SECTION 625
DRILLED CAISSON FOUNDATIONS

625.1 – DESCRIPTION:

The work of this section includes the furnishing of all materials and the construction of foundations consisting of reinforced concrete caissons placed within drilled excavations. Each drilled caisson foundation shall consist of a shaft section, with the lower portion in a drilled rock socket and with the upper portion in a steel casing. This casing will normally be removed during concrete placement unless otherwise shown in the plans or directed by the Engineer.

625.2 - TESTS AND SUBMITTALS:

The Contractor shall deliver all submittals required by this specification to the Engineer no later than one month prior to constructing any drilled caissons shown in the plans. No drilled caissons shall be constructed prior to the Engineer's review and acceptance of all submittals and test hole results.

625.2.1 - Experience:

1) A satisfactory record of experience in drilled caisson construction is considered to be of the utmost importance in obtaining a satisfactory drilled caisson installation. The installation of the drilled caisson is required to be performed by a contractor or specialty subcontractor specializing in installing drilled caissons and having experience with caissons of similar length, diameter, and subsurface conditions as those shown in the contract documents.

2) The Contractor shall submit data on at least two projects performed during the past ten years, for which the Contractor (or the Subcontractor if applicable) has installed drilled caissons of a range of diameters and lengths similar to those shown in the plans, in similar quantities, and under similar subsurface conditions. The list of projects shall contain names and phone numbers of owners' representatives who can verify the participation in those projects.

3) The Engineer shall review and approve the Contractor' s (Subcontractor' s) caisson. If in the opinion of the Engineer the Contractor' s qualifications are not adequate, the Contractor shall submit to the Engineer a proposed method of obtaining the necessary qualifications.

4) The installation of all components of the drilled caisson including; drilling, reinforcement placement, concrete placement, and required wet hole condition work, casing installation and removal, slurry placement, and any other work required to complete the drilled caisson, shall be performed by the approved contractor or specialty

subcontractor.

625.2.2 - Site Inspection: A signed statement shall be submitted affirming that the Contractor (or the Subcontractor if applicable) has inspected the project site and the available subsurface information including any available soil or rock samples.

625.2.3 - Installation Plan: The Contractor shall submit an Installation Plan for review by the Engineer. This plan shall provide information on the following:

a) Name and experience record of the drilled caisson superintendent in charge of drilled caisson operations for this project.

b) List of proposed equipment to be used on the project, including barges, cranes, templates, drill rigs, drills, augers, bailing buckets, final cleaning equipment, slurry desanding equipment, slurry pumps, core sampling equipment, welding equipment, tremie or concrete pumps, casing, etc.

c) Details of overall construction operation sequence and the sequence of caisson construction in the piers and/or the abutments; taking due care not to damage fresh concrete by drilling in the immediate vicinity too quickly.

d) Method for maintaining drilled caisson position and alignment during excavation, and details and sequencing of caisson excavation.

e) Details of casing and splices to be used, including calculations (signed and stamped by a Professional Engineer knowledgeable in drilled caissons) showing ability of casing to withstand anticipated hydraulic and earth pressures and to withstand stresses due to installation without undue deformation. Description for withdrawal of casings to demonstrate that concrete will not be lifted during withdrawal.

f) When the use of slurry is anticipated, details of the methods to mix, circulate, and desand slurry. Any request to use a slurry displacement method for the construction of caissons shall also provide information for the Engineer's approval as follows:

    1. Detailed description of proposed construction method.
    2. Concrete mix, as modified for use with the slurry displacement method.
    3. Components and proportions in proposed slurry mixture.

4. Tests proving slurry mixture will not degrade rock or interfere with bond.
5. Methods to agitate slurry mixture prior to concrete placement.
6. Methods to clean slurry mixture for re-use.
7. Disposal methods for used slurry.

g) Details of methods to thoroughly clean the caisson excavation.

h) Details of reinforcing cage fabrication and placement including support of the reinforcing cage during handling, after installation, and during concrete placement, along with methods and devices that will be used to center the reinforcing cage and maintain concrete cover over the bars.

i) Details of concrete placement including proposed operational procedures for free-fall, tremie, pumping or other methods.

j) Sample of proposed drilled caisson report, proposed drilled caisson log, and proposed Preinstallation core hole log.

k) Welding procedures and qualifications of welders and tackers as specified in ANSI/AWS D1.1 for casing steel and in ANSI/AWS D1.4 for reinforcing steel.

l) Preinstallation Coring procedure.

m) Qualifications and experience record of firm proposed to perform Preinstallation Coring, including experience record of the supervisor designated to oversee the work.

n) Mix design for concrete and for non-shrink grout.

o) Plan to minimize vibration and wheel loads in the vicinity of newly placed caissons.

p) Plan for compliance with applicable environmental regulations, including but not limited to the protection of river water from degradation due to material excavated from drilled caisson locations or due to other harmful erosion, protection of the environment from slurry spillage or discharge if slurry is used, and general environmental protection of the area from all operations related to drilled caissons.

The Engineer will evaluate the Drilled Caisson Installation Plan for conformance with the Plans and Specifications. Within 14 days after receipt of the

plan, the Engineer will notify the Contractor in writing of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given by the Engineer shall be subject to trial in the field and shall not result in any additional cost to the Division if they fail to perform also shall not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the Plans and Specifications.

625.2.4 - As-Built Records: Within 24 hours of the completed construction of each drilled caisson, the Contractor shall submit a report on the actual location, alignment, elevation, and dimensions of the drilled caisson, and will also submit a completed drilled caisson log as specified herein.

625.2.5 - Test Hole: A test hole shall be drilled at the location and to the diameter and depth shown in the plans. The test hole shall be unreinforced but shall otherwise be constructed the same as other drilled caissons in this specification. The Contractor shall revise his methods and equipment as necessary during construction of the test hole when he is unable to carry out the requirements of this specification. Completed test holes shall be left in place except that the top of the caisson shall be removed to a depth of 2 feet (600 mm) below final ground line. Disturbed areas at the site of the test hole shall be restored to their original condition. If the Contractor fails to demonstrate the adequacy of his methods or equipment, the Engineer shall require additional test holes be provided at the Contractor's expense.

625.2.6 - Nondestructive Testing

625.2.6.1 - General Requirements: The nondestructive testing method known as Crosshole Sonic Logging (CSL) shall be used on any drilled caisson which is constructed with the placement of concrete underwater or as required in the plans. The testing shall not be conducted until at least twenty-four hours after placement of concrete is concluded in the caisson, and will be completed within 14 calendar days after such placement.

The CSL tests shall be conducted by the Engineer with the cooperation of the Contractor. The Contractor shall provide suitable working space and access to every tested caisson and shall provide a reliable 1000-watt generator for use by the Engineer.

625.2.6.2 - Preparation for Testing: To accommodate the CSL test requirements, the Contractor shall install a number of tubes in each caisson to be tested. The number of tubes per caisson shall be as tabulated below:

TABLE 625.2.6.2

Caisson Diameter	Number of Tubes	Tube Spacing
Up to 42" (1 049 mm)	3	120º
42" to 60" (1 050 mm to 1 499 mm)	4	90º
60" to 96" (1 500 mm to 2 399 mm)	6	60º
96" (2 400 mm) and larger	8	45º

The tubes shall be per section 625.4.4. Each tube shall have a round, regular internal diameter free of defects or obstructions including defects or obstructions at pipe joints; in order to permit the free, unobstructed passage of 1½ inch (35 mm) diameter source and receiver probes. The tubes shall be watertight and free from corrosion with clean internal and external faces to ensure passage of the probes inside and a good bond with the concrete outside.

Each tube shall be fitted with a watertight shoe on the bottom and a removable cap or plug on the top. The tubes shall be securely attached to the interior of the reinforcing steel cage. The tubes are typically wire-tied to the reinforcing cage every 40 inches (1 000 mm), or otherwise secured such that the tubes stay in position during placement of the cage and during placement of concrete. The tubes shall be installed in each shaft in a regular, symmetric pattern such that the tube spacing in degrees will correspond to that shown in the table above.

The tubes shall be as near to parallel as possible. They shall extend from 6 inches (150 mm) above the caisson bottom to at least 40 inches (1 000 mm) above the caisson top. No tube may be allowed to rest on the bottom of a drilled excavation. If the caisson top is sub-surface, then the tubes shall extend at least 2 ft (600 mm) above the ground surface or above the water surface if the ground surface is below water. Any joints required to achieve full length tubes shall be made watertight. Care shall be taken during placement of the reinforcing steel cage so as not to damage the tubes.

After placement of the cage, and before placement of concrete, the tubes shall be filled with clean water and the tube tops shall be capped or sealed to keep debris or other foreign matter out of the tubes. Care shall be exercised in the removal of caps or plugs so as not to apply excess torque, hammering, or other stresses that could break the bond between the tubes and the concrete.

625.2.6.3 - CSL Logging Procedures: Before placement of concrete, the Contractor shall investigate at least one tube per shaft. This investigation is to make sure that there are no bends, crimps, obstructions or other impediments to the free passage of the testing probes. A record of the tube length or lengths, including a note of the projection of the tubes above the top of the shaft shall be made. The Contractor shall provide information on the shaft bottom and top

elevations, length and construction dates to the Engineer prior to the CSL tests.

The Contractor shall make the caisson and the caisson site available to the Engineer for the conduct of the CSL tests. Any defects indicated by tests shall be evaluated by the Engineer and further tests may be conducted in regard to the extent of such defects. Any time required by such tests will be considered incidental to the work and will not be cause for extra compensation related to a claim or extension of contract.

625.2.6.4 - CSL Testing Results: The CSL test results will be compiled into a caisson integrity testing report for each caisson. The report will summarize and analyze any defect zones indicated on the logs. A copy of each report will be provided to the Contractor.

625.2.6.5 - Evaluation of CSL Test Results: The Engineer will evaluate the CSL test results and will determine whether or not the drilled caisson as constructed is acceptable. If the Engineer determines that the drilled caisson is acceptable based on the CSL tests, then the caisson and the caisson site will be turned back to the Contractor and further construction may proceed.

The acceptance of each drilled caisson shall be the decision of the Engineer, based on the results of the caisson integrity testing report and other information on the caisson placement. Rejection of a caisson shall require conclusive evidence that a defect exists in the caisson, which will result in inadequate or unsafe performance under service loads. If the Non Destructive Testing records are complex or inconclusive, the Engineer may require the Contractor to verify caisson conditions, in accordance with 625.2.6.6. If a defect is confirmed, the Contractor shall pay for all coring and grouting costs. If no defect is encountered, compensation for all coring and grouting will be in accordance with 104.3 and 109.4 of the Standard Specifications.

In the case that any caisson is determined to be unacceptable, the Contractor shall submit a plan for remedial action to the Engineer for approval. Any modifications to the foundation caisson and load transfer mechanisms caused by the remedial action will require calculations and working drawings stamped by a professional engineer registered in the State of West Virginia for all foundation elements affected. All labor and materials required to perform remedial caisson action shall be provided at no cost to the Division and with no extension of the contract time.

625.2.6.6 - Evaluation by Core Drilling: A drilled caisson that is found to be unacceptable shall be cored by the Contractor using double tube core barrels. One or more core holes shall be drilled at the location(s) as determined by the Engineer. A core sample shall be taken from each defect location, at a length specified by the Engineer. An accurate log of the core shall be kept and the core shall be crated and properly marked showing the caisson depth at each interval of core recovery. The core along with five copies of the coring log shall be provided to the Engineer.

If the quality of the caisson, as represented by the core samples, is

determined to be acceptable, then the caisson and the caisson site will be turned back to the Contractor and further construction may proceed. If the quality of the caisson is determined to be unacceptable, then the Contractor shall proceed in accordance with 625.2.6.5.

625.3 - DIMENSIONAL REQUIREMENTS:

The dimensional requirements for Placement Tolerances and Caisson Diameters shall be met prior to placement of reinforcing steel. The Contractor shall submit his corrective plan for any deviation from the caisson location, alignment and elevation tolerances, and reinforcement dimensional requirements to the Engineer for approval. The cost of any corrective action shall be borne by the Contractor.

625.3.1 - Placement Tolerances: For any drilled caisson the maximum permissible deviation from plumb shall be 1% or a ratio of 1:100 with respect to a truly vertical axis. For any drilled caisson at its top, the maximum deviation of the center shall be 3 inches (75 mm) from its project plan location.

625.3.2 - Caisson Diameters: Rock sockets shall be of a minimum diameter equal to the caisson diameter shown in the plans. Casings, extending upward from the rock surface, shall have a minimum inside diameter equal to the caisson diameter shown in the plans, but may be larger in diameter to expedite the Contractor's operations.

625.3.3 - Bottom Excavation: Excavation equipment and methods shall provide the completed caisson excavation with a flat bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of plus or minus 1¼ in. per 40 in. (30 mm per 1 000 mm) of diameter.

625.3.4 - Caisson Cutoff Elevations: For any drilled caisson the maximum permissible deviation from finished top of shaft elevation shall be minus 1 inch (25 mm) and plus 1 inch (25 mm).

625.3.5 - Reinforcement: After all concrete has been placed, the top of the reinforcing steel cage shall be no more than 4 inches (100 mm) above, and no more than 2 inches (50 mm) below, the plan elevation. The clearance to the reinforcing steel shall be 4 inches (100 mm), plus or minus 1 inch (25 mm). An absolute minimum clearance of 3 inches (75 mm) to the reinforcing steel is strictly required.

625.4 – MATERIALS:

625.4.1 - Concrete: Concrete for the drilled caissons shall be Class "B" (modified) and shall conform to the requirements of Section 601 of the Standard Specifications. The design 28-day compressive strength shall be not less than

4500 psi (31 Mpa) unless shown otherwise in the plans. The Contractor will prepare a mix design to attain this strength, retaining the basic characteristics of Class "B" concrete. Slump for dry placement will be 7 inches (175 mm) plus-or-minus 1 inch (25 mm). Unless otherwise specified in the plans, the cement shall be Type I.

For placement of caisson concrete by tremie or pumping, the cement content shall be increased to 8 bags per cubic yard (435 kg/m³), the slump shall be 8 inches (200 mm) plus-or-minus 1 inch (25 mm) and shall maintain a slump in excess of 4 inches (100 mm) throughout the concrete placement, and the maximum aggregate size shall be 1 inch (25 mm).

625.4.2 - Reinforcing Steel: Reinforcing steel for main vertical bars and ties shall conform to Section 709.1, deformed type, grade 60 (400). Reinforcing steel for use as spirals shall conform to Section 709.1, plain type, grade 60 (400).

625.4.3 - Casing: Metal casing shall be used whenever required to prevent caving of the soil material or to exclude ground water. Casing shall be metal, of unit or sectional construction, be strong enough to withstand handling stresses, withstand the pressures of concrete and of the surrounding earth and ground water, and prevent seepage of water. Also, the casing used shall be selected by the Contractor to control dimensions and alignment of excavations within tolerances, to seal the casing into impervious materials, and to execute all other construction operations.

Casing pipe shall conform to ASTM A 252/A 252M, Grade 2, for either temporary or permanent application.

Any required casing splices shall be welded in accordance with Section 625.2.3 e) of this specification with no interior splice plates, producing true and straight casing. All welding shall be in accordance with ANSI/AWS D1.1.

Permanent casing is required in all caissons where noted on the plans. All temporary casing shall be removed during placement of concrete unless otherwise noted on the plans. Should the Contractor be unable to remove the temporary casing, the Contractor shall pressure grout the annular space between the casing and soil. Materials and methods for grouting operation shall be submitted to the Engineer for approval for the grouting operation at no additional cost to the Division.

625.4.4 – CSL Testing Tubes: Tubes required for CSL Tests shall be ASTM A53, Grade B, nominal 2 inch (50 mm) diameter. Hydrostatic test requirements are waived. Threaded Couplings shall be used per ASTM A 865.

625.5 – CONSTRUCTION:

625.5.1 - General: The following sequence describes a generalized construction method that is expected to be appropriate for the installation of the drilled caissons. Deviations will be permitted with the Engineer's approval.

625.5.1

a) Excavate to top of shaft elevation.

b) Drilling of a "Preinstallation Core Hole" prior to drilling of caisson hole. The drilling and sampling of the preinstallation core holes shall be done by use of double tube core barrels. Additional preinstallation core holes in other locations may be required where directed by the Engineer. Such additional core holes shall be paid for at the contract unit bid price. The preinstallation core hole will be drilled at the bottom of the rock socket, downward a distance equal to the caisson diameter below the expected bottom of rock socket. Its purpose is to assure that the rock just below the socket is sound and able to carry the loads that will be imposed on it.
A preinstallation core hole is a 2 inches (50 mm) nominal diameter hole, with coring, where the quality of the rock core and the rate of drilling are used to determine if there is satisfactory rock of sufficient type and thickness, and to locate the presence of open joints, voids, soft rock or other deleterious material. Logs of the core hole shall be provided to the Engineer within 24 hours of completion of coring. All cores shall be maintained by the Contractor until completion of the project and shall then become the property of the Engineer.

c) Drilling of cased hole through the soil overburden down to top of competent rock. Sealing bottom of casing if necessary to prevent entry of ground water.

d) Drilling of rock socket to the minimum diameter shown in the plans and to a depth shown on the drawings or otherwise directed by the Engineer.

e) Cleaning of the drilled hole, particularly the rock socket and the inside face of the casing; inspection of the hole and approval for placement of the caisson material.

f) Placement of the pre-assembled cage of reinforcing steel and securing it in place against movement during concreting and during casing withdrawal. It also must be secured in such a way that the minimum clear cover over the bars is maintained. Placement of tubes as required for CSL testing.

g) Placement of concrete in either dry or wet conditions. In the case of dry conditions, concrete placement shall be by the free-fall method with the concrete carefully directed down the center of the caisson without striking the casing, the reinforcing steel, the CSL tubes or the sides of the rock socket. In the case of wet conditions, concrete placement shall be by tremie or pumping with the mix adjusted

accordingly. If the temporary casing is to be removed it shall be withdrawn carefully and slowly so as not to leave any voids in the concrete and so as not to dislocate any reinforcing steel. Any concrete not meeting this specification's slump requirements shall be rejected.

h) For any parts of any caisson that extend above either the existing or permanent grade, that portion shall be placed by use of forms of the diameters shown in the plans. Curing, stripping, and finishing shall be the same as for other structural concrete. Casing may be used as forms.

i) Turning the site over to the Engineer for CSL testing if required. Cooperation with the Engineer in the conduct of the testing, as specified herein. Corrective measures for any unacceptable caissons. Removal of water from the CSL tubes and filling with an approved grout. All core holes must be filled with an approved grout.

625.5.2 - Excavation:

625.5.2.1 - Scope: All excavation of the foundations in which drilled caissons are to be constructed shall be completed down to the bottom of the footing before caisson construction begins, unless otherwise authorized by the Engineer. The Contractor shall drill one core hole at each caisson location. The Contractor shall perform all excavations required for the caissons and the rock sockets, through whatever materials are encountered, to the dimensions shown in the plans, or required by the site conditions, or directed by the Engineer. The Contractor shall make each caisson excavation available to the Engineer for inspection, providing tools, equipment, and safety measures as hereinafter specified. Upon direction of the Engineer, the Contractor will drill preinstallation core holes. Based on preinstallation core hole information or on general inspection of the rock socket, the Contractor shall drill the rock socket deeper if directed by the Engineer.

625.5.2.2 - Excavation through Overburden: Unless otherwise shown in the plans, drilled caisson excavations in the overburden shall be vertical bored holes extending from the ground surface down to the surface of competent rock. Temporary or permanent casings will be required down to the competent rock surface and shall be seated in rock in a manner that prevents caving and prevents the entry of ground water. In the event of a groundwater condition, appropriate measures shall be taken subject to the Engineer's approval. Such measures may include pumping from within the excavation, external dewatering, or excavation through a slurry-filled hole until the casing can be seated and sealed. In cases in which the water is difficult to control, the Engineer may permit wet excavation which could require later inspection by diving methods and would require later

placement of concrete by underwater methods.

625.5.2.3 - Excavation in Rock: Rock sockets shall be excavated to the dimensions and depths shown in the plans, forming a flat bearing area at the bottom of the socket. Each socket shall be excavated into continuous rock for the indicated length, by use of methods subject to the Engineer's approval. Blasting methods will not be permitted.

Upon completion of each rock socket excavation, the Engineer may (1) accept the socket, or (2) order deeper excavation based upon preinstallation core hole data or general inspection of the socket. The adequacy of each socket will depend on the soundness of its bottom surface and on the soundness of its underlying layers. The Contractor shall drill required preinstallation core holes as directed and shall excavate sockets to the depth directed by the Engineer.

Contractor is cautioned not to over-drill the rock sockets. Unauthorized over-drilling will be at the Contractor' s expense. In the case where over-drilling would bring the caisson base too close to a coal seam or other weak layer, then drilling must be extended through such weak layer, at the Contractor' s expense, to a satisfactory deeper bearing level as determined by the Engineer.

No portion of the rock socket shall be exposed to drilling fluid or groundwater for more than 96 hours. Any portion of the rock socket exposed to drilling fluid or water for more than 96 hours, and any portion of the rock socket which, in the opinion of the Engineer, has deteriorated due to exposure to air or water, shall be reamed with an approved grooving tool to a depth of not less than ¼ in. (6 mm), or as directed by the Engineer. Reaming of the socket, if necessary, is considered incidental to the cost of drilling the rock socket, and no separate payment will be made for this work.

625.5.2.4 - Providing for Socket Inspection: Upon completion of the excavation of each rock socket, and upon thorough cleaning of the socket, the Contractor shall make the socket available to the Engineer for inspection. The Contractor shall provide suitable access for inspection, electric lighting, devices for checking dimensions, alignment and plumbness, ventilation equipment, the protective cage, radio communication, and auxiliary safety line. The air in the caisson shall be tested for noxious and/or explosive gases prior to and during entry of inspection personnel, to assure a safe working environment.

625.5.2.5 - Disposal of Materials: Disposal of excavated materials shall be accomplished under the general provisions of Section 207.6 of the Standard Specifications.

625.5.2.6 - River Area: Drilled caisson construction in the river shall employ whatever special methods the Contractor finds necessary for access and for accomplishing the work. These methods may include cofferdams, temporary sand islands, or other suitable measures. The Contractor will be responsible for conforming to all regulatory and environmental requirements related to the river, and for obtaining any permits that are required by his river operations.

625.5.2.7 - Safety Measures: Safety of all persons is to be considered an objective of the utmost importance on this project. Therefore, the Contractor will take whatever measures are necessary to protect his own personnel, his subcontractors' personnel, the Engineer or other agents of the state, regulatory personnel, and others including the general public. The following list is presented as representative of issues that the Contractor must address. It is not intended as all-inclusive and does not relieve the Contractor of conforming to other regulations, laws, requirements, or other measures reasonably required for safe excavating operations. The Contractor shall develop a safety plan in accordance with these requirements and provide this plan to the Engineer for his review.

a) Any required equipment within an excavation shall be operated by air or electricity. The use of gasoline-driven engines or diesel engines within an excavation will not be permitted. All lighting shall be electric and precautions shall be taken in regard to potential short circuits of electric current within ground water.

b) The Contractor will take precautions to assure that no explosive or noxious gases are present. Fresh air shall be supplied into the excavation and foul air shall be removed whenever any personnel are present in the hole.

c) A safety harness or chair lift, with separate safety line, protective cage, and two-way radio communication shall be used for any entry into an excavation.

d) No open excavation shall be left unattended. During non-working hours excavations shall be protected by the use of solid, safe covers that are firmly fastened in place.

625.5.3 - Reinforcing Steel Installation: Prior to installation of reinforcing steel, the steel cage shall be checked and cleaned of any materials that would tend to prevent bonding. The excavated hole shall also be checked and any remaining or newly deposited debris shall be removed. Immediately upon the Engineer's approval of the condition of the cage and his acceptance of the socket, and just prior to placement of concrete, the fully assembled cage of reinforcing steel shall be installed into the excavation.

The cage will consist of longitudinal (vertical) bars, spiral or tie bars, cage stiffener bars as required, spacing devices, and any other appurtenances required to maintain alignment, shape, and clearances. Cages shall include steel tubes in shafts where CSL testing is to occur. Each cage shall be placed in one unit by lowering into the hole in a manner that will prevent distortion. Concrete spacers or other approved noncorrosive spacing devices shall be used at sufficient intervals (near the bottom and at intervals not exceeding 10 ft (3 000 mm) along the caisson) to ensure concentric spacing for the entire cage length. The minimum

number of centering devices at each level shall be three. All steel centering devices shall be epoxy coated. The cage shall be supported from the top by use of a ground surface frame or other positive means. Setting the cage on the socket bottom without support will not be permitted.

All intersections of drilled caisson reinforcing steel shall be tied with cross or "figure 8" ties. The reinforcing steel in the caisson shall be 100% tied and supported so that the reinforcing steel will remain within allowable tolerances for position. Unless otherwise shown in the plans, splicing shall be by mechanical connectors or couplers which develop at least 125% of yield strength of the reinforcing bar. No more than 50% of the longitudinal reinforcing shall be spliced within 60 bar diameters of any lapped splice location or within 2 ft (600 mm) of any mechanical splice or coupler location. Cage stiffener bars shall be used as required to provide a reinforcement cage of sufficient rigidity to prevent racking, permanent deformations, etc. during installation. If the concrete is to be placed by the free-fall method, these bars must first be removed.

In the event that the caisson has been excavated below the anticipated tip elevation, the reinforcing cage may be extended at the tip (low) end by lap splices, mechanical connectors, or welded splices in conformance with the Standard Specifications. In this instance, splices need not be staggered and 100% of the reinforcing bars may be spliced at a given location. Lap splice lengths shall be as shown in the plans or approved by the Engineer.

Prior to placing the reinforcement cage, the Contractor shall demonstrate to the satisfaction of the Engineer that the fabrication and handling methods to be used will result in a reinforcing cage placed in the proper position, with the proper clearances, and without permanent bending or racking of the reinforcement cage.

The elevation of the top of the steel cage shall be checked before and after the concrete is placed. If the rebar cage is not maintained within the specified tolerances, corrections shall be made by the Contractor to the satisfaction of the Engineer. No additional caissons shall be constructed until the Contractor has modified his rebar cage support system in a manner satisfactory to the Engineer.

625.5.4 - Placement of Concrete: Prior to concrete placement, the Contractor shall make all necessary arrangements to assure the uninterrupted delivery of concrete so that there will not be any cold joints in the caissons. Placement of concrete shall generally conform to the applicable portions of Section 601.10 of the Standard Specifications. The rate of placement of concrete, as related to the height of fresh concrete at any time, will be subject to the Engineer's approval. The placement method will be developed by the Contractor, taking account of set time, hydraulic pressures and casing removal.

The placement of concrete in **dry conditions** shall be by a free-fall method. The height of free fall is not limited, but segregation of the concrete is not permitted. In order to qualify as a dry condition the caisson excavation must meet two requirements. The first requirement is the infiltration rate shall not exceed 3 in. (75 mm) of depth per hour as measured in the bottom 18 inches (450 mm) of the rock socket. The second requirement is that at the time of concrete placement the depth of water in the bottom of the rock socket shall not

exceed 2 in. (50 mm). The dry concrete placement method may be used only when the sides and the bottom of the caisson excavation remain stable without detrimental caving, sloughing or swelling, and water can be satisfactorily removed prior to inspection and prior to placing concrete.

In a case where the Engineer determines that dry conditions cannot be attained, he will require placement by the wet placement method shown in the approved Installation Plan. The casing shall be filled with clean water to an elevation not less than 4 feet (1 200 mm) above the water elevation outside the casing, to provide a positive water pressure inside the casing. Concrete will then be placed by conventional tremie or pumping methods. Tremie or pump placement methods shall not utilize aluminum parts which would be in contact with the concrete.

Tremies used to place concrete shall consist of a tube of sufficient length, weight, and diameter to discharge concrete at the caisson base elevation. The tremie inside diameter shall not be less than 10 inches (250 mm). The inside and outside surfaces of the tremie shall be clean and smooth to permit both flow of concrete and unimpeded withdrawal during concreting. The wall thickness of the tremie shall be adequate to prevent crimping or sharp bends which restrict concrete placement.

The tremie used for concrete placement shall be watertight. Concrete placement shall not begin until the tremie is placed at the caisson base elevation. Valves, bottom plates, or plugs may be used only if concrete discharge starts within approximately 2 inches (50 mm) above the excavation bottom. Plugs shall either be removed from the excavation or be of a material approved by the Engineer which will not cause defects in the caisson if not removed.

The discharge end of the tremie shall be constructed to permit the free radial flow of concrete during placement operations. The tremie discharge end shall remain at or near the bottom of excavation as long as practicable during concrete placement. The tremie discharge end shall remain immersed as deep as practicable in the concrete, consistent with the Contractor's construction methods, and shall be immersed at least 10 ft (3 000 mm) in concrete at all times after starting the flow of concrete. The flow of the concrete shall be continuous. The concrete in the tremie shall be maintained at a positive pressure differential at all times to prevent water or slurry intrusion into the caisson concrete.

All pump lines shall have a minimum diameter of 5 inches (125 mm) and shall be constructed with watertight joints. Concrete placement shall not begin until the pump line discharge orifice is at the caisson base elevation. A plug or similar device shall be used to separate the concrete from the fluid in the hole until pumping begins. The plug shall either be removed from the excavation or be of a material approved by the Engineer which will not cause a defect in the caisson if the plug is not removed. The discharge orifice shall remain at least 10 ft (3000 mm) below the surface of the fluid concrete.

If at any time during the concrete pour, the tremie line orifice or the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the entire drilled caisson shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and

concrete, complete any necessary sidewall removal directed by the Engineer and repour the caisson. All costs of replacement of defective caissons shall be the responsibility of the Contractor and shall be at no cost to the Department.

After the concrete level has reached the required top elevation, it will be forced to overflow in the case of tremie or pump placement, leaving only fresh, uncontaminated concrete. In the case of placement by free fall (dry conditions), the concrete will be continued high enough to compensate for any settlement due to removal of casing.

The top 10 ft (3 000 mm) of each drilled caisson shall be vibrated except, when more than 10 ft (3 000 mm) is to be exposed above the ground line or the riverbed, then the entire exposed portion shall be vibrated. Exposed portions of each drilled caisson shall be cured in accordance with Section 601.12 of the Standard Specifications.

625.5.5 - Removal of Casing: Removal of the casing from a shaft may occur gradually as concrete is placed. In all cases, extraction of casing shall begin within one hour from the beginning of concrete placement in the cased portion of the shaft. Insofar as possible, casing extraction shall be done at a slow uniform rate by application of a steady vertical upward pull in the direction of the axis of the shaft. To facilitate extraction, tapping on the casing, exertion of temporary downward pressure, and slight rotation will be permitted, but care must be taken to avoid harmful impacts or disturbances to the fresh concrete. Vibration or rodding may not be used to break the casing loose for extraction.

If, during extraction of casing, upward movement of concrete and/or reinforcing steel occurs, the Engineer shall be notified immediately. If he considers the movement to be minor, he may permit the extraction of the casing to continue. If, however, the movement is deemed significant and indicative of squeezing of the surrounding soil thus resulting in a reduction of the caisson diameter, then he may order the casing to be left in place, or he may permit extraction to proceed and order a later non-destructive load test, or may order other procedures as appropriate at no additional cost to the Division.

For the upper portions of drilled caissons that will be exposed and visible, the casing may remain in place as a form until the concrete has attained a strength that enables it to stand alone without further deformation. Casing shall then be removed.

625.6 - INSPECTION OF SOCKETS:

625.6.1 - Depth of Rock Socket: Each rock socket shall be drilled to the shaft diameter shown in the plans unless otherwise directed by the Engineer based on subsurface conditions encountered.

The top elevation of competent rock must be confirmed as the socket drilling is started. The effective "top elevation" is based on observation of the boundary zone where broken or weathered rock becomes competent rock, and is also influenced by the presence of any shale or coal seams. Based on that elevation, and the information from the preinstallation core hole, the Engineer will

determine the final depth of socket and bottom elevation. The drilled rock socket will then be inspected per 625.5.2.3 and will either be accepted or drilled deeper as determined by the Engineer.

625.6.2 - Inspection Under Water: In a case where it is considered unfeasible to dewater a caisson, the Contractor shall provide drilled caisson logs and screenings to the Engineer for evaluation. If this material is not sufficient for a proper judgement, the Engineer will reserve the right to order an inspection by diving or other methods either through a separate specialty subcontractor or through the Contractor in which case compensation would be under Sections 104.3 and 109.4 of the Standard Specifications. Any time required for inspection under water will be considered incidental to the work and will not be cause for extra compensation related to a claim or extension of contract time.

625.7 - METHOD OF MEASUREMENT:

Drilled caissons and Rock Socket foundations will be measured by the linear foot (meter). Drilled Caissons are the portion from the finished top of each caisson to the top of competent rock. Rock Socket is the portion from the top of competent rock to the bottom of the caisson as shown in the plans or as directed by the Engineer. Each measured caisson is to be complete in place, accepted, and ready to function. "Top of caisson" is the top of concrete as shown in the plans. "Top of competent rock" is as tabulated in the drilled shaft schedules in the plans unless a difference of one 1 foot (300 mm) or more is found during drilling.

Drilled Caisson test hole will be measured in Lump Sum basis. Preinstallation core hole shall be measured by the linear foot (meter) based upon actual length drilled.

625.8 - BASIS OF PAYMENT:

The accepted quantities of drilled caisson foundations, measured as provided above, will be paid for at the contract unit price per linear foot (meter); complete in place including excavation, slurry if required, temporary or permanent metal casing, steel reinforcing, concrete, curing, and any required forming and finishing. No additional payment will be made for temporary casing that remains in place and pressure grouting due to the Contractor's inability to stabilize a drilled excavation, for the need to place concrete by tremie or pumping, for the need to use slurry for drilling, or for extra excavation and concrete that may be required due to drilling diameters larger than the minimum diameters specified. No additional payment will be made for methods employed to gain access to drilled caisson construction or for means required to provide a dry working environment within the drilled caissons. Tubes for CSL testing, other responsibilities related to testing and inspection assistance are incidental, with no separate payment being made.

Drilled caisson test holes will be paid for at the contract lump sum price for each such hole.

Preinstallation core hole will be paid for by the linear foot (meter).

625.9 - PAY ITEMS:

ITEM	DESCRIPTION	UNIT
625001-*	DRILLED CAISSONS "D" DIAMETER	LINEAR FOOT (METER)
625003-*	"D" ROCK SOCKET FOUNDATION	LUMP SUM
625004-* 625005-*	"D" DRILLED CAISSON TEST HOLE PREINSTALLATION CORE HOLE	LUMP SUM LINEAR FOOT (METER)

* Sequence number

D = Diameter of drilled caisson, in inches (millimeters)

SECTION 626
RETAINING WALL SYSTEMS

626.1 - DESCRIPTION:

This work shall consist of furnishing the design, wall construction plans, materials, and construction of cast-in-place reinforced concrete or Mechanically Stabilized Earth (MSE) walls in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown in the plans.

626.2 - GENERAL:

Unless specified otherwise in the contract documents the wall may be, at the Contractor's option, any one of the wall systems on the approved vendor list corresponding to the applicable pay Item. The approved Vendor Lists are available through the Materials Section of the Contract Administration Section.

The Contractor shall indicate which wall system is to be constructed by the bid alternative chosen in the proposal. No change of the wall system indicated in the bid proposal shall be permitted after the bid opening unless approved by the Engineer.

The wall design and detail plans for construction shall be submitted to the Engineer for approval. The time required for preparation and review of these submittals shall be charged to the allowable contract time. Delays caused by untimely submittals or insufficient data will not be considered justification for time extensions. No additional compensation will be made for any additional material, equipment, or other items found necessary to comply with the project specifications as a result of the Engineer's review. The proposed wall design shall be compatible with the Contractor's proposed method of construction, and shall be compatible with any method of construction shown in the plans. The Division does not assume nor warrant any wall system's compatibility with any particular construction methods.

626.3 - DESIGN CRITERIA:

626.3.1 - General: The size of all structural elements shall be determined such that the design load stresses do not exceed the allowable