PART 4

STRUCTURES

SECTION 400

FURNISH PILE DRIVING EQUIPMENT

400.01 GENERAL. - The Contractor shall furnish and maintain at the site, and subsequently remove from the site as his property, all equipment, and appurtenances, including spuds, jets, and pumps, and shall do all Incidental Work, all as required to satisfactorily drive all piles furnished under the contract, all in accordance with the requirements set forth herein.

The Contractor shall include the cost of moving the pile-driving equipment between the various pile locations in the price bid for furnishing pile-driving equipment.

For the purpose of computing progressive payments, the work shall be prorated as set forth in the following table:

a) Furnish all necessary pile-driving equipment at the site and satisfactorily driving the first pile	60%
b) Maintaining all necessary pile-driving equipment and completing the satisfactory driving of all piles under the contract	30%
c) Removing all pile-driving equipment from the site	10%
Total	100%

For purpose of payment, no work shall be considered performed until the first pile has been satisfactorily driven. The work allocated under b), above, for maintaining the pile-driving equipment and completing all pile-driving shall be prorated in accordance with the percentage of the number of piles satisfactorily driven.

400.02 PILE DRIVER. - The pile driver shall have fixed leads which shall be capable of guiding the hammer from the highest to the lowest point of travel and holding the pile firmly in axial alignment with the hammer. The leads shall be secured to the body of the crane or supporting tower by rigid members in a manner that will prevent movement and maintain alignment of the leads during driving operations.

The pile hammer shall be an approved steam, air, or diesel hammer, and shall be of such weight that when operating at the rated number of blows per minute specified by the manufacturer it will be capable of delivering to the pile at least 15,000 foot pounds of energy per blow. The adequacy of the hammer for a particular job shall be subject to approval by the Engineer.

Steam or air hammers shall be furnished with boiler or air capacity at least equal to that specified by the manufacturers of the hammers to be used. The boiler or compressor shall be equipped with an accurate pressure gage at all times. The valve mechanism and other parts of steam, air, or diesel hammers shall be maintained in first class condition so that the length of stroke and number of blows per minute for which the hammer is designed will be obtained. Inefficient steam, air, or diesel hammers shall not be used.

Suitable anvils, driving caps, or cushions shall be used to prevent damage to the pile butts.

Equipment for the driving of test piles shall be the same as that for driving all other piles under the contract.

The use of vibratory hammers and other vibratory equipment will be subject to the approval of the Engineer; however, such approval does not relieve the Contractor of the responsibility for any damages or injuries resulting from the use thereof.

The use of high frequency vibrating equipment, or sonic equipment, for the driving or withdrawal of sheet piling is prohibited.

400.03 FOLLOWER. - The use of a follower will be permitted provided the follower is of the type that will adequately and properly, as determined by the Engineer, transmit the energy of the hammer blow to the pile head. The follower shall have a minimum length of 20 feet, and its average weight shall not be less than 80 pounds per foot. The use of a timber follower of any type will not be permitted.

The Contractor shall submit to the Engineer for approval complete detailed data on the follower he intends to use, prior to commencement of use thereof.

Further, if the Contractor proposes to drive piles using a follower, he shall drive all piles, including test piles, using the same follower.

400.04 JETTING EQUIPMENT. - Jetting equipment shall be capable of delivering, and shall be outfitted with, the following:

1) A constant supply of water at 300 to 500 gallons per minute, as necessary, at the nozzle of the jet pipe;
2) A minimum pressure of 250 psi at the nozzle of the jet pipe;
3) A jet nozzle of 3/4 inch to 1 inch diameter with four to six side holes 1/8 inch in diameter, evenly spaced around the nozzle;
4) Sufficient jet pipe to reach the specified depth;
5) Jet pipe permanently and visibly marked in five foot increments commencing at 40 feet from the tip of the nozzle.

The pressure and the discharge rate of the water at the jet shall be adequate to freely erode materials adjacent to the pile.

400.05 SPUD. - If a spud is used, the size and the strength thereof shall be adequate to drive through miscellaneous fill materials such as gravel, small boulders, rubble, and timbers.

400.06 PAYMENT. - Furnish pile-driving equipment will be paid for at the lump sum price bid to satisfactorily furnish, maintain and remove the specified equipment and appurtenances.

SECTION 401

DRIVING PILES

401.01 GENERAL. - The Contractor shall drive piles, including test piles, spliced piles, and batter piles, where and as shown on the plans, or where directed, and shall do all Incidental Work, all in accordance with the requirements set forth herein.

401.02 BORING DATA. - In most cases, prior to pile driving, the City will have completed under separate contracts soil borings in close proximity of the work. Generally in such cases, the logs and locations of the borings and the results of soil tests made on samples taken during the borings will be shown on the plans. In the event such information is made available to the Contractor, it shall be understood that the City will assume no responsibility for the accuracy of such information nor for any deductions or conclusions that the Contractor may make therefrom.

401.03 OBSERVATION AND RECORDING OF PILE BEHAVIOR. - The Contractor shall provide the Engineer with every reasonable facility for properly observing and recording the behavior of each pile during the entire driving operation, including allowing access to the behavior information recorded by the Contractor. The Contractor shall clearly mark the piles in identifiable five foot increments, and when directed by the Engineer shall clearly mark the piles in one foot increments.

When driving is interrupted before final penetration is reached, the record for penetration shall not be taken, except as otherwise directed by the Engineer, until twelve inches of penetration have been obtained on resumption of driving.

401.04 EXISTING PILES. - Should existing piles conflict in location with piles to be driven, substitute pile locations will be determined by the Engineer. Piles shall be driven at such substitute locations at no extra cost to the City.

401.05 OBSTRUCTIONS. - If, during driving, an obstruction, such as a large boulder, prevents further driving or jetting of a pile, the pile may be ordered abandoned by the Engineer and another pile ordered by him to be driven close by. A pile so abandoned shall be cut off as Incidental Work one foot below normal cut-off elevation. Payment, under the appropriate Bid Item, for the furnishing of each abandoned pile will be for the ordered length or for the length from tip to cut-off, as applicable. Payment for the driving of each such pile will be made under the appropriate Bid Item.

401.06 DRIVING. - Driving of piles, steel pipe, or steel shells within 50 feet of newly constructed concrete structures or cast-in-place concrete piles will not be permitted until the concrete in such structures or piles has attained a compressive strength of at least 2500 psi based on field cured cylinders.

The Contractor prior to driving piles, steel pipe, or steel shells shall either excavate to cut-off elevation or provide a hole for the piles, steel

pipe, or steel shells by either spudding or drilling to at least the cut-off elevation in accordance with Section 401.07.

In addition, for steel piles or steel shells, when necessary to obtain the specified penetration or to prevent damage to the pile during driving, the Contractor shall provide special driving tips or heavier pile sections or take other measures as approved by the Engineer.

Unless otherwise noted, all piles shall be driven to "refusal"; "refusal" shall be defined as a blow count of 10 blows per inch of penetration. However, should any pile meet "refusal" in a stratum under-lain by weak, highly compressible soils, the Engineer may direct the Contractor to drive the pile through the weak layer or layers to a stratum capable of supporting such pile, all as determined by the Engineer.

When it is desirable to penetrate a sand stratum and high resistance is encountered, jetting, if specified in the Special Provisions shall be employed to facilitate the driving of the piles all as directed by the Engineer.

After the specified jetting, the piles, steel pipe, or steel shell, shall be driven to the required penetration or to "refusal" all as determined by the Engineer.

In all cases in the driving of test piles, jetting if specified shall be employed as necessary, as determined by the Engineer, for the full ordered length or to the elevations set forth in the Special Provisions or shown on the plans.

The heads of concrete piles or casings shall be protected from direct impact of the hammer by a cushion driving block. The cushion shall be maintained in good condition during the entire driving operation. The cushion driving block shall be so arranged that any reinforcing bars projecting above the piles will not be displaced or injured in driving.

Precast concrete piles shall not be driven until 14 days after casting.

All piles shall be driven plumb for vertical piles and at the batter indicated for batter piles, and shall be located true to line and spacing as shown on the plans. Each pile, at cut-off elevation, shall not be more than 4 inches out of place. If such allowable deviation is exceeded, the pile shall be abandoned and another driven, unless the Contractor constructs, on top of the driven pile, an approved equivalent support. All such abandoned piles or additional construction or other work caused by piles being out of place, shall be at the sole expense of the Contractor.

401.07 SPUDDING OR DRILLING. - In order to decrease the frictional resistance for all piles, the Contractor shall, by means of spudding or drilling, provide holes completely through the overburden to the cut-off elevation, or if specified, to the elevation set forth in the Special Provisions. The minimum diameter of each spudded or drilled hole shall be 2 inches greater than the butt diameter of the pile to be driven.

The hole shall be cleared sufficiently of materials so as to allow the placing of the tip of the pile at the bottom of the hole with the aid of no more than the weight of the hammer on the pile. Any hole which does not permit such placing of the pile shall be respudded or redrilled, and, if necessary, repeatedly respudded or redrilled and/or protected by the use of casing, to the extent that the hole will be sufficiently clear to

allow the placing of the pile in the spudded hole in the manner specified.

After driving the pile the space around the pile shall be filled to ground surface with dry sand or pea gravel.

In the event the Contractor provides holes as specified by drilling, he shall furnish and operate, at his own expense, the necessary drilling apparatus.

401.08 JETTING. - In order to obtain the required penetration, when specified in the Special Provisions, the Contractor shall supply and operate water jets with adequate pumping equipment. Jetting shall start only after refusal has been reached.

Where jets have been employed, they shall be withdrawn and jetting not permitted once the final bearing stratum has been reached.

Jetting shall be done with care so as not to loosen adjoining piles already driven. Piles that have lifted shall be redriven at the sole expense of the Contractor.

Jets shall not be used at locations where the stability of embankments or other improvements would be endangered.

When jetting is specified, the Contractor shall continuously maintain on the pile driver, jet pipes and jetting equipment in good operating condition, so that they will be available for immediate use when necessary. No pile-driving will be permitted unless such jetting equipment is available, and the cost of any and all delays caused by non-compliance with this requirement will be at the sole expense of the Contractor.

Should City water from hydrants be required by the Contractor for jetting purposes, he shall first obtain written permission from the Chief of the San Francisco Fire Department, and shall then contact the Water Distribution Division Manager of the San Francisco Water Department for final approval.

401.09 UNSATISFACTORY PILE, STEEL PIPE, OR STEEL SHELL. - Any pile, steel pipe, or steel shell misaligned or damaged as a result of the Contractor's operations to an extent that will make it incapable, in the opinion of the Engineer, of performing the function for which it was designed, will be considered unsatisfactory. Such unsatisfactory pile, steel pipe, or steel shell shall be withdrawn and removed by the Contractor as his property, or, if approved by the Engineer, abandoned with the upper section removed to at least one foot below the cut-off elevation.

The Contractor shall satisfactorily replace all such removed or abandoned piles, steel pipe, or steel shells. Such satisfactory replacements will be paid for under the appropriate Bid Items therefor. However, as set forth under Section 401.10, no payment will be made for unsatisfactory piles.

401.10 PAYMENT. - Driving of a pile, satisfactorily as specified, will be paid for at the applicable unit price bid per pile as set forth in the Proposal, including test piles, spliced piles, and batter piles.

For the purpose of payment for driving, a spliced pile, regardless of length, the circumstances of splicing, and the number of component parts, will be considered a single pile.

In the event several length categories for driving are included in the Proposal, the length of a pile shall be as measured between the tip and the cut-off.

No payment will be made for furnishing, driving, withdrawing, removing, or abandoning unsatisfactory piles, steel pipe, or steel shells, which are defective, or damaged as a result of the Contractor's operations, or are otherwise unsatisfactory as set forth in Section 401.09. However, piles which during driving encounter obstructions will be paid for as set forth under Section 401.05.

Ordered jetting time for piles will be paid for at the price bid per minute of actual satisfactorily effective jetting done as specified, including jetting required to lower the jet pipe to proper elevation for ordered jetting but not including any time for setting up equipment or any other time when the jets are not functioning as intended. When refusal has been met and jetting ordered by the Engineer, the jetting time shall be recorded in minutes from initial jetting until the pile has "broken through" the resistive material.

The ordered jetting time for each pile shall be recorded on a City-furnished pile-driving form. The form shall be initialed by the Resident Engineer and the Contractor, or his representative, over their last names printed on the form. When the form has been initialed, it will signify that both the City and the Contractor have agreed on the accuracy of the pile driving record.

SECTION 402

FURNISH TIMBER PILES

402.01 GENERAL. - The Contractor shall furnish timber piles of lengths ordered by the Engineer, or specified, including certifying, handling, storing, treating, splicing, disposing of stubs and surplus piles, and doing all other related Incidental Work, all in accordance with the requirements set forth herein.

Checks in untreated timber piles, and checks prior to treatment for treated timber piles, shall not exceed 1/4-inch in width or be continuous for 10 feet in length. After treatment, checks shall not exceed 3/8-inch in width or be continuous for 15 feet in length. Checks shall be considered continuous unless separated from other checks by at least 1/2-inch thickness of wood. Checks shall be defined as a separation along the grain, the greater part of which occurs across the rings of annual growth.

Splits in untreated and treated timber piling shall not be longer than the butt diameter of the pile. A split shall be defined as a lengthwise separation along any continuous path through the cross section of the pile and common to, and apparent at, two locations on the circumference of the pile. Lengthwise separations not extending through the pile shall conform to the limits specified for checks.

All timber piles shall be clean-peeled Douglas fir Class "A" piles in accordance with the requirements of ASTM "Standard Specification for Round Timber Piles," Designation D 25.

Timber piles to be creosoted shall be inspected prior to creosoting.

Timber piling shall be protected with steel straps placed at not more than 10-foot centers along the pile. Five additional straps shall be placed on each pile; one each at 3 inches, 6 inches, and 12 inches from the tip and 2 within 2 feet of the butt.

Steel strapping shall be approximately 1¼ inches wide, 0.030-inch in nominal thickness and shall be fabricated from cold-rolled heat-treated high tensile strapping. Strapping shall develop a tensile strength of at least 5,000 pounds. Straps shall be held in place with clips which are secured by crimping twice in the clip length with a notch-type sealer. The clip shall be approximately 2¼ inches long and fabricated from 0.036-inch thick steel. The clip joint shall develop at least 75 percent of the strap tensile strength. Straps shall encircle the pile once and shall be tensioned as tight as possible either by hand operated or pneumatic tensioning tools.

Timber piles shall be fresh-headed and square and when permitted by the Engineer, the heads of the piles may be protected by means of heavy steel or wrought iron rings. During driving operations timber piling shall be restrained from lateral movement at intervals not to exceed 20 feet over the length between the driving head and the ground surface. During driving operations, the timber pile shall be kept moving by continuous operation of the hammer.

402.02 CERTIFICATION. - Certification, in writing, by an independent recognized testing laboratory approved by the City, that the piles furnished are Douglas fir and conform to the specifications for Class "A" piles of ASTM Designation D 25, to these specifications, and to the Special Provisions, will be required. Two copies of the certification for each shipment shall be delivered to the Engineer prior to the shipment of the piles.

Positive identification of each approved pile shall be effected by burning or indelibly imprinting a characteristic stamp or mark of the testing laboratory thereon at the time of inspection. No direct or additional payment will be made for the above certification, and the Contractor shall include all costs thereof in his bid prices.

402.03 CREOSOTING. - Timber piles, when specified in the Special Provisions or indicated on the plans to be treated, shall be pressure treated with creosote in accordance with Section 415. For spliced piles, treatment will only be required for the upper components. The heads of all treated piles shall receive a brush coat of creosote, in accordance with Section 415.09.

402.04 SPLICING. - Pile splices shall be in accordance with the details shown on the plans and will only be permitted to be used in the following instances:

(1) When the length of pile, ordered by the Engineer, is 70 feet or longer, the Contractor, at his option, may use a spliced pile. For such spliced pile, only one splice will be permitted, and the splice shall be placed at least 30 feet below the cut-off elevation, unless otherwise specified. In this instance, materials furnished for the pile splice, and the construction of the splice, shall be at the sole expense of the Contractor, and no direct or additional payment will be made therefore;

(2) When a pile, whole or spliced, as permitted under (1) above, has been driven to its full ordered length without having reached the bearing result desired by the Engineer, the Engineer will order the splicing of an additional length of pile. In this instance, the ordered pile splice will be paid for as set forth under Section 404.

Tip diameters, of other than the lowest component, of a spliced pile shall be 11 inches.

402.05 CUT OFF AND EXTENSION. - Timber piles shall be cut off square at the elevation designated. Piles inaccurately cut off shall be replaced or, when permitted by the Engineer, shall be extended with approved reinforced concrete caps, all at the sole expense of the Contractor.

Extensions for piles, necessary as replacements for those portions of damaged piles which were cut off due to brooming or splitting, shall be constructed at the sole expense of the Contractor.

402.06 DISPOSING OF STUBS AND SURPLUS PILES. - After the completion of all pile driving operations, all timber pile stubs and surplus timber piles, except those marked by the Engineer to be retained by the City, shall remain the property of the Contractor and shall be disposed of by him as his property. The City will assume the responsibility for the loading and removal of those pile stubs and surplus piles to be retained by the City.

402.07 PAYMENT. - Timber piles, as specified, satisfactorily furnished at the site, will be paid for at the price bid per linear foot.

SECTION 403

TIMBER TEST PILES

403.01 GENERAL. - When required in the Special Provisions, the Contractor shall drive timber test piles where shown on the plans, or where directed, and in accordance with the requirements set forth herein.

The Contractor shall furnish all equipment in accordance with Section 400 and timber piles in accordance with Section 402. He shall drive the timber test piles in accordance with Section 401.

The approximate locations and lengths of test piles to be driven shall be as shown on the plans and specified in the Special Provisions. From the results obtained in driving test piles, the Engineer will determine the lengths of all other piles to be used under the contract and will furnish to the Contractor the pile length list for the piles located between each four consecutive test piles within ten working days after the satisfactory driving of such test piles. Timber pile lengths, as measured from cut-off elevations, will be given in standard stock lengths and will include allowances for cut-offs as well as allowable variations in lengths set forth under ASTM Designation D 25.

Nothing in the above, however, shall be construed as preventing the Contractor, in the interest of expediting work, from supplying himself, in advance, at his own risk, with some piling at the job site to commence pile driving operations.

Test piles shall be so located that they may be cut off and become a part of the completed structure. Test piles shall be driven using the same type of equipment and the same procedures that will be used in driving all other piles under the contract.

If the information obtained from a required test pile is, in the opinion of the Engineer, inconclusive, he will order the driving of an additional test pile in the immediate vicinity at a location designated by him. Upon the completion of the driving of all test piles, unused additional test piles will be considered piles ordered from the pile list and payment will be made for the full ordered lengths of such unused test piles.

If, at the option of the Contractor, test piles are driven in the street area prior to excavation, each pile butt shall be driven or cut off below the existing street pavement grade, and immediately following the driving of the pile, the opening in the street shall be backfilled and topped with a minimum of 2 inches of temporary pavement. Such work shall be done as Incidental Work and no additional payment will be made therefor.

Test piles will be ordered in lengths measured from the cut-off elevations. If at the Contractor's option test piles are to be driven prior to excavation, allowance should be made for the additional lengths required, or a follower should be used. Such furnishing of the additional lengths of piles, or the use of the follower shall be at the Contractor's sole expense and no additional payment will be made therefor.

403.02 PAYMENT. - Timber test piles will be paid for as set forth under Sections 400, 401 and 402, as applicable, and no direct or additional payment over and above that provided under such Sections will be made by virtue of any pile being a test pile.

SECTION 404

ORDERED TIMBER PILE SPLICE

404.01 GENERAL. - In each instance where the length of a timber pile ordered by the Engineer is insufficient to attain the required bearing result and a splice is ordered by the Engineer, the Contractor shall furnish materials for and construct such ordered timber pile splice where directed by the Engineer, including doing all related Incidental Work.

In accordance with Section 402.04, approved timber pile splices constructed by the Contractor at his option for piles ordered to be 70 feet or longer will not be included for payment under this Section but shall be done as Incidental Work.

404.02 PAYMENT. - Ordered timber pile splice satisfactorily furnished and constructed, complete in place, as specified, will be paid for at the unit price bid therefor.

SECTION 405

FURNISH AND CONSTRUCT CONCRETE-FILLED STEEL PIPE PILES

405.01 GENERAL. - The Contractor shall furnish and construct concrete-filled steel pipe piles where and as shown on the plans or where directed, including steel pipe, splices, concrete, reinforcing steel, welded steel end plates, and all other related Incidental Work, all in accordance with the requirements specified herein.

The Contractor shall drive steel pipes in accordance with Section 401. Each steel pipe shall be driven to the required bearing value before being filled with concrete.

After being driven and prior to the placing of reinforcing steel and concrete, each steel pipe shall be examined for damage or reduced diameter at any point. Any pipe improperly driven or broken, or which shows partial collapse to an extent that will materially decrease its bearing value, will be rejected as unsatisfactory and shall be replaced by the Contractor.

Driven pipe shall be free of water before reinforcing steel and concrete are placed.

The Contractor shall have available at all times a suitable light for inspecting the entire length of each pipe before placing reinforcing steel and concrete.

405.02 STEEL PIPES. - Steel pipe piles shall be constructed using steel pipe with an O.D. of 10 3/4 inches and a minimum wall thickness of 0.188 inch.

Steel pipe shall be new steel pipe conforming to the requirements for Grade 2 of ASTM "Standard Specification for Welded and Seamless Steel Pipe Piles," Designation A-252. The Contractor shall furnish to the Engineer, written certification from the pipe manufacturer or from an independent recognized testing laboratory that the pipe supplied meets

the requirements of such ASTM Specifications. The welded end plate shall be watertight with a diameter not more than 1/4-inch larger than the pipe shell.

Each length of pipe shall be legibly marked with the manufacturer's identifying symbol, together with size, weight, length, wall thickness, and the words "Grade 2 Piling" as required in the ASTM Specifications.

405.03 CONCRETE. - Concrete for steel pipe piles shall be Class 7-4000-¼ as set forth in Section 800.11.

The Concrete shall be vibrated in the length of the pipe.

Reinforcement for concrete shall be in accordance with Section 411.05.

405.04 SPLICING. - The Contractor shall determine the component lengths of pipe for the piles. His attention is directed, however, to required minimum tip elevations and the allowable number of splice connections.

Steel pipes may be spliced before or during driving operations. Each splice connection shall be made by a continuous butt weld in accordance with the requirements of Section 806. The pipe sections shall be properly aligned so that the longitudinal axis of each completed pile will be in a straight line.

The number of splice connections in any pile shall not exceed 3, unless otherwise specified or permitted by the Engineer.

405.05 PAYMENT. - Concrete-filled steel pipe piles satisfactorily furnished and constructed complete, in place, as specified, except for driving which will be paid for as set forth in Section 401, will be paid for at the price bid per linear foot.

The quantity to be paid for will be the aggregate length of concrete-filled steel pipe piles measured in place along the longitudinal centerlines thereof between tip and cutoff.

SECTION 406

FURNISH AND CONSTRUCT CONCRETE-FILLED STEEL SHELL PILES

406.01 GENERAL. - The Contractor shall furnish and construct concrete-filled steel shell piles where and as shown on the plans or where directed, including steel shells, splices, concrete, and reinforcing steel, and all other related Incidental Work, all in accordance with the requirements specified herein.

The Contractor shall drive steel shells in accordance with Section 401. Each steel shell shall be driven to the required bearing value before being filled with concrete.

After being driven, and prior to the placing of reinforcing steel and concrete, each steel shell shall be examined for damage or reduced diameter at any point. Any shell improperly driven or broken, or which shows partial collapse to an extent as to materially decrease its bearing value will be rejected as unsatisfactory. Rejected shells shall be removed and replaced, or a new shell driven adjacent thereto. Rejected shells which cannot be removed shall be filled with concrete by the Contractor at his expense.

Driven shells shall be free of water before reinforcing steel and concrete are placed.

The Contractor shall have available at all times a suitable light for inspecting the entire length of each shell before placing reinforcing steel and concrete.

406.02 STEEL SHELLS. - Steel shells shall be of sufficient strenth and rigidity to permit driving, and to prevent distortion caused by soil pressures or the driving of adjacent piles, until filled with concrete. The shells shall also be sufficiently watertight to exclude water.

The shells may be cylindrical or tapered, step-tapered, or a combination of either, with cylindrical sections. The tip diameter shall not be less than 8 inches and the butt diameter shall not be less than 12 inches.

Shells to be driven without a mandrel shall be equipped with heavy steel driving tips, and all splices in the shell shall be continuously welded to develop the full strength of the section.

406.03 CONCRETE. - Concrete for steel shell piles shall be Class 7-4000-3/4, as set forth in Section 800.11.

The bottom of each shell shall be filled with mortar to a depth of not less than 2 feet immediately before placing the concrete. The mortar shall consist of one part Portland Cement to 3 parts fine aggregate mixed to a suitable consistency, or Class 7-4000-3/4 Concrete with the 3/4-inch and larger aggregate removed.

The Concrete shall be vibrated for the length of the shell.

Reinforcement for concrete shall be in accordance with Section 411.05.

406.04 PAYMENT. - Concrete-filled steel shell piles satisfactorily furnished and constructed complete, in place, as specified, except for driving which will be paid for as set forth in Section 401, will be paid for at the price bid per linear foot.

The quantity to be paid for will be the aggregate length of concrete-filled steel shell piles measured in place along the longitudinal centerlines thereof between tip and cut-off.

No payment will be made for an unsatisfactory pile.

SECTION 407

FURNISH PRECAST CONCRETE PILES

407.01 GENERAL. - The Contractor shall furnish precast concrete piles of the lengths ordered by the Engineer, or specified, including handling, storing, and doing all other related Incidental Work, all in accordance with the requirements specified herein.

Precast concrete piles shall be constructed of Class 7-4000-3/4 Portland Cement Concrete in accordance with the requirements of Sections 800.11, 411 and 412, as applicable.

Reinforcing steel shall be in accordance with Section 411.05 and pre-stressing steel in accordance with Section 412.03.

Concrete for precast concrete piles shall be placed in smooth mortar-tight forms, so supported as to prevent appreciable deformation or settlement during placing or curing. When removed from the form, the pile shall present true, smooth, even surfaces free from honeycombs and voids and shall be so straight that a line stretched from butt to tip on any face will not be more than 1 inch from the face of the pile at any point.

Concrete piles, both conventionally reinforced and prestressed, shall be cured as provided in Section 800.16.

When raising or transporting precast concrete piles, the Contractor shall provide slings or other equipment to avoid any appreciable bending of the pile or cracking of the concrete. Piles materially damaged in handling or driving shall be replaced by the Contractor at his expense. Concrete piles shall be handled at all times so as to avoid breaking or chipping the edges.

407.02 PAYMENT. - Precast concrete piles, as specified, satisfactorily furnished at the site will be paid for at the price bid per linear foot.

SECTION 408

CONCRETE PILES CAST IN DRILLED HOLES

408.01 GENERAL. - The Contractor shall construct concrete piles cast in drilled holes where and as shown on the plans, or where directed, including drilling holes, installing casing, furnishing and placing steel reinforcement and concrete, and doing all other related Incidental Work, all in accordance with the requirements specified herein.

408.02 DRILLED HOLES. - Holes for cast concrete piles shall be drilled so that the maximum deviation of the longitudinal axis at any point from the axis specified shall not be more than one percent of the length of the hole.

All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed before placement of concrete therein.

The use of water for drilling operations or for any other purpose where it may enter the hole will not be permitted. Surface water shall not be permitted to enter the hole and all water which may have infiltrated into the hole shall be removed before placement of concrete therein.

408.03 CASING. - The Contractor, where necessary for the construction of the piles, or the safety of workmen, shall furnish and drive casing in the drilled holes, and shall subsequently withdraw from the holes, and remove, such casing from the site as his property.

Casing shall be removed from the hole as concrete is placed therein. The bottom of the casing shall be maintained not more than 5 feet, nor less than one foot, below the top of the concrete during withdrawal and placing operations.

Should it be necessary to leave sections of casing in place in drilled holes, such sections of casing shall become the property of the City at no cost to the City.

408.04 CONCRETE. - Concrete shall be Class 7-4000-3/4 as set forth in Section 800.11.

The concrete shall be vibrated for the length of the pile.

The reinforcing cage shall be placed and secured symmetrically about the axis of the pile and shall clear the sides of the hole.

The Contractor shall place the reinforcing steel and concrete within 24 hours after completion of each uncased pile hole.

Steel reinforcement shall be in accordance with Section 411.05.

408.05 PAYMENT. - Concrete piles cast in drilled holes satisfactorily constructed complete, in place, as specified, will be paid for at the price bid per linear foot.

The quantity to be paid for will be the aggregate length of concrete piles cast in drilled holes measured in place along the longitudinal axis from the lower limit to cutoff.

SECTION 409

FURNISH STEEL H-BEAM PILES

409.01 GENERAL. - The Contractor shall furnish steel H-beam piles, as required, including splices, steel plate caps, and all other related Incidental Work, all in accordance with the requirements specified herein.

The Contractor shall drive piles in accordance with Section 401.

409.02 H-BEAMS. - H-beams shall be of structural steel conforming to ASTM "Standard Specification for Structural Steel," Designation A 36. If approved by the Engineer manufactured welded sections may be used.

408.03 SPLICES. - The length of a steel H-beam pipe may consist of spliced sections. The section shall be of identical cross sections and may be spliced before or during driving operations. Splice connections shall be made by full butt welding the entire cross section in accordance with the requirements of Section 806. The sections shall be properly aligned so that the longitudinal axis of each completed pile will be a straight line. The number of splice connections in the length of a pile shall not exceed 2 unless otherwise permitted by the Engineer.

409.04 CUTOFF. - Piles shall be accurately cut off and capped with a steel plate as shown on the plans. Piles not accurately cut off shall be extended, or provided with an approved equivalent construction, all at the sole expense of the Contractor.

409.05 PAYMENT. - Steel H-beam piles satisfactorily furnished complete, in place, as specified, except for driving which will be paid for as set forth in Section 400, will be paid for at the price bid per linear foot.

The quantity to be paid for will be the aggregate length of steel H-beam piles measured in place along the longitudinal centerlines thereof between tip and cutoff.

SECTION 410

METAL DRIVING SHOE FOR PILES

410.01 GENERAL. - The Contractor shall furnish and install metal driving shoes, where and as specified or shown on the plans, or where directed, including all related Incidental Work, all in accordance with the requirements specified herein.

Piles equipped with metal driving shoes shall be driven to rock. The pile shall penetrate the rock 18 inches and driving shall terminate with a blow count of not less than 10 blows per inch. However, if the required blow count is reached before the penetration has been attained, the Contractor shall thereafter continue driving until 120 blows into such rock have been delivered to the pile or until the required penetration has been reached, whichever occurs first.

410.02 PAYMENT. - Metal driving shoe satisfactorily furnished and installed complete in place, as specified, will be paid for at the unit price bid therefor.

SECTION 411

CONCRETE STRUCTURES

411.01 GENERAL. - The Contractor shall construct plain and reinforced concrete structures, including constructing falsework and formwork, and removal thereof, furnishing and placing reinforcing steel, furnishing, mixing, placing, protecting and curing concrete, surface finishing waterproofing, and all other necessary, or required, Incidental Work, all where and as shown on the plans and in accordance with the requirements specified herein.

411.02 CONCRETE. - Concrete and related materials and work, including mixing, placing, protecting and curing, shall be in accordance with Section 800. The Contractor shall use Class 6-3500-1½ unless otherwise specified on the plans or in the Special Provisions. However, if reinforcement clearances will not permit the use of 1½ inch aggregate, as determined by the Engineer, then a Class 6.5-3500-3/4 concrete shall be used, and any additional cost therefor will be paid for as Extra Work.

411.03 FALSEWORK. - The Contractor shall furnish, in accordance with the requirements of Secton 106.08, to the Engineer for his approval, plans of falsework to be used for the work. The design of the falsework shall provide for the traffic lanes and widths necessary to comply with the specified traffic routing requirements. Falsework vertical clearance less than 15'-0" shall be clearly signed, both at and preceding the impaired clearance from both directions. Approval by the Engineer shall not be construed as relieving the Contractor of full responsibility for the accuracy of dimensions and strength and safety of the falsework during construction. If required in the Special

Provisions, the Contractor shall engage a registered civil engineer to prepare the plans, and supervise the installation of the formwork.

Falsework and forms shall be constructed to produce in the finished structures the lines and grades indicated on the plans. Suitable jacks, wedges, or camber strips shall be used in conjunction with falsework or centering to set the forms to the required grade or camber and to take up any settlement in the formwork either before or during the placing of concrete.

Removal of falsework shall be in accordance with the applicable requirements of Section 411.09.

All falsework materials shall be completely removed upon completion of the work, and all debris and refuse resulting from the work shall be removed and the premises left in a neat and presentable condition.

411.04 FORMWORK

General. - Forms shall be constructed of sound material, mortar tight, and shall be of the correct shape and dimensions. Formwork shall be braced and tied together, sufficiently and in such manner as to prevent movement or displacement occasioned by any phase of the construction operations. In addition, formwork shall be designed for easy removal.

Form supports shall be placed on adequate foundations and shall have sufficient strength and bracing to prevent settlement or distortion from anticipated loading. Supports shall rest on double wedge shims, or other approved devices so that the forms will be maintained at the proper grade.

Form panels for exposed surfaces shall be plywood conforming to or exceeding the requirements of U.S. Product Standard PS 1 for Exterior B-B (Concrete Form) Class I Plywood or any material other than plywood which will produce a smooth uniform concrete surface substantially equal to that which would result from the use of such plywood. Only form panels in good condition free of defects, such as scars, dents or delaminations, shall be used for exposed surfaces.

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

Joints in form materials shall be located as directed, so that the resulting marks in the concrete conform to the general lines of the structure. Plywood shall be used in full sheets not less than 4 feet by 8 feet in size except where shape and size of the form prevents the use of a full sheet, or where the plywood is retained in a fabricated metal frame or patent form.

Fillets and chamfers shall conform to the size and design shown on the plans or specified in the Special Provisions.

Forms for exposed surfaces shall be constructed with triangular fillets not less than 3/4" by 3/4" attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp edges of the concrete.

Forms for exposed concrete surfaces shall be designed and constructed so that the formed surface of the concrete does not undulate excessively in any direction between studs, joists, form stiffeners, form fasteners, or wales. Undulations exceeding either 3/32 inch or 1/270 of

the center to center distance between studs, joists, form stiffeners, form fasteners or wales will be considered to be excessive. Should any form or forming system, even though previously approved for use, produce a concrete surface with excessive undulations, its use shall be discontinued until modifications satisfactory to the Engineer have been made. Portions of concrete structures with surface undulations in excess of the limits herein may be rejected by the Engineer.

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

Forms for exposed surfaces shall be faced with form panels. A form panel shall be considered to be the continuous section of form facing material, unbroken by joint marks, against which the concrete is placed.

Curved surfaces shall be formed with metal, plywood, or adequately supported, surfaced and match Douglas fir boards not more than 4 inches wide.

Form marks shall not be readily discernible and the number thereof shall be kept to a practicable minimum.

Handrails, balustrades and similar small or intricate structures, or parts thereof, shall be formed with metal, or clear lumber providing an impervious approved non-staining surface. The workmanship of the lumber forms for such work shall be the equivalent of first-class pattern work.

Openings shall be located at the bottom of forms where necessary to facilitate the clearing out of sawdust, wood scraps and debris and to provide drainage. Such openings shall be closed with watertight and secure cover pieces prior to placing concrete. In addition, inspection holes, and covers therefor, shall be provided in the formwork where directed.

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

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

Form fasteners and anchors shall be of such types that they can be removed as required for form bolts in Section 411.10 without chipping, spalling, heating or otherwise damaging the concrete surface.

Plumbing, Leveling, Repairing and Maintaining Forms. - Before concrete is placed in any form, the horizontal and vertical position, or the line and grade, as the case may be, of the form shall be carefully verified and all inaccuracies corrected. All wedging and bracing shall be completed in advance of the placing of concrete. All formwork must be approved by the Engineer before any concrete is placed therein.

Forms that have been damaged, or that have checked or warped prior to placing of concrete, shall be replaced or corrected in an approved manner.

The Contractor shall assign a sufficient number of men to maintain the forms and reinforcement, and to satisfactorily remedy any displacement or looseness thereof occurring during the placing of concrete.

411.05 REINFORCING STEEL

General. - Reinforcing steel bars, welded wire fabric, and all required appurtenances, shall be furnished and installed where and as shown on the plans and in accordance with the requirements specified herein.

Reinforcing steel bars, numbers 3 through 18, inclusive, shall be in accordance with ASTM "Standard Specifications for Deformed Billet-Steel Bars for Concrete Reinforcement," Designation A 615, Grade 60, unless otherwise specified on the plans or in the Special Provisions.

Spiral reinforcement shall conform to the strength requirements of ASTM Designation A 615, Grade 60 or shall be cold-drawn steel wire conforming to ASTM "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement," Designation A 82.

Reinforcing steel number 2 bars are plain bars and shall conform to the strength requirements of ASTM Designation A 615, Grade 40 or Grade 60.

Identification. - Each bundle of steel shall be tagged at the mill with an identifying mill tag showing the name of the mill and the melt or heat number. This tag shall be a metal tag attached with a lead seal and placed in an exposed position for easy identification by the Engineer.

A certified mill copy of mill tests on each heat showing physical and chemical analyses shall be furnished to the Engineer. Two or more samples, each 2 feet long, may be taken at random from each size in each melt or heat.

No reinforcing steel shall be incorporated in the work until it has been tested, if required, and approved by the Engineer.

Drawings. - The Contractor shall submit to the Engineer for approval reinforcing steel shop drawings, in sextuplicate, showing a complete list of materials, dimensions, and bending details. No reinforcing steel shall be installed until after such shop drawings have been approved.

No deviation from the approved lists will be permitted, unless by written consent of the Engineer.

Approval by the Engineer shall not be construed as relieving the Contractor from full responsibility for the accuracy of said shop drawings.

Storage. - Reinforcing steel shall be stored in a manner that will prevent rusting, or coating by dirt or other objectionable matter, or loss of identification after bundles are broken. All steel which cannot be properly identified will be rejected, and shall be immediately removed from the work.

Bending and Straightening. - Reinforcing steel bars shall be shop bent. Field bending will not be permitted, except that Number 5 and smaller bars may be bent in the field when allowed by the Engineer.

Bars shall not be damaged in bending or straightening, and bars with kinks or improper bends shall not be used.

Hooks shall be as recommended by, and conforming to, the provisions of the Building Code Requirements for Reinforced Concrete (ACI 318-63) of the American Concrete Institute.

Cleaning. - Before placing concrete, the reinforcement shall be cleaned of mortar, oil, grease, dirt, loose mill scale, loose rust, and any other coating of a character that would destroy or reduce the bond.

Placing. - Reinforcing bars shall be firmly and securely held in position by wiring with No. 14 and No. 16-guage black annealed wire at intersections, and by using precast mortar blocks or metal chairs, spacers, metal hangers, supporting wires, and other approved devices of sufficient strength to resist crushing under full load.

Metal supports which extend to the surface of the concrete shall have plastic dipped feet. Wooden supports shall not be used.

Placing bars on layers of fresh concrete as the work progresses, or adjusting bars during the placing of concrete, will not be permitted.

Reinforcing steel adjacent to bottom forms may be supported on precast mortar blocks of a thickness sufficient to provide the required clearance from the face of the concrete. Concrete protective covering from the face of vertical forms to the reinforcing steel shall be provided by the use of temporary supports which shall be removed as the concrete is placed and rising in the forms.

Minimum clear protective covering for reinforcement adjacent to concrete surfaces shall be in accordance with the "Building Code Requirements for Reinforced Concrete" (ACI 318-63) of the American Concrete Institute except that all members exposed to sewage shall have 2 inches of protective concrete covering.

The minimum clear bar spacing shall be in accordance with the "Building Code Requirements for Reinforced Concrete," (ACI 318-63) of the American Concrete Institute.

Splicing of Reinforcing Steel. - Splices of the main reinforcement shall be located where shown and at points of minimum stress.

Splices of adjacent reinforcing bars shall be staggered unless otherwise indicated.

Splicing shall be accomplished by placing the bars in contact with each other and wiring together in such manner as to maintain the required clear distance to the other bars and to the surface of the concrete.

Splicing of reinforcing bars shall be in accordance with the "Building Code Requirements for Reinforced Concrete," (ACI 318-63) of the American Concrete Institute.

In no case shall any splice be less than 24 nominal bar diameters, and 12 inches, in length.

Welded Splices. - Where welded splices are required for reinforcing bars, the splices shall be full penetration butt welds conforming to the requirements of AWS D2.0 and AWS D12.1 and the requirements of these specifications and the Special Provisions.

Welding operators shall be prequalified in accordance with Section 806.02 of these Standard Specifications. Welded splices shall be subjected to radiographic or other non-destructive testing unless otherwise specified by the Engineer.

Inspection. - No concrete shall be deposited until the Engineer has inspected the reinforcement and given permission to place concrete.

Welded Steel Wire Fabric. - Welded steel wire fabric for concrete and air blown mortar welded reinforcement shall be fabricated from steel wire and electrically welded at all joints and points of intersection, all in accordance with the requirements of ASTM "Standard Specifications for Welded Steel Wire Fabric for Concrete Reinforcement," Designation A 185.

The wire used in the manufacture of welded wire fabric shall conform to ASTM "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement," Designation A 82.

Where wire fabric is used as reinforcement for air blown mortar on flat surfaces such as walls and slabs, it shall be 4 X 4-6/6.

Where wire fabric is bent around members for protection, repair or reinforcing thereof by the use of air blown mortar, it shall be 2 X 2-12/12.

Where wire fabric is used as reinforcement for concrete pavement slabs, it shall be 6 X 6-6/6.

Splicing for Welded Steel Wire Fabric. - Splices in structural slabs shall be lapped not less than 12 inches; other splices shall be lapped not less than two meshes.

Epoxy-Coated Reinforcing Bars. - In addition to the requirements set forth above, the following requirements apply to epoxy-coated reinforcing bars.

All epoxy-coated reinforcing bars shall conform to ASTM "Standard Specification for Epoxy-Coated Reinforcing Steel Bars", Designation A 775.

When required, damaged epoxy-coating shall be repaired with patching material conforming to ASTM A 775. Repair shall be done in accordance with the patching material manufacturer's recommendations. Hereinafter, all references to repair of damaged epoxy-coating shall imply the use of the above procedure.

Bar mats shall conform to ASTM A 184. Bar mats may be fabricated from epoxy-coated reinforcing bars. Metal clips shall be epoxy-coated. Non-metallic clips may be used. Coating damage at the clipped or welded intersections shall be repaired as described hereinbefore.

All reinforcement shall be bent cold unless otherwise permitted by the Engineer.

Epoxy-coated reinforcing bars supported from formwork shall rest on coated wire bar supports, or on bar supports made of dielectric material or other acceptable materials. Wire bar supports shall be coated with dielectric material for a minimum distance of 2 inches from the point of contact with the epoxy-coated reinforcing bars. Reinforcing bars used as support bars shall be epoxy-coated. In walls having epoxy-coated reinforcing bars, spreader bars where specified by the Engineer, shall be epoxy-coated. Proprietary combination bar clips and spreaders used in walls with epoxy-coated reinforcing bars shall be made of corrosion-resistant material.

Epoxy-coated reinforcing bars shall be fastened with nylon-, epoxy-, or plastic-coated tie wire, or other acceptable materials.

Splices of reinforcing bars shall be made only as required or permitted by the Contract Documents, or as authorized by the Engineer.

Welded splices, when required or permitted, shall conform to AWS D 1.4. Unless otherwise permitted, welding of crossing bars (tack welding) for assembly of reinforcement is prohibited. Suitable

ventilation shall be provided when welding epoxy-coated reinforcing bars.

After completion of welding on epoxy-coated reinforcing bars, coating damaged shall be repaired as specified hereinbefore. All welds, and all steel splice members when used to splice bars, shall be coated with the same material used for repair of coating damaged.

Mechanical connections, when required or permitted, shall be installed in accordance with the splice device manufacturer's recommendations. After installing mechanical connections on epoxy-coated reinforcing bars, coating damage shall be repaired as specified hereinbefore. All parts of mechanical connections used on coated bars, including steel splice sleeves, bolts, and nuts shall be coated with the same material used for repair of coating damaged.

Reinforcing bars partially embedded in concrete shall not be field bent, except as indicated on the Contract Documents or permitted by the Engineer. When heat is used to field bend epoxy-coated reinforcing bars, suitable ventilation shall be provided. When epoxy-coated reinforcing bars are field bent, coating damaged shall be repaired as specified hereinbefore.

Unless permitted by the Engineer, reinforcing bars shall not be cut in the field. When epoxy-coated reinforcing bars are cut in the field, the ends of the bars shall be coated with the same material used for repair of coating damage. Equipment for handling epoxy-coated bars shall have protected contact areas. Bundles of coated bars shall be lifted at multiple pick-up points to minimize bar-to-bar abrasion from sags in the bundles. Coated bars or bundles of coated bars shall not be dropped or dragged. Coated bars shall be stored on protective cribbing. Fading of the color of the coating shall not be cause for rejection of epoxy-coated reinforcing bars. Coating damage due to handling, shipment and placing need not be repaired in cases where the damaged area is 0.1 square inches or smaller. Damaged areas larger than 0.1 square inches shall be repaired as specified hereinbefore. The maximum amount of damage including repaired and unrepaired areas shall not exceed 2 percent of the surface area of each bar.

411.06 EXPANSION JOINTS AND FILLER

Expansion Joints. - All walls, steps, copings, and other concrete structures extending above the ground shall have expansion joints placed not more than sixty feet apart. Expansion joints shall also be placed at the junction of steps with other structures, and at the top and bottom of any flight of steps.

Joints shall be made with expansion joint filler, 1/4-inch in thickness, in accordance with the requirements specified hereinafter.

The edges of concrete, at the joints, shall be edger finished.

Expansion Joint Filler. - Expansion joint filler shall consist of preformed strips of a durable, resilient, nonextruding compound.

Preformed joint filler material shall be in accordance with the requirements of ASTM "Standard Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)," Designation D 1751, or ASTM "Standard Specifications for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient

Nonbituminous Types)," Designation D 1752, as designated in the Special Provision or most suitable for the purpose intended. The filler, further, shall meet the requirements of ASTM "Standard methods of Testing Preformed Expansion Joint Fillers for Concrete (Nonextruding and Resilient Types)," Designation D. 545.

Where stiffness is lacking in preformed expansion joint filler, the strips shall be encased in saturated felt, asphalt-impregnated cotton webbing, or other satisfactory material. Any material or fabric used for encasement shall be firmly sealed to the body of the joint filler and shall not become detached therefrom after immersion in water for a period of forty-eight hours.

If 10 percent or more of any lot or shipment of expansion joint filler is of nonuniform or improper construction, the entire lot or shipment may be rejected.

Expansion joint filler shall be installed so that it will not be displaced when concrete is deposited against it. Where it is necessary to use more than one piece of filler to cover any surface, the abutting pieces shall be placed in close contact, and the joint shall be covered with a layer of 2-ply roofing felt adhered with hot asphalt to insure proper retention. Any concrete or mortar that has filled the void spaces where expansion joint sealant is to be placed shall be neatly cut and removed.

Expansion Joint Sealant. - Expansion joints shall be sealed with expansion joint sealant when specified in the Special Provisions.

The sealant shall be mixed and placed strictly in accordance with the manufacturer's directions and to the depth of joint shown o the plans.

Concrete surfaces against which the sealant is placed shall be thoroughly cleaned by wire brushing and shall be dry. The concrete surfaces shall then be given a prime coat of the primer specified, or that recommended by the manufacturer. The primer shall be worked into the concrete.

The primer shall be allowed to dry tack-free before application of the sealant.

Liquid sealant placed in vertical joints shall be retained with forms lined with polyethylene film.

The joint sealant shall, in all cases, be installed flush with the concrete surfaces on either side of the joint.

411.07 WATERSTOPS. - Waterstops shall be furnished and installed where and in accrodance with the details shown on the plans and specified herein.

Waterstops, unless otherwise specified, shall be natural rubber, synthetic rubber or polyvinyl chloride (PVC), at the option of the Contractor.

Natural rubber waterstops shall be manufactured from stock containing not less than 72 percent by volume of new plantation rubber. When tested in accordance with ASTM "Standard Method of Tension Testing of Vulcanized Rubber," Designation D 412, the tensile strength shall not be less than 3,500 pounds per square inch with an elongation at breaking of 550 percent. The unit stresses producing 300 percent and 500 percent elongation shall be not less than 1,100 pounds and 2,800 pounds per square inch, respectively. When tested in accordance with ASTM "Standard Method of Test for Indentation Hardness of Rubber and Plastics by Means of a Durometer," Designation D 2240, the Shore

durometer indication (hardness) shall be between 55 and 65. When tested in accordance with ASTM "Standard Method of Test for Accelerated Aging of Vulcanized Rubber by the Oxygen-Pressure Method," Designation D 572 and after seven days in air at 158 degrees Fahrenheit (±2°F.), or after forty-eight hours in oxygen at 158 degrees Fahrenheit (±2°F.) and 300 pounds per square inch pressure, the tensile strength and elongation shall not be less than 65 percent of the original.

Synthetic rubber waterstops shall be manufactured from a compound containing not less than 70 percent by volume of neoprene or GRS. When tested in accordance with ASTM Desgination D 412, the tensile strength shall be not less than 2,500 pounds per square inch with an elongation at breaking of 425 percent. When tested in accordance with ASTM Designation D 676, the Shore durometer indication (hardness) shall be between 50 and 70. When tested in accordance with the test method of ASTM Designation D 572, and after seven days in air at 158 degrees Fahrenheit (±2°F.), or after forty-eight hours in oxygen at 158 degrees Fahrenheit (±2°F.) and 300 pounds per square inch pressure, the tensile strength shall be not less than 65 percent of the original.

Polyvinyl chloride waterstops shall be manufactured from polyvinyl chloride conforming the the Corps of Engineers Specification Number CRD-C572. A certificate shall be furnished with the test sample supplied stating that the sample complies with all of the performance requirements specified under paragraph 6 of said Specification.

Waterstops shall be manufactured with an integral cross-section which shall be uniform within plus or minus 1/8-inch in width, and the web thickness or bulb diameter, within plus 1/16-inch and minus 1/32-inch. The number of splices shall be kept to a minimum. Strips and special connection pieces shall be well cured in a manner such that any cross section shall be dense, homogeneous and free from all porosity. All junctions in the special connection pieces shall be full molded. During the vulcanizing period, the joint shall be securely held by suitable clamps. The material at the splices shall be dense and homogeneous throughout the cross section.

Field splices for either natural or synthetic rubber waterstops shall be vulcanized, or mechanical using stainless steel parts, or made with a rubber splicing union of the same stock as the waterstop, at the option of the Contractor. All finished splices shall have a full-sized tensile strength of 100 pounds times the width in inches.

Field splices for polyvinyl chloride waterstops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's directions. A thermostatically controlled electric source of heat shall be used to make all splices. The heat shall be sufficient to melt, but not char, the plastic.

Waterstops shall, when being installed, be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion of the web or flange.

411.08 ELASTOMERIC BEARING PADS. - Elastomeric bearing pads shall be made of neoprene, cast in molds under pressure and heat, and shall have the properties listed hereinafter, as determined by ASTM "Standard Methods of Compound and Sample Preparation for Physical Testing of Rubber Products," Designation D15:

1) Tensile strength, ASTM Designation
D 412.....2,500 psi minimum

2) Elongation at break, ASTM Designation D 412.....350 minimum
3) Compression set, ASTM Designation D 395, Method "B" 22 hours at 158 degrees Fahrenheit.....25% maximum
4) Tear strength, ASTM Designation D 624, Die "C".....275 lbs. per inch of thickness, minimum
5) Durometer hardness, Shore "A," ASTM Designation D 2240.....55 ± 3
6) Change in durometer hardness, ASTM Designation D 573, heat aged, 70 hours at 212 degrees Fahrenheit.....+10 points, maximum

In addition to these requirements, the material shall show no checking when subjected to an exposure of 110 hours in an atmosphere containing 100 ±20 parts of ozone per 100,000,000 parts of air to conform with ASTM "Standard Method of Test for Accelerated Ozone Cracking of Vulcanized Rubber," Designation D 1149.

Elastomeric bearing pads shall be of the thickness, width and length indicated on the plans. The pads shall be neatly punched to receive dowels where necessary or indicated.

The Contractor shall furnish the Engineer a certification by the manufacturer that the elastomer in the elastomeric bearing pads to be furnished conforms to all of the requirements specified hereinbefore. The certification shall be supported by a certified copy of the results of tests performed by the manfuacturer upon samples of the elastomer to be used in the pads, covering all of the hereinbefore mentioned requirements.

411.09 REMOVAL OF FORMS. - Side forms for footings, foundations, slabs on grade, or other components that do not resist bending shall not be removed in less than forty-eight hours after pouring of concrete. At times of low temperature or other adverse weather conditions, the Engineer may increase the required time to five days.

The falsework and forms supporting concrete girders, beams, joists, slabs, or other members subject to bending stress, shall not be removed or released in less than fourteen days after the concrete has been placed, or if the members are constructed of Type III (high-early strength) Portland cement, in less than seven days after the concrete has been placed. The addition of one-half sack of cement per cubic yard of concrete will be considered a satisfactory substitute for Type III Portland cement provided no additional water is added. In any case, the falsework and forms supporting the members shall not be removed until the concrete has attained a compressive strength of at least 2,500 pounds per square inch based on field, cured cylinders. Furthermore, such members shall not be loaded until the concrete has attained its 28-day compressive strength.

The removal of forms for sewers and sewer structurs shall be in accordance with the requirements of Section 303.05, unless otherwise specified in the Special Provisions.

411.10 ORDINARY SURFACE FINISH FOR STRUCTURAL COMPONENTS. - Unless otherwise specified, all surfaces of concrete, shall be given Ordinary Surface Finish, except that such surfaces, or

portions thereof, covered by backfill in the completed work need not be "sacked."

Immediately after the forms have been removed, the Contractor shall remove all form bolts or ties to a depth of at least 1½ inches below the surface of the concrete. All holes and depressions caused by the removal or setting back of the form bolts or ties shall be cleaned out. All fins caused by form joints and other objectionable projections, shall be removed, except in cases where they are buried or otherwise not visible in the completed structure and do not interefere with the designed function of the structure. All rock pockets shall be chipped back and cleaned out. All depressions caused by the removal of form bolts, tie rods, rock pockets or other imperfections shall be filled with Class "B" mortar containing no more water than that necessary for complete hydration. Care shall be exercised to obtain a perfect bond with the concrete, and to obtain the same color in the mortar as in the surrounding concrete. In areas visible in the completed work, cement shall be used in sufficient quantity to obtain the required color. While the mortar filling is still "green," it shall be wiped smooth or have the form grain imprinted in it. Steel finishing tools will not be permitted. At the same time, all surfaces shall be "sacked" by wiping with a folded hemp sack on which a sufficient amount of mortar has been placed to substantially fill the small holes that commonly appear in concrete surfaces.

411.11 CLASS 1 SURFACE FINISH. - After the completion of Ordinary Surface Finish, all surfaces shall be thoroughly rubbed with coarse carborundum stones and all unsightly bulges or depressions, caused by form marks or other imperfections, shall be removed so that a smooth surface of uniform texture and appearance is obtained. A mechanical finisher may be used for this purpose, in which case not less than four days shall elapse between the time the concrete is poured and the finishing started. If the surface is rubbed by hand, a period of not less than two days will be required.

After the hereinbefore referred to process has been completed, the surface shall be washed with water to remove stains and free particles which adhere to the surface after rubbing.

411.12 CLASS 2 SURFACE FINISH. - Where Class 2 Surface Finish is specified, Ordinary Surface Finish and Class 1 Surface Finish shall be completed in succession. A thin cement mortar, consisting of one part Portland cement and one part fine sand, all of which will pass a No. 20 sieve, to which has been added two pounds of calcium chloride per sack of cement, shall then be brushed on the surface. When the cement film has set so that the sand particles or cement will not drag out of the surface pinholes, but before final set has taken place, the entire surface shall be rubbed thoroughly with fine carborundum stones, Nos. 25 to 30, until a smooth, even surface of uniform texture is obtained. No greater amount of mortar shall be applied in advance of rubbing than can be completely rubbed before final setting takes place. Immediately after the rubbing process, the finished surface shall be thoroughly washed with water.

This finish shall be deferred until all other work which would in any way mar or affect the final finish is completed.

411.13 EXPOSED AGGREGATE FINISH. - Exposed aggregate finish, when specified, shall be obtained by using "Control-Set," as manufactured by the Conrad Sovig Company, San Francisco, or equal, retardant. Methods and details of application shall conform to the manufacturer's directions.

In areas to receive exposed aggregate finish, wall forms, including their abutting edges, shall be coated with two coats of "Control-Set" and such coating shall be protected from removal, or damage by water or otherwise, from the time of coating to the time of pouring. Such forms shall be stripped two days after pouring, unless otherwise directed by the Engineer. The surface of the concrete shall be washed and rinsed using a stiff brush, and if necessary shall be sandblasted to remove the mortar film surrounding the aggregate to a minimum depth of 1/8-inch.

411.14 BROOM FINISH. - Walkway surfaces on overpass and ramp structures shall be given a light broom finish by floating to a true and dense finish with a wood float or power floating machine, followed by steel troweling after the concrete has hardened sufficiently to prevent excess fine material from working to the surface. The finish shall be brought to a smooth surface free from defects and blemishes. No dry cement, or mixture of dry cement and sand, shall be sprinkled on the surface of the concrete to absorb moisture or to stiffen the mix.

The concrete wearing surface shall be given a final finish by brooming lightly, in a direction transverse to the path of travel, with a fine hair broom to produce a uniform nonskid surface.

411.15 DAMPPROOFING OF CONCRETE STRUCTURES. - All surfaces of concrete structures specified on the plans or in the Special Provisions to be dampproofed, and all back surfaces on concrete abutment walls, wing walls and retaining walls, shall be dampproofed with at least two coats of approved emulsified asphalt, allowing adequate drying time between coats, unless some other dampproofing procedure has been stipulated.

Structure and wall surfaces shall be clean and dry and weather conditions suitable, as approved by the Engineer, with an air temperature of not less than 50 degrees Fahrenheit, at the time of applying the emulsified asphalt coatings.

When waterproofing is called for it shall be done in conformance with Section 418 of these Specifications.

411.16 DRAINAGE FOR RELIEF OF HYDROSTATIC HEAD BEHIND WALLS AND UNDER CONCRETE ON GRADE. - When shown on the plans or specified in the Special Provisions, the Contractor shall construct adequate drains and appurtenances behind walls and under concrete on grade. Unless otherwise specified, pipe to carry such drainage shall be perforated vitrified clay pipe of adequate size, but not less than 6 inches in diameter.

Such perforated vitrified clay pipe shall be "extra strength," of the bell-and-spigot type, and in accordance with the applicable requirements of ASTM "Standard Specifications for Standard and Extra Strength Perforated Clay Pipe," Designation C 211, except that the minimum thickness of the barrel of the pipe shall conform to the Regional Western Standard of the Clay Pipe Institute. Perforated vitrified clay pipe shall be installed with tight-closed joints, but without any mortar or other

joining material. The pipe shall be sloped as shown on the plans and each piece of pipe shall be placed, with the perforations facing downward, on a 3-inch deep minimum bed of filter material.

The section of filter material to be placed around drains shall be as shown on the plans or specified in the Special Provisions, and when not shown or specified shall be at least 3 inches thick all around the pipe.

Placement of filter material and the backfill thereover shall be as specified in Section 711.

411.17 PAYMENT. - Concrete structures, satisfactorily constructed as specified, each will be paid for at the lump sum price bid therefor.

Any concrete structure for which the Proposal does not contain provision for payment shall be constructed as Incidental Work.

SECTION 412

PRESTRESSED CONCRETE CONSTRUCTION

412.01 GENERAL. - The Contractor shall construct prestressed concrete structures and structural components, where and as shown on the plans or where directed, and shall do all related Incidental Work. Unless otherwise specified, prestressing may be done by either pretensioning or post-tensioning. Equipment, methods, and operations shall be in accordance with these specifications, with what is considered generally acceptable for prestressing construction, and with the applicable requirements of the Building Code, Part II, Chapter I of the San Francisco Municipal Code.

Prior to starting prestressed construction, the Contractor shall submit to the Engineer for approval, in accordance with Sections 106.08 and 107.04, complete details including substantiating calculations of the prestressing system and of the methods, material and equipment he proposes to use. Any proposed deviations during construction must likewise be submitted. Such details shall outline the method of prestressing, and shall include the amount, arrangement, and complete specifications of prestressing steel in the members, the quantity and arrangement of the mild steel reinforcement in anchorage areas in the members, the proposed locations of bar couplers, if used, anchoring stresses, sequence of cutting or releasing prestressing steel, type of post-tensioning ducts, and specifications and details of anchoring devices, distribution plate or assemblies if required, and pressure-grouting materials and equipment for post-tensioning, together with complete drawings of the forms proposed for casting the member. Such details, calculations and drawings shall be prepared by a Civil Engineer licensed by the State of California.

Approval of new prestressing systems will be contingent on prequalification testing as directed by the Engineer, at the Contractor's expense, of complete tendon assemblies and other devices peculiar to the system as proposed for use and the submittal of written information as requested by the Engineer.

Approval or the part of the Engineer of any proposed method, materials, or equipment shall not be construed of relieving the Contractor, in any respect, of full responsibility for successfully

completing prestressing operations in accordance with the specified requirements.

Longitudinal steel, prestressed by the post-tensioning or pretensioning method, shall maintain the path of the center of gravity of prestressing force as shown on the plans.

Suitable horizontal and vertical spacers shall be provided as required to hold the tendons in place in true position in the enclosures.

Deflection devices shall be removed, after transfer of the prestressing force, to a depth of 1/2-inch below the surface of the unit and grouted flush therewith.

The prestressing tendons shall be deflected in such a manner that they are not damaged or distorted and so that there is no appreciable variation in tension over the length of the tendon due to frictional losses at the yokes.

When prestressing steel for pretensioning is placed in the stressing bed and is exposed to the elements for more than 36 hours prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect said steel from contamination or corrosion.

Whenever electric welding is performed on or near members containing prestressing steel, the welding ground shall be attached directly to the steel being welded.

All pretensioned prestressing steel shall be cut off flush with the end of the member and the exposed ends of the prestressing steel and a one-inch strip of adjoining concrete shall be cleaned and painted. Cleaning shall be by wire brushing or abrasive blast cleaning to remove all dirt and residue which is not firmly bonded to the metal or concrete surfaces. The surfaces shall be coated with one thick coat of zinc rich paint conforming to the requirements of Military Specification MIL-P-21035. The paint shall be thoroughly mixed at the time of application and shall be worked into any voids in the prestressing tendons.

The minimum horizontal or vertical clear spacing between pretensioning steel elements at ends of members shall be 3 times the diameter of the steel, or 1-1/3 times the maximum size of the coarse aggregate, whichever is greater.

Where pretensioning steel is harped or deflected, strands may be grouped together at midspan with 3 strands in a vertical row or 2 strands in a horizontal row. The minimum clear distance between groups shall be 1-1/8 inches for 3/8-inch strands, and 1-1/2 inches for 7/16-inch strands.

The strands shall be separated at the ends to provide minimum spacing between strands as indicated above which shall be maintained for a minimum distance of 3 feet at each end of the member.

Precast units shall be stored, transported and placed so that they will not be overstressed or damaged.

Units shall be listed using suitable approved lifting devices located at points which will produce minimum deflectin during installation. Lifting devices shall be removed 1½ inches below the surface of the concrete and the resulting holes filled with an approved expansive grout after units are installed in place.

Post-tensioned precast members shall not be moved until at least 24 hours after pressure-grouting of enclosures. Prestressed members shall not be lifted by attachment at any point more than 3 feet from the ends

or points of final support of such members. Prestressed members shall be lifted in the same position with regard to top and bottom faces as that of the final installation of the members and shall be handled so that there will be no sideway, tipping, or racking.

The minimum clear concrete cover for prestressed units shall be as specified in Section 7.7 of the latest edition of the ACI code.

412.02 CONCRETE. - Concrete and related work for prestressed concrete construction shall be in accordance with the following specifications and the applicable requirements of Sections 411 and 800.

The maximum size of aggregate used in prestressed concrete shall be one-inch.

Cememt used in prestressed concrete construction shall be either Type I or Type II Portland cement at the option of the Contractor. The Contractor shall not however, for the purpose of producing increased strength at an early date, increase the amount of cement from that specified, unless such increase has been specifically approved by the Engineer.

Type III (high-early strength) Portland cement, or calcium chloride as an admixture, shall not be used in the construction of any prestressed concrete structure, nor shall calcium chloride be used in the construction of any concrete member of any other structure in contact with the prestressed steel reinforcement.

Unless otherwise specified, prestressed concrete shall have a minimum strength of not less than 5,000 psi at 28 days, as determined from breaks of test cylinders made and cured under laboratory conditions in accordance with the requirements of ASTM "Standard Method of Test for Compressive Strength of Molded Concrete Cylinders," Designation C 39.

The Contractor shall be responsible for furnishing satisfactory materials for the manufacture of the concrete, proportioned to contain not less than 7 nor more than 8½ sacks of cement per cubic yard of concrete with the maximum net water content not to exceed 5 gallons per sack of cement, that will produce a workable concrete complying with the foregoing requirements for strength.

Five sets of test cylinders, consisting of 2 cylinders per set, shall be taken during the concreting operations from each day's pour, but not less than 5 sets from each 50 cubic yards of concrete poured, in accordance with Section 106.15. One-half the number of cylinders shall be stored for laboratory curing and testing. The remainder of the cylinders shall be cured at the site under conditions of curing identical to those of the proto-type structure.

Compression tests shall be taken at 3, 7, 14 and 28 days for the purpose of ascertaining when tensioning of post-tensioned prestressing steel or release of pretensioning steel may be commenced, which will be determined based on the strength of the field cured cylinders.

Concrete shall be fully vibrated and consolidated. Approved external vibrators shall be used for the consolidation of concrete inaccessible for adequate internal vibration in the prestressed members. The forms shall be designed and constructed to provide the necessary rigidity to resist displacement or damage as a result of such external vibration.

Concrete shall be cured according to "Curing Precast Concrete Members" as specified in Section 800.16.

Attention shall be given to the prevention of shrinkage or settlement cracks due to rate or sequence of pouring. If shrinkage cracks appear

during the curing process for post-tensioning the Contractor, at no extra cost to the City, shall partially prestress the girder, as directed by the Engineer.

412.03 PRESTRESSING STEEL.

General. - Prestressing steel shall be high-tensile wire conforming to ASTM Designation: A 421, high-tensile wire strand conforming to ASTM Designation: A 416, or uncoated high-strength steel bars conforming to ASTM Designation: A 722, including all supplementary requirements.

In addition to the requirements of ASTM Designation: A 722, for deformed bars, the reduction of area shall be determined from a bar from which the deformations have been removed. Such a bar shall be machined no more than necessary to remove the deformations over a length of 12 inches, and reduction will be based on the area of the machined portion.

All bars in any individual member shall be of the same grade, unless otherwise permitted by the Engineer.

When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the manufacturer's minimum guaranteed ultimate tensile strength of the bars. Failure of any one sample to meet this requirement will be cause for rejection of the heat of bars and lot of couplers. The location of couplers in the member shall be subject to approval by the Engineer.

Wires shall be straightened if necessary to produce equal stress in all wires or wire groups or parallel lay cables that are to be stressed simultaneously or when necessary to insure proper positioning in the ducts.

Where wires are to be button-headed, the buttons shall be cold formed symmetrically about the axes of the wires. The buttons shall develop the minimum guaranteed ultimate tensile strength of the wire. No cold forming process shall be used that causes indentations in the wire. Buttonheads shall not contain wide open splits, more than 2 splits per head, or splits not parallel with the axis of the wire.

All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of visible rust or other results of corrosion shall be cause for rejection, when ordered by the Engineer.

Prestressing steel shall be packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor which prevents rust or other results of corrosion shall be placed in the package or form, or shall be incorporated in a corrosion inhibitor carrier type packaging material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

The shipping package or form shall be clearly marked with a statement that the package contains high-strength prestressing steel, and the type of corrosion inhibitor used, including the date packaged.

Prestressing steel for post-tensioning which is installed in members prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion, until grouted, by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the requirements specified herein.

When steam curing is used, prestressing steel for post-tensioning shall not be installed until the steam curing is completed.

All water used for flushing ducts shall contain either quick lime (calcium oxide) or slaked lime (calcium hydroxide) in the amount of 0.1-pound per gallon. All compressed air used to blow out ducts shall be oil free.

When acceptable prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within 10 days after the installation of the prestressing steel, rust which may form during said 10 days will not be cause for rejection of the steel. Prestressing steel installed, tensioned and grouted in this manner, all within 10 days, will not require the use of a corrosion inhibitor in the duct following installation of the prestressing steel. Prestressing steel installed as above but not grouted within 10 days shall be subject to all the requirements in this section pertaining to corrosion protection and rejection because of rust.

412.04 PRESTRESSING. - All prestressing steel shall be tensioned by means of hydraulic jacks so that the force in the prestressing steel shall not be less than the value shown on the plans.

Unless otherwise specified or shown on the plans, the average working stress in the prestressing steel shall not exceed 60 percent of the specified minimum ultimate tensile strength of the prestressing steel. The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed 75 percent of the specified minimum ultimate tensile strength of the prestressing steel. The prestressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the plans, but in no case shall the initial stress exceed 70 percent of the specified minimum ultimate tensile strength of the prestressing steel.

Working force and working stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, creep of steel, losses in post-tensioned prestressing steel due to sequence of stressing, friction and take up of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

The loss in stress in post-tensioned prestressing steel due to creep and shrinkage of concrete, creep of steel, and sequence of stressing shall be assumed to be 32,000 pounds per square inch for wire or strand and 22,000 pounds per square inch for bars. If lightweight concrete is used, said loss shall be assumed to be 40,000 pounds per square inch.

The loss in stress in pretensioned prestressing steel due to creep and shrinkage of concrete, creep of steel, and elastic compression of concrete shall be assumed to be 45,000 pounds per square inch. If lightweight concrete is used, said loss shall be assumed to be 50,000 pounds per square inch.

The following formula and friction coefficients shall be used in calculating friction losses in tendons:

$$T_o = T_x e^{(Ua+Kl)}$$

T_o = steel stress at jacking end
T^x = steel stress at any point x
e^x = base of Naperian logarithms
U = friction curvature coefficient
a = total angular change of prestressing steel profile in radians from jacking end to point x
K = friction wobble coefficient
l = lengh of prestressing steel from jacking end to point x

Type of Steel	Type of Duct	K	U
Wire or strand	Galvanized - rigid	0.0002	0.25
Plain bars	Galvanized	0.0002	0.15
Deformed bars	Galvanized	0.0003	0.30

Each jack used to stress tendons shall be equipped with either a pressure gage or a load cell for determining the jacking stress, at the option of the Contractor. The pressure gage, if used, shall have an accurately reading dial at least 6 inches in diameter and each jack and its gage shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart. The load cell, if used, shall be calibrated and shall be provided with an indicator by means of which the prestressing force in the tendon may be determined. The range of the load cell shall be such that the lower 10 percent of the manufacturer's rated capacity will not be used in determining the jacking stress.

The prestressing force shall be tested by a qualified independent testing agency. The Contractor shall provide sufficient labor, equipment, and material to install and support such testing equipment at the prestressing tendons and to remove the testing equipment after the testing is complete, as ordered by the Engineer.

Prior to post-tensioning any member, the Contractor shall demonstrate to the satisfaction of the Engineer that the prestressing steel is free and unbonded in the duct.

Prestressing forces shall not be applied to cast-in-place concrete until at least 10 days after the last concrete has been placed in the member to be prestressed and until the concrete complies with one of the following requirements:

1. When the concrete is designated by compressive strength, the concrete compressive strength shall have reached the strength shown on the plans at the time of stressing.
2. When the concrete is designated by Class or cement content, either the concrete compressive strength shall have reached the strength shown on the plans at the time of stressing, or at least 28 days shall have elapsed since the last concrete to be prestressed has been placed, whichever occurs first.

Subject to prior approval by the Engineer, a portion of the total prestressing force may be applied to a precast member when the strength of the concrete in the member is less than the value shown on

the plans and the member may then be moved. Approval by the Engineer of such partial prestressing and moving shall in no way relieve the Contractor of full responsibility for successfully constructing the members.

Prestressing steel in pretensioned members shall not be cut or released until the concrete in the member has attained a compressive strength of not less than the value shown on the plans or 4,000 psi, whichever is the greater.

When ordered by the Engineer, prestressing steel strands in pretensioned members, if tensioned individually, shall be checked by the Contractor for loss of prestress not more than 3 hours prior to placing concrete for the members. The method and equipment for checking the loss of prestress shall be subject to approval by the Engineer. All strands which show a loss of prestress in excess of 3 percent shall be retensioned to the original computed jacking stress.

When prestressing steel in pretensioned members is tensioned at a temperature appreciably lower than the estimated temperature of the concrete and the prestressing steel at the time of initial set of the concrete, the calculated elongation of the prestressing steel shall be increased to compensate for the loss in stress, but in no case shall the jacking stress exceed 75 percent of the specified minimum ultimate tensile strength of the prestressing steel.

The cutting and releasing of prestressing steel in pretensioned members shall be performed in such an order that lateral eccentricity of prestress will be a minimum.

The tensioning process as applied to post-tensioned members shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured at all times.

Except as provided herein, tendons in continuous post-tensioned members shall be tensioned by jacking at each end of the tendon. Where one-end stressing is shown on the plans, tensioning of such tendons shall be done by jacking from one end or both ends of the tendon at the option of the Contractor.

Prestressing tendons in simple span post-tensioned members may be tensioned by jacking from one end only.

412.05 DUCTS FOR PRESTRESSED STEEL. - Duct enclosures for prestressing steel shall be rigid ferrous metal, galvanized, mortar tight, and accurately placed at the locations shown on the plans or approved by the Engineer.

Ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at the connections. Ducts shall be bent without crimping or flattening. Transition couplings connecting said ducts to anchoring devices need not be galvanized.

All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing.

Ducts for prestressing steel when bars are used shall have a minimum inside diameter 3/8 inch larger than the diameter of the bars to be used.

Ducts for prestressing steel shall be securely fastened in place to prevent movement.

After installation in the forms, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris. If prestressing steel is to be installed after the concrete has been placed, the Contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel.

Vents shall be placed at not more than 400 foot intervals in all ducts and shall be located within 6 feet of a high point in the duct profile. Vents shall be 1/2 inch minimum diameter standard pipe or suitable plastic pipe. Connections to ducts shall be made with metallic or plastic structural fasteners. Plastic components, if selected, shall not react with the concrete or enhance corrosion of the prestressing steel, and shall be free of water soluble chlorides. The vents shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents. Ends of vents shall be removed one inch below the roadway surface after grouting has been completed.

412.06 BONDING AND GROUTING. - Post-tensioned prestressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout.

Grout shall consist of portland cement and water, and may contain an admixture if approved by the Engineer.

Portland cement shall conform to the provisions in Section 800.02, "Portland Cement."

Water shall comply with the provisions in Section 800.07, "Water."

The use of admixtures shall comply with the provisions in Section 800.08, "Admixtures," except that the admixtures shall not contain chloride ions in excess of 0.25-percent by weight of admixture and the admixtures may be dispensed in solid form.

Water shall be first added to the mixer followed by cement and admixture.

The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. The water content shall be not more than 5 gallons per 94 pounds of cement. Retempering of grout will not be permitted. Grout shall be continuously agitated until it is pumped.

The quality of the grout shall be determined by the Engineer in accordance with California Test 541. The efflux time of a grout sample immediately after mixing shall be not less than 11 seconds.

Grouting equipment shall be capable of grouting at a pressure of at least 100 pounds per square inch.

Grouting equipment shall be furnished with a pressure gage having a full-scale reading of not more than 300 pounds per square inch.

When vents are required, standby flushing equipment capable of developing a pumping pressure of 250 pounds per square inch and of sufficient capacity to flush out any partially grouted ducts shall be provided.

All ducts shall be clean and free of water and deleterious materials that would impair bonding of the grout or interfere with grouting procedures.

All grout shall pass through a screen with 0.07-inch maximum clear openings prior to being introduced into the grout pump.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Vents and ejection pipes shall be fitted with valves capable of withstanding the pumping pressures. Valves shall not be removed or opened until the grout has set.

Leakage of grout through the anchorage assembly shall be prevented by positive mechanical means.

Grout shall be pumped through the duct and continuously wasted at the outlet until no visible slugs or other evidence of water or air are ejected and the efflux time of ejected grout is not less than 11 seconds. The outlet valve shall then be closed and the pumping pressure held momentarily. The valve at the inlet shall then be closed while maintaining this pressure.

When hot weather conditions would contribute to quick stiffening of the grout, the grout shall be cooled by approved methods as necessary to prevent blockages during pumping operations.

When freezing weather conditions will prevail during and following the placement of grout, the Contractor shall provide adequate means to protect the grout in the ducts from damage by freezing or other causes.

The surfaces of concrete against which concrete encasement over anchorage assemblies is to be placed shall be abrasive blast cleaned and clean aggregate exposed after grouting of the ducts has been completed.

412.07 DISTRIBUTION PLATES AND ANCHORAGES FOR POST-TENSIONED PRESTRESSING STEEL. - All post-tensioned prestressing steel shall be secured at the ends by means of approved permanent type anchoring devices.

All anchorage devices for post-tensioning shall hold the prestressing steel at a load producing a stress of not less than 95 percent of the specified ultimate tensile strength of the prestressing steel.

When headed wires are used, the outside edge of any hole for prestressing wire through a stressing washer or through an unthreaded bearing ring or plate shall not be less than 1/4 inch from the root of the thread of the washer or from the edge of the ring or plate.

The load from the anchoring device shall be distributed to the concrete by means of approved devices that will effectively distribute the load to the concrete. Such approved devices shall conform to the following requirements:

(1) The final unit compressive stress on the concrete directly underneath the plate or assembly shall not exceed 3,000 pounds per square inch.

(2) Bending stresses in the plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when 95 percent of the specified ultimate tensile strength of the tendons is applied as determined by the Engineer.

Should the Contractor elect to furnish an anchoring device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in the concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

If loop tendon anchorages are used, they shall be enclosed in ducts for their entire length.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed so that the ends of

the prestressing steel and all parts of the anchoring devices will be at least 2 inches inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with grout, and finished flush. The grout shall consist of one part cement and 2 parts sand.

412.08 TESTING PRESTRESSING STEEL AND ANCHORAGE ASSEMBLIES

General. - The City will designate an independent recognized testing laboratory to which the Contractor shall deliver, for testing, the necessary samples from each lot of prestressing steel and anchorage assemblies to be used in the work. Lengths of samples, practicable for testing, shall be as required by such laboratory.

All testing in the laboratory will be done at City expense and at no cost to the Contractor.

Sampling and testing shall conform to the specifications of ASTM Designation: A 416 and ASTM Designation: A 421 and as specified herein.

Samples from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coil of prestressing wire and from each lot of anchorage assemblies and bar couplers to be used shall be furnished for testing. With each sample of prestressing steel wires, bars or strands furnished for testing, there shall be submitted a certification stating the manufacturer's minimum guaranteed ulimate tensile strength of the sample furnished.

All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies or bar couplers received at the site will be rejected.

The following samples of materials and tendons, selected by the Engineer from the prestressing steel at the plant or job site, shall be furnished by the Contractor to the Engineer well in advance of anticipated use:

(1) For wire or bars, one 7-foot long sample and for strand, one 5-foot long sample, of each size shall be furnished for each heat or reel.

(2) If the prestressing tendon is a bar, one 7-foot length shall be furnished and in addition, if couplers are to be used with the bar, two 4-foot lengths of bar equipped with one coupler and fabricated to fit the coupler shall be furnished.

Each wire or strand sample shall be cut from separate spools. For post-tensioning strand, samples shall be furnished with anchorage units attached and complete with any distribution plates or assemblies required.

In addition, the Contractor shall furnish at least 2 post-tensioning anchorage assemblies, complete with distribution plates, of each size or type to be furnished, if anchorage assemblies are required and are not attached to reinforcement samples.

All samples submitted shall be accompanied by a written certification from the Contractor that the samples were taken from, and are representative of, each lot to be furnished.

All of the material specified to be furnished for testing shall be furnished to the laboratory free of cost to the City, and it shall be the Contractor's responsibility to make certain that such materials shall be furnished well in advance of the desired time of use in order that there will be ample time for testing and no delay in the work.

For prefabricated tendons, the Contractor shall give the Engineer at least 10 days notice before commencing the installation of end fittings or the heading of wires. The Engineer will inspect end fitting installations and wire headings while such fabrication is in progress at the plant and will arrange for the required testing of the material to be shipped to the site.

No prefabricated tendon shall be shipped to the site without first having been released by the Engineer, and each tendon shall be tagged before shipment for identification purposes at the site. All unidentified tendons received at the site will be rejected.

Job site or site as referred to herein shall be considered to mean the location where the members are to be manufactured whether at the structure site or a removed casting yard.

The release of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

412.09 GROUTED KEYWAYS AND CONNECTIONS. - Keyways and connections shall be grouted with Class "C" mortar in accordance with the following specifications and the applicable requirements of Section 800.09. The water/cement ratio by weight shall be between 0.30 and 0.35. The consistency shall be such that, upon squeezing a portion of the mortar in the hand, the mortar will form a hard ball without oozing through the fingers or showing surplus moisture on the outside.

The mortar shall be placed in the joint in layers not to exceed 3 inches in thickness. Each layer shall be firmly tamped before the next layer is placed.

No equipment or other loads will be allowed until the grout in keyways and connections has attained a compressive strength of 3,000 psi.

412.10 INSPECTION AND TESTING OF PRECAST UNITS AT OFF-SITE PLANT. - If precast units are fabricated at off-site plants, the Contractor shall furnish the Engineer, or his designated representative, ready access to such plant at all times work on the units is in progress, and shall provide suitable facilities for inspecting and testing tensioning, casting, and curing operations, including the taking and storage of concrete test cylinders.

The Contractor shall notify the Engineer, in writing, at least four weeks in advance of the approximate date of start of fabrication of the units, and subsequently shall notify the Engineer three days in advance of the specific date for start of fabrication.

412.11 STAGING AND FALSEWORK. - Staging and falsework shall be in accordance with the requirements of Section 411.03.

412.12 REMOVAL OF FORMS AND FALSEWORK. - Falsework and forms supporting cast-in-place prestressed concrete members shall not be released until after the prestressing steel for all elements of the structure has been tensioned. Retention of falsework beyond this time may be required under certain structural conditions.

412.13 SAFETY REQUIREMENTS. - The Contractor shall post adequate signs prohibiting public access to the site of prestressing operations, and at each end of the member in which prestressing tendons are to be tensioned shall erect barriers adequate to absorb the energy of flying material should any failure occur. During stressing operations he shall adequately prevent passage by anyone between the barriers and the unit being stressed, and shall make sure that no workmen are in the line of the tendons. Further, the Contractor's attention is drawn to the requirement for safety specified in Section 108.13.

412.14 PAYMENT. - Prestressed concrete construction shall be done as Incidental Work and payment therefor shall be included in the price or prices bid.

SECTION 413

STEEL AND OTHER METAL STRUCTURES

413.01 GENERAL. - The Contractor shall construct steel and other metal structures and shall do related work where and as shown on the plans and in accordance with the applicable requirements specified herein. Materials, workmanship, fabrication, erection, fireproofing, and design of steel structures and related metalwork shall be in accordance with the applicable requirements of the San Francisco Building Code and the following specifications, as applicable:

1) Bridges. - "Standard Specifications for Highway Bridges," of the American Association of State Highway Officials (AASHO), and "Specifications for Steel Railway Bridges," of the American Railway Engineering Association (AREA);
2) Buildings and Other Structures. - "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings," of the American Institute of Steel Construction (AISC); and
3) Aluminum Alloy Structures and Metalwork. - "Suggested Specifications for Structures of Aluminum Alloys 6061-T6, 6062-T6, 6063-T5 and 6063-T6," American Society of Civil Engineers (ASCE).

413.02 SHOP DRAWINGS. - The Contractor shall furnish shop drawings, in accordance with the requirements of Section 106.08, for all steel structures and related metalwork.

413.03 MATERIALS. - Unless otherwise specified, materials shall be in accordance with the applicable of the following ASTM Specification Designations:

MATERIALS DESIGNATION	ASTM
Structural Steel	A 36
Structural Rivet Steel	A 502
Bolts and Nuts	A 307
High Strength Steel Bolts, Nuts and Washers	A 325
Carbon Steel Forgings for Pins and Rollers	A 235, Class C1
Cold-Finished Carbon Steel for Pins and Rollers	A 108
Cast Steel	A 27, Grade 65-35
Malleable Iron Castings	A 47, Grade 32510
Steel Pipe for Columns and Railings	A 53
Light Gauge Steel Sheets	A 245
Bronze Castings	B 22

ALUMINUM-ALLOYS	ASTM
Sheet and Plate	B 209
Drawn Seamless Tubes	B 210
Bars, Rods and Wire	B 211
Extruded Bars, Rods, Shapes, and Tubes	B 221
Standard Structural Shapes	B 308

413.04 TESTS OF MATERIALS. - Unless the Contractor furnishes certified test results from an approved independent recognized testing agency, or mill laboratory, or mill, to prove that the materials are in accordance with the requirements set forth herein, such materials shall be limited to use in minor parts not affecting the strength of the structure.

413.05 STORAGE OF MATERIALS. - Materials to be stored shall be placed above the ground on platforms, skids, or other supports, and shall be kept free from dirt, grease, and other foreign materials and properly drained and protected from corrosion.

Long members, such as columns and chords, shall be uniformly supported on skids sufficient in number to prevent undue deflection.

413.06 BOLTS, NUTS AND WASHERS. - Unless otherwise specified, all bolts, nuts and washers, including anchor bolts, shall be galvanized.

Unless otherwise specified, high strength steel bolts, nuts and washers shall not be galvanized and the method of installation shall be in accordance with the applicable requirements of Section 802.02.

413.07 WELDING. - Welding shall be in accordance with tha applicable requirements of Section 806.

413.08 GALVANIZING. - Galvanizing of metalwork shall be in accordance with the applicable requirements of Section 807.

413.09 PAINTING. - Painting of metalwork shall be in accordance with the applicable requirements of Section 809.

413.10 PAYMENT. - Steel structures and related metalwork, satisfactorily constructed as specified, each will be paid for at the lump sum price bid therefor.

Any steel structure or related metalwork for which the Proposal does not contain provision for payment shall be constructed as Incidental Work.

SECTION 414

TIMBER STRUCTURES

414.01 GENERAL. - The Contractor shall construct timber structures where and as shown on the plans and in accordance with the applicable requirements specified herein.

Materials, workmanship, fabrication, erection, firproofing and design of timber structures shall be in accordance with the applicable requirements of the San Francisco Building Code and the "National Design Specification for Stress Grade Lumber and its Fastenings" published by the National Lumber Manufacturers' Association, which shall be referred to herein as the National Design Specification.

414.02 SHOP DRAWINGS. - The Contractor shall furnish shop drawings, in accordance with the requirements of Section 106.08, for all timber structures.

414.03 MATERIALS.

Structural Framing Members. - All structural framing members for wood shall be Douglas fir construction grade (1500 f), as graded by the West Coast Lumbermen's Association. Other species of wood and grade specified shall be in accordance with the applicable requirements of the National Design Specification.

Treated Wood. - All treated wood shall be pressure-treated with creosote. The pressure treatment with creosote, and other preservatives when specified, shall be in accordance with the applicable requirements of Section 415.

Plywood. - All plywood used in locations exposed to weather shall be Douglas fir plywood C-C Grade, and in all other locations, C-D Grade, in accordance with the applicable requirements of the "Douglas Fir Technical Data Handbook," published by the Douglas Fir Plywood Association.

Glued Laminated Lumber. - Glued laminated lumber shall be in accordance with the applicable requirements of the "Standard Specifications for Structural Glued Laminated Douglas Fir Lumber," as published by the West Coast Lumbermen's Association.

Fasteners for Wooden Members. - Fasteners for wooden members, such as wood connectors, bolts with the required nuts and washers, lag screws, wood screws, spikes, nails, etc., shall be in accordance with

the applicable requirements of the National Design Specification. All bolts and lag screws shall be provided with malleable iron or plate washers under heads and nuts. All fasteners shall be galvanized when used in locations exposed to the weather.

414.04 HANDLING AND STORAGE OF WOOD MEMBERS. - Lumber and timber shall be protected by the Contractor from the elements, to the satisfaction of the Engineer, until incorporated into the structure for which it is intended.

Untreated lumber and timber shall be open-stacked at least 12 inches above the ground. Lumber and timber that has been treated with preservative shall be close-stacked and piled to prevent warping.

Lumber and timber shall be piled so that it may be readily inspected, and shall be handled in a manner that will avoid injury or breakage. Treated lumber and timber shall be handled with rope slings. Cant hooks, peaveys, or other sharp instruments shall not be used in handling lumber and timber. Undue injury in handling will be cause for rejection.

Materials exposed to the elements through improper storage or transportation shall be subject to reinspection. Materials failing to meet the original requirements of grade and moisture content in reinspection shall be replaced at the sole expense of the Contractor.

414.05 FRAMING OF WOOD MEMBERS. - All wooden members shall be accurately cut and framed to a close fit in such manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth, and tenons shall fit snugly. No shimming will be permitted when making joints nor will open joints be allowed.

Wooden columns or posts shall be framed to true end bearings. Mud sills shall be firmly and evenly bedded in solid material.

Wooden members shall be connected together in a secure manner so that all forces will be adequately transferred from one member to another.

Holes for drift pins and dowels in untreated lumber and timber shall be bored with a bit 1/16-inch less in diameter than the pin or dowel to be used.

Holes for drift pins and dowels in treated lumber and timber shall be bored with a bit of the same diameter as the pin or dowel.

Holes for rods shall be bored with a bit 1/16-inch greater than the rod diameter.

Holes for lag screws shall be bored with a bit not larger than the base of the thread. Holes in small timbers for boat or wire spikes shall be bored with a bit of the same diameter or smallest dimension of the spike, when necessary to prevent splitting.

The use of bolts and other fastenings for the connection of wooden members shall be in accordance with the applicable requirements of the National Design Specification.

Countersinking shall be done whenever smooth faces are required. Recesses therefor shall be saturated with preservative, when specified, in accordance with the requirements of Section 415.01.

Minimum nailing of different connections shall be in accordance with the San Francisco Building Code.

414.06 PAYMENT. - Timber structures, satisfactorily constructed as specified, each will be paid for at the lump sum price bid therefor, except as otherwise specified in the Special Provisions.

When timber structures are specified to be paid for on the basis of the quantity of lumber and timber incorporated into a structure, measurement will be made in accordance with the applicable requirements of Section 111.04.

Any timber structure for which the Proposal does not contain provision for payment shall be constructed as Incidental Work.

SECTION 415

WOOD PRESERVATIVE TREATMENT

415.01 GENERAL. - The Contractor shall treat lumber and timber, required to be treated, with wood preservative, in accordance with the requirements set forth in the Special Provisions and herein.

Timber piles required to be treated shall be pressure treated with creosote unless otherwise specified on the plans or in the Special Provisions.

So far as practicable, all cutting, adzing, boring, chamfering, gaining, mortising, surfacing, and the like, shall be done prior to treatment.

All pressure treatment shall be done in accordance with the applicable requirements of Federal Specification TT-W-571, "Wood Preservation; Treating Practices," and other specifications therein included, except as modified herein, on the plans or in the Special Provisions.

Maximum possible penetration shall be obtained with whatever preservative and vehicle is specified and used, and such penetration shall conform to or exceed that outlined as minimum in the hereinbefore referred to Federal Specificaiton. The depth of penetration, measured at right angles to the surface of the wood, shall be determined by means of borings. After testing, the bored holes shall be filled with tight-fitting treated plugs. Test borings in piles shall be made midway between the ends.

Treated lumber, timber, and timber piles, the surface of which have been damaged by cutting, gouging, boring, or otherwise, in such manner as to reduce the effectiveness of the treatment, will be rejected unless, in the opinion of the Engineer, the damaged treated areas can be satisfactorily repaired. The repair of damaged areas, when permitted, shall be by saturating or coating with a preservative material furnished by the company that pressure treated that particular lot of wood, in accordance with the recommendations of that company.

Unless permitted by the plans or Special Provisions in the case of small quantities of materials, no creosoted or otherwise treated material from stock will be accepted.

When specifically permitted on the plans or in the Special Provisions, small quantities of untreated wood members may receive on-the-job preservative treatment, after cutting, surfacing, boring and the like, by dipping or brushing with the preservative material specified on the plans or in the Special Provisions. Three saturating coats shall be

successively applied to every surface, including borings, with adequate drying time allowed between coats, the last coat being applied after the wood members have been framed in place.

Wood members specified for on-the-job preservative treatment, unless otherwise specified, shall not be incised on the surfaces as set forth hereinafter. Preservative shall not be applied to wet wood or to wood surfaces on which free moisture is present.

415.02 INSPECTION. - All lumber and timber to be treated shall be in accordance with the applicable requirements of Section 414 and grade marked prior to treatment. Timber piles shall be in accordance with the requirements of Section 402. After treatment, all lumber, timber and timber piles shall be inspected, with respect to the treatment, by an inspector from an independent recognized testing laboratory, or inspection service, approved by the Engineer. Each piece shall be stamped by the inspector with a mark different from that used for grade marking. No preservative treatment inspection stamp will be required for on-the-job dip or brush treatment.

The Contractor shall furnish the City with the official inspection certificate of the laboratory or inspection service.

Treated lumber, timber, and timber piling shall be subject to inspection by the Engineer after arrival at the site or after being placed in the completed structure, and no previous inspection at the plant shall bar rejection in the completed structure.

415.03 HANDLING. - All treated lumber, timber, and timber piles shall be carefully handled with rope slings without sudden dropping, breaking of the outer fibers, bruising, or penetration of the surface. Cant dogs, hooks, pike poles or similar tools shall not be used except in the case of creosoted piles where such tools may be used within 3 feet of either end of the piles.

Treated lumber, timber, and timber piles, the surfaces of which have been damaged in handling, will be rejected or shall be repaired as specified hereinbefore in Section 415.01.

415.04 PREPARATION AND TREATMENT. - Lumber, timber, and timber piles which are to be creosoted or otherwise treated shall be air-seasoned, or seasoned by boiling under a vacuum, until all water which would interfere with the treatment process has been removed.

Before treatment, all sawed lumber and timber 2 inches or more in thickness shall be incised on all 4 sides by means of a suitable power-driven machine with cutting teeth designed to give a uniform penetration and a regular pattern. The spacing of the incisions shall be in accordance with the recommendations of the manufacturer of the preservative, and the depths of the incisions shall not be less than the depths set forth in the following table:

Thickness of Timber	Depth of Incision
6" and over	3/4"
3" and under 6"	1/2"
2" and under 3"	1/4"

415.05 PRESSURE TREATMENT WITH CREOSOTE. - Pressure treatment with creosote shall be in accordance with the requirements of Table I of Federal Specification TT-W-571, and shall be with the creosote-vehicle combination specified, or if not specified, best suited for the material, its condition and intended use. The creosote used shall be in accordance with the requirements of the ASTM "Standard Specifications for Creosote," Designation D 390.

The minimum net retention of preservative shall be 12 lbs. per cubic foot for coal-tar creosote and for creosote-coal tar solutions, and 14 lbs. per cubic foot for creosote-petroleum solution.

415.06 PRESSURE TREATMENT WITH PENTACHLOROPHENOL. - Pressure treatment with pentachlorophenol, including the preservative solution used, and the degree of retention and penetration, shall be in accordance with the requirements of Table II of of Federal Specification TT-W-571 and other specifications therein included, unless otherwise specified.

Pentachlorophenol shall be used where the treated material will not be in contact with salt water, where the use of creosote would be objectionable, where the surfaces shall be paintable, or where specified on the plans or in the Special Provisions, except that unless otherwise specified it shall not be used for timber piles. Special attention shall be given to the type of petroleum solvent used and the period of seasoning after treatment where the requirements of Section 415.08, the plans, or the Special Provisions require the surface to be paintable.

When pentachlorophenol-liquefied petroleum gas solution is used, the solution, retention, and penetration shall conform to the following requirements:

1) The solution shall be made up of: 1) pentachlorophenol conforming to requirements of Federal Specification TT-W-570 and; 2) volatile petroleum solvents having a distillation end point not greater than 40°F.
2) The retention of pentachlorophenol shall not be less than the following:
   Under five inches thick -
   0.50-pound per cubic foot;
   Five inches and thicker -
   0.40-pound per cubic foot.
3) The penetration in inches of percent of sapwood penetration of pentachlorophenol shall not be less than the following:
   Under five inches thick -
   3/8-inch penetration or 90 percent of sapwood;
   Five inches and thicker -
   1/2-inch penetration or 90 percent of sapwood;

415.07 PRESSURE TREATMENT WITH WATER-BORNE PRESERVATIVES. - Pressure treatment with water-borne preservatives, including the preservative solution used, and the degree of retention and penetration, shall be in accordance with the requirements of Table III of Federal Specification TT-W-571 and other specifications therein included, unless otherwise specified.

Treatment with water-borne preservatives shall be used where specifically permitted on the plans or in the Special Provisions, for

moderate leaching conditions where there is no exposure to marine borers, and where wood treated with oil-borne preservatives would not be satisfactory due to odor, color, oily surface or possible unpaintability.

Lumber and timber treated with water-borne preservatives shall be dried to a moisture content that will not interfere with the application or retention of paint.

415.08 ARSENIC AND CREOSOTE PRESERVATIVES PROHIBITED WHERE ACCESSIBLE TO PUBLIC. - Wood treated with solutions containing any form of arsenic, creosote or other agent similarly toxic or otherwise hazardous to persons, livestock or domestic animals, shall not be used in locations accessible to persons, livestock or domestic animals, especially in locations where food or beverages are to be prepared, consumed or stored. Preservatives used in such locations shall be of the type that can be satisfactorily painted over without bleeding, and shall be painted over.

415.09 TREATMENT OF TIMBER PILE HEADS. - The heads of all treated piles which are not embedded in concrete shall be treated by one of the following methods, after the piles have been driven and cut off to the proper elevation:

(1) An application of wood preservative conforming to the provisions specified in Section 415.01 shall first be applied to the head of the pile and a protective cap shall then be built up by applying alternate layers of loosely woven fabric and hot asphalt or tar similar to membrane waterproofing, using 3 layers of asphalt or tar and 2 layers of fabric. The fabric shall measure at least 6 inches more in each direction than the diameter of the pile and shall be turned down over the pile and the edges secured by binding with 2 turns of No. 10 galvanized wire. The fabric shall be wired in advance of the application of the final layer of asphalt or tar which shall extend down over the wiring.

(2) The sawed surface shall be covered with 3 applications of a hot mixture of 60 percent creosote and 40 percent roofing pitch, or thoroughly brushcoated with 3 applications of hot creosote and covered with hot roofing pitch. A covering of galvanized sheet iron shall be placed over the coating and bent down over the sides of each pile to shed water.

The method to be used shall be at the option of the Contractor, unless otherwise provided on the plans or in the Special Provisions.

The treatment of pile heads encased in concrete will not be required.

415.10 FIRE RETARDANT TREATED WOOD. - Fire retardant treated wood shall meet the requirements, for the specific use intended, of the Building Code, Part II, Chapter I, of the San Francisco Municipal Code.

415.11 PAYMENT. - Wood preservative treatment, satisfactorily performed, including inspection and handling, shall be done as Incidental Work and payment therefor shall be included in the price or prices bid.

SECTION 416

MASONRY

416.01 GENERAL. - The Contractor shall do all masonry work, including all Incidental Work necessary or required, to complete all brickwork, concrete block structures, or other masonry, where and as shown on the plans, or where directed, and in accordance with the requirements specified herein.

Materials, workmanship, and installation shall be in accordance with the applicable requirements of the San Francisco Building Code.

Mortar used for jointing masonry units shall be Class "B" or "C" in accordance with the requirements of Section 800.09. Mortar shall be mixed with the minimum amount of water necessary to secure proper hydration.

416.02 BRICK. - Brick shall conform to the requirements of ASTM "Standard Specifications for Building Brick (Solid Masonry Units Made from Clay or Shale)" Designation C 62, Grade MW.

416.03 CONSTRUCTION. - All masonry work shall be of the highest quality.

Masonry units shall be built plumb and true to lines, with the courses level, and shall be constructed with tight joints. Bricks, blocks, or other units for walls, shall be laid with the vertical joints aligning over the center of the unit below (running bond). All joints shall be approximately 3/8-inch thick and be completely filled with mortar. Masonry units shall be shoved into place; buttering will not be permitted. Excess mortar shall not be struck off in such a manner as to pull the mortar from adjoining unit faces. Joints shall be finished flush.

416.04 WATERPROOFING OF MASONRY WALLS. - Masonry walls against which earth is to be placed shall be waterproofed as specified in Section 418. The waterproofing shall be a minimum of one square yard per linear foot of wall, unless otherwise specified on the plans or in the Special Provisions, and shall be placed where directed by the Engineer. The remaining portion of the wall against which earth is placed shall be dampproofed as specified in Section 411.15.

416.05 PAYMENT. - Masonry and the accompanying waterproofing shall be constructed as Incidental Work and payment therefor shall be included in the price or prices bid.

SECTION 417

AIR-BLOWN MORTAR

417.01 GENERAL. - The Contractor shall construct air-blown mortar where and as shown on the plans, or where directed, including furnishing the necessary equipment, preparing the surface to receive air-blown mortar, furnishing and installing reinforcement, coloring, placing, finishing, curing, and doing all other related Incidental Work, all in accordance with the requirements set forth herein.

Air-blown mortar shall not be placed during freezing or other adverse weather conditions unless approved protective measures are taken.

Only experienced foremen, gunmen, nozzlemen and rodmen shall be employed and, if requested, the Contractor shall furnish satisfactory written evidence of such experience to the Engineer.

417.02 OPERATING REQUIREMENTS. - Not less than 500 cubic feet of air per minute, (manufacturer's rated compressor capacity) at a minimum pressure of 45 psi in the gun chamber, shall be required for proper air-blown mortar placement and adequate "blowout" jet requirements. Water under a pressure of at least 15 psi in excess of air pressure shall also be required. Pressure requirements shall be increased with the height of the operation above the gun and length of hose required.

The cement gun shall be operated with a minimum air pressure of 45 psi in the gun tank when 100 feet or less of hose is used and the pressure should be increased 5 psi for each additional 50 feet of hose required.

417.03 WIRE MESH REINFORCEMENT. - Steel wire mesh reinforcement shall be in accordance with the requirements of Section 416.05.

The wire mesh shall be firmly secured in place so that no vertical or transverse displacement will occur during placement of the gunite.

The wire mesh shall be supported on concrete blocks of a thickness sufficient to provide the required clearances.

417.04 MATERIALS. - Air-blown mortar shall be a mixture of Portland cement and sand, mixed dry, passed through a cement gun, or other similar device, hydrated at the nozzle and properly shot by air pressure into its final position.

Air-blown mortar shall have the proportion of one part Portland cement by volume, to not more than 4 parts loose, dry sand, by volume.

The word "dry" as applied to the sand means that it shall not contain more than 5 percent nor less than 3 percent of moisture.

Sand for air-blown mortar shall consist of material of siliceous, granitic or igneous origin, and shall be hard and durable. It shall be free from oil and injurious amounts of clay, shale, mica or other objectionable materials.

When tested in accordance with the requirements of the ASTM "Method of Test for Amount of Material Finer than No. 200 Sieve in Mineral Aggregates by Washing," Designation C 117, no more than 4 percent by weight shall pass the No. 200 sieve.

When tested in accordance with the requirements of ASTM "Method of Test for Organic Impurities in Sands for Concrete," Designation C 40, sand shall not show a solution color darker than the standard color solution.

The dry sand shall have a particle size distribution such that the percentage composition by weight, determined by test using standard sieves of square mesh wire construction, will conform to the following grading requirements:

Sieve Size or Number	Percent by Weight Passing
3/8"	100
No. 4	93-100
No. 16	42- 88
No. 50	7- 38
No. 100	2- 10

No particle shall be larger than 3/8-inch in diameter. The sand shall have a fineness modulus of between 2.50 and 3.30. Any variation in the fineness modulus during the progress of the work greater than 0.20 plus or minus from the initial value of the accepted sand, shall be cause for rejection of the sand for further use.

The cement and dry sand shall be thoroughly mixed for not less than on minute in a dry state in a mechanical mixer, except that, where specifically permitted small quantities shall be mixed by hand. Mixed materials, if not placed within one hour after preparation, or if allowed to become damp, shall be rejected.

Air-blown mortar at the age of 7 days shall develop a compressive strength of not less than 3,000 psi, and at 28 days not less than 4,000 psi, unless calcium-aluminate, as specified in Section 417.05, is required.

417.05 CALCIUM-ALUMINATE. - Calcium-aluminate cement shall be used in accordance with the directions of the manufacturer. The amount of calcium-aluminate cement added to the mix shall not exceed 20 percent of the total amount of cement used. The time of initial set shall not be less than 15 minutes nor more than 30 minutes. The 7-day and 28-day strengths of the air-blown mortar to which calcium-aluminate cement has been added shall not be less than 1,500 psi and 3,000 psi, respectively.

417.06 COLORING. - When coloring is required, the Contractor, prior to the commencement of work, shall furnish the Engineer samples of the specified color. The Engineer will select the shade. The coloring agent shall be integrally mixed with the air-blown mortar in strict accordance with the manufacturer's recommendations. The color and shade of the completed and cured air-blown mortar shall be uniform.

417.07 SURFACE PREPARATION. - All bonding surfaces upon which air-blown mortar is to be applied shall first be satisfactorily cleaned of dirt, vegetable matter, grease, oil, rust, scales and all other substances that would prevent complete and adequate bond.

Concrete surfaces to receive air-blown mortar shall be prepared by wire brushing, using high pressure air and water, sandblasting,

combinations thereof, or approved equivalent means, to remove all foreign and loose materials.

Earth surfaces to receive air-blown mortar shall be prepared by removing vegetation, debris, and loose materials; by excavating and constructing embankment, if specified; by moistening and compacting the area to receive air-blown mortar in order to form a firm foundation; and applying an approved soil sterilizing agent prior to placing wire mesh.

417.08 PLACING. - Air-blown mortar shall be applied only to those surfaces approved by the Engineer.

Air-blown mortar shall not be applied to surfaces upon which there is free water, but the surface shall be sufficiently damp to prevent absorption.

Ground or gaging wires shall be used as alignment guides to establish thicknesses, surface planes and finish lines. The wires shall be located at intervals sufficiently close to assure proper thickness of the air-blown mortar throughout, shall each be stretched tight between individual supports, and shall remain undisturbed in place until the finish coat of air-blown mortar has been applied.

Expansion joints shall be constructed as shown on the plans. Expansion joint filler shall be in accordance with Section 411.06. The top or outer 1/2-inch of all expansion joints shall be filled with an approved asphalt-latex emulsion joint sealant. Any mortar that has sealed across any expansion joint shall be neatly cut and removed.

Air and water shall be supplied to the air-blown mortar placing machine under such pressure as necessary to produce the most satisfactory results. The pressure shall be constant and free from pulsation.

The consistency of the air-blown mortar shall be such that there is no tendency for it to flow down the slope or separate while being placed.

In spraying the hydrated mixture on any surface, the nozzle shall generally be held about 3 and not more than 5 feet from the surface. The nozzle shall be held so that the stream will impinge, as nearly as possible, normal to the surface, with the material arriving at the nozzle uniform in stream and texture. Care shall be taken to prevent the occurrence of sand pockets, and if any develop, they shall be immediately cut out and satisfactorily replaced with mortar.

The time interval between successive applications in sloping, vertical or overhanging work must be sufficient to allow initial, but not final, set to develop. At the time the initial set is developing, the surface shall be lightly and carefully broomed to remove all laitance and provide a better bond with succeeding applications.

Constructions joints, or the day's work joints, shall be sloped off to a thin, clean, regular edge at a 45 degree slope. Before placing the adjoining work, the sloped edges and the surrounding air-blown mortar shall be thoroughly cleaned and wetted with water, following which the free water shall be blown off with an air jet or removed by other approved means.

Materials that have been mixed for more than 45 minutes and have not been incorporated in the work shall not be used, unless permitted by the Engineer.

417.09 TEST CYLINDERS. - When required by the Engineer, test cylinders shall be taken representing the quality of the air-blown mortar placed by each nozzleman. Each cylinder shall be dated, numbered, and the name of the nozzleman noted, together with the part of the structure into which he placed the gunite. Test cylinders shall be made by shooting air-blown mortar into a mold of 3/4-inch metal mesh (hardware cloth) to make cylinders 6 inches in diameter and 12 inches long. The excess material outside the mold shall be trimmed off with a sharp-edged trowel. About 24 hours after making the cylinders, the hardware cloth form shall be removed and the cylinders stored for curing and testing in accordance with the requirements of ASTM "Methods of Test for Compressive Strength of Molded Concrete Cylinder," Designation C 39.

417.10 REBOUND. - Material which rebounds and does not fall clear of the work shall be blown off and removed from the work in a suitable manner, and shall not be reused. When an air blow-out jet is used to remove rebound, care must be taken to avoid interference with the flow of air-blown mortar, or the work of the nozzleman. No rebound material shall be dumped upon streets, into catchbasins, or otherwise into the City sewer system.

417.11 FINISHING. - Air-blown mortar surface finish shall be "Class 1, Nozzle Finish" unless specified otherwise. Air-blown mortar finishes shall be of the following classes:

Class 1, Nozzle Finish. - The air-blown mortar shall be brought during application to an even plane and to well-formed corners by working up to ground wires or other thickness or alignment guides.

Class 2, Screeded and Flashcoated Finish. - High spots shall be trimmed off and low spots exposed by using a thin edge screed, by working up against gravity and by employing a slicing motion. A thin finishing flash coat shall be applied to remove rough areas after the ground wires have been removed.

Class 3, Float Finish. - A Class 1, nozzle finish shall first be attained, then lightly rubbed with a flat burlap or rubber pad with a circular or spiral motion. No hand patching will be allowed.

Class 4, Trowel Finish. - A Class 2, screeded and flashcoated finish shall first be attained, then steel troweled to obtain more free smooth surfaces with a minimum of trowel pressure. Troweling shall be done not more than an hour after placing the air-blown mortar.

417.12 CURING. - Air-blown mortar lining shall be cured in accordance with the requirements of Section 800.16.

417.13 PAYMENT. - Air-blown mortar satisfactorily constructed, complete in place, as specified, will be paid for at the price bid per sack of cement incorporated into the completed gunite lining.

Each sack of cement shall contain 94 lbs. of cement, net weight. As the cement sacks are emptied, they shall be neatly bundled into bundles of 50 to facilitate counting by the Engineer.

SECTION 418

WATERPROOFING CONCRETE AND MASONRY

418.01 GENERAL. - The Contractor shall furnish and apply membrane waterproofing consisting of a coat of primer and a firmly bonded membrane composed of two layers of saturated glass fabric and 3 moppings of waterproofing asphalt, to the surface of concrete or masonry, where and as shown on the plans or specified, including doing all Incidental Work necessary or required for a complete, satisfactory job.

418.02 MATERIALS. - Waterproofing asphalt shall conform to the requirements for Type I asphalt of ASTM "Standard Specifications for Asphalt for Use in Constructing Built-Up Roof Coverings", Designation D 312.

Fabrics shall conform to the requirements of ASTM "Standard Specifications for Woven Glass Fabrics Treated with Bituminous Substances for Use in Waterproofing," Designation D 1668.

Primer for use with asphalt in waterproofing shall conform to the requirements of ASTM "Standard Specifications for Primer for Use With Asphalt in Dampproofing and Waterproofing," Designation D 41.

418.03 APPLICATION. - All concrete and masonry surfaces which are to be waterproofed shall be reasonably smooth and free from holes and projections which might puncture the membrane. The surfaces to be waterproofed shall be dry and shall be thoroughly clean of dust and loose materials.

Primer and asphalt shall be applied in accordance with the manufacturer's specifications. No primer or asphalt shall be applied in wet weather, nor when the temperature is below 65° F., without authorization in writing from the Engineer. The primer shall be applied uito the surface and allowed to dry before the first coat of asphalt is applied. The waterproofing asphalt shall be applied at a temperature of not less than 300° Fahrenheit, nor more than 350° Fahrenheit.

Beginning at the low point of the surface to be waterproofed, the waterproofing asphalt shall be thoroughly mopped onto the primed surface. A strip of fabric of half the width of the roll shall be rolled onto the hot asphalt immediately, and carefully pressed into place so as to eliminate all air bubbles and obtain close conformity with the surface. This strip, and an adjacent section of the surface of the width equal to slightly more than one-half the width of the fabric being used, shall then be mopped with hot asphalt and a full width of the fabric shall be rolled into this, completely covering the first strip, and shall be pressed into place as before. This second strip and an adjacent section of the concrete surface shall then be mopped with hot asphalt and the third strip of fabric shingled on so as to lap the first strip by not less than 2 inches. This process shall be continued until the specified surface is covered, each strip of fabric lapping at least 2 inches over the last strip but one. The specified surface shall then be mopped with hot asphalt. Special care shall be taken at all laps to see that they are thoroughly sealed down.

The work shall be so regulated that at the close of each day's work the final mopping of asphalt shall have been applied to all the fabric in place.

418.04 PROTECTION OF MEMBRANE. - The Contractor shall submit, for the approval of the Engineer, the method he intends to use to protect the membrane waterproofing during construction.

Any waterproofing membrane which loses its bond with the concrete or masonry shall be removed and replaced with new membrane waterproofing by the Contractor at his expense.

418.05 PAYMENT. - Membrane waterproofing satisfactorily applied, complete in place, as shown on the plans or specified, will be paid for at the price bid per square yard of surface to which the waterproofing is bonded and covers.

END PART 4