TABLE OF CONTENTS
SECTION 400

SECTION 400 – STRUCTURES CONSTRUCTION

SECTION 401 – STRUCTURAL EXCAVATION

401.01 DESCRIPTION

401.01.01 – GENERAL

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.

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 City Engineer.

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.

401.01.02 – COFFERDAMS

Cofferdams for foundation construction shall be carried well below the bottom of the footings and shall be well braced and reasonably watertight. The interior dimensions of cofferdams shall provide sufficient clearance inside the wales for constructing forms and driving piles and to permit pumping outside the forms.

If, in the judgment of the Contractor, the clearance provided on the plans between the outside line of the footing and any pile or interior wall or surface is not sufficient to permit the driving of piles or building of forms, he may provide such necessary clearance by constructing the cofferdam sufficiently large to provide such clearance as he may deem necessary. Any such enlargement more than one (1) foot outside the dimensions of the footing as shown on the plans shall be considered as being for the sole purpose of expediting the work of the Contractor and such excavation and backfill shall be at the Contractor's expense.

Cofferdams which are tilted or moved out of position by any cause during the process of sinking shall be plumbed or enlarged to provide the necessary clearance and proper pier location and such work shall be at the Contractor's expense.

In tidal water or in streams at a time of probable flood, cofferdam walls shall be vented at low water elevation to insure equal hydrostatic head both inside and outside of the cofferdam during the period of pouring and setting of seals.

No shoring will be permitted in cofferdams which will induce stress, shock, or vibration in the permanent structure.

For substructure work, the Contractor shall submit drawings showing his proposed method of cofferdam construction and other details left open to his choice or not fully shown on the plans. The type and clearance of cofferdams, insofar as such details affect the character of the finished work, will be subject to the approval of the City Engineer, but other details of design will be left to the Contractor who will be submitted a minimum of ten (10) to thirty (30) days in advance of the time the Contractor begins construction of the cofferdams.

After completion of the substructure, the cofferdams will all sheeting and bracing, shall be removed at least two (2) feet below the level of the stream bed, by the Contractor at his expense, and such removal shall be performed in a manner that will not disturb or mar the finished concrete or masonry.

401.02 MATERIALS — VACANT

401.03 EQUIPMENT — VACANT

401.04 CONSTRUCTION METHODS

A) Excavation

1) 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 City 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 over excavation is directed by the City 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.

2) Excavated material required to be used for backfilling 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 City 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.

3) Excavated material required to be wasted shall be disposed of as directed by the City 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.

4) 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 two (2) feet below bottom of culvert for culverts two (2) feet or more in height, and to a depth equal to the height of culvert for culverts less than two (2) feet in height. Such excavation shall be carried at least one (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 City 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 of sufficient stability to sustain properly the adjacent sections of the roadway embankment will be considered a suitable foundation material for the culvert.

5) 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 six (6) inches below the footing grade and backfilled with a material like the compressible

foundation used for the rest of the structure.

6) 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 City Engineer has inspected the footing and authorized such changes found necessary to provide an adequate foundation.

B) Backfill

Structural back fill shall not be placed until the structure footings or other portions of the structure or facility have been inspected by the City 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 seven (7) days. No backfill shall be placed adjacent to box culverts until the top slab has been in place at least four (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 four (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 six (6) inches in depth (loose measurement) and compacted to that each layer and the completed backfill has a density of not less than ninety-five (95) percent of the maximum density as determined by ASTM Designation D-698.

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 will be permitted when, as determined by the City 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 two (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 four (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 using vibratory or other compaction equipment when necessary to obtain the required compaction.

401.05 TESTING — VACANT

401.06 METHOD OF MEASUREMENT

Measurement for payment will be for material excavated within the limits shown on the plans or as directed by the City 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 provisions 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.

401.07 – BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) STRUCTURAL EXCAVATION	Cubic Yard [Cubic Meter]

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.

SECTION 402 – DRILL SHAFT FOUNDATIONS

402.01 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.

402.02 MATERIALS

All concrete materials and their preparations shall be in accordance with the requirements of Section 901, "Portland Cement Concrete", and the additional requirements herein.

When Casing of the shaft is required, the following shall apply:

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

B) 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 thirty (30) minutes. If a set retarding admixture is used, this time shall not exceed one (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 ten (10) minutes. If a set retarding admixture is used, this time shall not exceed thirty (30) minutes.

C) When the temperature of the air or concrete is above eighty-five (85) degrees F, an approved set retarding admixture will be required in all drilled shaft concrete.

D) Reinforcing steel shall conform to the requirements of Section 923, "Reinforcing Steel". The sizes and dimensions shall be as shown on the plans.

402.03 EQUIPMENT — VACANT

402.04 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 one and one-half (1 ½) inches for depths up to and including ten (10) feet plus an additional tolerance of five hundredths (0.05) inch per foot for depths more than the first ten (10) feet. When bells are required, they shall be excavated 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 City 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.

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 City Engineer. Alterations in plan depths shall be made as judged proper to satisfactorily comply with the design requirements.

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.

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.

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.

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 ensure 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 always maintained 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 one (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 one (1) inch, all 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 City Engineer.

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 City 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.

The Contractor shall provide suitable access and lighting for the City 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 City 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. The depth of such soundings or cores will not be required to exceed five (5) feet below the proposed footing grade. 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.

A) 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 twelve (12) inches on centers to provide a rigid unit.

   For cased shafts where the reinforcing steel cage is over thirty (30) feet in length, the longitudinal bars shall be tied at each intersection of the spiral hooping for a distance of one-fifth (1/5) 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.

B) Concrete - The work shall be performed in accordance with the provisions of Section 403, and in conformance with the requirements herein.

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 non-jointed 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.

After a placement is completed, the top surface shall be cured, and any construction joint area shall be treated as prescribed in Section 404.

402.04.01 – TEST HOLES

When shown on the plans, or when ordered by the City 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 City Engineer.

402.04.02 – TEST BELLS

When shown on the plans, or when ordered by the City 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 City Engineer.

402.05 TESTING — VACANT

402.06 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 City 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 City 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".

A) Drilled Shaft will be paid for the completed length per the plan quantity or authorized by the City Engineer.

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

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

D) Test bells, of the specified diameter, will be paid for at the contract unit price bid for each "Test Bell".

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.

402.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) DRILLED SHAFT (DIAMETER)	Linear Foot [Meter]
(B) BELL FOOTING	Cubic Yard [Cubic Meter]
(C) TEST HOLE	Each
(D) TEST BELL	Each

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.

SECTION 403 – CONCRETE STRUCTURES

403.01 DESCRIPTION

Before starting work, the Contractor shall inform the City 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 City Engineer. Plans for forms and falsework for concrete piers and concrete superstructure spans over twenty (20) feet in length and for all widening

details shall be submitted to the City Engineer for review and approval. Similar plans shall be submitted for other units of structure if requested by the City Engineer. The plans shall be prepared on standard twenty-two (22) inch by thirty-six (36) inch sheets. 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 City 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.

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 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 two (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 City Engineer. Authorization may be given after the last slab concrete has been in place at least fourteen (14) days for light construction traffic not to exceed a three-fourths (3/4) ton vehicle.

Authorization may be given after the last slab concrete has been in place thirty (30) days or as authorized by the City Engineer for the structures to be opened for normal construction traffic and to the traveling public. Construction vehicles with a minimum of three (3) axles may be operated across structures if the total gross load does not exceed fifty-one thousand (51,000) 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 ten (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 City Engineer may permit such crossing after a structural analysis is made considering 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 City 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:

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

B) Welds will not be permitted on the tension flange of the members in that area where the stress exceeds seventy-five (75) percent of the allowable stress.

C) Welds shall be made with low hydrogen electrodes.

D) Welding shall be done by a certified welder.

403.01.01 – 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 three (3) inches in diameter with a permissible variation of plus or minus one-fourth (1/4) inch. A neat pocket shall be excavated at each weep hole for placing the indicated volume of gravel. Washed gravel from three-eights (3/8) inch to one and one-half (1 1/2) inch 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.

403.01.02 – 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 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 to secure full effectiveness of the expansion joints.

403.01.03 – 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 City 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 one (1) part cement to two (2) parts sand or painted with an approved bonding agent.

403.01.04 – 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 six (6) inches below finished ground level. Falsework and piling in a stream or lake shall be removed completely to a point specified by the City Engineer to prevent any obstruction to the waterway.

403.01.05 – FORMS

A) General - Forms shall be of suitable material and of a type, size, shape, quality, and strength to ensure 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. Any lumber or material which becomes badly checked or warped, prior to placing concrete, shall not be used.

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 U.S. Department of Commerce, National Bureau of Standards, Commercial Standards, latest edition. Plywood shall be furnished and placed in forty-eight (48) inch widths and in uniform lengths of not less than ninety- six (96) inches, except where the dimension of the member formed is less than the specified panel dimension. Plywood shall be placed with the grain of the outer plies in the direction of the span.

B) Molding - 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.

C) 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 one-half (1/2) inch from the surface of the concrete. Burning off rods, bolts, or ties will not be permitted. The cavities produced shall be carefully cleaned and filled with retempered sand cement mortar mixed in proportions of one (1) to three (3), and the concrete shall be left smooth and even.

D) 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 City Engineer.

Holes in steel members for support of overhanging brackets may be punched or drilled full size or may be torch cut to one-fourth (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.

403.02 MATERIALS

A) Concrete - All concrete shall conform to the provisions of Section 901, "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.

B) Expansion Joint Material

1) Preformed Fiber Material - Preformed fiber expansion joint material shall be of the dimensions shown on the plans and shall conform to the provisions of Section 901.08. “Joint Fillers and Sealants".

2) Joint Sealing Material - Joint sealing material shall conform to the provisions of Section 901.08. “Joint Fillers and Sealants".

3) Asphalt Board- Asphalt board shall consist of two (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 D-944, the asphalt board shall not deflect from the horizontal more than one (1) inch in three and one-half (3 1/2) inches.

C) Waterstop

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

2) Rubber waterstop or PVC waterstop.

3) Other types as specified on the plans.

D) Curing Materials - The membrane curing compound shall conform to the provisions of Section 901.07, “Curing Agents”.

403.03 EQUIPMENT — VACANT

403.04 CONSTRUCTION METHODS

403.04.01 – PLACING REINFORCEMENT

Reinforcement in concrete structures shall be placed carefully and accurately and rigidly supported as provided in Section 923, "Reinforcing Steel".

403.04.02 – PLACING CONCRETE - GENERAL

The minimum temperature of concrete at the time of placement shall be not less than fifty (50) degrees F.

The maximum temperature of cast-in-place concrete used in bridge superstructure shall not be more than eighty-five (85) degrees 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 ensure that the concrete remains plastic in not less than three (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 Section 901.03, "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:

Table 403:1 Maximum Time Intervals	
Air or Concrete	
Max Temperature	Time
Non-Agitated Concrete	
80º F or Above 35º to 79º F	15 Minutes 40 Minutes
Agitated Concrete	
90º F or Above 75º F to 89º F 35º F to 74º F	45 Minutes 60 Minutes 90 Minutes

The use of an approved cement dispersing agent in the concrete will permit the extension of each of the above temperature time maximums by thirty (30) minutes, except that for non-agitated concrete, the maximum time shall not exceed thirty (30) minutes.

The Contractor shall give the City 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. In case of drop in temperature, the provisions set forth in Section 403, shall be applied.

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.

After the concrete has taken initial set, the forms shall not be jarred, or strain placed on projecting reinforcement.

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 one (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) in accordance with Section 901.03, "Concrete Admixtures", shall be used to control stress cracks and/or unauthorized cold joints.

Laitance or foreign matter of any kind shall not be permitted to accumulate inside the forms; and openings in forms necessary for removal of same shall be provided.

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 one (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 ensure 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 eighteen (18) to thirty (30) 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.

403.04.03 – 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 thirty-five (35) degrees F, or when conditions indicate that the temperature may fall to thirty-five (35) degrees F within twenty-four (24) hours, except with the written permission of the City Engineer and only after such precautionary measures for the protection of the work have been taken as he may direct.

Concrete shall be effectively protected from freezing or frost for a period of five (5) days after placing.

When the temperature of the air is above eighty-five (85) degrees F, an approved retarding mixture will be required in all concrete used in superstructures, top slabs of direct traffic culverts and cased drilled shafts.

Concrete placement shall be stopped when rainfall is sufficient to cause damage to the work.

403.04.04 – PLACING CONCRETE IN WATER

Concrete shall be deposited in water only when specified on the plans or with written permission of the City 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 always maintain approximately horizontal surfaces.

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 watertight 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 one-half (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.

403.04.05 – PLACING CONCRETE IN SUPERSTRUCTURE

To ensure 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 one and one-half (1 1/2) percent 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 City 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.

When the curb forms are filled, the curbs shall be brought to the correct camber and alignment and struck off.

As soon as concrete is placed in a section of the slab of sufficient width to permit finishing operations, the slab shall be finished as specified in Section 403.04. 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.

403.04.06 – 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 four (4) feet in clear height, an interval of not less than one (1) hour nor more than two (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 in Section 403.04.09. On a fill type culvert which does not carry direct traffic, the top slab shall be given a reasonably smooth finish.

403.04.07 – PLACING CONCRETE IN FOUNDATIONS AND SUBSTRUCTURE

Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the City 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 City 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 slower level of the cap, or each tie beam and placement delayed for not less than one (1) hour nor more than two (2) hours before proceeding.

403.04.08 – TREATMENT/ 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, as specified by the City Engineer. 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.

403.04.09 – 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 enough times (not less than three

(3)) and at such intervals to produce a uniform surface true to grade and free of voids.

Spans over fifty (50) feet in length may be screeded in two (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 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 ten

(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 one-sixteenth (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.

Unless otherwise shown, 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. Work bridges shall be provided from which to perform all finishing operations.

Rail support holes shall be filled with concrete and finished to match the top of the slab.

After the final set of the concrete, the roadway surface shall be tested again with a standard ten (10) foot metal straightedge for irregularities and the surface shall be corrected, if necessary, to conform to the following:

The straightedge shall be placed parallel to the centerline of road to bridge any depressions and touch high spots. Ordinates measured from the face of the straightedge to the surface of the slab shall not exceed three-sixteenths (3/16) inch. The surface shall be corrected by grinding off the high spots as required to conform to these limits. Vertical curvature and required camber shall be considered when straight edging.

In all roadway slab finishing operations camber for specified vertical curvature and transverse slopes shall be provided.

For concrete slab or concrete girder spans which are cast-in-place on falsework, an additional amount of camber shall be provided to offset the initial and final deflections of the span. The additional amount of camber shall be determined from the dead load deflection diagram shown on the plans. When dead load deflection is not shown on the plans, the additional amount of camber shall be one-eighth (1/8) inch per ten (10) feet of span length but not greater than one-half (1/2) inch. For concrete girder spans the additional camber for initial and final deflections shall be one-half (1/2) inch for thirty (30) foot spans and three-fourths (3/4) inch for forty (40) foot spans.

Roadway slabs supported on pre-stressed concrete, steel beams, or girders shall receive no additional amount of camber, except that for slabs without vertical curvature, the longitudinal camber shall be approximately one-fourth (1/4) inch.

Dead load deflection shall be considered in the setting of headers and rail systems.

403.04.10 – CURING CONCRETE

Careful attention shall be given to the proper curing of all concrete. The Contractor shall inform the City 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 City Engineer to stop all construction on the job until approved curing is provided.

All concrete shall be cured for a period of four (4) days except as noted herein:

TABLE 403.2
EXCEPTIONS TO 4-DAY CURING

Description	Required Curing
Upper Surfaces of Bridge Roadway, Median and Sidewalk Slabs and Top Slabs of Direct Traffic Culverts	8 Curing Days

A curing day is defined as a calendar day when the temperature, taken in the shade away from artificial heat, is above fifty (50) degrees F for at least nineteen (19) hours (or colder days if satisfactory provisions are made to maintain the temperature at all surfaces of the concrete above forty (40) degrees F for the entire twenty-four (24) hours).

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:

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

B) 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. The water used for curing shall meet the requirements for concrete mixing water as specified in Section 901.

   1) Wet Mat - 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 made from nine (9) ounce stock 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 three (3) hours after finishing of the roadway slab.

      The mats shall be weighted down adequately to provide continuous contact with all concrete surfaces where possible. The surfaces of the concrete shall be kept wet for the required curing time. Surfaces which cannot be cured by contact shall be enclosed with mats, anchored positively to the forms or to the ground so that outside air cannot enter the enclosure. Sufficient moisture shall be provided inside the enclosure to keep all surfaces of the concrete wet.

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

   3) Ponding - This method requires the covering of the surfaces with a minimum of two (2) inches of clean granular material always kept wet, 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.

C) Membrane Curing - Unless otherwise shown on the plans, Type 2 membrane curing compound may be used where permitted. Material requirements and construction methods shall be as required in Section 901. Membrane shall be applied in a single, uniform coating at the rate of coverage recommended by the manufacturer and as approved by the City Engineer, but not less than one (1) gallon per two hundred ten (210) feet of area. Tests for acceptance shall be at this specified rate.

   Membrane curing shall not be applied to dry surfaces but shall be applied to horizontal surfaces just before free moisture has disappeared. Formed surfaces and surfaces which have been given a first rub shall be dampened and shall be moist at the time of application of the membrane.

   When membrane is used for complete curing, the film shall remain unbroken for the minimum curing period specified. Membrane, which is damaged, shall be corrected immediately by reapplication of membrane. Membrane wire will not be used in areas where concrete is to be placed and bonded later.

403.04.11 – REMOVAL OF FORMS AND FALSEWORK

Except as herein provided, forms for vertical surfaces may be removed when the concrete has aged not less than one (1) day for normal concrete and not less than one-half (1/2) day 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 four (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 City Engineer.

In no case shall forms under parts of structures carrying loads be removed in less time than shown by the following table. Days on which the temperature falls below fifty (50) degrees F shall not be counted.

TABLE 403.3 Form Removal Time	
Shores and Centering Under Slabs, Beams, Girders and Arches Less than 20 feet	4 days
Over 20 feet and less than 35 feet	6 days
Over 35 feet and less than 50 feet	8 days
Over 50 feet and less than 60 feet	9 days
Over 60 feet	10 days
Floor slabs on steel stringers	4 days
All other parts	3 days

After removal of forms, supports, and centering, concrete may be subjected to not more than the design load of the structure.

If all beams made for the purpose of form removal have been broken without attaining the required strength, forms shall remain in place for a total of fourteen (14) curing days.

The above provisions relative to form removal shall apply only to forms or parts of forms which are so constructed as to permit removal without disturbing forms or falsework which are required to be left in place for a longer period on other portions of the structures.

403.04.12 – 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.

All concrete surfaces shall be reasonably true and even, free from stone pockets, excessive depressions, or projections beyond the surface. The concrete in bridge seats and walls shall be brought flush with the finished top surface and struck off with a straightedge and floated. The concrete surfaces which are not in an acceptable condition, or which are designated on the plans to be surface finished, shall be rubbed to a smooth and uniform texture with a carborundum brick and clean water as soon as the forms are removed, and the concrete is ready to hone. The loose material formed on the surface, due to the rubbing with a carborundum brick, shall be removed as soon as it dries by means of rubbing the surface with burlap or by other approved methods. The finished surface shall be free from all loose material. A neat cement wash shall not be used.

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 ensure 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.

Unless otherwise provided on the plans, all reasonably true and even surfaces obtained by use of a form liming, which are of a uniform color, free from stone pockets, honeycomb, excessive depressions, or projections beyond the surface shall be considered as acceptable surfaces and a rubbed surface finish will not be required.

The above provisions for surface finish shall not preclude requiring the use of a dry carborundum brick for straightening molding lines, removing fins, etc., or requiring a rubbed surface finish on all portions of the structure which do not present an acceptable surface even though a form lining is used.

When so indicated on the plans, or with written permission of the City Engineer, painting of concrete surfaces in lieu of rubbing will be permitted. When painting is permitted, all surfaces to be coated shall be prepared in the following manner:

Soon after form removal any porous spots, honeycombed areas, untrue surfaces, and lines shall be corrected. All fins, form marks, runs, drips, or mortar shall be removed leaving a smooth and uniform surface.

When preparing the completed structure for final acceptance, all grease, dirt, mortar drips, and remaining curing membrane shall be removed from the pertinent surfaces after which the surfaces shall be painted with a latex-base adhesive grout.

The grout shall consist of one (1) part latex base adhesive, two (2) parts white cement, two (2) parts natural cement, two (2) parts fine masonry sand, and one (1) part water. Mixture should have the consistency of a thick paint.

The finished surface shall have a uniform appearance and texture. Thickness of coating shall be approximately one-sixteenth (1/16) to one-eighth (1/8) of an inch.

403.05 TESTING

All tests prescribed in this Section 400 and Section 900 as applicable will be made of each designated sample specified after concrete is placed. 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 City 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.

403.06 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 City Engineer.

403.07 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 subsidiary to the pay items required by the plans and the contract.

SECTION 404 – STRUCTURAL CONCRETE

404.01 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 City Engineer.

404.02 MATERIALS

Materials shall meet the requirements specified in the following Sections of 900 – Materials:

Portland Cement Concrete	901
Elastomeric Bearing Pads	935

404.03 EQUIPMENT

All concrete materials and their preparations shall be in accordance with the requirements of Section 901, "Portland Cement Concrete".

404.04 CONSTRUCTION METHODS

A) Handling, Measuring and Batching materials shall be in accordance with Section 314.04

B) Mixing - The mixing of concrete shall be in accordance with Section 314.04

C) 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. Undressed lumber may be used for backing or other unexposed surfaces.

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 two (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.

D) Handling, Placing and Vibrating Concrete

1) General - 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 to avoid segregation of the materials and the displacement of the reinforcement. The City 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 five (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 City Engineer or as provided herein.
- Vibrators shall be of a type and design approved by the City Engineer. The manufacturer's rated capacity shall be not less than four thousand (4000) impulses per minute.
- The intensity of vibration shall be such as to visibly affect a mass of concrete of one (1) inch slump over a radius of at least eighteen (18) inches.
- The Contractor shall provide enough vibrators to properly consolidate each batch of concrete immediately after it is placed in the forms.
- Vibrators shall be manipulated 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 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. It shall not be used to make concrete flow in the forms.
- Vibration shall be supplemented by such spading as is necessary to ensure 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 City Engineer, the manufacturer's methods of consolidation may be used.

Concrete shall be placed in horizontal layers no more than twelve (12) inches thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set. Each layer shall be compacted, to avoid the formation of a construction joint with a preceding layer, before it has taken initial set.

When the placing of concrete is temporarily discontinued the concrete, after becoming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, as in the sloped top surface of a wingwall, inset form work shall be used to produce a blocked-out portion in the preceding layer which shall produce an edge thickness of not less than six (6) inches in the succeeding layer. Work shall not be discontinued within eighteen (18) inches of the top of any face, unless provision has been made for a coping less than eighteen (18) inches thick, in which case, if permitted by the City Engineer, the construction joint may be made at the underside of the coping.

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.

2) 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 as specified herein. In the construction of box culverts four (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 four (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.

3) Girders, Slabs and Columns - Concrete, preferably, 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 twelve (12) inches thick.

   Concrete in girder haunches less than three (3) feet or more, the abutment or columns, the haunch and the girder shall be placed in three (3) successive stages; first up to the lower side

of the haunch; second, to the lower side of the girder; and third, to completion.

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 two (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 City Engineer. The size and location of these keys shall be computed. In general, suitable keys may be formed using timber blocks approximately two (2) inches by four (4) inches in cross section and having a length four (4) inches less than the width of the girder stem. These key blocks shall be spaced along the girder stems as required, but the spacing shall be not greater than one (1) foot center to center. The blocks shall be beveled and oiled in such manner as to ensure their ready removal, and they shall be removed as soon as the concrete has set sufficiently to retain its shape.

Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set at least two (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 five (5) days, unless otherwise permitted by the City Engineer.

4) Pneumatic Placing - Pneumatic placing of concrete will be permitted only if specified in the special provisions.

5) Pumping - Placement of concrete by pumping will be permitted provided the equipment is so arranged that vibrations will not damage freshly placed concrete.

   Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work. Aluminum pipe shall not be used. The operation of the pump shall be such that a continuous stream of concrete without air pockets is delivered.

E) Placing Concrete under Water - Concrete shall be deposited in water only with the permission of the City Engineer and under supervision. When depositing in water is allowed, the concrete shall be carefully placed in the space in which it is to remain in a compact mass by means of a concrete pump that does not permit the concrete to fall through the water. Concrete placed under water shall be deposited in one continuous operation and shall be allowed to set for a period of at least forty-eight (48) hours before the caisson is dewatered. After dewatering, the laitance and soft concrete shall be cut away and the top surface cleaned. Concrete shall not be placed in running water, and forms which are not reasonably watertight shall not be used for holding concrete deposited under water. The concrete shall not be disturbed after being deposited.

   Ten (10) percent of additional cement shall be added to all concrete placed under water. No allowance will be made the Contractor for additional cement required for placing concrete under water. The water pressure shall be equal inside and outside the forms before any concrete is placed under water. The quantity of mixing water shall be the minimum amount to permit the passage of concrete through the concrete pump.

F) Joints - Whenever the work of placing concrete is delayed until the concrete shall have taken its initial set, the point of stopping shall be deemed a construction joint. So far as possible, the location of construction joints shall be planned, and the placing of concrete carried continuously from joint to joint. These joints shall be perpendicular to the principal lines of stress.

Where dowels, reinforcing bars, or other adequate methods are not shown on the plans, keys shall be made by placing water-soaked beveled timbers of a size shown on the details, or as directed by the City Engineer. The key material shall be removed when the concrete has set. In resuming work the surface of the concrete previously placed shall be thoroughly cleaned of laitance, or other soft material with stiff wire brushes, and if deemed necessary by the City Engineer, shall be roughened by a steel tool.

Construction joints shall be made only where located on the plans or shown in the placing schedule, unless otherwise approved by the City Engineer. Shear keys or continuous reinforcement shall be used to transmit shear and/or bond the two sections together.

In parapets, railings, and other light work superimposed on heavy work, the expansion joints shall be placed as shown on the plans.

To maintain the proper alignment of the different parts of the work, they shall be provided with keys at approximately one-third (1/3) of the area of the cross sections of the wall or with the equivalent thereof in dowels.

G) Curing Concrete - All concrete shall be cured as provided in these specifications for the various parts of structures. Specific references are as follows:

Concrete Bridge Floors	409

The side forms on all piers, abutments, retaining walls, wingwalls, and reinforced concrete boxes may be left in place for at least three (3) days or if removed before the three (3) days have elapsed, the surfaces shall be cured for the remaining part of the three (3) day period by one of the following methods:

1) Cured for at least three (3) days with an approved polyethylene burlap.

2) Cured for at least three (3) days with three (3) layers of wet burlap.

3) Cured for at least three (3) days with wetted cotton mats as specified. The surface of the concrete shall be entirely covered with mats. The mats used shall be of such length or width that as laid they will extend at least twice the thickness of the slab beyond the edges of the slab. The mat shall be placed so that the entire surface and both edges of the slab are completely covered. Prior to being placed, the mats shall be saturated thoroughly with water. The mats shall be so placed and weighted down as to cause them to remain in intimate contact with the surface covered, and the covering shall be maintained fully wetted and in position for seventy-two (72) hours after the concrete has been placed unless otherwise specified.

4) Cured with an approved membrane curing compound (Red) as specified below and in Section 901.

The curing compound shall be applied under pressure, by means of a spray nozzle, in such a manner as to cover the entire exposed surface thoroughly and completely with a uniform film. Sufficient pressure shall be applied to the spray machine to force the compound to leave the nozzle as a fine mist. The application of curing compound shall be always close to the finishing and all finished concrete shall be sprayed immediately after the superficial water, if any, has subsided.

Formed surfaces shall be coated with the curing compound as soon as practicable after removal of the forms.

The curing compound shall be applied on concrete for sidewalks, curbs, and floors, other than concrete bridge floors, as soon as possible after finishing. On surfaces requiring a surface finish or surfaces poured against forms, the curing materials shall not affect concrete surface bond.

If hair checking develops before the curing compound can be applied, the procedure set forth above shall be modified in that initial curing with wet burlap shall be performed as specified in Standard Specifications for the work under construction.

If discontinuities, or pinholes, or abrasions in the membrane exist, a second coat shall be applied to the affected areas. Walking on the cured surface will not be permitted for twenty-four (24) hours after application. If any abrasions occur within twenty-four (24) hours, they shall be corrected using additional compound.

H) Rate of Application - The curing compound shall not be applied at a coverage rate lighter than specified below:

Steel Trowel Finish	225 SF/GAL
Rough float Finish	200 SF/GAL

Whenever the atmospheric temperature is one hundred (100) degrees F or more, the City Engineer may require an additional coat at a rate of approximately two hundred seventy (270) square feet per gallon if he deems the additional material essential to obtain adequate water retention. When required, the second coat shall be applied thirty (30) minutes after the first.

When the desired results are not obtained by this method, the membrane method shall be discontinued, and the curing shall be by other methods specified in these specifications.

I) Removal of Forms - To make possible the obtaining of satisfactory surface finish, forms on ornamental work, railings, parapets, and vertical surfaces which do not carry loads, and which require a special concrete surface finish shall be removed as soon as practicable.

Forms supporting the main slabs and girders shall remain in place at least twenty-one (21) days and during unfavorable curing conditions as much longer as the City Engineer may direct.

The above specified time may be decreased in case test beams are cast at the time the concrete is placed. Beams shall be made, cured, and tested as provided in Section 404.05.

The forms may be removed when the test beams meet strength requirements as provided in Section 403.04.11, except as modified hereafter.

In no case shall the forms supporting main slabs, girders or concrete beams be removed in less than ten (10) days after the concrete is placed. Forms for vertical walls on columns, piers, abutments, and retaining walls requiring a concrete surface finish shall be removed in warm weather within twenty- four (24) hours after the concrete is placed and in the cool weather within forty-eight (48) hours - at least as soon as they may be removed without damaging the concrete. Forms under concrete caps on pile bents and under web walls shall remain in place at least five (5) days, if test beams have the required strength as provided above.

As soon as the forms are removed, all rough places, holes, and porous spots shall be filled and all bolts, wires or other appliances used to hold the forms, and which pass through the concrete shall be cut off flush with the surface. For all finished surfaces, all wires shall be cut off one-fourth (1/4) inch below the surface and the depression filled with cement mortar at once. This shall be left

rough for several hours and then rubbed smooth with the surface.

Honeycomb shall be repaired as soon as the forms are taken off by removing any aggregate that is loose or that is not thoroughly bonded to concrete mass, washing the surface with clean water, using a wire brush to remove any loose particles, and applying a thin coating of neat cement mortar. Patched areas shall be dressed flush with the surrounding area.

Small cavities shall be neatly pointed up with cement mortar of the same mix as used in the body of the work, immediately after removing forms. Care shall be taken to remove any thin surfaces or edges and expose the whole cavity before pointing up.

J) Defective Work - Any defective work discovered after the forms have been stripped shall be removed immediately and replaced. If the surface of the concrete is bulged, uneven, or shows excess honeycombing or settlement, which cannot be repaired satisfactorily, the entire section shall be removed and replaced. No additional compensation will be allowed for this work.

K) Drainage and Weep Holes - Drainage openings and weep holes shall be constructed in the manner and where indicated on the plans or directed by the City Engineer.

L) Placing Pipes and Conduits - Pipes and conduits for utility service lines which are to be encased in the concrete shall be placed by the Contractor during construction.

M) Placing Anchors, Bolts, Grillages, Etc. - The Contractor shall place all anchors, bolts, grillages, etc., securely, and accurately in the locations shown on the plans or as otherwise required.

404.05 TESTING

Slump will be determined using AASHTO T-119, and air content using AASHTO T-152 for gravel and stone aggregate and AASHTO T-196 for slag and other highly porous coarse aggregate. Test specimens will be made and cured in accordance with AASHTO T-23 except that after the initial curing, quality control specimens will be cured in a medium maintained at forty (40) degrees F to eighty-five (85) degrees F until they are delivered to the laboratory. Specimens will be tested in accordance with AASHTO T-22 for cylinders or AASHTO T-97 for beams (third point loading) or AASHTO T-177 for beams (center loading).

Unless otherwise provided, the minimum modulus of rupture when test beams are permitted as a criterion for removal of forms, placing a structure in service, driving piling, etc., shall be five hundred fifty (550) psi when tested with the third point method or six hundred fifty (650) psi when tested with the midpoint method and the minimum compressive strength of cylinders shall be thirty-five hundred (3500) psi.

404.06 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 City Engineer.

404.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) STRUCTURAL CONCRETE	Cubic Yard [Cubic Meter]

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.

SECTION 405 – PRE-STRESSED CONCRETE FOR STRUCTURES

405.01 DESCRIPTION

This section covers the furnishing and placing in the structure of the pre-stressed beams or other members in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions shown on the plans or established by the City Engineer.

Plans for members will show Pre-stressing by one of the following methods:

A) Pre-tensioning: In which the reinforcing tendons are stressed initially, after which concrete is placed and cured and the stress is released from anchorages to concrete after development of specified concrete strength.

B) Post-tensioning: In which the reinforcing tendons are installed in voids or ducts within the concrete and are stressed and anchored after the development of specified concrete strength. As a final operation under this method the voids or ducts are pressure grouted.

C) Combined Method: In which part of the reinforcing is pre-tensioned and part post-tensioned. Under this method all applicable requirements for Pre-tensioning and for Post-tensioning shall apply to the respective reinforcing elements using these methods.

405.02 MATERIALS

Materials shall meet the requirements specified in the following Section 900 – Materials:

Portland Cement Concrete	901
Joint Fillers and Sealers	901.08
Reinforcing Steel	923
Bearing Pads	933.06

405.03 EQUIPMENT — VACANT

405.04 CONSTRUCTION METHODS

A) Concrete for Pre-stressed Members - The concrete shall have the minimum compressive strength at twenty-eight (28) days as shown on the plans and as specified in Section 901. The strength of the concrete at transfer of Pre-stress shall be eighty (80) percent off, or four thousand (4000) psi, whichever is greater.

B) If steam curing is used, the methods shall meet the following requirements:

1) Steam curing shall be done under a suitable enclosure to contain the live steam to minimize moisture and heat losses. The initial application of the steam shall be from two (2) to four (4) hours after the final placement of concrete to allow the initial set of the concrete to take place. If retarders are used, the waiting period before application of the steam shall be increased from four (4) to six (6) hours.

2) The steam shall be at one hundred (100) percent relative humidity to prevent loss of moisture and to provide excess moisture for proper hydration of the cement. Live steam shall not be applied directly on the concrete or in harmful, concentrated jets of the forms.

3) During application of the steam the ambient air temperature shall increase at a rate not to exceed forty (40) degrees F per hour until a maximum temperature of one hundred-forty (140) degrees F to one hundred-sixty (160) degrees F is reached.

4) The maximum temperature shall be held until the concrete has reached the desired strength. In discontinuing the steam, the ambient air temperature shall not decrease at a rate to exceed forty (40) degrees F, per hour until the approximate temperature of the air to which the concrete will be exposed has been reached.

C) Forms - Forms and centering shall be made and maintained during their use true to the shapes and dimensions shown on the approved drawings.

Forms shall be well braced and stiffened against deformation under pressure of the wet concrete and shall have smooth joints and inside surfaces accessible for adequate cleaning before each use.

Forms may be treated with a commercial quality form oil or other equivalent coating which will permit the ready release of the forms and will not discolor the concrete. Adequate measures shall be taken by the Contractor, as approved by the City Engineer, to prevent the contamination or corrosion of the Pre-stressing steel.

D) Stressing Requirements - General - In all methods of tensioning, the stress induced in the reinforcing members shall be measured both by jacking gauges and by elongations of the reinforcement. Elongations and jacking pressures shall make appropriate allowance for friction and all possible slippage or relaxation of the anchorage. All jacks shall be equipped with accurate and calibrated gauges for registering jacking pressures. Means shall be provided for measuring the elongation of reinforcement to at least the nearest one thirty-second (1/32) inch.

Prior to use in manufacture of pre-stressed members under these specifications, all jacks to be used, together with their gauges, shall be calibrated by a reputable testing laboratory at the expense of the Contractor. Calibration of jacks and gauges shall be repeated at intervals of not more than one (1) year. During progress of the work if any jack or gauge appears to be giving erratic results, or if gauge pressure and elongation indicate materially differing stresses, recalibration will be required.

It is anticipated that there may be a possible difference in indicated stress between jack pressure and elongation of about five (5) percent. In such event the error shall be so placed that the discrepancy shall be on the side of a slight overstress rather than under stress. In the event of an apparent discrepancy between gauge pressure and elongation of more than five (5) percent, the entire operation shall be carefully checked, and the source of error determined before proceeding further.

Straight tendons may be tensioned from one end. The draped tendons shall be stressed by jacking from both ends of the bar unless otherwise provided on the plans or in the proposal.

In all stressing operations the stressing force shall be kept symmetrical about the vertical axis of the members.

E) Stressing Procedure - The Contractor shall submit his plan and procedure for stressing each type of unit to the City Engineer for approval prior to fabrication. The procedure should include, but not be limited to initial tensioning force to equalize stresses and eliminate slack in the strands; uplift and hold down devices; method of Pre-tensioning and detensioning; measurement of elongation; and anchorage details.

1) Pre-tensioning - The amount of stress to be given each cable shall be as shown on the plans. Cable stress shall be maintained between anchorages until the concrete has reached the required compressive strength.

2) Post-tensioning - For all Post-tensioned bars, the anchor plates shall be set exactly normal in all directions to the axis of the bar. Parallel wire anchorage cones shall be recessed within the beams. Tensioning shall not be done until the concrete has reached the required compressive

strength.

3) Combined Method - If the girders are manufactured with part of the reinforcement pre-tensioned and part post-tensioned, the applicable portions of requirements listed above shall apply to each type.

4) Ducts for Post-tensioning Bars - Ducts in the girders for the post-tensioning bars or parallel wire cables shall be formed by means of flexible metal conduits, metal tubing, or other approved means. They shall be mortar tight, accurately placed, and accurately held in place. Metallic conduit shall be of a ferrous metal.

   The ducts through post-tensioned members in which the bars or cables are installed shall be equipped with approved grouting vents. After completion of stressing, the annular space between sides of the bar or cable and sides of hole shall be grouted in a manner approved by the City Engineer.

F) Construction, Testing, and Inspection - Construction methods and testing shall be in accordance with the AASHTO Standard Specifications for Highway Bridges and as supplemented herein.

1) The Contractor shall notify the City Engineer of the time at which the stressing procedure, casting procedure, or releasing of strands are to take place so that an Inspector can be present during casting and Pre-stressing of the beams.

2) After the stressing of pre-tensioned strands has been completed and before side forms are erected, the Inspector shall examine the strands, and any strand found contaminated with the bond breaking substance used on the forms shall be replaced or satisfactorily cleaned with a solvent.

   The Inspector shall inspect batching and placement and make six (6) cylinders for each casting operation: three (3) of the cylinders shall be used to determine when concrete has reached the required strength and is ready for stressing, and the remaining cylinders shall be tested at twenty- eight (28) days to determine that the design strength has been reached. Cylinders shall be cured in the same manner as the structural member which is represented by the cylinders until the requirements for stressing have been attained and the remaining period for the twenty-eight (28) day cylinders shall be in accordance with AASHTO T-23. Cylinders shall be tested in accordance with AASHTO T-22.

G) Transportation and Storage - Pre-cast girders should be maintained in an upright position, and points of support and directions of the reactions with respect to the girder shall be approximately the same during transportation and storage as when the girder is in its final position.

Care shall be taken during storage, hoisting, and handling of the pre-cast units to prevent cracking excessive camber, side bow, or other damage. Units damaged by improper storing or handling shall be replaced by the Contractor at no additional cost to the City. Minor chipping, spalling and scars may be repaired if approved by the City Engineer.

H) Erection, Bearings and Anchorage - All bearing areas on the pre-stressed members, as well as on the bridge seats, shall be finished to a true surface to give full and uniform bearing over the entire bearing area. In case such a uniform bearing is not obtained, the defect shall be corrected in a manner approved by the City Engineer.

All anchorages shall be carefully constructed as shown on the plans. Before any member is erected, the City Engineer will check the elevations of all bridge seats. Any elevation which is off more than .02 feet shall be corrected in a manner approved by the City Engineer. Pre-stressed beams shall be blocked or braced as they are set in place to assure lateral stability.

I) Tolerances - Maximum dimensional tolerances are listed below. It is intended that the dimensions

of all members shall be well within these tolerances and the maximum values shall be permitted to be approached or equaled only occasionally. The Inspector shall document to the City Engineer any unit with dimensions out-of-tolerance.

TABLE 405:1 Pre-stressed Concrete I-Beams Tolerance in Inches	
Depth (flanges, web and fillets)	¼"
Depth (overall)	½" to -¼"
Width (flanges and fillets)	⅜" to -¼"
Width (web)	⅜" to -¼"
Length of Beams	1"
Exposed Beam Ends Deviation from Square or Designated Skew – Horizontal	½"
Diaphragm Bolt Holes (spacing between centers of inserts and from the centers of inserts to the ends of the beams)	½"
Bearing Plates (spacing between the centers of bearing plates)	/8" per 10 LF
Bearing Plates (spacing from the centers of bearing plates to the ends of the beams)	½"
Bearing Plat or Bearing Area Deviation from Plane	1/8"
Stirrup Bars – Projection Above Top of Beam	¾"
Stirrup Bars – Longitudinal Spacing	1"
End Stirrup Bars	½" from Plan
Horizontal Alignment (deviation from a straight line parallel to the centerline of beam)	/8" per 10 LF
Camber Differential between Adjacent Beams 1/8 per 10 ft. of span to maximum of 1	¼"
Center of Gravity of Strand Group	½"
Center of Gravity of Depressed Strand Group at end of Beam	¼"
Position of Post-Tensioning Duct	6"
Position of Hold Down Points for Depressed Strand	6"
Position of Handling Devices	6"

Variations greater than specified above shall be corrected to within these tolerances or be subject to a structural review by the City Engineer for acceptance.

J) Finish - The facia girder on grade separation structures shall receive a surface finish consistent with other areas of the superstructure. Surface finish shall be in accordance with Section 403.

405.05 TESTING — VACANT

405.06 METHOD OF MEASUREMENT

Accepted Pre-stressed concrete beams will be measured by the linear foot of pre-stressed concrete beam complete in place as specified and as shown on the plans.

Joint fillers, joint sealers, shoes, bearing plates, and elastomeric bearing pads will not be a separate pay item, but the cost of same shall be included in the price of other bid items unless otherwise shown on the plans. When approved by the City Engineer, twenty (20) percent additional cement and admixture can be used in lieu of High Early Strength Portland Cement.

405.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	Pay Unit:
(A) PRE-STRESSED CONCRETE BEAMS	Linear Foot [Meter]

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.

SECTION 406 – HIGH EARLY STRENGTH CONCRETE

406.01 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 Section 901. It shall be used for structures or portions of structures only when approved by the City Engineer or called for on the plans or in the special provisions.

406.02 MATERIALS

Materials shall meet the requirements specified in Section 901.

406.03 EQUIPMENT — VACANT

406.04 CONSTRUCTION METHODS

A) Tests - Test specimens shall be in accordance with Section 901.

B) Curing

1) Floor slabs shall be cured as provided in Section 409.

2) The side forms on curbs and piles may be left in place for at least three (3) days or if removed before the three (3) days have elapsed, the surfaces shall be cured for the remaining time by one of the methods specified herein. Surfaces that require a concrete surface finish shall be shrouded with wet burlap or wet mats from the time the forms are removed until the three (3) day curing period has elapsed.

C) Removal of Forms - To obtain a satisfactory surface finish, forms on ornamental work, railings, parapets, curbs, and vertical surfaces, which do not carry loads and will be exposed in the finished work, shall be removed within forty-eight (48) hours, depending upon weather conditions, and in any event while a satisfactory finish can still be obtained.

Before forms are removed or the concrete placed in service on portions of structure carrying loads the compressive strengths of test cylinders or modulus of rupture of test beams shall be as provided in Sections 403.04.11 and 404.05 as applicable.

D) Reinforced Concrete Piling - High Early Strength Concrete piling shall not be moved and stacked in less than three (3) days after casting, nor driven in less than seven (7) days after casting, and in no event until a compressive strength of thirty-five hundred (3,500) psi or a modulus of rupture of six hundred (600) psi when tested with third point method or seven hundred (700) psi when tested with midpoint method in accordance with Section 901.

406.05 TESTING — VACANT

406.06 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.

406.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) HIGH EARLY STRENGTH CONCRETE	Cubic Yard [Cubic Meter]

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.

SECTION 407 – PNEUMATICALLY PLACED CONCRETE

407.01 DESCRIPTION

This section covers premixed sand and Portland Cement pneumatically transported through a pipe or hose in a dry state to a nozzle where hydration takes place immediately prior to expulsion.

407.02 MATERIALS

The cement, water, and sand shall conform to the requirements of Section 901, "Portland Cement Concrete". The sand, when tested by approved laboratory methods, shall conform to the following gradation requirements:

Passing No. 4 Sieve	98-100% (by weight)
Passing No. 20 Sieve	60-85%
Passing No. 50 Sieve	15-35%
Passing No. 100 Sieve	0-5%

Bar reinforcement and wire fabric reinforcement shall conform to the requirements of Section 923, "Reinforcing Steel".

Expansion joint material shall conform to the requirements of Section 901.08, "Preformed Expansion Joint Filler for Concrete".

Steel drive pins or studs used for the attachment of reinforcing when covering designed portions of concrete structures with pneumatically placed concrete shall be capable of being driven to the specified depth without deforming or otherwise becoming unsuitable for the purpose intended. The pins shall have a minimum diameter of one-eighth (1/8) inch and a minimum length of two (2) inches. Size and location of drive pins or studs and method of attachment of reinforcing shall be as specified herein or as detailed on the plans.

The equipment used for driving the pins or studs shall be of the type which uses an explosive for the driving force and shall be capable of inserting the stud or pin to the required depth without damage to the concrete. The City Engineer may require that a test be made of the equipment prior to approving

it for use.

Unless otherwise specified, the concrete shall consist of a mixture of cement and sand in the proportions by volume of one (1) part cement to four and one-half (4 1/2) parts sand. The sand shall contain not less than three (3) percent nor more than six (6) percent of moisture by weight. The sand and cement shall be mixed thoroughly in a power mixer for at least one and one-half (1 1/2) minutes before placement in the chamber of the gun mechanism. The dry mixed material shall be used promptly after mixing and any material that has been mixed for more than forty-five (45) minutes shall be rejected and removed from the worksite.

The mixer shall be cleaned at regular intervals to remove all adherent material from the mixing vanes and from the drum.

At the beginning of work the City Engineer may require that cylinders be made to represent the quality of the pneumatically placed concrete. Additional cylinders will be made during prosecution of the work as directed by the City Engineer. If, in the opinion of the City Engineer, the cylinder strengths are indicating undesirable variation in the concrete, the Contractor may be required to change the mix design and/or method of placing to correct this condition.

The Contractor shall furnish especially constructed cylinders six (6) inches in diameter and twelve (12) inches high, made of three-fourths (3/4) inch square mesh hardware cloth. Test cylinders for pneumatically placed concrete shall be shot with the same air pressure and nozzle tip as the pneumatically placed concrete. At the end of the first twenty-four (24) hours curing period the hardware cloth form shall be removed and the cylinders stored and cured as directed by the City Engineer.

The use of approved admixtures conforming to the requirements of Section 901, "Concrete Admixtures", will be permitted at the option of the Contractor.

407.03 EQUIPMENT

The gun mechanism should be operated at a minimum air pressure of forty-five (45) pounds per square inch on the gun tank when one hundred (100) feet or less of material hose is used and the pressure should be increased five (5) pounds for each additional fifty (50) feet of hose required. Nozzles used for guniting shall have a maximum size of one and five-eighths (1 5/8) inch unless otherwise permitted by the City Engineer.

Water used for hydration shall be maintained at a uniform pressure, which shall be at least fifteen (15) pounds per square inch above air pressure at the gun.

407.04 CONSTRUCTION METHODS

A) Placement - Earth surfaces to which concrete is to be applied shall be neatly trimmed to line and grade and shall be free of all loose material.

   No high subgrade will be permitted. Excavation made below subgrade shall be backfilled with compacted fill or, at the Contractor's option, with concrete. However, no additional compensation will be allowed for such compacted fill nor for increased thickness of concrete placed because of low subgrade.

   Asphaltic concrete surfaces shall be thoroughly cleaned of any organic Material, silt and clay, or any other material detrimental to the concrete and then washed with water under pressure.

   Masonry, rock, and concrete surfaces shall be examined, and all loose material removed therefrom. The surface shall be thoroughly cleaned with steel scrapers or brushes to remove all dust, dirt, mortar, grease, or other deleterious substances and then washed with water.

Whenever brushing and scraping do not secure suitable results, sandblasting may be required.

All surfaces shall be wetted with water before application of concrete. Concrete shall not be applied to surfaces on which free water exists.

The velocity of the material as it leaves the nozzle shall be maintained uniformly at a rate determined for given job conditions. Material which rebounds and does not fall clear of the work, or which collects on the surfaces shall be blown off or otherwise removed. Rebound shall not be used in any portion of the work and no payment will be made for rebound or other concrete losses.

The nozzle shall be held at such distance and position that the stream of flowing material will impinge at approximately right angles to the surface being covered. Any portion of the placed concrete which tends to sag, or which shows soft or sandy pockets or is otherwise unsatisfactory, shall be cut out and replaced with new concrete. Reinforcement damaged or destroyed by such repairs shall be replaced by trimming the concrete back and properly lapping and tying additional steel as may be required by the City Engineer.

Reinforcement shall be firmly supported in the position shown on the plans. Mortar blocks, metal chairs, clips, or spacers with wire ties or other acceptable means shall be used to anchor and place the reinforcement properly.

Where material is placed on overhead surfaces the amount of water used shall be so adjusted that approximately three-fourths (3/4) inch of the placed material shall adhere without support. The limit of thickness shall be considered to have been exceeded when the material begins to sag or slough.

B) Forms and Ground Wires - The forms shall be built in accordance with applicable provisions of these specifications, except all forms shall be built to permit the escape of air and rebound.

Ground wires shall be installed in such a manner that they accurately outline the finished surface as indicated on the plans. They shall be located at intervals sufficient to insure proper thickness throughout. Wires shall be stretched tight and shall not be removed prior to application of the finish coat.

Headers will be required where the plans indicate a formed edge and at plan joints.

C) Joints - Construction joints shall be sloped off at an angle of approximately forty-five (45) degrees to the surface to which the concrete is being applied. Before applying concrete in the adjacent sections, the sloped portion shall be thoroughly cleaned and wetted by means of air and water blast. The plan joints shall be formed in accordance with and placed in the locations designated on the plans.

D) Finish - Upon reaching the thickness and shape outlined by forms and ground wire, the surface shall be rodded off to true lines. Any low spots or depressions shall be brought up to proper grade by placing additional concrete. Ground wires shall then be removed, and unless otherwise specified, the surface shall then be broom finished to secure a uniform surface texture. Rodding and working with a wood float shall be held to a minimum. Rebound or accumulated loose sand shall be thoroughly cleaned up and disposed of by the Contractor. In no case shall it be floated into the surface of the work.

When a nozzle finish is specified on the plans, ground wires shall not be used, and the surface shall be left as uniform as possible without rodding. Nozzle finishes will not be permitted where the underlay has been floated. Concrete shall not be applied to a surface containing frost or ice. Where standing or running water is encountered it shall be removed before applying the concrete. No work shall be done without the permission of the City Engineer when the temperature is lower than forty (40) degrees F. After placing, the concrete shall be protected from freezing or quick

drying.

E) Curing - Pneumatically placed concrete shall be cured in accordance with Section 403, "Concrete Structures".

F) Workmen - Only experienced foremen, gunmen, nozzlemen, and rodmen shall be employed, and satisfactory written evidence of such experience shall be furnished the City Engineer or his representative upon demand.

407.05 TESTING — VACANT

407.06 METHOD OF MEASUREMENT

Measurement for pneumatically placed concrete will be made by the square foot in place. For encasement of structural steel members and covering portions of structures, the actual contact area shall be the basis for measurement.

Pneumatically placed concrete, measured as provided above, will be paid for at the unit price bid per square foot for "Pneumatically Placed Concrete", of the type specified. The unit price bid per square foot shall be full compensation for all cement, sand, water, reinforcement, furnishing and driving all steel drive pins, for mixing and placing pneumatically placed concrete, and for all labor, tools, equipment, and incidentals necessary to complete the work. Excavation for channel and canal lining will be paid for in accordance with Section 200, “Excavation”. Shaping and fine grading of channel or canal slopes and floors are not to be paid for directly but shall be included in the unit price bid for "Pneumatically Placed Concrete".

407.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) PNEUMATICALLY PLACED CONCRETE	Square Foot [Square Meter]

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.

SECTION 408 – STEEL STRUCTURES

408.01 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.

408.02 MATERIALS

408.02.01 – GENERAL

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.

408.02.02 – SHOP DRAWINGS

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. The drawings shall be prepared on sheets twenty-four (24) inches by thirty-six (36) inches, or as designated by the City Engineer.

All shop drawings shall be checked by the fabricator before being submitted for approval by the City 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 City Engineer.

408.02.03 – STORING MATERIALS

All materials shall be handled in such manner that no injury will result. Material to be stored shall be placed on skids above the ground and shall be kept clean and properly drained. Girders and beams shall be placed upright and shored. Long members, such as columns, shall be supported on skids placed closely enough to prevent excessive deflection.

408.03 EQUIPMENT

Before starting work, the Contractor shall inform the City 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 City Engineer. The approval of the City 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 City 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.

408.04 CONSTRUCTION METHODS

408.04.01 – 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 A-6.

Before being laid out or worked, rolled material shall be straight. If straightening is necessary, it shall be done by methods approved by the City 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 City 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.

408.04.02 – RIVETED AND BOLTED STRUCTURES

Unless prohibited by the plans, 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.

408.04.03 – HOLES FOR BOLTS OR RIVETS

Holes shall be either punched full size, punched, and reamed, or drilled. The finished hole shall be one- sixteenth (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 three thirty- seconds (3/32) inch.

A) Holes for Shop Rivets shall be sub punched, or subdrilled at the fabricator's option, one-fourth (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:

   1) Holes in material thicker than seven-eighths (7/8) inch shall not be punched; however, at the fabricator's option, they may be subdrilled to the diameter specified for sub punching or may be drilled full size with the parts assembled, provided that the parts are adequately bolted or clamped together.

   2) Holes in rolled beams and plate girders, including stiffeners and active fillers at bearing points, may be sub punched one-eighth (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 one-eighth (1/8) inch.

   3) Holes in material not more than seven-eighths (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 sub punched one-eighth (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 sub punched for the fabricator's convenience, or the assembled material is not over five (5) plies thick, of which the main material consists of not more than three (3) plies.

B) Holes for Field Rivets shall be sub punched or subdrilled at the fabricator's option, one-fourth (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:

   1) 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 three (3) abutting sections assembled and with milled ends of compression chords

in full bearing.

2) 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.

3) Field connections of lateral, longitudinal, or sway bracing shall conform to the requirements of holes for shop rivets.

4) Holes in material thicker than seven-eighths (7/8) inch shall not be punched but shall be subdrilled to the diameter specified for sub punching 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.

   Mis-punched members shall not be corrected by welding without the approval of the City Engineer.

408.04.04 – REAMED WORK

Reaming shall be done after the pieces forming a built-up member are assembled and so firmly bolted together that the surfaces are in close contact. Burrs and sharp edges of each reamed hole under both rivet heads shall be removed with a countersinking tool making one-sixteenth (1/16) inch fillets. The pieces shall be taken apart before riveting, if necessary, and any shavings removed. If it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked that they may be reassembled in the same position. Reamed parts shall not be interchanged.

408.04.05 – DRILLED HOLES

Drilled holes shall be one-sixteenth (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 one-sixteenth (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 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.

408.04.06 – ASSEMBLING STEEL

Steel parts shall be assembled in the shop or in the field in accordance with the following:

A) 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.

B) 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 City Engineer.

408.04.07 – RIVETING

Shop and field riveting shall conform with the following provisions:

A) 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.

B) 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 ensure good bearing shall be used. Sufficient air capacity shall be maintained to keep the air pressure at one hundred (100) pounds per square inch 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 City Engineer.

408.04.08 – BOLTED CONNECTIONS

When high strength bolts are required or permitted, the bolts shall be in conformance with ASTM A-325-81 and ASTM A-194.

408.04.09 – JOINTS AND CONNECTIONS

A) Edge Planing - Sheared edges of plates more than five-eighths (5/8) inch in thickness and carrying calculated stress shall be planed to a depth of one-fourth (1/4) inch.

B) Facing of Bearing Surfaces - Surfaces of bearing and base plates and other metal bearing surfaces that are to meet each other, with ground concrete surfaces, or with asbestos sheet packing shall be machined flat to within one thirty-second (1/32) inch tolerance in twelve (12) inches and to within one-sixteenth (1/16) inch tolerance overall. Surfaces of bearing and base plates and other metal bearing surfaces that are to meet preformed fabric pads, elastomeric and elastic bearing pads, or Portland Cement grout shall be machined flat to within one-eighth (1/8) inch tolerance in twelve (12) inches and to within three-sixteenths (3/16) inch 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.

C) 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.

D) 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.

E) 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.

F) 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.

G) 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.

H) 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.

I) Screw Threads - Screw threads shall make close fits in the nuts and shall be Unified Standard Series conforming to USASI B1.1-1960.

408.04.10 – BEARINGS AND ANCHORAGE

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 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 City 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 one (1) part Portland Cement and three (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 twenty-four (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 three (3) days. All improperly cured or otherwise defective grout shall be removed and replaced at the Contractor's expense.

408.04.11 – EXPANSION AND ROTATION ASSEMBLIES

Before leaving the shop or foundry the rockers or roller nests shall be completely assembled with the bearing plates for checking and approval by the City Engineer.

408.04.12 – 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 with at least point bearing. Local clearances between the end of the plate and the flange shall not exceed one-sixteenth (1/16) inch.

Unless otherwise shown on the plans or specified, 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.

408.04.13 – 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 Section 984 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.

A) **Cleaning** - 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. 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.

   1) Solvent Cleaning is a procedure for removing foreign matter such as oil, grease, soil, drawing and cutting compounds and other contaminants from steel surfaces using solvents, emulsions, cleaning compounds, steam cleaning or similar materials and methods which involve a solvent

or cleaning action.

2) 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.

3) 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:

   i) 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.

   ii) The surfaces to be painted shall be cleaned and dehydrated (freed of occluded moisture) by the passage of oxyacetylene flames which have an oxygen to acetylene ratio of at least one (1). The inner cones of these flames shall have a ratio of length to port diameter of at least eight (8) and shall be not more than 0.15-inch center to center. 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 three hundred (400) degrees 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.

   iii) 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.

   iv) 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 and the following will apply:

   The inside surfaces of boxed cleaning operation after the member is assembled shall be cleaned as specified in paragraphs 1 and 2 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 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.

4) 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. At least two-thirds (2/3) of each square inch of surface area shall be free of all visible residues and the remainder shall be limited to light discoloration, slight staining or light residues mentioned above.

The maximum size of sand, crushed grit or shot shall be no larger than that passing the No. 16 sieve.

The height of the profile of the anchor pattern produced on the surface shall be limited to a maximum height that will not be detrimental to the life of the paint film. The maximum particle sizes specified may produce an anchor pattern that is too high or too rough for the paint systems used. In such cases, the abrasive sizes should be reduced. If the application of the second coat of paint is deferred, an adequate reduction in anchor pattern height shall be made (reduction in abrasive size).

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 City Engineer prior to painting.

5) 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.

B) **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.

C) **Mixing** - 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 City 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 one (1) part thinner to eight (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.

D) **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.

If stripe painting is specified, all edges, corners, crevices, rivets, bolts, weld, and sharp edges shall be stripe painted with the priming paint before the steel receives its full prime coat of paint. Such striping shall extend for at least an inch from the edge. When practicable, this stripe coat shall be permitted to dry before the prime coat is applied; otherwise, the prime coat shall set to touch before the full prime coat is applied. However, the stripe coat shall not be permitted to dry for a period long enough to allow rusting of the unprimed steel.

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 City 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 two (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.

Steel surfaces not in direct bonded contact but inaccessible after assembly shall receive the full specified paint system before assembly.

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

1) 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.

2) 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.

3) 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 always 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 meet 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 always responsible for safeguarding both public and private property from all hazards and damage resulting from the work.

408.04.14 – 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 City 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.

408.04.15 – 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, considering the dead load deflection of the slab and rail as shown on the dead load deflection diagram.

408.04.16 – 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 City Engineer, and his approval of the method of correction shall be obtained. The correction shall be made in the presence of the City Engineer who will check the material. Such work is to be done at the entire expense of the Contractor.

408.05 TESTING — VACANT

408.06 METHOD OF MEASUREMENT

No direct compensation will be made for "Steel Structures". 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.

408.07 BASIS OF PAYMENT

Structural Steel, measured as provided above, will be paid for at the contract unit price for:

Pay Item:	Pay Unit:
(A) STRUCTURAL STEEL	Pounds [Kilogram]

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.

SECTION 409 – CONCRETE BRIDGE FLOORS

409.01 DESCRIPTION

This section covers the construction of concrete bridge floors in accordance with these specifications and in reasonably close conformity with the lines, grades and dimensions shown on the plans or established by the City Engineer.

409.02 MATERIALS

Materials shall meet the requirements specified in the following Materials:

Portland Cement Concrete	901
Joint Fillers and Sealers	901.08
Reinforcing Steel	923
Curing Materials	901.07

409.03 EQUIPMENT — VACANT

409.04 CONSTRUCTION METHODS

A) **Construction Joints** - Construction joints shall be made only where located on the plans, shown in the concrete placing schedule, or as directed by the City Engineer. Shear keys or inclined reinforcement shall be used where necessary to transmit shear and/or bond the two (2) sections together.

B) **Forms** - All forms shall conform to the requirements of Section 404.04 (C).

C) **Placing Reinforcing Steel** - All reinforcing steel shall be placed in accordance with Section 411.

D) **Expansion Devices** - Expansion devices shall be those shown on the plans. They will be carefully checked for line, grade, and crown.

E) **Placing and Finishing Concrete** - An Approved self-propelled finishing machine shall be used on all bridge decks. Supports for the finishing machine shall be parallel to the centerline of the structure, firmly fastened in place and set to correct line and grade with proper allowances for dead load deflections. A transverse finish shall be provided throughout the entire bridge length unless otherwise approved in writing by the City Engineer.

Concrete bridge floors shall not be struck off longitudinally unless approved by the City Engineer. In such case the templates shall be supported on header boards cut to the crown of the roadway. The header boards shall be surfaced with steel plates unless otherwise approved by the City Engineer. These templates shall be of sufficient weight and rigidity or trussed so that the desired finish camber is obtained longitudinally.

Before placing floor concrete, the forms shall be thoroughly wetted. The concrete shall be placed slightly higher than the finished surface of the floor. Immediately after the concrete has been placed and compacted as specified under Section 404.04 (D), it shall be carefully struck off to proper crown and finished to a smooth, even surface.

While the concrete is still plastic, the surface of the concrete shall be tested for trueness with a ten (10) foot straightedge. Any depressions found shall be filled immediately with freshly mixed concrete, and any high areas shall be cut down. The surface shall be struck off, consolidated and refinished. Special attention shall be given to ensure that the surface across joints fully meet the requirements for smoothness. Final finish shall be uniformly textured by transverse brooming or other methods approved by the City Engineer unless otherwise specified on the plans.

The Contractor shall furnish enough work bridges, a minimum of two (2), to enable his workmen to satisfactorily perform the floating, straight-edging, curing and final finishing at the proper times. The surface shall be given a further test for trueness using a ten (10) foot straightedge or other specified device before final acceptance. Areas showing high spots of more than one-eighth (1/8) inch shall be marked and immediately ground down with an approved grinding tool to tolerance requirements. The skid resistant surface shall then be restored in all ground down areas in a manner

approved by the City Engineer.

Tops of curbs shall be finished with a wooden float. Chamfer strips on curbs shall be set to established line and grade after the floor is placed.

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 ensure 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.

F) **Curing Floors and Parapets** - Floors, curbs and parapets shall be cured in accordance with Section 403.04.10. with approved materials immediately after the finishing operations have been completed and marring of the concrete will not occur. The curing shall be maintained for a period of seven (7) days. Materials shall meet the requirements of Section 901.

If a penetrating sealer is called for in the plans, application shall be made following the minimum curing period.

G) **Removing Forms** - The side curb and parapet forms shall be removed in warm weather within twenty-four (24) hours after the concrete is placed and in cool weather within forty-eight (48) hours or at least as soon as they may be removed without damaging the curb. All wires shall be cut one- fourth (1/4) inch back of the surface of the concrete and the holes shall be filled with stiff cement mortar at once.

Forms supporting concrete floors placed on truss or I-beams, plate girder or pre-stressed girder spans shall be left in place at least fourteen (14) days. In unfavorable weather, the specified time shall be increased at the discretion of the City Engineer.

The above specified time may be decreased in case test beams or test cylinders made, cured, and tested in accordance with Section 901 meet the specified minimum requirements.

In no case shall the forms supporting concrete floors on truss or I-beams, or girder spans be removed in less than five (5) days after the concrete is poured.

H) **Load on Floors** - Loads shall not be placed on floor slabs for a period of seven (7) days or until forms are removed. Pneumatic-tired concrete carts or "buggies" holding not more than six (6) cubic feet of concrete per tire and holding not more than twenty-one (21) cubic feet of concrete per cart or "buggy", may pass over the floor after forty-eight (48) hours have elapsed after the completion of the placement. Plank runways of three (3) inch minimum thickness placed on a sand cushion having a depth of not less than four (4) inches must be provided for the carts or "buggies". If High Early Strength Concrete is used, the carts or "buggies" may pass over the floor after twenty-four (24) hours on runways with sand cushion as provided above. In no case shall a mixer be operated on concrete bridge floors without prior approval of the City Engineer. Stockpiles of material placed on concrete floors shall not exceed sixty-four (64) pounds per square foot.

I) **Opening to Traffic** - Concrete bridge floors on I-beams, girders and trusses may be opened to

traffic after a period of twenty-one (21) days has elapsed since the last concrete was placed in the floor.

The above specified time may be decreased if test beams, or test cylinders are cast at the time the last concrete was placed in the floor. Test beams and test cylinders shall be made, cured, and tested in accordance with Section 901. The bridge may be opened to traffic when the test beams meet strength requirements as provided in Section 901 or when test cylinders have a minimum compressive strength of three thousand (3000) psi. In no case shall bridge floors on I-beams, plate girders, pre-stressed concrete girders, and trusses be opened to traffic in less than seven (7) days after the last concrete is placed in the floor.

When unusually low temperatures prevail during the curing period, the time of opening to traffic may be extended beyond the limits designated above, if required by the City Engineer.

When the use of High Early Strength Concrete is approved by the City Engineer in bridge floors, the time of opening to traffic will be governed by Section 406.

409.05 TESTING — VACANT

409.06 METHOD OF MEASUREMENT

The accepted quantities which constitute the completed floor will be measured by the cubic yard of concrete according to the plans. Additional concrete required to take care of deflection will be included under this item, unless otherwise shown on the plans.

409.07 BASIS OF PAYMENT

Concrete bridge floors, measured as provided above, will be paid for at the contract unit price for Section 404.07 Structural Concrete which shall be full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

SECTION 410 – PORTLAND CEMENT CONCRETE OVERLAY OF BRIDGE FLOORS

410.01 DESCRIPTION

A) **Repair.** Repair of bridge decks consists of removing loose, delaminated, spalled, or deteriorated concrete from the existing surface, replacing with new high-density concrete, or latex modified concrete and other necessary work as specified in the contract documents. When the bridge deck is to be overlaid, the replacement material for Class A and Class B repair shall be the same as the overlay material.

The City Engineer will make a field inspection of all bridge decks and determine the areas of concrete deck to be repaired. These areas will be marked by the City Engineer and repaired by the Contractor. The lower limit for Class A and Class B bridge deck repair shall be to suitable existing concrete, as determined by the City Engineer. Bridge deck repair shall be classified as follows:

1) *Class A Bridge Deck Repair.* Class A bridge deck repair consists of:

   i) Removing unsound concrete down to the top mat of reinforcing steel.

   ii) Disposing of concrete removed.

   iii) Replacing the excavated volume of concrete with high density concrete or latex modified concrete.

2) *Class B Bridge Deck Repair.* Class B bridge deck repair consists of:

i) Removing unsound concrete below the top mat of reinforcing steel.

ii) Cleaning existing concrete from the top mat of reinforcing steel in the repair area.

iii) Disposing of concrete removed.

iv) Replacing the excavated volume of concrete with high density concrete or latex modified concrete.

3) *Class C Bridge Deck Repair*. Class C bridge deck repair consists of:

i) Removing all unsound concrete for the full depth of the deck.

ii) Cleaning existing concrete from both mats of reinforcing steel in the repair area.

iii) Disposing of concrete removed.

iv) Replacing the excavated volume of concrete with Class AA concrete.

B) **Overlays.** Overlay of bridge decks consists of deck preparation and overlaying with either high density concrete or latex modified concrete, and other necessary work as specified in the contract documents. Unless otherwise specified, the overlay shall raise the roadway surface and shall cover the entire concrete deck. Deck preparation and overlaying consist of:

1) Sandblasting and/or chipping the concrete to a depth as necessary to remove rust, oil, and other foreign matter leaving a clean etched concrete surface free of any laitance; (Where the original deck concrete was cured by linseed oil emulsion, the entire deck shall be scarified to a depth of ¼ inch (6mm) below the original surface.)

2) Disposing of concrete removed.

3) Overlaying with the specified overlay concrete to the depth designated in the contract documents.

Thickness of the concrete overlay shall be measured from the level of the original surface to the specified final raised surface as shown on the Plans. When the deck is to receive Class A or Class B repairs, the replacement material may be placed monolithically with the overlay course or separately prior to the overlay.

410.02 MATERIALS

Use materials conforming to the following Sections:

High Density Concrete	901.10
Latex Modified Concrete	901.11

For repairs and overlays, use either high density concrete or latex modified concrete as specified in the contract documents. Limit the maximum concrete temperature to 85°F (30°C).

410.03 EQUIPMENT

Provide all equipment with suitable traps, filters, drip-pans, or other devices to prevent oil or other deleterious matter from being deposited on the deck.

A) **Surface Preparation Equipment.** Use the following types of surface preparation equipment:

1) *Sawing Equipment.* Use sawing equipment capable of sawing concrete to the specified depth.

2) S*andblasting Equipment.* Use sandblasting equipment capable of removing rust and old concrete from the exposed reinforcement.

3) *Power Driven Hand Tool*s. Power driven hand tools for removal of concrete will be permitted with the following restrictions:

- Limit the nominal size class of jack hammers to a maximum of 30 pounds (125n).
- Operate jack hammers or mechanical chipping tools at an angle less than 45° measured from the surface of the slab.
- For removing concrete from beneath any reinforcing bar, limit the nominal size class of chipping hammers to a maximum of 15 pounds (65N).

4) *Scarifying equipment.* Use a scarifier for preparing an existing deck for an overlay. Use a power-operated mechanical scarifier capable of uniformly scarifying or removing the old surface to the depths required.

B) **Proportioning and Mixing Equipment.**

1) *For High Density Concrete.* Use proportioning and mixing equipment meeting the requirements of Section 901 for high density concrete. Use a construction or stationary concrete mixer of the rotating-paddle type, or a continuous mixer used in conjunction with volumetric proportioning.

2) *For Latex Modified Concrete.* Use proportioning and mixing equipment of a self- contained, mobile, continuous-mixing type meeting the following requirements:

i) The mixer shall be self-propelled and shall be capable of carrying sufficient unmixed, dry, bulk cement, sand, coarse aggregate, latex modifier, and water to produce on the site not less than 5 cubic yards (5m 3) of concrete.

ii) The mixer shall be capable of positive measurement of cement being introduced into the mix. The recording meter visible always and equipped with a ticket printout shall indicate this quantity.

iii) The mixer shall provide positive control of the flow of water and latex emulsion into the mixing chamber. Water flow shall be indicated by a flowmeter and shall be readily adjustable to provide for minor variations in aggregate moisture.

iv) The mixer shall be capable of being calibrated to automatically proportion and blend all components of indicated composition on a continuous or intermittent basis as required by the finishing operation and shall discharge mixed material through a conventional chute directly in front of the finishing machine. Sufficient mixing capacity of mixers shall be provided to permit the intended placement of the mixed material without interruption.

C) **Placing and Finishing Equipment**.

1) *Placing Equipment.* For placing and rough finishing, use adequate hand tools for placement of stiff plastic concrete to approximately the strike off level of the screed.

2) *Finishing Machines.*

i) *Repairs.* For deck repairs, use a vibrating screed to finish the deck surface.

ii) O*verlays.* Place and finish overlays with an approved finishing machine meeting the following requirements.

Use a finishing machine capable of screeding concrete within 12 inches (300mm) of the face of the existing curb or parapet wall. Make the screed sufficiently long to extend at least 6 inches (150mm) beyond the sides of the placement section, overlapping previously

placed courses, overlay forms, and existing and planned sawcut edges. Provide each screed with positive control of the vertical position, the angle of tilt, and the shape of the crown.

Power and gear the finishing machine to maintain smooth finishing operations under all conditions in forward and reverse. Make provisions for raising the screeds to clear the screeded surface for traveling in reverse.

Use a finishing machine capable of final screeding within 10 minutes of depositing the concrete on the deck under normal operating conditions.

Support the finishing machine on rails that are fully adjustable, not shimmed, to obtain the correct profile.

When placing concrete in a lane abutting a previously completed lane, equip the finishing machine to travel on the completed lane without marring or damaging its surface.

For high density concrete overlays, use a mechanical strike-off to provide a uniform thickness of concrete in front of the oscillating screed. Equip the oscillating screed(s) to consolidate the concrete to 98% of the unit weight determined by AASHTO T 121. Install identical vibrators along the screed length on 5-foot maximum centers. Make the bottom face of this screed at least 5 inches wide with a turned up or rounded leading edge to minimize tearing of the surface of the plastic high density concrete.

For latex modified overlays, use a finishing machine equipped with not less than two finishing devices:

- A vibrating screed designed to consolidate the modified composition to 98% of the rodded unit weight, and one of the following,
- A vibrating oscillating screed, or
- A finishing device consisting of one or more rotating cylindrical drums not exceeding 4 feet in length.

Equip the vibrating screed(s) for latex modified concrete with positive control of vibration so that vibration frequency can be varied between 3000 and 6000 vibrations per minute. Make the bottom face of the screed at least 4 inches wide.

410.04 CONSTRUCTION METHODS

A) **General.** Comply the requirements of Section 403 unless otherwise specified.

B) **Work Plan.** Before starting the work, submit a work plan to the City Engineer and obtain approval. Allow 14 days for the City Engineer's review. Include descriptions of the material, equipment, and forms to be used, and the labor requirements.

C) **Preparation of Surfaces**.

1) *General Requirement for Repairs.* Remove all unsound deck concrete as specified. Repair areas will be enlarged, reduced, or reclassified as directed by the City Engineer, based upon inspection. Do not revise the size of a repair area without permission.

Provide a saw-cut vertical edge around the perimeter of the repair areas. Make the saw cut at least 1 inch (25mm) deep measured from the original surface of the deck. Avoid cutting, stretching, or damaging any exposed reinforcing steel. Blast clean reinforcing steel to remove all concrete. Replace damaged reinforcing steel, lapping new and old reinforcing as directed.

After removing all unsound concrete, clean and dry the repair area using sandblasting and

filtered air blast. Remove all rust, oil, and other foreign matter to provide a clean, dry, etched concrete surface.

2) *Class A Bridge Deck Repair.* For Class A repair, remove unsound concrete by chipping with power hand tools. In Class A repair areas, notify the City Engineer before removal below the top mat. Where removal of material beneath the top mat of reinforcing steel is directed, the repair will be classified as Class B repair.

3) *Class B Bridge Deck Repair.* For most Class B repair, remove unsound concrete by the methods used for Class A repair. If removing unsound concrete deeper than 50% of the original deck thickness, use 15-pound (65N) chipping hammers or hand tools to prevent damage to remaining concrete. In Class B repair areas, notify the City Engineer before removing concrete below the mid-depth level. Remove concrete at least 1 inch (25mm) below the top mat. If the depth of the bottom mat is reached, remove the full depth of the deck. Full depth removal will be classified as Class C repair.

4) *Class C Bridge Deck Repair.* For Class C repair, remove the concrete for full depth of the deck, leaving the reinforcing steel intact. Provide forms enable placement of new concrete in the full depth opening. For areas of one square yard or greater, support forms from the existing superstructure. For smaller areas, the forms may be suspended from existing reinforcing bars by wire ties. Remove all forms when completed. Show typical forming details in the work plan submittal.

5) *Overlays.* Clean the entire existing concrete deck area uniformly using sandblasting alone or chipping followed by sandblasting. Sandblast that portion of the curb or parapet wall against which new concrete is to be placed. Remove all rust, oil, and other foreign matter to provide a clean, etched concrete surface free of laitance. If the original deck concrete was cured with linseed oil emulsion, scarify to a depth of 1 / 4 inch (6mm) below the original deck before cleaning. Place expansion joints as shown on the contract drawings. The longitudinal and transverse profile and the elevation of all expansion joints will be established by the City Engineer.

D) **Mixing**.

1) *High Density Concrete.* Mix high density concrete at the project site in accordance with Section 901.

2) *Latex Modified Concrete.* Comply with the following requirements for the proportioning and mixing latex modified concrete materials:

i) *Measurement of Materials.* Accurately proportion all materials for the specified mixture using a mobile continuous mixer. Calibrate the proportioning equipment for each material in the presence of the inspector. Operate the proportioning equipment at the manufacturer recommended speed during calibration, checks, and normal operation. Make yield checks as needed.

ii) *Mixing of Materials.* Mix materials in accordance with the specified requirements for the equipment used. The mixture, as discharged from the mixer, shall be uniform in composition and consistency. Mixing capability shall be such that finishing operations can proceed at a steady pace with final finishing completed before the formation of the plastic surface film.

3) *Class AA Concrete.* Comply with Section 901.

E) **Placing and Finishing Concrete for Repairs**.

1) *General.* Concrete for repairs may be placed either monolithically with overlays or separately. In addition to the surface screed vibration, vibrate the fresh concrete internally if the concrete thickness is 3 inches (75mm) or more.

   If to be overlaid, leave the repair rough textured. If not to be overlaid, match the surface texture of the repair with the existing deck. Unless part of an overlay, place concrete to the level to the existing deck.

2) *Surface Preparation Immediately before Concreting*

   i) G*routing for High Density Concrete.* Before placing high density concrete, scrub a thin coating of bonding grout into the dry, prepared surface. Exercise care to ensure that all parts receive a thorough, even coating, and excessive grout does not collect in pockets. Limit the application rate of grout to ensure the grout does not dry before concrete placement. Since grout will dry on a vertical surface more rapidly than the flat deck surface, give special attention to maintaining the grout in the required condition.

   ii) *Surface Wetting for Latex Modified Concrete.* Before placing latex modified concrete, clean the repair areas with air blast followed by flushing with water. Keep the surfaces wet for an hour or more before placing latex modified concrete. Remove puddles of free water before concrete placement.

F) **Placing and Finishing Concrete for Overlays**.

1) *Dimensions.* Make high density overlays 2 inches (50mm) ± ¼ inch (6mm) thick and latex modified overlays 1 ½ inches (38mm) ± ¼ inch (6mm) thick. Limit the width of each overlay pass to a maximum of 26 feet (8m).

2) *Joints.*

   i) H*igh Density Concrete.* Saw the previously placed high density concrete overlay course to have straight and vertical edges at transverse and longitudinal joints, before placing the adjacent overlay course. Remove all slurry produced by wet sawing of concrete joints from prepared areas before placing new concrete.

   ii) *Latex Modified Concrete.* Install transverse bulkheads, equal in depth to the thickness of the latex modified concrete, to the required grade and profile before placing concrete. 3. *Finishing Machine Setup.* Adjust the finishing machine to provide the required overlay profile. Place finishing machine rails outside the area to be concreted. Positively anchor the rails to provide horizontal and vertical stability for the rails. Do not use a hold-down device shot into the concrete unless the concrete is to be subsequently resurfaced. Submit working drawings for anchoring support rails for approval.

3) *Trial Run*. Before concrete is placed, make a dry run with the finishing machine to check anticipated overlay thickness. Attach a filler block having a thickness 1 / 8 inch (3mm) less than overlay thickness to the bottom of the screed. With screed guides in place, pass the screed over the area to be concreted. Correct, in an approved manner, those areas not having the required clearance.

4) *Surface Preparation Immediately before Concreting.* Prepare the surface to be overlaid in the manner specified for repairs using like concrete type.

5) *Placement.* Place concrete in a continuous operation throughout the pour. In case of a long delay in latex modified concrete placement, install a transverse bulkhead. During shorter delays of less than one hour, protect the end of the placement from drying with several layers of wet burlap.

Place and mechanically strike off the new concrete overlay slightly above the final grade. Mechanically consolidate to 98% of the unit weight, determined by AASHTO T 121, and screed to final grade. In addition to the surface screed vibration, vibrate fresh concrete internally if 3 inches (75mm) or more in thickness. Hand finish with a wood float as required to produce a tight, uniform surface.

6) *Work Bridges.* Always keep a minimum of two movable work bridges on hand during concrete placement. Use one of the work bridges for nuclear density measurements and surface finishing and texturing. Use the other work bridge to apply the curing.

7) *Evaporation Control and Curing.* Control evaporation of moisture from the fresh overlay concrete and cure. Cracking or other damage caused by improper curing will be cause for rejection of the work.

8) *Ambient Temperature Limitations.* Do not place concrete when the air or deck temperature is cooler than 45°F or the deck temperature is hotter than 85°F.

The City Engineer may require placing concrete during the nighttime hours during hot weather. The City Engineer will inform the Contractor, in writing, if night placing becomes necessary.

G) **Straightedge Testing and Surface Tolerance**. Immediately after completing the surface of either a repair or overlay and before final finishing, test the surface for trueness with a 10-foot (3m) straightedge. When the straightedge is laid on the repaired pavement or overlay in a direction parallel to the centerline, the surface shall not vary more than 1/8 inch (3mm) from the lower edge of the straightedge. The transverse slope of the pavement shall be uniform to a degree such that no depression greater than 1/8 inch is present when tested with the 10-foot straight edge laid in a direction transverse to the centerline and extending from edge to edge in a traffic lane.

After completing curing, retest the surface and grind any high areas more than the specified tolerances. Groove the ground surfaces to have a texture equal to the surrounding surfaces.

H) **Transverse Groove Final Finish for Overlays**. Do not tine finish overlays within 2 inches (50mm) of a construction joint.

1) *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.

2) *Latex Modified Concrete.* After completing the finishing, apply the transverse groove final finish. 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 ensure 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) *Limitation of Operations.*

i) *Traffic Control.* During the construction period of the project, provide such traffic controls as required by the contract documents.

ii) *Loading.* After removing old concrete and before placing new concrete, restrict loading on bridge decks to approved construction equipment. Limit the wheel and axle loads of construction vehicles to 8000 pounds (35kN) and 16,000 pounds respectively. Any combination of axles spaced closer than 4 feet center-to-center of axles will be considered as one axle. Unless otherwise specified, keep traffic off the finished surface during the specified curing period. Do not perform preparation work in the adjacent lane on areas

adjoining new concrete during the specified curing period.

410.05 TESTING — VACANT

410.06 METHOD OF MEASUREMENT

Class A Bridge Deck Repair, Class B Bridge Deck Repair, And Class C Bridge Deck Repair will be computed in square yards from measurements of the areas so repaired. All classes of bridge deck repair will be measured prior to the actual placement of the concrete. Bridge deck overlay will be measured in square yards from measurements of the areas so overlaid.

410.07 BASIS OF PAYMENT

The accepted quantities, measured as specified in this Section, will be paid at the contract price per unit of measurement for the pay items listed below that are shown in the Plan bid schedule. Payment will be full compensation for the respective work prescribed in this Section including concrete material, reinforcing steel, sawing, removals, and other incidental items. Payment will be made under:

Pay Item:	**Pay Unit:**
(A) CLASS A BRIDGE DECK REPAIR	Square Yard [Square Meter]
(B) CLASS B BRIDGE DECK REPAIR	Square Yard [Square Meter]
(C) CLASS C BRIDGE DECK REPAIR	Square Yard [Square Meter]
(D) BRIDGE DECK OVERLAY	Square Yard [Square Meter]

SECTION 411 – REINFORCING STEEL

411.01 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.

411.02 MATERIALS

Materials shall meet the requirements of Section 923.

Bar List - 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.

411.03 EQUIPMENT — VACANT

411.04 CONSTRUCTION METHODS

Reinforcing steel shall be always protected 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.

Unless otherwise permitted, 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 City Engineer. Should the City 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.

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 twelve (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 one-sixth (1/6) of the spacing between bars, and the average over ten (10) spaces shall not vary more than one-twentieth (1/20) of the specified spacing. Perpendicular to the nearest surface of concrete, bars shall not vary from plan placement by more than one-fourth (1/4) inch in slabs and walls up to and including eight (8) inches in total thickness, the bars shall not vary more than one-half (1/2) inch from plan placement. The placement of deck reinforcement in bridge floors shall not deviate more than one-fourth (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 City 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 City Engineer. Splices shall be staggered as far as possible.

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 twelve (12) inches of concrete under the bars shall be lapped as given in the following table for 'top bars':

TABLE 411.1
Required Length of Lap in Inches

Size (No.)	4	5	6	7	8	9	10	11
Top Bar	15	19	24	32	45	54	68	83
Other Bars	12	13	17	23	40	48	59	60

The required length for lap splices given in the table is based on Grade 40 Reinforcing Steel. If Grade 60 Reinforcing Steel is specified, the required length for lap splices shall be increased by fifty (50)

percent. No more than one-half (1/2) 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 City Engineer prior to use.

The minimum spacing center to center of parallel bars shall be two and one-half (2 1/2) times the diameter, but in no case shall the clear distance between the bars be less than one and one-half (1 1/2) 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 two (2) inches or as otherwise shown on the plans. In the footings of abutments and retaining walls and in piers the minimum covering shall be three (3) inches.

411.05 TESTING — VACANT

411.06 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 placed in accordance with these specifications. The weights calculated shall be based upon the following table:

TABLE 411.2
Reinforcing Steel Weights

Bar Designation Number	Nominal lb/ft	Weight kg/m
¼	0.167	0.249
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.

411.07 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:

Pay Item:	Pay Unit:
(A) REINFORCING STEEL	Pounds [Kilogram]

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.

SECTION 412 – PENETRATING SEALER FOR CONCRETE SURFACES

412.01 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.

412.02 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.

412.03 EQUIPMENT — VACANT

412.04 CONSTRUCTION METHODS

A) **Weather Limitation** - The materials shall not be applied when the air or surface temperature is less than forty (40) degrees F or while the surface is wet.

B) **Surface Preparation** - 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.

C) **Application of Penetrating Sealer** - The penetrating sealer shall consist of application to be applied at the rate recommended by the manufacturer.

412.05 TESTING — VACANT

412.06 METHOD OF MEASUREMENTS

The penetrating sealer system will be measured by the square yard in place.

412.07 BASIS OF PAYMENT

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

Pay Item:	Pay Unit:
(A) PENETRATING SEALER	Square Yard [Square Meter]

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

SECTION 450 – CONSTRUCTION REQUIREMENTS FOR STORM SEWERS

450.01 DESCRIPTION

This section covers general construction requirements of storm sewers and sewer appurtenances as described herein. This section is intended to be used in conjunction with the individual pipe material specifications to form project documents.

450.01.01 – REFERENCES

A) **ASTM International**

1) ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
2) ASTM C506, Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
3) ASTM C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
4) ASTM C1479, Standard Specification for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
5) ASTM C1577, Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD
6) ASTM C1675, Standard Practice for Installation of Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers
7) ASTM C1840, Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain, and Storm Sewer Pipe
8) ASTM D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers & Other Gravity-Flow Applications
9) ASTM F2764, Standard Specification for 30 to 60 in. Polypropylene (PP) Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications.
10) ASTM F2881, Standard Specification for 12 to 60 in. Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications
11) ASTM A760, Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
12) ASTM A742, Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
13) ASTM A762, Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains

B) **AASHTO**

1) AASHTO LRFD Section 12 Buried Structures and Tunnel Liners

450.01.02 – PREQUALIFICATION

As a minimum, all Contractors and Bidders shall meet the prequalification requirements of the City's Prequalification Board and be prequalified to perform work in the "Storm Sewer Construction" Category.

Prequalification for additional categories of work, when required may be specified in the Special Provisions.

450.02 MATERIALS

450.02.01 – APPROVED PIPE PRODUCTS

Storm water pipe materials will be approved by the City. All materials shall be manufactured, designed, installed, and inspected according to this specification.

The professional engineer responsible for preparation of engineering drawings is also responsible for structural design of storm sewer installations. In all cases, designers shall keep a record of structural design calculations associated with each project in accordance with the appropriate Standard Practice. Design calculations for specific projects shall be provided to the Owner upon request.

A) **Reinforced Concrete Pipe**

1) Manufacturing Specification – ASTM C76, C506, and C507
2) Design Specification – AASHTO LRFD Section 12
3) Installation Specification – ASTM C1479
4) Post Installation Inspection Specification – ASTM C1840

B) **Reinforced Concrete Box**

1) Manufacturing Specification – ASTM C1577
2) Design Specification – AASHTO LRFD Section 12
3) Installation Specification – ASTM C1675
4) Post Installation Inspection Specification – Section 451.05 Field Performance and Acceptance Tests

C) **Corrugated Metal Pipe**

1) Manufacturing Specification – ASTM A760, A742, and A762
2) Design Specification – AASHTO LRFD Section 12
3) Installation Specification – ASTM A798 and A807
4) Post Installation Inspection Specification – Section 451.05 Field Performance and Acceptance Tests

D) **Polypropylene Pipe**

1) Manufacturing Specification – ASTM F2881 & F2764
2) Design Specification – AASHTO LRFD Section 12
3) Installation Specification – ASTM D2321
4) Post Installation Inspection Specification – Refer to Section 451.05 Field Performance and Acceptance Tests (PP Section PII)

450.02.02 – PIPE APPLICATION

Table 450:1 Pipe Application Table					
Type of Pipe	Under Paving			Outside Paving	
	Cross Drain	Storm System	Side Drain	Storm System	Side Drain
RCP	Yes	Yes	Yes	Yes	Yes
RCB	Yes	Yes	Yes	Yes	Yes
CMP	No	No	No	No	Yes
Polypropylene	No	No	No	Yes	Yes

A) **Definitions**

1) **Cross Drain** – Open ended culvert aligned perpendicular to the direction of traffic.

2) **Storm System** – A drainage system consisting of a series of at least two interconnecting pipes and two structures (manholes, catch basins etc.) designed to intercept and convey stormwater runoff from specific storm event without surcharge.

3) **Side Drain** – Open ended culvert aligned parallel to the direction of traffic. (i.e., under a commercial drive entrance would be considered under paving while a rural drive would be considered outside paving)

4) **Rejection** – Materials that fail to meet the requirements of these specifications shall be rejected by the City or its representative.

450.02.03 – PLAN REQUIREMENTS

The design engineer must convey all assumptions used in design calculations such as trench widths, embedment materials and compaction effort, with clear detailed drawings and proper specifications. The design engineer shall not use less than one-foot cover for all pipe products.

Plan and profile drawings must indicate:

- Total length of the pipe run (ft)
- Pipe diameter (inch)
- Strength class (ASTM C76)
- Pipe grade, in percent
- Other special pipe fittings, if applicable
- Flowline

450.02.04 - SUBMITTALS

Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction of pipe and fittings, together with complete data covering all materials proposed for use, shall be submitted.

450.03 EQUIPMENT — VACANT

450.04 CONSTRUCTION METHODS

Physical properties, compaction characteristics, and gradations of pipe zone materials must meet local

material specifications and sourced from approved vendors. At the City's request, the contractor shall be required to perform field density tests to ensure that the pipe installation conforms to the requirements of the contract.

450.04.01 – TEMPORARY SEWER AND DRAIN CONNECTIONS

When existing sewers must be taken up or removed, the Contractor at his own expense, shall provide and maintain temporary outlets and connections for all private or public drains, sewers, or sewer inlets. the Contractor shall also take care of all sewage and drainage which will be received from these drains, sewers, and sewer inlets; and for this purpose, the Contractor shall provide and maintain at his own expense, adequate pumping facilities and temporary outlets or diversions. The Contractor shall construct such trough, pipe, or other structures necessary and be always prepared to dispose of drainage and sewage received from these temporary connections until such time as the permanent connections are built and in service. The existing sewers and connections shall be kept in service and maintained under the contract, save where specified or ordered to be abandoned by the City Engineer. All water or sewage shall be disposed of in a satisfactory manner so that no nuisance is created and that the work under construction will be adequately protected.

450.04.02 – CLEANUP

After installation of each section of drainage facility, the Contractor shall remove all spills resulting from work, debris, construction materials and equipment from the site of work, grade, smooth over surfaces and leave the right-of-way in a clean, neat, and serviceable condition prior to inspection.

450.05 TESTING

450.05.01 POST INSTALLATION INSPECTION

After all storm lines, manholes and related structures have been cleaned the system must be inspected to ensure that the sewer is free of defects and that the sewer was installed to the line and grade noted on the construction drawings. Pipeline inspection must be carried out for all types of sewer systems and shall include the following:

1) Visual inspection of surface features, manholes, and larger sewers.
2) Image-based video inspection of the smaller sewers (up to and including 36" diameter). Pipe larger than 36" shall be inspected and observations recorded during a walk-through by a Pipeline Assessment & Certification Program (PACP) certified operator or by image-based video inspections where authorized by the City Engineer (subject to obtaining acceptable data quality).
3) Initial and final deflection tests for all flexible pipe (CMP and all approved thermoplastics).

All gravity pipes will be visually (or CCTV) inspected no sooner than 30 days following final backfill. The inspection will be completed only by a certified third-party inspector as outlined in this specification. A final inspection at the end of the warranty period shall be performed to verify performance.

450.06 METHOD OF MEASUREMENT

Storm sewer will be measured by the linear foot in accordance with the dimensions shown on the plans or directed by the City Engineer. Storm sewer, complete with all necessary appurtenances as described

in this section, shall be measured by the unit complete and in place.

450.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	Pay Unit:
(A) (TYPE) STORM SEWER (SIZE)	Linear Foot [Meter]

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.

SECTION 451 – REINFORCED CONCRETE PIPE (RCP)

NOTE: This Section is for Storm Sewer only.

451.01 DESCRIPTION

This section covers the requirements for reinforced concrete pipe and fittings intended for non-pressure storm sewers, storm culverts, and fittings.

451.01.01 – REFERENCES

A) **American Concrete Pipe Association**

1) ACPA Quality Cast (QCast) Plant Certification Manual
2) ACPA Concrete Pipe and Box Culvert Installation Manual
3) ACPA Post Installation Evaluation and Repair of Installed Reinforced Concrete Pipe

B) **ASTM International**

1) ASTM C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
2) ASTM C443, Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
3) ASTM C506, Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe
4) ASTM C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe
5) ASTM C655, Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
6) ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manholes, Structures, Pipes and Laterals
7) ASTM C990, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
8) ASTM C1417, Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design
9) ASTM C1479, Standard Specification for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations

10) ASTM C1840, Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain, and Storm Sewer Pipe

C) **AASHTO**

1) AASHTO R73, Standard Practice for Evaluation of Precast Drainage Products

2) AASHTO LRFD Bridge Design Specifications, Section 12

D) **American Society of Civil Engineers**

1) ASCE 15, Direct Design of Buried Precast Concrete Pipe Using Standard Installations (SIDD)

451.02 MATERIALS

451.02.01 – PLAN REQUIREMENTS

The design engineer must convey all assumptions used in design calculations such as trench widths, embedment materials and compaction effort, with clear detailed drawings and proper specifications. The design engineer shall not use less than one-foot cover for all pipe products.

Plan and profile drawings must indicate:

- Total length of the pipe run (ft)
- Pipe diameter (inch)
- Strength class (ASTM C76)
- Pipe grade, in percent
- Other special pipe fittings, if applicable
- Flowline
- Other markings as specified by the Owner

451.02.02 – SUBMITTALS

Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction of pipe and fittings, together with complete data covering all materials proposed for use, shall be submitted. The drawings and data shall include, but shall not be limited, to the following for each size of pipe.

A) Strength Class
B) Details of joints
C) Details of gasket
D) Details of fittings and specials
E) Test reports

All material furnished under certification shall be tagged, stenciled, stamped, or otherwise marked with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification.

451.02.03 – QUALITY ASSURANCE

Pipe size, type, and strength class shall be consistent throughout a pipe run. All concrete pipe and fittings shall be supplied from a manufacturer that is prequalified by an independent third-party certification agency to produce products according to applicable ASTM manufacturing standards.

All pipe products shall be marked with a certification body's logo confirming that the production of the pipe is in accordance with the quality and requirements of an acceptance standard. Quality assurance programs recognized specifically for manufactures of concrete pipe and precast drainage products in Oklahoma are:

All manufacturers will have two years from the effective date of this specification to become QCast or NPCA certified.

A) **Quality Cast Plant Certification Program (QCast)**

B) **NPCA – National Precast Concrete Association**

451.02.04 – PIPE MATERIALS

A) **Manufacturing Standard Designation**

1) Reinforced circular pipe and fittings shall be manufactured in accordance with ASTM C76, ASTM C655, and ASTM C1417.
2) Arched pipe shall be manufactured in accordance with ASTM C506.
3) Elliptical pipe shall be manufactured in accordance with ASTM C507.
4) Under the roadway - all circular reinforced concrete pipe shall have water resistant joints using elastomeric gaskets in accordance with ASTM C443.
5) Outside the roadway - all circular reinforced concrete pipe shall have soil tight joints using Omni-flex gaskets in accordance with ASTM C990.

B) **Concrete Pipe Strength Classifications (ASTM C76)**

1) Reinforced concrete pipe manufactured to ASTM C76 shall be of three classes: Class III, Class IV, and Class V.

C) **Markings**

The following information must be clearly marked on each section of pipe:

- Nominal pipe size (inch).
- Pipe strength classification.
- Manufacturer's name or trademark.
- Plant identification, if applicable.
- Manufacturing standard designation.
- Date of Manufacture.
- Quality certification program logo.

451.02.05 – PIPE DESIGN

A) **Flow Capacity**

Pipe capacities shall be calculated using Manning's formula with a roughness coefficient (n) of 0.013 for all smooth-walled pipe materials. Final design shall be in accordance with the latest revisions of the city drainage ordinance and drainage criteria manual.

B) **Structural Design**

1) The design engineer responsible for the preparation of engineering drawings is also responsible for the structural design of storm sewer installations. In all cases, engineers shall keep a record of structural design calculations for pipe associated with each project. Design calculations for specific projects shall be provided to the City upon request.
2) All minimum and maximum fill height tables are only intended to provide answers to general cover height questions and shall not be used for project design.
3) Depth of cover for concrete pipe is measured from the ultimate finished ground elevation to the outside top of the pipe.
4) Reinforced concrete pipe designed using the indirect design method shall be in accordance with the AASHTO LRFD Bridge Design Specifications, Section 12. *
5) Reinforced concrete pipe designed using the direct design method shall be in accordance with ASCE 15.

*PipePac (indirect design) software is available for free at www.pipepac.com.

451.02.06 – JOINTS

Joint classification for concrete pipe shall follow ASTM C1840.

1) Soil Tight Joint – A joint that is resistant to infiltration of particles larger than those retained on a No. 200 sieve. Soil tight joints shall be in accordance with ASTM C990.
2) Silt Tight Joint – A joint that is resistant to infiltration of particles smaller than those retained on the No. 200 sieve. Silt tight joints shall be in accordance with ASTM C443.
3) Leak Resistant Joint – A joint that limits water leakage at a maximum rate of 200 gallons/inch of internal diameter/mile of pipeline/24hrs. Leak resistant joints shall be in accordance with ASTM C443.

Table 451:1

Joint Application Table	
Under Paving	Outside Paving
O-Ring / Profile Joint (ASTM C443)	Tongue & Groove Joint (ASTM C990)

451.03 EQUIPMENT — VACANT

451.04 CONSTRUCTION METHODS

451.04.01 – GENERAL

Industry recommendations for the installation of concrete pipe are provided in the ACPA Concrete Pipe Installation Manual.

1) The contractor must achieve all the design assumptions in the field. Conditions that arise during construction that fails to meet any design assumptions, such as trench widths, must be reviewed to confirm whether the design is still valid.
2) Pipe shall be laid within the alignment and grade tolerances specified in the contract documents. Begin at the downstream end of the pipe run with bell end of the pipe facing upstream.

451.04.02 – DELIVERY AND PRE-INSTALLATION INSPECTION

All product RCP deliveries shall be inspected for damages and defects according to AASHTO R73 prior to unloading. Any pipe, fitting, or gaskets that are unsound or damaged shall be rejected. The contractor shall confirm the quantity, class, and joint treatment options match the project documents.

451.04.03 – INSTALLATION

Physical properties, compaction characteristics, and gradations of pipe zone materials must meet local material specifications and sourced from approved vendors. At the City's request, the contractor shall be required to perform field density tests to ensure that the pipe installation conforms to the requirements of the contract.

1) The pipe embedment zone consists of the foundation, bedding, and haunch, and initial backfill as detailed in the applicable City Standard Details for pipe installation.
2) Materials for use as foundation, embedment, and backfill for pipe include natural, manufactured, and processed aggregates and the soil types classified according to ASTM C1479.
3) Reinforced concrete pipe installations consist of Type 1, Type 2, Type 3, or Type 4 embedment and detailed in ASTM C1479 or the applicable City Standard Details for pipe installation.

451.04.04 – MOVABLE SUPPORT SYSTEMS

Unless sheathing is to be left in place, it shall be pulled out in vertical increments to permit placement and compaction of fill material for the full width of the trench.

When trench shields or boxes are moved, the previously placed pipe shall not be disturbed. It may be necessary to restrain the installed pipe by use of deadman anchors or other means. Voids that are created by movement of a shield or box shall be filled and compacted per the contract documents.

451.04.05 – MINIMUM COVER FOR CONSTRUCTION LOADS

If the passage of construction equipment over an installed pipeline is necessary during project construction, compacted overfill in the form of a ramp shall be constructed to a minimum elevation of 3 ft over the top of the pipe or to a height such that the equipment loads on the pipe do not exceed the pipe design strength.

451.05 TESTING

451.05.01 – CLEANING AND FLUSHING

All reinforced concrete shall be cleaned and flushed immediately prior to inspection and acceptance.

451.05.02 – POST INSTALLATION INSPECTION

All reinforced concrete pipe will be visually, or CCTV inspected in accordance with ASTM C1840.

The Initial Inspection shall take place no sooner than 30 days following final backfill. A Final Inspection at the end of the warranty period shall be performed to verify performance. All inspection will be completed only by a certified third-party inspector as outlined in ATSM C1840.

Inspection of reinforced concrete pipe shall include the following:

1) Visual inspection of surface features, manholes, and larger sewers.
2) Image-based video inspection of the smaller sewers (up to and including 36" diameter). Pipe larger than 36" shall be inspected and observations recorded during a walk-through by a Pipeline Assessment & Certification Program (PACP) certified operator or by image-based video inspections where authorized by the City Engineer (subject to obtaining acceptable data quality).
3) Evaluation of cracks, joints, and infiltration as per ASTM C1840.

451.05.03 – CRACK EVALUATION

The evaluation of crack width will take place during the Initial and Final Inspections.

The contractor will be responsible for the performance of the installed pipeline. Longitudinal cracks greater than the limits listed in the following table will be the responsibility of the contractor to repair or replace.

Table 451:2
Rigid Pipe Crack Evaluation Table

Longitudinal Crack Width (inches)	Evaluation
0.00 to 0.05	Accepted
0.05 to 0.10	Accepted[(1)] or Remediate or Replace at contractor's expense [(2)]
Greater than 0.10	Remediate or Replace at contractor's expense [(2)]

(1) Pipe located in areas where soil and or runoff Ph is 5.5 or greater shall not require remediation if cracking is less than or equal to 0.1".

(2) Provide the City in writing a method for repairing the observed cracking. Do not begin work until the method has been approved. Cracks > 0.10" will be given consideration by the City to replace the pipe or allow for site specific repair. Refer to Site Specific Repairs at the end of this specification.

451.05.04 – SITE SPECIFIC REPAIRS

Site specific repairs will be sealed by a Professional Engineer and submitted to the City by the contractor for evaluation and approval. Examples of major repairs for reinforced concrete pipe can be found in the ACPA "Post Installation Evaluation and Repair of Installed Reinforced Concrete Pipe" Manual.

Any repairs made to the installed pipe must be certified by the contractor and the repair contractor. This certification will state that all repairs will have the same service life as newly installed pipe.

451.06 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.

451.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) REINFORCED CONCRETE PIPE (SIZE)	Linear Foot [Meter]

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.

SECTION 452 – POLYPROPYLENE PIPE (PP)

NOTE: This Section is for Storm Sewer only.

452.01 DESCRIPTION

This section covers the requirements for polypropylene pipe intended for non-pressure storm sewers and storm culverts.

452.01.01 – REFERENCES

A) **ASTM International**

1) ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
2) ASTM D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers & Other Gravity-Flow Applications
3) ASTM D2412 Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading

4) ASTM D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).

5) ASTM F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe

6) ASTM F2764, Standard Specification for 30 to 60 in. Polypropylene (PP) Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications.

7) ASTM F2881, Standard Specification for 12 to 60 in. Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications

B) **AASHTO**

1) AASHTO LRFD Bridge Construction Specifications, Section 30

2) AASHTO LRFD Bridge Design Specifications, Section 12

3) R 82-17 Standard Practice for Pipe Joint Selection for Highway Culvert and Storm Drains

C) **OSHA (Occupational Safety and Health Standards)**

1) 29 CFR Part 1926, OSHA Standards for the Construction Industry

452.02 MATERIALS

452.02.01 – PLAN REQUIREMENTS

The design engineer must convey all assumptions used in design calculations such as trench widths, embedment materials and compaction effort, with clear detailed drawings and proper specifications. The design engineer shall not use less than one-foot cover for all pipe products.

Plan and profile drawings must indicate:

- Total length of the pipe run (ft)
- Pipe diameter (inch)
- Pipe material type
- Maximum fill height
- Pipe grade, in percent
- Other special pipe fittings, if applicable
- Flowline
- Other markings as specified by the owner

452.02.02 – SUBMITTALS

Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction of pipe and fittings, together with complete data covering all materials proposed for use, shall be submitted. The drawings and data shall include, but shall not be limited, to the following for each size of pipe.

A) Details of joints
B) Details of gasket
C) Details of fittings and specials
D) Test reports

All material furnished under certification shall be tagged, stenciled, stamped, or otherwise marked

with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification.

452.02.03 – QUALITY ASSURANCE

Pipe size and type shall be consistent throughout a pipe run. All pipe and fittings shall be supplied from a manufacture that is prequalified according to this specification.

All pipe products shall be marked with a certification body's logo confirming that the production of the pipe is in accordance with National Transportation Product Evaluation Program (NTPEP).

452.02.04 – PIPE MATERIALS

All thermoplastic pipe shall have a minimum stiffness of 46 lbs/in/in at 5% deflection. The maximum diameter for PP pipe under ASTM F2881 is 30 inches.

A) **Manufacturing Standard Designation**

1) Dual-wall PP pipe (12 – 30in) and triple-wall pipe PP pipe (30 – 60in) shall be used for storm sewer applications only.

2) Dual-wall PP pipe and fittings shall be manufactured in accordance with ASTM F2881.

3) Triple-wall PP pipe and fittings shall be manufactured in accordance with ASTM F2764.

4) All PP pipe shall have water resistant joints using elastomeric gaskets in accordance with ASTM F477.

5) PP pipe shall be installed within two years from the production date indicated on the pipe.

B) **Markings**

The following information must be clearly marked on each section of pipe:

- Nominal pipe size (inch).
- Pipe ring stiffness.
- Manufacturer's name or trademark.
- Plant identification, if applicable.
- Manufacturing standard designation (ASTM)
- Date of Manufacture.
- Cell classification of materials.
- Quality certification program logo.

452.02.05 – PIPE DESIGN

A) **Flow Capacity**

Pipe capacities shall be calculated using Manning's formula with a roughness coefficient (n) of 0.013 for all smooth-walled pipe materials (concrete and polypropylene). Final design shall be in accordance with the latest revisions of the city drainage ordinance and drainage criteria manual.

B) **Structural Design**

1) The design engineer responsible for the preparation of engineering drawings is also responsible

for the structural design of sewer installations. In all cases, engineers shall keep a record of structural design calculations for pipe associated with each project. Design calculations for specific projects shall be provided to the Owner upon request.

2) All minimum and maximum fill height tables are only intended to provide answers to general cover height questions and shall not be used for project design.

3) Depth of cover for PP pipe is measured from the ultimate finished ground elevation to the outside top of the pipe.

4) Strength limit states calculations shall be completed per AASHTO LRFD Bridge Design Specifications, Section 12.
   a) Thrust
   b) Buckling
   c) Combined Strain

5) Buoyancy of PP pipe should be considered, and flotation of pipes should be prevented with appropriate construction where high groundwater conditions are anticipated.

6) A design check for deflection shall be completed per AASHTO LRFD Bridge Design Specifications, Section 12.

452.02.06 – JOINTS

Pipe shall be joined with a gasketed integral bell & spigot joint meeting the requirements of ASTM F2881 and ASTM F2764.

1) Soil/Silt Tight Joint – Shall conform to ASTM F477
2) Leak Resistant Joint – Shall conform to ASTM D3212

452.03 EQUIPMENT — VACANT

452.04 CONSTRUCTION METHODS

452.04.01 – GENERAL

All flexible pipes are to be installed per ASTM D2321.

1) The contractor must achieve all the design assumptions in the field. Conditions that arise during construction that fails to meet any design assumptions, such as trench widths, must be reviewed to confirm whether the design is still valid.

2) Pipe shall be laid within the alignment and grade tolerances specified in the Contract Documents. Begin at downstream end of pipe run with bell end of the pipe facing upstream.

3) The installation of PP is not permitted under public paving. Please see Table 450.02.02 Pipe Application Table.

452.04.02 – PRE-INSTALLATION INSPECTION

All product deliveries shall be inspected for damages and defects prior to unloading. Any pipe, fitting,

or gaskets that are unsound or damaged shall be rejected. The contractor shall confirm that the quantity, diameter, sheet thickness, and connecting band options match the project documents.

452.04.03 – INSTALLATION

Physical properties, compaction characteristics, and gradations of pipe zone materials must meet local material specifications and be sourced from approved vendors. At the City's request, the contractor shall be required to perform field density tests to ensure that the pipe installation conforms to the requirements of the contract.

1) The pipe embedment zone consists of the foundation, bedding, and haunch, and initial backfill as detailed in ASTM D2321 and applicable City Standard Details for flexible pipe installation.

2) Materials for use as foundation, embedment, and backfill for PP pipe are classified in Table 1 and Table 2 in ASTM D2321. They include natural, manufactured, and processed aggregates and the soil types according to ASTM D2487 and applicable City Standard Details for flexible pipe installation.

    a. Class I, Class II, and Class III materials are suitable to use as foundation material and in the embedment zone subject to the limitations noted in Table 3 of ASTM D2321.
    b. Class IV-A materials should only be used in the embedment zone in special design cases, as they would not normally be construed as a desirable embedment material for thermoplastic pipe.
    c. Class IV-B and Class V Soils are not permitted in the embedment zone and should be excluded from the final backfill except where specifically allowed by project specifications.

3) Pipe shall be laid within the alignment and grade tolerances specified in the Contract Documents. Begin at downstream end of pipe run with bell end of the pipe facing upstream.

452.04.04 – MOVABLE SUPPORT SYSTEMS

Movable support systems (trench boxes or cages) shall be used in accordance with applicable Occupational Health and Safety requirements. Movable support systems with PP pipe must be used in accordance with ASTM D2321. When using movable support systems with PP pipe, the pipe location, jointing, and its embedment shall not be disturbed. This can be accomplished by limiting the use of standard movable trench boxes that are more than 2.5 pipe diameters on either side of the pipe to below the top of the pipe, or to a shelf above the top of the pipe. When advancing trench boxes or shields, longitudinal pipe movement or disjointing shall not be allowed.

452.04.05 – MINIMUM COVER FOR CONSTRUCTION LOADS

If the passage of construction equipment over an installed pipeline is necessary during project construction, compacted overfill in the form of a ramp shall be constructed to a minimum elevation of 3 ft over the top of the pipe or to a height such that the equipment loads on the pipe do not exceed the pipe design strength.

452.05 TESTING

452.05.01 – CLEANING AND FLUSHING

All storm sewer pipe shall be cleaned and flushed immediately prior to inspection and acceptance.

452.05.02 – POST INSTALLATION INSPECTION

PP pipe installed within The City of Oklahoma City which are, or will become, owned by the City of Oklahoma City shall be tested for deflection and inspected visually for defects. All inspections will be completed only by a certified third-party inspector.

An initial inspection shall take place no sooner than 30 days following final backfill. The initial inspection will include the following:

1) Visual inspection of surface features, manholes, and larger sewers.

2) Image-based video inspection of the smaller sewers (up to and including 36" diameter). Pipe larger than 36" shall be inspected and observations recorded during a walk-through by a Pipeline Assessment & Certification Program (PACP) certified operator or by image-based video inspections where authorized by the City Engineer (subject to obtaining acceptable data quality).

3) A deflection test by mandrel. The deflection limit of the initial inspection is 5%.

A final inspection shall take place at the end of the warranty period. The initial inspection will include the following:

1) Visual inspection of surface features, manholes, and larger sewers.

2) Image-based video inspection of the smaller sewers (up to and including 36" diameter). Pipe larger than 36" shall be inspected and observations recorded during a walk-through by a Pipeline Assessment & Certification Program (PACP) certified operator or by image-based video inspections where authorized by the City Engineer (subject to obtaining acceptable data quality).

3) A deflection test by mandrel. The deflection limit of the final inspection is 7.5%.

452.05.03 – DEFLECTION TESTING

Mandrel deflection testing shall be performed on all pipe sewers or culverts constructed using PP pipe. The allowable deflected pipe diameter is calculated as a percentage of the base inside diameter of the pipe. The initial inspection will be limited to 5%, and final inspection will be limited to 7.5%.

The following procedure outlines the mandrel test:

1) A suitably designed device as defined below shall be pulled through the pipe sewer to demonstrate that the pipe deflection does not exceed the allowable deflected pipe diameter.

2) For the Initial Inspection, the device shall be pulled manually through the pipe not sooner than 30 Days after the completion of backfilling and installation of service connections.

3) The suitably designed device shall be a mandrel, cylindrical in shape, and constructed with an odd number of evenly spaced arms or prongs, minimum 9 in number. The minimum diameter of the circle scribed around the outside of the mandrel arms shall be equal to the allowable deflected pipe diameter ± 0.04 in.

4) The mandrel shall be checked with a go-no-go proving ring. The proving ring shall have a diameter equal to the allowable deflected pipe diameter ± 0.04 in. An acceptable mandrel shall not pass through the proving ring. The proving ring shall be fabricated from steel a minimum of

5) ¼ in thick.

6) Any section of pipe that does not allow the mandrel to pass shall be considered to have failed the deflection test.

7) All sections of pipe that fail the deflection test shall be repaired or replaced, then retested.

452.05.04 – DEFLECTION EVALUATION

The evaluation of deflection will take place during the initial and final inspections.

The contractor will be responsible for the performance of the installed pipeline. Deflection greater than the limits listed in the following table will be the responsibility of the contractor to repair or replace.

Table 452:1
Initial Inspection - Deflection Evaluation Table

Deflection	Evaluation
0 to 5%	Accepted
Greater than 5%	Remediate or replace at contractor's expense

Table 452:2
Final Inspection - Deflection Evaluation Table

Deflection	Evaluation
0 to 7.5%	Accepted
Greater than 7.5%	Remediate or replace at contractor's expense

452.06 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.

452.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	Pay Unit:
(A) POLYPROPYLENE PIPE (SIZE)	Linear Foot [Meter]

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.

SECTION 453 – CORRUGATED STEEL PIPE (CSP)

NOTE: This Section is for Storm Sewer only.

453.01 DESCRIPTION

This section covers the requirements for corrugated steel pipe and fittings intended for non-pressure storm sewers, storm culverts, and fittings.

453.01.01 – REFERENCES

A) **ASTM International**

1) ASTM A760, Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
2) ASTM A742, Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe
3) ASTM A762, Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains
4) ASTM A796, Standard Practice for Structural Design of Corrugated Steel Pipe, Pipe Arches, and Arches for Storm and Sanitary Sewers and Other Buried Applications
5) ASTM A798, Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications
6) ASTM A807, Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications

B) **AASHTO**

1) AASHTO M36, Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains
2) AASHTO M218, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized), for Corrugated Steel Pipe
3) AASHTO M246, Standard Specification for Steel Sheet, Metallic-Coated and Polymer-Precoated, for Corrugated Steel Pipe
4) AASHTO M274, Standard Specification for Steel Sheet, Aluminum-Coated (Type 2), for Corrugated Steel Pipe
5) AASHTO M245, Standard Specification for Corrugated Steel Pipe, Polymer-Precoated, for Sewers and Drains

453.02 MATERIALS

453.02.01 – PLAN REQUIREMENTS

The design engineer must convey all assumptions used in design calculations such as trench widths, embedment materials and compaction effort, with clear detailed drawings and proper specifications. The design engineer shall not use less than one-foot cover for all pipe products.

Plan and profile drawings must indicate:

- Total length of the pipe run (ft)

- Pipe size, diameter (in.) of circular pipe, or span and rise (in. x in.) of pipe-arch section
- Maximum fill height
- Pipe grade, in percent
- Other special pipe fittings, if applicable
- Flowline
- Other markings as specified by the owner.

453.02.02 – SUBMITTALS

Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction of pipe and fittings, together with complete data covering all materials proposed for use, shall be submitted. The drawings and data shall include, but shall not be limited, to the following for each size of pipe.

A) Details of joints
B) Details of gasket
C) Details of fittings and specials
D) Test reports

All material furnished under certification shall be tagged, stenciled, stamped, or otherwise marked with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification.

453.02.03 – QUALITY ASSURANCE

Pipe diameter, corrugation size, and sheet thickness shall be consistent throughout a pipe run.

A) **Pipe Ends**

1) Pipe ends shall have a minimum of two reformed annular corrugations to accommodate connecting bands.

B) **Connecting Bands**

1) Connecting bands shall be of the dimpled type and shall be designed to accommodate flexible rubber gaskets when required.
2) Connecting bands shall be of the same material as the pipe; and shall be not more than three nominal sheet thicknesses lighter than the connecting pipe.
3) Connecting bands shall meet the performance criteria set for in Section 23 of AASHTO Standard Specifications for Highway Bridges.

453.02.04 – PIPE MATERIALS

A) **Manufacturing Standard Designation**

1) Corrugated circular and arch pipe and fittings shall be manufactured in accordance with AASHTO M36.

B) **Acceptable Types**

The following types of CSP shall be acceptable based on appropriate hydraulic and durability considerations:

1) Galvanized (AASHTO M218)

2) Aluminized (AASHTO M274)

3) Polymeric coated (AASHTO M245)

C) **Markings**

The following information must be clearly marked on each section of pipe:

1) Heat number

2) Sheet thickness

3) Manufacturer's name or trademark.

4) Mill identification

5) Manufacturing standard designation.

453.02.05 – PIPE DESIGN

A) **Flow Capacity**

Pipe capacities shall be calculated using Manning's formula with a roughness coefficient of 0.024. Final design shall be in accordance with the latest revisions of the city drainage ordinance and drainage criteria manual.

B) **Structural Design**

1) The design engineer responsible for the preparation of engineering drawings is also responsible for the structural design of sewer installations. In all cases, designers shall keep a record of structural design calculations for pipe associated with each project. Design calculations for specific projects shall be provided to the Owner upon request.

2) All minimum and maximum fill height tables are only intended to provide answers to general cover height questions and shall not be used for project design.

3) Depth of cover for corrugated steel pipe is measured from the ultimate finished ground elevation to the outside top of the pipe.

453.03 EQUIPMENT — VACANT

453.04 CONSTRUCTION METHODS

453.04.01 – GENERAL

Corrugated steel pipe to be installed per ASTM A798.

1) The contractor must achieve all the design assumptions in the field. Conditions that arise during construction that fails to meet any design assumptions, such as trench widths, must be reviewed to confirm whether the design is still valid.

2) Pipe shall be laid within the alignment and grade tolerances specified in the Contract Documents.

Begin at downstream end of the pipe run with the inside seam laps pointing downstream.

3) The installation of CSP is not allowed in any storm sewer system that will be dedicated to the city for maintenance. See table 450.02.02.

453.04.02 – DELIVERY

Use slings for handling CSP. The pipe should be lifted and placed into the location for storage; the pipe should never be dumped from a truck bed or dragged into position to protect the coating from damage.

453.04.03 – PRE-INSTALLATION INSPECTION

All product deliveries shall be inspected for damages and defects prior to unloading. Any pipe, fitting, or gaskets that are unsound or damaged shall be rejected. The contractor shall confirm that the quantity, diameter, sheet thickness, and connecting band options match the project documents.

453.04.04 – INSTALLATION

Physical properties, compaction characteristics, and gradations of pipe zone materials must meet local material specifications and sourced from approved vendors. At the City's request, the contractor shall be required to perform field density tests to ensure that the pipe installation conforms to the requirements of the contract.

1) The pipe embedment zone consists of the foundation, bedding, and haunch, and initial backfill as detailed in the applicable City Standard Details for pipe installation.

2) Materials for use as foundation, embedment, and backfill for pipe include natural, manufactured, and processed aggregates and the soil types classified according to the applicable City Standard Details for pipe installation.

453.04.05 – MOVABLE SUPPORT SYSTEMS

Unless sheathing is to be left in place, it shall be pulled out in vertical increments to permit placement and compaction of fill material for the full width of the trench.

When trench shields or boxes are moved, the previously placed pipe shall not be disturbed. It may be necessary to restrain the installed pipe by use of deadman anchors or other means. Voids that are created by movement of a shield or box shall be filled and compacted per the contract documents.

453.04.06 – MINIMUM COVER FOR CONSTRUCTION LOADS

If the passage of construction equipment over an installed pipeline is necessary during project construction, compacted overfill in the form of a ramp shall be constructed to a minimum elevation of 3 ft over the top of the pipe or to a height such that the equipment loads on the pipe do not exceed the pipe design strength.

453.05 TESTING

453.05.01 – CLEANING AND FLUSHING

All storm sewer pipe shall be cleaned and flushed immediately prior to inspection and acceptance.

453.05.02 – DEFLECTION

The maximum allowable deflection is five percent (5%), which must be based on the nominal diameter. When deflection exceeds 5%, the pipe will be replaced with a new pipe. The pipe is required to be tested, at the contractor's expense, not less than 30 days after installation and again during the final inspection to ensure that the pipe has not exceeded 5% deflection.

453.06 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.

453.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	Pay Unit:
(A) CORRUGATED METAL PIPE (SIZE)	Linear Foot [Meter]

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.

SECTION 454 – PRECAST REINFORCED CONCRETE BOX CULVERT (RCB)

NOTE: This Section is for Storm Sewer only.

454.01 DESCRIPTION

This section covers the requirements for precast reinforced concrete box culvert and fittings intended for non-pressure storm sewers, storm culverts, and fittings.

454.01.01 – REFERENCES

A) **American Concrete Pipe Association**

1) ACPA Quality Cast (QCast) Plant Certification Manual
2) ACPA Concrete Pipe and Box Culvert Installation Manual
3) ACPA Post Installation Evaluation and Repair of Installed Reinforced Concrete Pipe

B) **ASTM International**

1) ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manholes, Structures, Pipes and Laterals
2) ASTM C990, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
3) ASTM C1479, Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installations
4) ASTM C 1577 (C 1577M): Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO LRFD

5) ASTM C1675, Standard Practice for Installation of Precast Reinforced Concrete Monolithic Box Sections for Culvert, Storm Drains, and Sewers

6) ASTM C1840, Standard Practice for Inspection and Acceptance of Installed Reinforced Concrete Culvert, Storm Drain, and Storm Sewer Pipe

C) **AASHTO**

1) AASHTO R73, Standard Practice for Evaluation of Precast Drainage Products

2) AASHTO LRFD Bridge Design Specifications, Section 12

D) **American Society of Civil Engineers**

1) ASCE 26-97: Standard Practice for Direct Design of Buried Precast Concrete Box Sections

454.02 MATERIALS

454.02.01 – PLAN REQUIREMENTS

The design engineer must convey all assumptions used in design calculations such as trench widths, embedment materials and compaction effort, with clear detailed drawings and proper specifications. The design engineer shall not use less than one-foot cover for all pipe products.

Plan and profile drawings must indicate:

- Total length of the box culvert run (ft)
- Box culvert width (ft) and height (ft)
- Design Standard – Section 12 AASHTO LRFD
- Live Load (HS-20)
- RCB grade, in percent
- Flowline
- Other markings as specified by the owner.

454.02.02 – SUBMITTALS

Drawings, specifications, schedules, and other data showing complete details of the fabrication and construction of pipe and fittings, together with complete data covering all materials proposed for use, shall be submitted. The drawings and data shall include, but shall not be limited, to the following for each size of pipe.

A) Concrete strength
B) Fill heights
C) Details of joints
D) Details of gasket
E) Details of fittings and specials

All material furnished under certification shall be tagged, stenciled, stamped, or otherwise marked with a lot number, heat number, order number, or other appropriate identification which can be readily recognized and checked against the certification.

454.02.03 – QUALITY ASSURANCE

All RCB and fittings shall be supplied from a manufacture that is prequalified by an independent third-party certification agency to produce products according to applicable ASTM manufacturing standards.

All RCB products shall be marked with a certification body's logo confirming that the production of the RCB is in accordance with the quality and requirements of an acceptance standard. Quality assurance programs recognized specifically for manufactures of concrete pipe and precast drainage products in Oklahoma are:

All manufacturers will have two years from the effective date of this specification to become QCast or NPCA certified.

A) **Quality Cast Plant Certification Program (QCast)**

B) **National Precast Concrete Association (NPCA)**

454.02.04 – PRECAST REINFORCED CONCRETE BOX CULVERT MATERIALS

C) **Manufacturing Standard Designation**

1) Precast reinforced concrete box culvert and fittings shall be manufactured in accordance with ASTM C1577 (LRFD).
2) All precast reinforced concrete box culvert shall have soil tight joints using Omni-flex gaskets in accordance with ASTM C990.

D) **Markings**

The following information must be clearly marked on each section of precast reinforced concrete box culvert:

- Manufacturer's name or trademark
- Plant location/identification
- Manufacturing standard designation
- Minimum and maximum bury depth (fill heights)
- Box size - span (ft), rise (ft)
- Date of Manufacture.
- Quality certification program logo.
- Other markings as specified by the Owner.

E) **Service Connections**

Service connections to the main storm lines shall be made using factory made tees, or other approved methods. Resilient connectors conforming to ASTM C923 shall be used for flexible connections.

454.02.05 – BOX CULVERT DESIGN

A) **Flow Capacity**

Box culvert capacities shall be calculated using Manning's formula with a roughness coefficient (n) of 0.013. Final design shall be in accordance with the latest revisions of the city drainage ordinance and drainage criteria manual.

B) **Structural Design**

1) The design engineer responsible for the preparation of engineering drawings is also responsible for the structural design of storm sewer installations. In all cases, designers shall keep a record of structural design calculations for pipe associated with each project. Design calculations for specific projects shall be provided to the City upon request.
2) All minimum and maximum fill height tables are only intended to provide answers to general cover height questions and shall not be used for project design.
3) Depth of cover for precast reinforced concrete box culvert is measured from the ultimate finished ground elevation to the outside top of the box culvert.
4) Precast Reinforced concrete Box Culverts shall be designed in accordance with AASHTO LRFD Bridge Design Specifications.

454.02.06 – FITTINGS

All bends, tees, closure pieces, wall fittings, and other fittings which are indicated on the drawings or required to complete the work shall be furnished. Except as modified or otherwise provided herein, the design and manufacture of fittings shall be governed by the same requirements as the connecting piping.

454.03 EQUIPMENT — VACANT

454.04 CONSTRUCTION METHODS

454.04.01 – GENERAL

Industry recommendations for the installation of precast reinforced concrete box culverts are provided in the ACPA Concrete Pipe and Box Culvert Installation Manual.

1) The contractor must achieve all the design assumptions in the field. Conditions that arise during construction that fails to meet any design assumptions, such as trench widths, must be reviewed to confirm whether the design is still valid.
2) Precast reinforced concrete box culvert shall be laid within the alignment and grade tolerances specified in the Contract Documents. Begin at downstream end of box culvert run with bell end of the box culvert facing upstream.

454.04.02 – DELIVERY AND PRE-INSTALLATION INSPECTION

All product Precast Reinforced Concrete Box Culvert deliveries shall be inspected for damages and defects according to AASHTO R73 prior to unloading. The contractor shall confirm the quantity, design and joint treatment options match the project documents.

454.04.03 – INSTALLATION

Physical properties, compaction characteristics, and gradations of precast reinforced concrete box culvert zone materials must meet local material specifications and sourced from approved vendors. At the Owners request, the contractor shall be required to perform field density tests to ensure that the installation conforms to the requirements of the contract.

1) The embedment zone consists of the foundation, bedding, and initial backfill as detailed in ASTM C1675 and applicable City Standard Details for RCB installation.
2) Materials for use as foundation, embedment, and backfill for RCB include natural, manufactured, and processed aggregates and the soil types classified according to the applicable City Standard Details for RCB installation.

454.04.04 – EXCAVATION, SHAPING, BEDDING AND BACKFILL

Excavate, shape, bed, and backfill in accordance with ASTM C1675.

Take precautions in placing and compacting the backfill to avoid any movement of the boxes or damage to the joints. Remove and replace boxes damaged by the Contractor at no expense to the Public Works Department.

When multiple barrel structures are specified, place the barrels a minimum of 2 inches apart. Place the material between culvert barrels in accordance with the Plans and the City Standard Details. When not specified in the Plans, use flowable fill or continuous concrete for gap material. Provide a minimum 6-inch cast-in-place concrete plug along the length of the barrels at the exposed ends of the barrel to prevent erosion of the gap material.

454.04.05 – PLACEMENT OF BOXES

Place the box sections in conformance with the plans or as directed when precast boxes are used to form multiple barrel structures. Place material to be used between barrels as shown on the plans or as directed. Start the laying of boxes on the bedding at the outlet end and proceed toward the inlet end with the abutting sections properly matched unless otherwise authorized. Fit, match, and lay the boxes to form a smooth, uniform conduit true to the established lines and grades. Lower the box sections into the trench, for trench installations, without damaging the box or disturbing the bedding and the sides of the trench. Carefully clean the ends of the box before it is placed. Prevent the earth or bedding material from entering the box as it is laid. Remove and re-lay, without extra compensation, boxes that are not in alignment or show excessive settlement after laying.

454.04.06 – MOVABLE SUPPORT SYSTEMS

Unless sheathing is to be left in place, it shall be pulled out in vertical increments to permit placement and compaction of fill material for the full width of the trench.

When trench shields or boxes are moved, the previously placed pipe shall not be disturbed. It may be necessary to restrain the installed pipe by use of deadman anchors or other means. Voids that are created by movement of a shield or box shall be filled and compacted per the contract documents.

454.04.07 – MINIMUM COVER FOR CONSTRUCTION LOADS

If the passage of construction equipment over an installed pipeline is necessary during project construction, compacted overfill in the form of a ramp shall be constructed to a minimum elevation of 3 ft over the top of the pipe or to a height such that the equipment loads on the pipe do not exceed the pipe design strength. Above all, the loads applied to the box section should not exceed those specified by the designer.

454.04.08 – STORAGE

Store precast sections on a level surface.

454.05 TESTING

454.05.01 – CLEANING AND FLUSHING

All precast reinforced concrete box culvert shall be cleaned and flushed immediately prior to inspection and acceptance.

454.05.02 – POST INSTALLATION INSPECTION

All precast reinforced concrete box culvert will be visually, or CCTV inspected in by a certified PACP inspector.

454.05.03 – SITE SPECIFIC REPAIRS

Site specific repairs will be sealed by a Professional Engineer and submitted to the City by the contractor for evaluation and approval.

454.06 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.

454.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) PRECAST REINFORCED BOX CULVERTS (SIZE)	Linear Foot [Meter]

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.

SECTION 455 – STORM SEWER MANHOLES

455.01 DESCRIPTION

This section covers construction of manholes. Manholes used in Storm Sewer construction shall be Precast Reinforced Concrete.

455.01.01 – REFERENCES

A) **ASTM International**

1) ASTM C478, Standard Specification for Circular Precast Reinforced Concrete Manhole Sections
2) ASTM C913 Standard Specification for Precast Concrete Water and Wastewater Structures
3) ASTM C890 Standard Practice for Minimum Structural Design Loading for Monolithic or Sectional Precast Concrete Water and Wastewater Structures
4) ASTM C1821 Standard Practice for Installation of Underground Circular Precast Concrete Manhole Sections
5) ASTM C479, Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile
6) ASTM C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals
7) ASTM C990 Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants
8) ASTM C443 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
9) ASTM A48, Standard Specifications for Gray Iron Castings

455.02 MATERIALS

455.02.01 – GENERAL

All materials for construction of round manholes shall be in accordance with ASTM C478.

All materials for construction of square or rectangular manholes shall be in accordance with ASTM C913.

This specification covers construction of precast reinforced concrete manhole base sections, riser sections (walls) and appurtenances in accordance with ASTM C478 Standard Specification for "Precast Reinforced Concrete Manhole Sections" or ASTM C913 Standard Specification for "Precast Concrete Water and Wastewater Structures", and as modified herein.

455.02.02 – SUBMITTALS

When requested be the City Engineer, the Contractor shall submit the following, but not limited to, for review and approval.

A) Concrete cylinder compressive test results as per the applicable specification
B) Amount and detail layout of steel reinforcement as per the applicable specification

C) Affidavit of compliance with these specifications.

455.02.03 – SIZES

Standard diameters for round manhole sections shall be from 4’ to 8’ diameter in 1’ increments. Wall lengths for flat walled manhole sections shall be 4’ to 8’ length in 1’ increments. Manholes shall be sized according to the connecting pipe diameters and per the pipe connector gasket manufacturers recommendations where applicable.

455.02.04 – MANHOLES, STEPS, AND LADDERS

Steps and ladders shall not be constructed unless otherwise directed by the City Engineer. If called for, they shall conform to Section 16 of ASTM C-478.

455.02.05 – HANDLING

Lifting holes shall not be allowed. Design of embedded lifting devices shall conform to requirements as specified in 8.4 under Special Loading Considerations of Practice C890.

455.02.06 – ACCEPTANCE

Acceptance of manhole structure shall be based on the conformance and performance of materials required in the applicable specification, and the City Engineer’s inspection of the installed product. The assessment shall include, but not be limited to, the City Engineer’s random plant inspections during production, the quantity and the placement of reinforcement, surface fractures and roughness, and the test results of compressive strength performed on cores and cured cylinders in accordance with Section 7 of ASTM C-497.

455.02.07 – MANHOLE INVERT AND BENCH

When required, inverts shall be formed in the field after pipe pipes have been properly connected. All loose materials shall be removed prior to shaping the invert. The invert shall be smooth, U-shaped, have a minimum depth of on half (1/2) pipe diameter and be channeled across the floor of the manhole using the materials specified herein to obtain the proper form and shape.

455.02.08 – MANHOLE RING AND COVER

Cast iron rings, tops, covers, gratings, and all cast iron fittings shall be sound, true to form and thickness and neatly finished and shall fit together in a satisfactory manner. Castings shall be clean, uniform, and whole, and without blow or sand holes, dorosit, hardspots, shrinkage, distortion or any other surface defects which would impair serviceability. Casting surfaces shall be smooth and well cleaned by shot blasting or other approved cleaning method. Plugging or filling of holes or other defects shall not be permitted.

Parting fins and pouring gates shall be removed. Sharp edges resulting from fabrication shall be dulled by any acceptable method to ensure safety in handling. Casting shall conform to the requirements of the Standard Specifications for Grey Iron Fittings ASTM A-48, Class “30 B” for rings and “35 B” for covers and the applicable City Standard Details for manholes.

All rings and covers shall be accurately and carefully placed. All rings shall be bedded in a substantial

layer of mortar, or a flexible ring seal, shall have a full bearing, and shall be set to the exact grade. Unless otherwise shown, the top of covers shall be flush with, or slightly above, the surrounding surface. When each cover is placed in any position on the ring, the side play shall not exceed one-eighth inch (1/8") in any direction. Wording and markings on covers shall be in accordance with the City Standard Details.

455.03 EQUIPMENT — VACANT

455.04 CONSTRUCTION METHODS

455.04.01 – FOUNDATION

Manholes shall be constructed in a dry excavation. A crushed rock foundation mat shall be constructed under the manhole. The mat shall be a minimum of six inches (6") thick. Placement of material and material properties shall comply with Section 212.04.04 and in accordance with the plans and the City Standard Details.

455.04.02 – BACKFILLING

Backfilling for all manholes shall conform to the requirements of section 212.

455.04.03 – MANHOLE TO PIPE CONNECTION AT INVERTS

Manhole to pipe connections shall be made pursuant to manufacturer's recommendations and the applicable City Standard Details for manhole connections. Grouted connections may be acceptable when connecting like materials such as concrete to concrete. Grouted connections should be made with a pre-packaged non- shrink or expansive grout, properly placed and cure prior to backfill as per grout Manufacturer's recommendations. When connecting flexible pipes to rigid concrete structures, flexible connectors per ASTM C-923 shall be used. Follow gasket manufacturer's requirements for installation and pipe clamping procedures. For manholes built over existing lines or for special conditions, horseshoe shaped openings may be accepted. The City Engineer prior to construction shall approve the method and materials used for grouting any remaining annular space. Flexible pipe seals may be accepted based on Type "D" Certification and a sample, provided that all applicable requirements are met, and that visual inspection shows the workmanship and condition of the material to be satisfactory. All material furnished under certification shall be tagged, stenciled, stamped, or otherwise marked with a lot number, head number, or other appropriate identification which can be readily recognized and checked against the certification.

455.04.04 – FINISHING MANHOLE TO GRADE

The manhole ring and cover shall be adjusted to grade with concrete grade rings.

Mortar shall be Class D, to which has been added an approved admixture unless otherwise shown on the plans or provided in the special provisions. All work shall be completed and finished in a careful, workmanlike manner.

455.05 TESTING

455.05.01 – MANHOLE INSPECTION

After manholes construction has been completed, the manhole shall be visually inspected by the City

Engineer for acceptability. Visual inspection shall be done to check for leaks, thin spots, honeycombs, voids, pinholes and conformance with these specifications.

455.05.02 – MANHOLE TESTING

Unlike sanitary sewer manholes, it may be acceptable for storm manholes to experience some level of infiltration, therefore no infiltration or vacuum testing is required for manholes used in storm sewer applications.

455.06 METHOD OF MEASUREMENT

Payment for *Storm Sewer Manhole* shall be made at the unit price bid per each size for a depth of zero (0') to six feet (6'). The price established shall be full compensation for excavation, backfill, crushed rock foundation, inverts and benches, walls and cones, manhole inserts when specified, ring and cover, removal of existing manhole when necessary or specified or called for on the plans, precast grade ring and all labor, materials, tools, equipment, and incidentals necessary to complete this item of work.

Payment for *Extra Depth Manhole Wall* shall be made at the unit price bid per vertical foot for each size. The price established shall be full compensation for excavation, backfill, removal of existing manhole, and all labor, materials, tools, equipment, and incidentals necessary to complete this item of work.

Extra depth shall be measured from the invert to within six feet (6') below top of cover.

455.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) (DIAMETER) STORM SEWER MANHOLE (0'-6')	Each
(B) EXTRA DEPTH MANHOLE WALL	Vertical Foot [Meter]

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.

SECTION 456 – ADJUSTMENT OF EXISTING MANHOLE

456.01 DESCRIPTION

This section covers various adjustments to existing manholes when called for on the plans or specified. This work may consist of abandoning and plugging, removing, raising, lowering, resetting ring & cover, or setting a new ring & cover on existing manholes.

456.02 MATERIALS

Manhole riser ring skirting and linkage shall be of stainless or galvanized steel and designed for use in storm sewer applications. Skirting shall be formed to produce a radial tension against the sides of the manhole frame when expanded and linkage shall be designed to produce no built-in moments in ring. Ring shall contract and expand without twisting, bending, or binding. Riser ring shall be

removable and reusable with no protruding parts that hinder entry into manhole or limit use of equipment. Expandable manhole riser ring shall be as manufactured by American Highway Prod's of Bolivar, Ohio, or an approved equal.

456.03 EQUIPMENT — VACANT

456.04 CONSTRUCTION METHODS

The manhole ring and cover must be adjusted to grade with concrete grade rings or steel risers and installed per manufactures instructions unless the manhole is being abandoned or removed. Steel risers can be expandable and sloped to meet finished grade. The manhole ring and cover must be adjusted to grade with concrete grade rings or course(s) of brick masonry. All brick masonry must meet the requirements of the Material Specifications. Mortar must be Class D, to which has been added an approved admixture unless otherwise shown on the plans or provided in the bidding documents. All brick must be laid in a full bed of mortar and all joints must be shoved joints completely filled with mortar. The joints on the inside face or exposed face of the masonry must be rubbed full and cut as the brickwork is built up. The masonry must be built up in level courses, true to line, grade and dimension. Bats must be used only when necessary to close joints. All brick must be thoroughly wet down immediately before being placed unless otherwise permitted by the City Engineer. All work must be completed and finished in a careful, professional manner. Old brick masonry must be thoroughly cleaned and wetted before joining new masonry thereto. Where a mortar coating is required, it must have the minimum thickness shown on the plans, must be troweled and re-troweled until a uniform, smooth and impervious surface is obtained.

All rings and covers must be accurately and carefully placed. All rings must be bedded in a substantial layer of mortar, or a flexible ring seal, must have a full bearing, and must be set to the exact grade. Unless otherwise shown, the top of covers must be flush with, or slightly above, the surrounding surface. When each cover is placed in any position on the ring, the side play must not exceed one eighth inch (0.125-in) in any direction. All new rings and covers including the wording and markings must be in accordance with the applicable City Standard Details.

A) **Abandoning Manhole** - This work shall be accomplished in accordance with the applicable City Standard Detail for abandoning manholes. The manhole shall be broken down to a point two (2) feet below proposed or existing grade.

   Manhole shall be filled with sand backfill and shall be compacted to remove all voids in material.

B) **Removing Manhole** - This work shall be accomplished in accordance with the applicable City Standard Detail for abandoning manholes except the manhole shall be broken down to a point two (2) feet below any proposed construction or totally removed when directed by the City Engineer.

   Any portion of the remaining manhole authorized to remain in place or the void created from the manhole removal, shall be filled with sand backfill and shall be compacted to remove all voids in material.

C) **Raising Manhole: Type I - less than or equal to one (1) foot** - When called for on the plans or directed by the City Engineer, the manhole shall be raised by using pre-cast concrete grade rings or courses of brick masonry. In no case, however, shall the chimney be greater than one (1) foot in height.

   Once the appropriate raising has been accomplished the existing ring and cover shall be reset to

the new grade.

D) **Raising Manhole: Type II - greater than one (1) foot** - When called for on the plans or directed by the City Engineer, the manhole shall be raised by initially removing the existing corbel or cone. Pre-cast manhole shall then be rebuilt in conformity with the size and shape of requirements for new manholes. Brick or cast-in-place manholes shall then be rebuilt in conformity with the applicable City Standard Detail for rebuilding manholes".

Once the appropriate raising has been accomplished the existing ring and cover shall be reset to the new grade.

E) **Lowering Manhole: Type I** - Manhole shall be lowered by removing pre-cast grade rings or courses of brick masonry, such that the frame maintains a minimum of two (2) inches of seat support.

Once the appropriate lowering has been accomplished the existing ring and cover shall be reset to the new grade.

F) **Lowering Manhole: Type II** - When the minimum seat support is not available, the corbel, cone, or wall shall be removed to an elevation which will accommodate installation of a pre-cast cone, grade rings, or brick masonry and the ring and cover. The manhole shall be rebuilt in conformance with the applicable City Standard Detail for rebuilding manholes.

Once the appropriate lowering has been accomplished the existing ring and cover shall be reset to the new grade.

G) **Resetting Existing Ring and Cover** - Once the appropriate adjustment (raising or lowering) has been accomplished the existing ring and cover shall be reset to the new grade.

The existing ring and cover shall be reset to the desired grade (elevation) by using pre-cast concrete grade rings or brick masonry as further specified in Section 456.04.

H) **Setting New Existing Ring and Cover** - Once the appropriate lowering has been accomplished the existing ring and cover shall be reset to the new grade.

When existing cast iron fittings are unsound or misshapen or when called for on the plans or directed by the City Engineer, a new ring and cover shall be set to the existing elevation (grade) by use of pre-cast concrete grade rings or brick masonry as further specified in Section 456.04.

I) **Raising Manhole Lid** - Existing manhole frame and cover must be in good condition and have a minimum one and one quarter (1-1/4) inch deck to accommodate riser ring. Loose rust and debris shall be removed with a wire brush from existing frame prior to installation. Manhole riser shall be installed as directed by the manufacturer as further specified in Section 456.04. Verify proper height and adjustment has been obtained.

In locations where an asphalt surface is not to be placed around the ring, a bead of bituminous or epoxy sealant shall be placed around the exterior circumference where the ring meets the frame before completing surface restoration.

456.05 TESTING — VACANT

456.06 METHOD OF MEASUREMENT

Measurement for *Abandoning Manhole* shall be made at the unit bid price per each when specified as an item of work. Measurement for *Removing Manhole* shall be made at the unit price bid per each when specified as an item of work.

Measurement for *Raising Manhole (Type I)* shall be made at the unit bid price per each when specified

as an item of work. Measurement for payment for *Raising Manhole (Type II)* shall be made from the finish grade to the limit of plan removal unless otherwise directed by the City Engineer.

Measurement for *Lowering Manhole (Type I)* shall be made at the unit bid price per each when specified as an item of work. Measurement for payment for *Lowering Manhole (Type II)* shall be made from the finish grade to the limit of plan removal unless otherwise directed by the City Engineer.

Measurement for *Resetting Existing Manhole Ring and Cover* shall be made at the unit price bid per each when specified as an item of work.

Measurement for *Setting New Manhole Ring and Cover* shall be made at the unit price bid per each when specified as an item of work.

Measurement for *Raising Manhole Lid* shall be made at the unit price bid per each ring when specified as an item of work.

456.07 BASIS OF PAYMENT

The items measured as provided above will be paid for at the contract unit price bid:

Pay Item:	**Pay Unit:**
(A) ABANDONDING MANHOLE (SIZE)	Each
(B) REMOVING MANHOLE (SIZE)	Each
(C) RAISING MANHOLE (TYPE I)	Each
(D) RAISING MANHOLE (TYPE II)	Vertical Foot [Meter]
(E) LOWERING MANHOLE (TYPE I)	Each
(F) LOWERING MANHOLE (TYPE II)	Vertical Foot [Meter]
(G) RESETTING EXISTING MANHOLE RING AND COVER	Each
(H) SETTING NEW MANHOLE RING AND COVER	Each
(I) RAISING MANHOLE LID	Each

Payment for *Abandoning Manhole* shall be made at the unit bid price per each. The price established shall be full compensation for all materials including sand backfill, labor, tools, equipment, and incidentals necessary to complete this item of work. The price established for *Removing Manhole* shall be full compensation for all materials including sand backfill, labor, tools, equipment, and incidentals necessary to complete this item of work. In the absence of the bid item, the price shall be included in the cost of *Storm Sewer Manhole* construction.

The price established for all other adjustment pay items shall be full compensation for all materials including excavation, backfill, resurfacing, tools, materials, labor, equipment, and incidentals necessary to complete this item of work.