1/8-inch less in diameter than the finished holes and reamed to size after assembly. This applies to holes for stitch rivets, lateral, longitudinal or sway bracing and their connecting material, lacing, stay plates, diaphragms which do not transfer shear or stress, inactive fillers, and stiffeners not at bearing points. However, holes through assembled material shall not pass through both reamed plies and plies punched full size unless the reamed holes have been subpunched for the fabricator's convenience, or the assembled material is not over 5 plies thick, of which the main material consists of not more than 3 plies. Holes for Field Rivets shall be subpunched or subdrilled at the fabricator's option, 1/4-inch less in diameter than that of the finished holes, and shall be reamed to size through steel templates with hardened steel bushings, with the following exceptions. Field splices in plate girders and in the chords of trusses shall be reamed with the members assembled. Other field connections may be reamed with the members assembled, at the fabricator's option. Chord splices or truss members shall, in all cases, be reamed or drilled with at least 3 abutting sections assembled and with milled ends of compression chords in full bearing. Assemblies such as floor systems to girders, complete trusses, rolled beam spans connected by diaphragms, and portals to trusses shall be reamed with the members assembled if

so indicated on the plans, and otherwise at the fabricator's option. Field connections of lateral, longitudinal, or sway bracing shall conform to the requirements of holes for shop rivets. Holes in material thicker than seven-eighths (7/8) inch shall not be punched but shall be subdrilled to the diameter specified for subpunching, or drilled full size with parts assembled. The accuracy of the punching shall be such that for any group of holes when assembled, seventy-five (75) percent shall admit a rod equal to the diameter of the cold rivet at right angles to the plane of the connection. Otherwise the holes shall be reamed. When the extent of the reaming is such that the holes cannot be properly filled or accurately adjusted after reaming, the faulty member shall be discarded and replaced. Mispunched members shall not be corrected by welding without the approval of the Engineer.

8.4.4 Drilled Holes. Drilled holes shall be 1/16-inch larger than the nominal diameter of the rivet. Burrs and sharp edges of each drilled hole under both rivet heads shall be removed with a countersinking tool making a 1/16-inch fillet. Burrs on the outside surfaces shall be removed. If members are drilled while assembled, the parts shall be held securely together while the drilling is being done. Drilled holes shall be drilled to finish size while all of the thicknesses of metal are assembled or subdrilled and reamed as required for punched and reamed holes. Holes shall be clean cut, without torn or ragged edges. Holes that must be enlarged to admit rivets shall be reamed. Drilling shall be done accurately.

8.4.5 Steel Assembly. Steel parts shall be assembled in the shop or in the field in accordance with the following.

- Shop Work - At the time of assembling and riveting, bolting, or welding, steel surfaces in contact for shop or field connection shall be thoroughly cleaned of rust, loose mill scale, dirt, grease, or other material foreign to the steel. No paint shall be applied to contact surfaces prior to riveting, bolting, or welding.

- Riveted or bolted trusses, continuous plate girder and I-beam spans, skew portals, skew connections, rigid frames, bents, and towers, shall be completely assembled in the shop and accurately adjusted to line and camber and holes for field connections and shall be drilled or reamed while assembled. Holes for other field connections, except those in lateral, longitudinal, and sway bracing, shall be drilled or reamed in the shop with the connecting parts assembled or drilled or reamed to a metal template with hardened bushings, without assembling.

- Long span truss work shall be assembled in lengths of not less than three (3) abutting panels, the members adjusted for line and camber, and holes for field connections drilled or reamed while assembled.

- Field riveted or bolted joints for girders shall be completely assembled, the members adjusted for line and camber, and holes for field connections drilled or reamed while assembled.

- Field butt joints for welded girders shall be completely assembled with the members adjusted for line and camber and prepared to fit for welding.

- All machinery shall be completely assembled. All bearings shall be fitted to the specified clearances and alignment. Gear reductions and all line gears shall have gear center distances set and the gears properly matchmarked.

- Field Work. The parts shall be accurately assembled as shown on the plans and all matchmarks 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 permitted. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Unless erected by the cantilever method, truss spans shall be erected on blocking so placed as to give the trusses proper camber. The blocking shall be left in place until the tension chord splices are fully riveted or bolted and all other truss connections pinned and bolted. Rivets or bolts in splices of butt joints of compression members and rivets or bolts in railings shall not be driven or torqued until the span has been erected in place, temporarily bolted, and the member is supporting its own weight.

- Splices and field connections shall have one-half (1/2) of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before riveting or bolting. Splices and connections carrying traffic during erection shall have three-fourths (3/4) of the holes so filled. Fitting-up bolts shall be of the same nominal diameter as the rivets, and cylindrical erection pins shall be one thirty-second (1/32) inch larger.

- The drifting done during assembling shall be only such as to bring the parts into position and not sufficient to enlarge the holes or distort the metal. If any holes must be enlarged to admit the rivets, they shall be reamed.

- Connecting parts assembled in the shop for the purpose of reaming holes in field connections shall be matchmarked and a diagram showing such marks shall be furnished to the Engineer.

8.4.6 Riveting. Shop and field riveting shall conform with the following provisions:

- Shop Work. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. Rivets, when heated and ready for driving, shall be free from slag, scale, and other adhering matter. When driven they shall completely fill the holes. The heads shall be of approved shape, full size, neatly formed, concentric with the shank, free from fins, and in full contact with the surface of the member.

- Loose, burned, or otherwise defective rivets shall be replaced. In removing rivets care shall be taken not to injure the adjacent metal. Caulking or recupping will not be permitted.

- Rivets shall be driven by direct acting riveters where practicable. If rivets are driven with a pneumatic hammer, a pneumatic bucker shall be used if practicable.

- Field Work. Pneumatic hammers shall be used for field riveting. Connections shall be accurately and securely fitted up before the rivets are driven. Drifting shall be only such as to draw the parts into position and not sufficient to enlarge he holes or distort the metal. Unfair holes shall be reamed or drilled. Rivets shall be heated uniformly to a light cherry red color and shall be driven while hot. They shall not be overheated or burned. Rivet heads shall be full and symmetrical, concentric with the shank, and shall have full bearing all around. They shall not be smaller than the heads of the shop rivets. Rivets shall be tight and shall grip the connected parts securely together. Cup faced dollies fitting the head closely to insure good bearing shall be used. Sufficient air capacity shall be maintained to

keep the air pressure at 100 psi at the hammers. Caulking or recupping will not be permitted. In removing the rivets the surrounding metal shall not be injured. The removal of loose or defective rivets by flame cutting will not be permitted, except upon written permission of the Engineer.

8.4.7 Bolted Connections. When high strength bolts are required or permitted, the bolts shall be in conformance with ASTM A325-81 and ASTM A194.

8.4.8 Joints and Connections. Sheared edges of plates more than 5/8-inch in thickness and carrying calculated stress shall be planed to a depth of 1/4-inch. Surfaces of bearing and base plates and other metal bearing surfaces that are to come in contact with each other, with ground concrete surfaces, or with asbestos sheet packing shall be machined flat to within 1/32-inch tolerance Surfaces of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric and elastic bearing pads, or Portland Cement grout shall be machined flat to within 1/8-inch tolerance in 12-inches and to within 3/16-inches tolerance overall.

- At the option of the Contractor, steel slabs, where not in contact with other metal bearing surfaces, may be heat straightened in lieu of machining, provided the above tolerances are met.
- Abutting Joints - When shown on the plans abutting joints shall be faced and brought to an even bearing. Where joints are not faced the opening shall not exceed one-fourth (1/4) inch.
- End Connection Angles - Floor beams, stringers, and girders having end connection angles shall be built to exact length back-to-back of connection angles. If end connections are faced, the finished thickness of the angle shall not be less than that shown on the detail drawings.
- Web Plates - In girders having no cover plates and which are not to be encased in concrete, the top edge of the web plate shall not extend above the backs of the flange angles and shall not be more than one-eighth (1/8) inch below at any point.
- Fit of Stiffeners - End stiffener angles of girders and stiffener angles intended as supports for concentrated loads shall be milled or ground to secure an even bearing against the flange angles. All fillers under stiffener angles shall fit sufficiently tight to exclude water after being painted.
- Pin and Bolted Connections - Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pin nuts on pin connections and the bolts on bolted connections shall be screwed up tight and the threads, except when high strength bolts are used, burred at the face of the nuts with a pointed tool.
- Pins and Rollers - Pins and rollers shall be accurately turned to the dimensions shown on the drawings and shall be straight, smooth, and free from flaws. The final surface shall be produced by a finishing cut.
- Pins and rollers more than seven (7) inches in diameter shall be forged and annealed.
- In pins larger than nine (9) inches in diameter, the forging shall be permitted to cool to a temperature below the critical range cooling and a hole not less than two (2) inches in diameter shall be bored full length along the axis of the pin before being

annealed.

- Pin holes in structural members shall be bored true to the specified diameter, smooth and straight, at right angles with the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.
- The distance outside to outside of holes in tension members and inside to inside of holes in compression members shall not vary from that specified more than one thirty-second (1/32) inch. Holes in built-up members shall be bored after riveting, bolting, or welding is completed.
- The diameter of the pin hole shall not exceed that of the pin by more than one- fiftieth (1/50) inch for pins five (5) inches or less in diameter, or one thirty- second (1/32) inch for larger pins.
- Screws Threads-Screw threads shall make close fits in the nuts and shall be Unified Standard Series conforming to USASI B1.1-1960.

8.4.9 Bearings and Anchorages. Anchor bolts shall be either headed bolts, installed with or without pipe sleeves, or swedge bolts installed in drilled holes as detailed on the plans. The anchor bolts shall be carefully installed to permit true positioning of the bearing assemblies. When anchor bolts are installed in pipe sleeves, the pipes shall be completely filled with grout at the time the grout pads are constructed or at the time the bearing assemblies or masonry plates are placed. Swedge bolts installed in holes shall be either sulphured in or grouted in as shown on the plans. All bearing assemblies shall be set level and to the elevations shown on the plans. Adjustments in the horizontal positions of bearing assemblies shall be made for temperature as directed by the Engineer. In conformance with the details shown on the plans, masonry plates and the bearing plates of bearing assemblies shall be set on ground concrete surfaces, on preformed fabric pads, or on grout pads. Grout to be placed below masonry plates or bearing plates of the bearing assemblies and in anchor bolt sleeves shall consist by volume of 1 part Portland Cement and 3 parts clean concrete sand. Concrete areas to be in contact with the grout shall be cleaned of all loose or foreign matter that would in any way prevent bond between the mortar and the concrete surfaces and shall be kept thoroughly saturated with water for a period of not less than 24 hours immediately prior to placing the grout. The grout shall contain only sufficient moisture to permit packing and shaping. The grout shall completely fill the anchor bolt sleeves and shall be tightly packed under the masonry or bearing plates to provide full bearing. After placing all exposed surfaces of the grout pads shall be kept covered with a heavy thickness of burlap saturated with water for a period of 3 days. All improperly cured or otherwise defective grout shall be removed and replaced at the Contractor's expense.

8.4.10 Welding. All shop and field welding shall be arc welding and shall be done in accordance with the current specifications of AWS Structural Welding Code as modified by AASHTO Standard Specifications for Highway Bridges.

- Radiographic and Magnetic Particle Inspection of welds will be paid for by the City as part of the structural steel inspection.
- Unless otherwise shown on the plans or specified, bearing assemblies that are to be machined after welding shall be stress relieved by heat treatment before machining in accordance with AWS Specifications.
- Portions of members in bearing assemblies or in direct bearing shall be straightened, planed, or otherwise corrected after fabrication as necessary to provide full bearing on bearing assemblies or bearing areas on level bearing plates. Where the end of a stiffener

plate is shown "tight-fit" on the plans, the end of the plate shall be so fitted that it bears on the beam flange. Local clearances between the end of the plate and the flange shall not exceed 1/16-inch.

- Erection bolts required for welded splices or welded connections may be left in place and the ends of all such erection bolts which project beyond the nut shall be burned off flush with the face of the nut. Where the bolt does not project, the end of the bolt and nut shall be tack welded to prevent loosening of the nut. Burning off projecting bolt ends and tack welding shall be performed prior to painting.

8.4.11 Painting. The painting of metal structures shall include, unless otherwise provided in the contract, the cleaning and preparation of the metal surfaces; the application, protection and drying of the paint coatings; and the supplying of all tools, tackle, scaffolding, labor and materials necessary for the entire work. In the event no particular paint system is specified, any of those listed in Materials Section suitable for the structure indicated may be used. However, paints will be applied only as a complete and compatible system and once selected will be used throughout the project. Shop painting, field painting, and maintenance painting are covered under these specifications. The prime coat shall be applied as soon as possible after cleaning and before deterioration of the surface occurs. Cleaning shall remove all dirt, rust, scale, loose rust, loose mill scale, welding flux and slag, oil, grease, corrosive chemicals, and other detrimental foreign matter which may impair the adhesion of the coating to be applied. Unless cleaning is to be done by blast cleaning, all weld areas, before cleaning is begun, shall be neutralized with a proper chemical after which it shall be thoroughly rinsed with water.

8.4.12 Five methods of cleaning, including Solvent Cleaning, Hand and Power Tool Cleaning, Flame Cleaning, Commercial Blast Cleaning, and Near White Blast Cleaning or combinations of these methods are permitted. All new structural steel or painting requiring removal to the base metal shall be cleaned by the Commercial Blast Cleaning method unless otherwise specified. Regardless of the method specified or used, the cleaned surface shall be primed or prepared as soon as possible and before any detrimental corrosion or recontamination occurs. Surfaces not intended to be painted shall be suitably protected from the effects of cleaning and painting operations.

- Solvent Cleaning is a procedure for removing foreign matter such as oil, grease, soil, drawing and cutting compounds and other contaminants from steel surfaces by the use of solvents, emulsions, cleaning compounds, steam cleaning or similar materials and methods which involve a solvent or cleaning action.
- Hand and Power Tool Cleaning is a method of preparing metal surfaces for painting using power impact tools, power sanders, power grinders, hand tools or a combination of this equipment to remove all detrimental foreign matter as defined above. All tools shall be operated in such a manner that no burrs or sharp ridges are left on the surface and no sharp cuts are made into the steel.
- Flame Cleaning is a method of preparing metal surfaces for painting using oxyacetylene torches with power or hand operated steel brushes to remove detrimental foreign matter as defined above. When this method is used all metal, except the inside of boxed members and other surfaces which will be inaccessible to the Flame Cleaning operation after the member is assembled, shall be Flame Cleaned in accordance with the following operations:
- Oil, grease and similar adherent matter shall be removed by washing with a suitable solvent. Excess solvent shall be wiped from the work before proceeding with subsequent

operations. The surfaces to be painted shall be cleaned and dehydrated (freed of occluded moisture) by the passage of oxyacetylene flames. The oxyacetylene flames shall be traversed over the surfaces of the steel in such manner and at such speed that the surfaces are dehydrated and dirt, rust, loose scale, scale in the form of blisters or scabs, and similar foreign matter are freed by the rapid, intense heating by the flames. The flames shall not be traversed so slowly that loose scale or other foreign matter is fused to the surface of the steel or the temperature of the steel raised above 400°F. The number, arrangement and manipulation of the flames shall be such that all parts of the surfaces to be painted are adequately cleaned and dehydrated.

- Promptly after the application of the flames, the surfaces of the steel shall be wire brushed, hand scraped wherever necessary, and then swept and dusted to remove all free material and foreign particles. Compressed air shall not be used for this operation. Paint shall be applied promptly after the steel has been cleaned and while the temperature of the steel is still above that of the surrounding atmosphere so that there will be no recondensation of moisture on the cleaned surfaces.

- Unless otherwise provided, the inside surfaces of boxed members and other surfaces which will be inaccessible to the flame cleaning operation after the member is assembled shall be cleaned by Hand Cleaning. If Flame Cleaning of such surfaces is required, it shall be so stated in the special provisions. The inside surfaces of boxed cleaning operation after the member is assembled shall be cleaned as specified above and wire brushed but not painted before the member is boxed or assembled. After all fabrication of the member is completed, its inside surfaces shall be hand wire brushed or hand scraped wherever necessary in order to remove dirt and other foreign substances which may have accumulated after the surfaces were originally cleaned. The outside surfaces of the members shall then be cleaned and dehydrated, wire brushed, and hand scraped wherever necessary. All surfaces shall then be swept and dusted to remove free material and foreign particles and the member completely painted.

- Commercial Blast Cleaning is a method by which all steel shall be cleaned by either the centrifugal wheel or the air blast method. The cleaning shall remove all mill scale and other substances down to the bare metal except for slight shadows, streaks or discolorations caused by rust stains, mill scale oxides or, if the surface is pitted, slight residues of rust in the bottom of the pits. The maximum size of sand, crushed grit or shot shall be no larger than that passing the No. 16 sieve. Special attention shall be given to the cleaning of the corners and reentrant angles. Before painting, all metallic shot and grit or sand shall be removed from the surfaces. The cleaning shall be approved by the Engineer prior to painting.

- Near White Blast Cleaning will be done with the same methods and procedures outlined in Commercial Blast Cleaning except for the degree of cleaning. Near White Blast cleaned surface finish is defined as one from which all oil, grease, dirt, mill scale, rust, corrosion products, oxides, paint and other foreign matter have been completely removed from the surface except for very light shadows, very slight streaks, or slight discolorations caused by rust stains or mill scale oxides. At least ninety-five (95) percent of each square inch of surface area shall be free of visible residues, and the remainder shall be limited to the light discoloration mentioned above.

8.4.13 Storage of Paint. All paint and thinner shall be stored in an area that is well ventilated and

protected from sparks, flames, direct rays of the sun and from excessive heat. Paint susceptible to damage by low temperatures shall be kept in a heated storage space when necessary.

- The paint shall be mixed in a manner which will insure breaking up of all lumps, complete dispersion of settled pigments, and a uniform composition. Paint shall be carefully examined for uniformity after mixing. All pigmented paint shall be strained after mixing except where application equipment is provided with adequate strainers. Strainers shall remove only skins and undesirable matter but will not remove the pigment.

- Thinner shall not be added to the paint unless necessary for proper applications without approval of the Engineer. Paints to be sprayed, if not specifically formulated for spraying, may require thinning when proper adjustment of spray equipment and air pressure does not result in satisfactory paint application. In no case shall more than 1 part thinner to 8 parts paint be added unless paint is intentionally formulated for greater thinning. The type of thinner shall comply with the paint consistency during the mixing process.

8.4.14 Application of Paint. Paint may be applied by brushing, air spraying, airless spraying, or hot spraying or a combination of these methods. Daubers or sheepskin may be used when no other method is practicable for proper application in places of difficult access.

- Paint shall not be applied when temperatures of the steel or paint are below forty (40) degrees F Paint shall not be applied when the surface temperature is expected to drop below thirty-two (32) degrees F before the paint has dried, or when steel temperature is below the dew point resulting in condensation of moisture. Paint shall not be applied to frosted or ice coated surfaces. Paint shall not be applied to steel which is at a temperature that will cause blistering or porosity or otherwise be detrimental to the life of the paint.

- A coat of paint shall not be applied until the preceding coat has dried. The paint shall be considered dry for recoating when another coat can be applied without the development of any film irregularities such as lifting or loss of adhesion of undercoats. Paint shall not be force dried under conditions which will cause checking, wrinkling, blistering, formation of pores, or detrimentally affect the condition of the paint. Driers shall not be added to paint on the job unless specifically called for in the specification for the paint.

- Shop and field paint shall be applied to the minimum dry mil film thickness specified for the paint system to be applied. The dry mil thickness will be measured in place with a calibrated magnetic film thickness gauge and repainting will be required for areas deficient in thickness. Paint shall be worked into all crevices and corners possible.

- Any runs or sags shall be immediately brushed out or after setting the paint shall be removed and the surface repainted in a manner approved by the Engineer. When using the brush method, the brushes shall be of a style and quality that will enable proper application of the paint. Uniform brushing shall be done so that a smooth coat as nearly uniform in thickness as possible is obtained. There shall be a minimum of brush marks left in the applied paint.

- The equipment used for all spray applications of paint whether air spray, airless, or hot spray, shall be suitable for the intended purpose. Any solvents left in the equipment shall be completely removed before applying paint to the surface to be painted.

- Blind sides of all rivets, bolts and all other areas inaccessible to the spray gun shall be

painted by brush, daubers or sheepskins. Brushes shall be used to work paint into cracks, crevices and blind spots which are not adequately painted by spray.

- Areas of steel surfaces to be in direct contact with the concrete, paving or footing or encased or embedded in concrete or coated with concrete shall not be painted. Contact surfaces of members to be joined by high strength bolts in friction type connections shall be left unpainted unless specifically authorized and shall be free of oil and grease coatings.

- Shop contact surfaces shall not be painted, but any resulting crevices shall be sealed off in the paint application. Steel shall not be painted within 2-inches of edges to be welded. Steel surfaces to be in contact only after field erection shall be painted except where the paint will interfere with assembly.

- Machine finished surfaces shall be coated with white lead or tallow, or an approved protective lubricant, before shipment or before rusting can occur.

- Shop Painting - The number of coats and the type of paint shall be as specified. Unless otherwise specified, all structural steel shall be painted with at least one (1) coat of primer in the shop where fabrication is done. If the shop coat is damaged in fabrication, it shall be repaired before leaving the shop. Erection marks and weight marks shall be copied on areas that have been previously painted with the shop coat.

- Field Painting - Shop coated steel members shall preferably be field painted after erection of such members is completed. Steel members may be field painted on the ground before erection providing such painting where damaged is touched up with the same number of coats and kind of paint after erection and provided the final complete coat of paint is applied after erection.

- Steel 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 or rivets, and all damaged or defective paint and rusted areas. For areas requiring rust removal or paint repair the degree of surface preparation shall be at least equal to that required for structural steel under these specifications. The Contractor may at his option clean and apply one (1) overall coat in place of touch up or spot painting.

- The final field coat shall not be applied until all concrete work is finished. All concrete spatter and drippings shall be removed before application of paint. If concreting or other operations damage any paint, the damaged surface shall be cleaned and repainted.

- All dirt, sand, drift, and other foreign material shall be removed from the bridge seats before applying paint to the shoes, bearing plates and other steel parts of the structure to be painted in the immediate vicinity of bearing areas. Cleaning and painting shall be so programmed that detrimental amounts of dust or other contaminants do not fall on wet, newly painted surfaces.

- Painting of Existing Structures - Only loose, cracked, brittle or nonadherent paint, loose mill scale, and loose rust shall be removed unless otherwise specified. All exposed edges shall be feathered and spot cleaned. Rust spots shall be thoroughly cleaned and the edges of all old paint shall be scraped back to sound materials.

- The Contractor shall at all times adequately protect traffic, the bridge floor and concrete surfaces from paint spray or splashes. Any paint spilled or sprayed on vehicles, curbs, bridge seats or bridge floors shall be removed by the Contractor at his expense.

- Empty paint cans, paper, or cloth which have come into contact with paint, and paint spilled on the vegetation, shall not be left in the channel or right-of-way or adjacent private property, but shall be removed from the work.
- The Contractor will be responsible at all times for safeguarding both public and private property from all hazards and damage resulting from the work.

8.4.14 Falsework. The falsework shall be properly designed for the loads to be supported and shall be constructed substantially and maintained. The Contractor shall prepare and submit plans for falsework to the Engineer for approval. The falsework plans shall be complete in all details of members, connections, equipment, etc., so that a structural check can be made of the falsework. Approval of the Contractor's plans shall not be considered as relieving the Contractor of any responsibility.

8.4.15 Grading Deck on Continuous Units. Forms shall not be erected or concrete placed until after all welding, bolting, or riveting is complete, the unit positioned, and bearings properly set. An accurate measurement shall be made of the elevations of girder or beam flanges at all grading control points as shown on the plans. Subsequent grading of forms and placing and finishing of concrete shall be governed by these measurements only, taking into account the dead load deflection of the slab and rail as shown on the dead load deflection diagram.

8.4.16 Misfits. Corrections of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets will be considered a legitimate part of the operation. Any error in shop work which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or 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 shall be obtained. The correction shall be made in the presence of the Engineer who will check the material. Such work is to be done at the entire expense of the Contractor.

8.5 METHOD OF MEASUREMENT.

8.5.1 Measurement and payment for quantities of structural metal, concrete, reinforcement, railing, and other proposal items which constitute the completed and accepted structures will be made in accordance with the provisions of pertinent specifications. When identified in the bid items, the steel structures shall be paid by structural steel in pounds.

8.5.2 Normally, no direct compensation will be made for "Steel Structures". When specified in the project contract documents, certain structural steel structures may be paid for as a complete assembly and on a lump sum basis. The limits of the structure shall be shown on the plans.

8.6 BASIS OF PAYMENT. Structural Steel, measured as provided above, will be paid for at the contract unit price for:

STRUCTURAL STEEL	LBS
or	
STRUCTURAL STEEL STRUCTURE (STRUC NO.)	LS

which shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

9.0 CONCRETE BRIDGE FLOORS. To be published.

10.0 PORTLAND CEMENT CONCRETE OVERLAY OF BRIDGE FLOORS. To be published.

11.0 REINFORCING STEEL

11.1 DESCRIPTION. This section shall cover the furnishing and placing of reinforcing steel in accordance with these specifications and in conformity with the plans. All reinforcement shall consist of deformed bars or wire mesh as specified. Deformed bars shall be of an approved deformed type such that a mechanical bond will be provided between the concrete and steel at frequent intervals. Square twisted bars shall not be used. The size shall be such that the minimum net sectional area of the bar shall be equal to the section of a plain bar of the nominal size indicated.

11.2 MATERIALS. Materials shall meet the requirements of the Materials Section. All reinforcing bar used on City projects shall be Grade 60. The bar list and bending schedule are made for the purpose of arriving at an estimate of quantities. The Contractor shall verify the quantity, size and shape of the bar reinforcement against the structure drawings and make the necessary corrections, if any, before ordering. Errors in the bar list and bending schedule shall not be cause for adjustment of contract unit price.

11.3 CONSTRUCTION METHODS

11.3.1 Reinforcing steel shall be protected at all times from damage. When placed in the work the reinforcing steel shall be substantially free from dirt, detrimental scale, paint, oil or other foreign substance. Thin powdery rust and tight rust that does not reduce the effective cross section is not considered detrimental and need not be removed.

11.3.2 All reinforcing bars shall be bent cold. Bars partially embedded in concrete shall not be field bent except as shown on the plans and in a manner approved by the Engineer. Should the Engineer approve the application of the heat for field bending reinforcing bars, precautions shall be taken to assure that the physical properties of the steel will not be materially altered.

11.3.3 All reinforcing steel shall be accurately placed within the tolerances specified herein. During the placing of concrete, reinforcing steel shall be firmly held by approved supports in the position shown on the plans.

- Reinforcing bars shall be fastened at alternate intersections with wire ties unless this results in ties being more than 12-inches apart in which case each intersection shall be tied. Spot welding of reinforcing steel will not be permitted.

- Spacing of parallel bars is shown center to center. Bar bends are out to out and distance from face of concrete to reinforcing steel is clear distance. In the plane of the steel parallel to the nearest surface of concrete, individual bar spacing shall not vary from plan placement by more than 1-inch. Perpendicular to the nearest surface of concrete, bars shall not vary from plan placement by more than 1/4-inch in slabs and walls up to and including 8-inches in total thickness, the bars shall not vary more than 1/2-inch from plan placement. The placement of deck reinforcement in bridge floors shall not deviate more than 1/4-inch from plan placement in the vertical direction.

- Approved metal bar supports of adequate strength, of proper depth and in sufficient

number shall be used for supporting the bars in slabs, beams, and girders. Both low and high approved metal chairs shall be used in I-Beam, truss and girder floors. The placing, wiring and supporting reinforcement in each section of the work shall be approved by the Engineer before any concrete is deposited in the section.

- All reinforcement shall be furnished in the full lengths indicated on the plans. Splicing of bars, except where shown on the plans, will not be permitted without written approval of the Engineer. Splices shall be staggered as practicable.

- Unless otherwise shown on the plans, bar splices in the bottom of beams and girders, and in walls, columns and haunches shall be lapped as given in the table below for 'other bars'. Bar splices near the top of beams and girders having more than 12-inches of concrete under the bars shall be lapped as given in the following table for 'top bars':

Required Length of Lap in Inches								
Size (No.)	4	5	6	7	8	9	10	11
Top Bar	22	29	36	48	66	80	102	120
Other Bars	18	20	25	45	60	60	90	90

- No more than one-half of the bars should be lap spliced within a required lap length.

- Bars larger than No. 11 bars shall not be lap spliced but shall be weld spliced in accordance with current AWS Specifications or spliced with other positive mechanical methods. The splice methods or devices shall be approved by the Engineer prior to use.

- The minimum spacing center to center of parallel bars shall be 2.5 times the diameter, but in no case shall the clear distance between the bars be less than 1.5 times the maximum size of the coarse aggregate. The minimum covering measured from the surface of the concrete to the face of any reinforcing bar shall be not less than 2-inches. In the footings of abutments and retaining walls and in piers the minimum covering shall be 3-inches.

11.4 METHOD OF MEASUREMENT. Reinforcing steel and wire mesh will be measured by the pound based on the theoretical number of pounds complete in place as shown on the plans or placed as ordered. The quantities of materials furnished and placed shall be based upon the calculated weights of the reinforcing steel actually placed in accordance with these specifications. The weights calculated shall be based upon the following table:

Bar Designation Number	Nominal lb/ft	Weight kg/m
3	0.376	0.560
4	0.688	0.994
5	1.043	1.552
6	1.502	2.235
7	2.044	3.042
8	2.670	3.973
9	3.400	4.960
10	4.303	6.403
11	5.313	7.906
14S	7.650	11.384
18S	13.600	20.239

No allowance will be made for clips, metal spacers, ties, etc., wire or other material used for

fastening or holding reinforcement or forms in place, except that wire hoops used in reinforced concrete columns and encased I-beams or similar construction, when included in the bar list shown on the plans, will be classed as reinforcing steel and will be paid for at the contract unit price per pound for reinforcing steel.

11.5 BASIS OF PAYMENT. The accepted quantities of reinforcing steel and wire mesh (unless wire mesh is included in other items) will be paid for at the contract unit price per pound for:

REINFORCING STEEL LBS

which shall be full compensation for furnishing all material, equipment, labor and incidentals required to complete the work as specified.

12.0 PENETRATING SEALER FOR CONCRETE SURFACES

12.1 DESCRIPTION. This section covers the furnishing and placing of a penetrating sealer system in reasonably close conformity with the requirements specified herein and as shown on the plans.

12.2 MATERIALS. The material shall be a penetrating sealer for Portland Cement Concrete. The penetrating sealer shall be as called for in the plans. If the type is not called for, the sealer shall be equal to or better than Chemical Products Corporation's CP-5003.

12.3 CONSTRUCTION METHODS. The materials shall not be applied when the air or surface temperature is less than 40°F or while the surface is wet. The surface shall be swept and/or washed to remove laitance, dirt, asphalt, and other foreign materials, exposing a surface of sound concrete. Equipment shall be fitted with suitable traps, filters, drip pans, or other devices to prevent oil or other deleterious matter from being deposited. The penetrating sealer shall consist of application to be applied at the rate recommended by the manufacturer.

12.4 METHOD OF MEASUREMENTS. The penetrating sealer system will be measured by the square yard in place.

12.5 BASIS OF PAYMENT. The accepted quantities of penetrating sealer system will be paid for at the contract unit price per square yard for:

PENETRATING SEALER SY

which shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

13.0 PRE-CAST BOX CULVERTS

13.1 DESCRIPTION. This section covers the requirements, method of measurement and payment of pre-cast reinforced concrete box sections.

13.2 MATERIALS. All materials conform to the requirements of the Materials section.

13.3 CONSTRUCTION METHODS. Must be in accordance with ASTM C789-79 or AASHTO

M259 and ASTM C850-79 or AASHTO M273.

13.4 METHOD OF MEASUREMENT. Will be measured by the linear foot in place. Payment shall be by the linear foot in place, but not to exceed quantity shown on the plans or called for in the special provisions.

13.5 BASIS OF PAYMENT. The items measured as provided above will be paid for at the contract unit price bid:

PRE-CAST BOX CULVERT LF

Such payment shall be compensation in full for furnishing all materials, labor, equipment, tools and incidentals, and for performing the work in accordance with these specifications.

14.0 STANDARD BID ITEMS FOR STRUCTURES. This section covers Standard Bid Items used in the contract documents for the construction of structures. Additional bid items may be called out in the Special Provisions, other sections of the Standard Specifications, or as directed by the Engineer for additional work covered and change orders.

SECTION	DESCRIPTION	UNIT
	STRUCTURAL EXCAVATION	CY
	DRILLED SHAFT (DIAMETER)	LF
	BELL FOOTING	CY
	TEST HOLE	EA
	TEST BELL	EA
	STRUCTURAL CONCRETE	CY
	PRE-STRESSED CONCRETE BEAM (TYPE)	LF
	HIGH EARLY STRENGTH CONCRETE	CY
	STRUCTURAL STEEL	LBS
	CLASS A BRIDGE DECK REPAIR	SY
	CLASS B BRIDGE DECK REPAIR	SY
	CLASS C BRIDGE DECK REPAIR	SY
	BRIDGE DECK OVERLAY	SY
	REINFORCING STEEL	LBS
	PENETRATING SEALER	SY
	(TYPE) STORM SEWER (SIZE)	LF
	PRE-CAST BOX CULVERT	LF