SPECIAL PROVISION
SECTION 501
(DRILLED SHAFTS)

501.01 DESCRIPTION

This work shall consist of all labor, materials, equipment and services necessary to perform all operations to complete the drilled shaft installation in accordance with this specification, the special provisions and with the details and dimensions shown on the plans. Drilled shafts shall consist of reinforced concrete. The embedment length of the drilled shafts may be modified by the Contractor, pending results of borings taken as a part of this work and based upon the results of the load tests described below.

501.02 MATERIALS

The materials shall conform to the following:

1. All reinforcing steel shall conform to the Project Specifications except as modified and supplemented herein.
2. Concrete for all drilled shafts shall be in accordance with the Project Specifications except as modified and supplemented herein.
3. Steel for the permanent drilled shaft casings shall conform to ASTM A-252, Grade 2.
4. Steel for Crosshole Sonic Tubing – schedule 40 steel pipe.
5. Osterberg Load Cells as manufactured by LOADTEST, Inc.

501.03 QUALIFICATIONS AND SUBMITTALS

The Contractor performing the work described in this specification shall have installed drilled shafts of both the diameter and length similar to those shown on the plans for a minimum of three (3) years prior to the bid date for this project. At the time of bid, the Contractor shall submit both a list containing at least three (3) projects completed in the last three years on which the Contractor installed drilled shafts of a diameter and length similar to those shown on the plans, and a signed statement that the Contractor has inspected both the project site and all the subsurface information including any soil or rock samples made available in the contract documents. The list of projects shall contain names and phone numbers of owner's representatives who can verify the Contractors participation on those projects.

No later than 30 days prior to constructing drilled shafts, the Contractor shall submit an installation plan for review by the Resident. This plan shall provide information on the following:

1. Name and experience record of the drilled shaft superintendent in charge of drilled shaft operations for this project. Name and experience record of the Contractor's drilled shaft Geotechnical Inspector. Drilled Shaft construction and testing shall be inspected by the Contractor's Geotechnical Inspector, who shall be a qualified, geotechnical engineering inspector, experienced in shaft construction inspection.
2. List of proposed equipment to be used including cranes, drills, augers, baling buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casing, etc.
3. Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
4. Details of shaft excavation methods in soils and rock, including methods of removing any obstructions such as boulders, cobbles or old concrete footings.

5. When slurry is required, details of the methods to mix, circulate and desand slurry.
6. Details of methods to clean the shaft excavation and checking the cleanliness and soundness of the rock socket sidewalls and bearing surface.
7. Details of reinforcement placement including support and centralization methods.
8. Details of concrete placement including proposed operational procedures for free fall, tremie or pumping methods.
9. Details for Crosshole Sonic Testing and Osterberg Cell Load Tests

The Resident will evaluate the drilled shaft installation plan for conformance with the plans, specifications and special provisions. Within 14 days, the Resident will notify the Contractor of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given by the Resident shall be subject to trail in the field and shall not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the plans and specifications.

501.04 EXPLORATION DRILLING

To determine the character of the material in and directly below the bottom of the proposed excavation for the shafts, the Contractor shall take borings (soil samples or rock cores) where shown on the plans or as directed by the Resident. The soil samples shall be extracted with a split spoon sampler, or undisturbed sample tube. The rock cores shall be cut with an approved double or triple tube core barrel. Soil samples shall be extracted or rock cores cut to a minimum of 10 feet below the bottom of the drilled shaft excavation. The Resident may require the depth of coring to be extended up to a total depth of 20 feet. Rock core and standard penetration test samples shall be measured, visually identified and described on the boring log. The samples shall be placed in suitable containers, identified by shaft location, elevation, project number and delivered with the Contractors field log to the Resident within 24 hours after the exploration is completed. The Contractor will inspect the samples/cores and determine the final depth of required excavation based on his evaluation of the materials found in the borings and upon completion of the load test. Two copies of the typed final Contractor boring log shall be furnished to the Resident at the time the shaft excavation is completed and accepted.

501.05 CONSTRUCTION METHODS AND EQUIPMENT

The Contractor shall control his operations to prevent damage to existing structures and utilities. Preventive measures shall include, but are not limited to, selecting construction methods and procedures that will prevent caving of the shaft excavation, monitoring and controlling the vibrations from construction activities such as the driving of casing or sheeting, drilling of the shaft, or from blasting, if permitted.

The Contractor shall perform the excavations required for shafts and bell footings if shown on the plans, through whatever materials are encountered, to the dimensions and elevations shown in the plans or otherwise required by the specifications and special provisions. The Contractor's methods and equipment shall be suitable for the intended purpose and materials encountered. Permanent casing shall be used only at locations shown on the plans or when authorized by the Resident. Blasting shall only be permitted if specifically stated on the plans or authorized in writing by the Resident.

The Dry Construction Method shall be used only at sites where the groundwater level and soil conditions are suitable to permit construction of the shaft in a relatively dry excavation, and where the sides and bottom of the shaft may be visually inspected by the Resident prior to placing concrete. The dry method

consists of drilling the shaft excavation, removing accumulated water and loose material from the excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry excavation.

The dry construction method shall only be approved by the Resident when the trial shaft excavation demonstrates that: less than 12 inches of water accumulates above the base over a one hour period when no pumping is permitted; the sides and bottom of the hole remain stable without detrimental caving, sloughing or swelling over a four hour period immediately following completion of excavation; and any loose material and water can be satisfactorily removed prior to inspection and prior to concrete placement. The Contractor shall use the wet construction method or the casing construction method for shafts that do not meet the above requirements for the dry construction method.

Where drilled shafts are located in open water areas, exterior casings shall be extended from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. The exterior casing shall be installed in a manner that will produce a positive seal at the bottom of the casing so that no piping of water or other materials occurs into or from the shaft excavation.

The Casing Method shall be used either when shown on the plans or at sites where the dry or wet construction methods are inadequate to prevent hole caving or deformation of the hole.

Temporary casings should be provided to aid shaft alignment and position, to prevent sloughing of the top of the shaft excavation and to prevent excessive deformation around the hole unless the Contractor demonstrates to the satisfaction of the Resident that the casing is not required. The casing may be either placed in a predrilled hole or advanced through the ground by twisting, driving or vibration before being cleaned out. The casing shall be installed in a manner that will produce a positive seal at the bottom of the casing so that no piping of water or other materials occurs into or from the shaft excavation.

501.051 EXCAVATION AND DRILLING EQUIPMENT

The excavation and drilling equipment shall have adequate capacity including power, torque and down thrust to excavate a hole of both the diameter and to a depth of 20 percent beyond the depth indicated on the plans.

When the material encountered cannot be drilled using conventional earth augers with soil or rock teeth, drill buckets, and/or under reaming tools, the Contractor shall provide drilling equipment including but not limited to: rock core barrels, rock tools, air tools, blasting materials, and other equipment as necessary to construct the shaft excavation to the size and depth required. Approval of the Resident is required before excavation by blasting is permitted.

Side wall over reaming shall be required when the side wall of the hole is determined by the Contractor to have either softened due to excavation methods, swelled due to delays in concreting, or degraded because of slurry cake buildup. Over reaming thickness shall be a minimum of ½ inch and a maximum of 3 inches. Over reaming may be accomplished with a grooving tool, over reaming bucket or other approved equipment. The thickness and elevation of side wall over reaming shall be as directed by the Resident. The Contractor shall bear all costs associated with both side wall under reaming and additional shaft concrete placement.

501.052 EXCAVATIONS

Shaft excavations shall be made at locations and to the top of shaft elevations, estimated bottom shaft excavations, shaft geometry and dimensions shown in the contract documents. The Contractor shall extend the drilled shaft tip elevations when so indicated by the results of the load test and/or the Resident determines that the material encountered during excavation is unsuitable or differs from that anticipated in the design of the drilled shaft.

The Contractors Inspector shall maintain a construction method log during shaft excavation. The log shall contain information such as: the description and approximate top and bottom elevation of each soil or rock material, seepage of groundwater, and remarks.

Excavated materials which are removed from shaft excavations shall be disposed of by the Contractor in accordance with the applicable specifications for disposal of excavated materials.

The Contractor shall not permit workmen to enter the shaft excavation for any reason unless: both a suitable casing has been installed and the water level has been lowered and stabilized below the level to be occupied, and adequate safety equipment and procedures have been provided to workmen entering the excavation.

The Contractor shall perform the necessary excavation for the drilled shaft under drilled shaft excavation earth and drilled shaft rock excavation items. No separate payment will be made for either excavation of materials or different densities or employment of special tools and procedures necessary to accomplish the excavation in an acceptable fashion.

When shown in the plans, bells shall be excavated to form the height and bearing area of the size and shape shown. The bell shall be excavated by mechanical methods. Any drilled shaft concrete over the theoretical amount required to fill any excavations for the bells and shafts dimensioned on the plans shall be furnished at the Contractor's expense.

On projects with cofferdams, the Contractor shall provide a qualified diver to insect the cofferdam conditions when a seal is required for construction. Prior to concrete seal placement the diver shall inspect the cofferdam interior periphery including each sheeting indentation and around each drilled shaft to insure no layers of mud or undesirable material remain above the planned bottom elevation of seal.

501.053 DRILLED SHAFT EARTH EXCAVATION.

Earth excavation is excavation accomplished with conventional tools such as augers fitted with either soil or rock teeth, drilling buckets, and over reaming (aside) buckets attached to drilling equipment of the size, power, torque, and down thrust (crowd) approved for use by the Resident, after successful construction of a trial drilled shaft.

501.054 DRILLED SHAFT ROCK SOCKET EXCAVATION

After removal of the overburden from within the casing, the casing shall be further advanced into bedrock, where shown on the plans or directed by the Engineer, if necessary to achieve sealing against the entry of overburden. Then the excavation shall continue into rock below the casing as an uncased rock socket of the length and diameter indicated. The inside surface of the casing shall be cleaned free of extraneous material prior to placing the concrete. The rock socket shall not be constructed until the casing is sealed in the rock and until the casing has been checked for plumbness. A method of excavation the rock socket that is capable of providing a cylindrical opening of the specific diameter and to the full-depth as shown of the plans or to the depth directed by the Engineer shall be used. Excavation shall not

be along the edge of the drilled shaft, and overbreakage of the rock surface shall be avoided, so as to not to destroy the seal at the bottom of the steel casing. the methods of excavating the rock socket shall be controlled to prevent undercutting of the steel casing.

Rock socket excavation is excavation in rock and requires rock specific tools and/or procedures to accomplish hole advancement. All excavation, performed below the depth where rock excavation is authorized shall be considered incidental regardless of the density or character of materials encountered.

501.055 OBSTRUCTIONS

Surface and subsurface obstructions at drilled shaft locations shall be removed by the Contractor. Such obstructions may include man-made materials such as old concrete foundations and natural materials such as boulders. Special procedures and/or tools shall be employed by the contractor after the hold cannot be advanced using conventional augers fitted with soil or rock teeth, drilling buckets and/or under reaming (aside) tools. Such special procedures/tools may include but are not limited to: chisels, boulder breakers, core barrels, air tools, hand excavation, temporary casing, and increasing the hole diameter. Blasting shall not be permitted unless specifically approved in writing by the Resident.

501.056 LOST TOOLS

Drilling tools which are lost in the excavation shall not be considered obstructions and shall be promptly removed by the Contractor without compensation. All costs due to lost tool removal shall be borne by the Contractor including but not limited to, costs associated with hole degradation due to removal operations or the time the hole remains open.

501.057 CASING

Casing material (temporary or permanent) shall conform to Subsection 711.01. Casings shall be steel, smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses and the pressure of both concrete and the surrounding earth materials. The outside diameter of casing shall not be less than the specified size of shaft. No extra compensation will be allowed for concrete required to fill an oversized casing or oversized excavation. All casings, except permanent casing, shall be removed from shaft excavations. Any length of permanent casing installed below the shaft cutoff elevation, shall remain in place.

When the shaft extends above ground or through a body of water, the portion exposed above ground or through a body of water may be formed with removable casing except when permanent casing is specified on the plans or by the Resident. Removable casing shall be stripped from the shaft in a manner that will not damage the concrete. Casings can be removed when the concrete has attained sufficient strength provided: curing of the concrete is continued for the full 72 hour period in accordance with specifications; the shaft concrete is not exposed to salt water or moving water for 7 days; and the concrete reaches a compressive strength of at least 2500 psi as determined from concrete cylinder breaks.

The procedures and methods to install the steel casings shall not subject the casing to stresses in excess of 50 percent over the basic design allowable for the type of steel specified. After installation, each casing shall be inspected using methods proposed in the installation plan above. Any casing that shows bends or kinks or other deformations that would impair the strength or efficiency of the completed shaft shall be replaced or repaired in a manner satisfactory to the Resident. Repairing or replacing any such damaged casing, when ordered to do so by the Resident, will be at no additional expense.

501.058 TEMPORARY CASING

All subsurface casing shall be considered temporary unless specifically shown as permanent casing in the contract documents. The Contractor shall be required to remove temporary casing before completion of concreting the drilled shaft. Telescoping, predrilling with slurry, and/or over reaming to beyond the outside diameter of the casing may be required to install casing.

If the Contractor elects to remove a casing and substitute a longer or larger diameter casing through caving soils, the excavation shall be either stabilized with slurry or backfilled before the new casing is installed. Other methods, as approved by the Resident, may be used to control the stability of the excavation and protect the integrity of the foundation soils.

Before the casing is withdrawn, the level of fresh concrete in the casing shall be a minimum of five feet above either the hydrostatic water level or the level of drilling fluid whichever is higher. As the casing is withdrawn, care shall be exercised to maintain an adequate level of concrete within the casing so that fluid trapped behind the casing is displaced upward and discharged at the ground surface without contaminating or displacing the shaft concrete.

Temporary casings which become bound or fouled during shaft construction and cannot be practically removed shall constitute a defect in the drilled shaft. The Contractor shall be responsible to improve such defective shafts to the satisfaction of the Resident. Such improvement may consist of, but is not limited to, removing the shaft concrete and extending the shaft deeper to compensate for loss of frictional capacity in the cased zone, providing straddle shafts to compensate for capacity loss, or providing a replacement shaft. All corrective measures including redesign of footings caused by defective shafts shall be done to the satisfaction of the Resident, by the Contractor ,without either compensation or an extension of the completion date of the project. In addition, no compensation will be paid for casing remaining in place.

501.059 PERMANENT CASING

Permanent casing shall be used wherever shown in the contract documents. The casing shall be continuous between the top and bottom elevations prescribed in the plans. After installation is complete, the permanent casing shall be cut off at the prescribed elevation and the shaft completed by installing necessary reinforcing steel and concrete in the casing.

In cases where special temporary casings are shown on the plans or authorized in writing by the Resident, the Contractor shall maintain both alignment of the temporary outer casing with the permanent inner casing and a positive watertight seal between the two casings during excavation and concreting operations.

Permanent casings shall be maintained in intimate contact with the surrounding soil after installation to preserve lateral load carrying capacity assumed for design. This requirement precludes placement of permanent casing in an oversized hole, unless post grouting of the exterior annular space is performed to create the intimate contact between the casing and the surrounding soil.

501.0591 SLURRY

Mineral or polymer slurries shall be employed when slurry is used in the drilling process unless other drilling fluids are approved in writing by the Resident. Mineral slurry shall have both a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated

material to a suitable screening system. The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement. During construction, the level of the slurry shall be maintained at a height sufficient to prevent caving of the hole. In the event of a sudden significant loss of slurry to the hole, the construction of that foundation shall be stopped until either methods to stop slurry loss or an alternate construction procedure has been approved by the Resident.

Mineral slurry shall be premixed thoroughly with clean fresh water and adequate time (as prescribed by the mineral manufacturer) allotted for hydration prior to introduction into the shaft excavation. Slurry tanks, of adequate capacity will be required for slurry circulation, storage and treatment. No excavated slurry pits will be allowed in lieu of slurry tanks without the written permission of the Resident.

Desanding equipment shall be provided by the Contractor as necessary to control slurry sand content to less than 4 percent by volume at any point in the borehole. Desanding will not be required for setting temporary casing, sign post, or lighting mast foundations unless shown in the plans or special provisions. The Contractor shall take all steps necessary to prevent the slurry from "setting up" in the shaft. Such methods may include but are not limited to; agitation, circulation and/or adjusting the properties of the slurry. Disposal of all slurry shall be done off-site in suitable areas by the Contractor.

Control tests using suitable apparatus shall be carried out on the mineral slurry by the contractor to determine density, viscosity and pH. An acceptable range of values for those physical properties is shown in the following table:

MINERAL SLURRY
(Sodium Bentonite or Attapulgite in Fresh Water)

Acceptable Range of Values

Property (Units)	At Time of Slurry Introduction	In Hole at Time of Concreting	Test Method
Density (pcf) Balance	64.3** - 69.1**	64.3** - 75.0**	Density
Viscosity (seconds/quart)	28 - 45	28 - 45	Marsh Cone
pH	8 - 11	8 - 11	pH paper pH meter

** Increase by 2 pcf in salt water

Notes: a. Tests should be performed when the slurry temperature is above 40 degrees Fahrenheit.

b: If desanding is required; sand content shall not exceed 4 percent (by volume) at any point in the bore hole as determined by the American Petroleum Institute sand content test.

Tests to determine density, viscosity and pH value shall be done during the shaft excavation to establish a consistent working pattern. A minimum of four sets of tests shall be made during the first 8 hours of slurry use. When the results show consistent behavior the testing frequency may be decreased to one set every four hours of slurry use.

The Contractor shall insure that heavily contaminated slurry suspension, which could impair the free flow of concrete, has not accumulated in the bottom of the shaft. Prior to placing concrete in any shaft excavation, the Contractor shall take slurry samples using a sampling tool similar to that shown in Figure 1. Slurry samples shall be extracted from the base of the shaft and at intervals not exceeding 10 feet up the shaft, until two consecutive samples produce acceptable values for density, viscosity, pH, and sand content.

When any slurry samples are found to be unacceptable, the Contractor shall take whatever action is necessary to bring the mineral slurry within specification requirements. Concrete shall not be poured until resampling and testing results produce acceptable values.

Reports of all tests required above signed by an authorized representative of the Contractor, shall be furnished to the Resident on completion of each drilled shaft.

During construction, the level of mineral slurry in the shaft excavation shall be maintained at a level not less than 4 feet above the highest expected piezometric pressure head along the depth of the shaft. If at any time the slurry construction method fails, in the opinion of the Resident, to produce the desired final results, then the Contractor shall both discontinue this method and propose an alternate method for approval of the Resident.

If the Contractor proposes to use a blended mineral-polymer slurry, the Contractor shall submit a detailed report specific to the project prepared and signed by a qualified slurry consultant describing the slurry materials, the mix proportions, mixing methods and quality control methods.

501.06 EXCAVATION INSPECTION

The drilled shaft installation shall be inspected by the Contractor's geotechnical inspector, who shall be a qualified geotechnical engineering inspector, experienced in drilled shaft construction inspection. The Contractor's Inspector shall keep a daily construction record, including the Inspection Forms and Reporting Forms.

The Contractor shall provide access and equipment for checking the dimensions and alignment of each permanent shaft excavation and for visual inspection of the rock socket. Final shaft depths shall be measured with a suitable weighted tape or other approved methods after final cleaning, unless otherwise stated in the plans. A minimum of 50 percent of the base of each shaft shall have less than ½ inch of sediment at the time of placement of the concrete. The maximum depth of sediment or any debris at any place on the base of the shaft shall not exceed 1.5 inch. Shaft cleanliness will be determined by the Resident, by visual inspection for dry shafts or other methods deemed appropriate to the Resident for wet shafts. In addition for dry excavations the maximum depth of water shall not exceed 3 inches prior to concrete pour.

Facilities shall be provided and maintained for the Resident to inspect each drilled shaft immediately prior to placing reinforcing steel, and again, if requested by the Resident, prior to depositing the drilled shaft concrete. Concrete placement shall not begin until the Resident's approval has been obtained. Prior to the placement of underwater concrete, a miniature shaft inspection device (Mini-SID) shall be provided and used to provide a comprehensive underwater inspection of the prepared rock socket and the steel casing. The Mini-SID inspections shall be recorded on videotape by the Contractor. The date, shaft number, and camera position shall be recorded on the videotape. Copies of all data (written, electronic, videotape, digital files, etc) obtained during inspections shall be submitted to the Department and become property of the Department.

501.07 CONSTRUCTION TOLERANCES

The following construction tolerances apply to drilled shafts unless otherwise stated in the contract documents:

1. The drilled shaft shall be within 3 inches of plan position in the horizontal plane at the plan elevation for the top of the shaft.

2. The vertical alignment of a vertical shaft excavation shall not vary from the plan alignment by more than ¼ inch foot of depth. The alignment of a battered shaft excavation shall not vary by more than ½ inch per foot of depth from the prescribed batter.

3. After all the concrete is placed, the top of the reinforcing steel cage shall be more than 6 inches above and no more than 3 inches below plan position.

4. All casing diameters shown on the plans refer to O.D. (outside diameter) dimensions. The dimensions of casings are subject to American Pipe Institute tolerances applicable to regular steel pipe. When approved, the Contractor may elect to provide a casing larger in diameter than shown on the plans.

5. Bells shall be excavated to the plan bearing area and height shown on the plans as a minimum. The actual diameter of the bells shall not exceed 3 times the specified shaft diameter. All other plan dimensions shown for the bells may be varied, when approved, to accommodate the Contractor's equipment.

6. The tip elevation of the shaft shall have a tolerance of plus 1 inch or minus 3 inches from the plan tip elevation of the shaft.

7. Excavation equipment and methods shall be designed to that the completed shaft excavation will have a planar bottom. The cutting edges of excavation equipment shall be normal to the vertical axis of the equipment within a tolerance of +/- 3/8 inch per foot of diameter.

Drilled shaft excavations and completed shafts not constructed within the required tolerances are unacceptable. The Contractor shall be responsible for correcting all unacceptable shaft excavations and completed shafts to the satisfaction of the Resident. Materials and work necessary, including engineering analysis and redesign to complete corrections for out of tolerance drilled shaft excavations shall be furnished without either cost to the Department or an extension of the completion dates of the project.

501.08 REINFORCING STEEL CAGE MATERIALS, CONSTRUCTION AND PLACEMENT

Reinforcing steel for drilled shafts shall be epoxy coated and conform to Subsection 709.01.

The reinforcing steel cage, consisting of longitudinal bars, ties, cage stiffener bars, spacers, centralizers, and other necessary appurtenances, shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted, and prior to concrete placement.

The clear spacing between bars of the rebar cage should be at least five times the size of the maximum coarse aggregate. Hooks at the top of the rebar cage should not be bent outward if there is any chance

that temporary casing will be used/ Interior hooks must be designed to permit adequate clearance for a concrete tremie pipe with a minimum 12 inch diameter.

The assembled rebar cage outside diameter must be at least 6 inches smaller than the drilled hole diameter. This clear space is necessary both to permit free flow of concrete up the annular space between the cage and the hole perimeter and to provide adequate concrete cover over the reinforcing cage.

Shafts which require a large amount of reinforcing steel should use bundled longitudinal bars to maintain the minimum clear spacing requirements.

The reinforcing steel in the shaft shall be tied and supported so that the reinforcing steel will remain within allowable tolerances given above. Concrete spacers or other approved non-corrosive spacing devices shall be used at sufficient intervals (near the bottom and at intervals not exceeding 10 feet up the shaft) to insure concentric spacing for the entire cage length. Spacers shall constructed of approved material equal in quality and durability to the concrete specified for the shaft. The spacers shall be of adequate dimension to insure a minimum 3 inch annular space between the outside of the reinforcing cage and the side of the excavated hole. Approved cylindrical concrete feet (bottom supports shall be provided to insure that the bottom of the cage is maintained the proper distance above the base.

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 Resident. No additional shafts shall be constructed until the Contractor has modified his rebar cage support in a manner satisfactory to the Resident.

If the bottom of the constructed shaft elevation is lower than the bottom of the shaft elevation in the plans, a minimum of one half of the longitudinal bars required in the upper portion of the shaft shall be extended the additional length. Tie bars shall be continued for the extra depth and the stiffener bars shall be extended to the final depth. These bars may be lap spliced, or unspliced bars of the proper length may be used. Welding to the reinforcing steel will not be permitted unless specifically shown in either the plans or special provisions.

501.081 CONCRETE: MATERIAL AND PLACEMENT

Portland cement concrete shall meet the requirements specified in the Project Specifications and Section 502 of the Standard Specifications. The use of a water-reducing admixture is permissible to provide a workable mix that will surround the reinforcement bars without the use of vibrators. Actual slump shall be 7 inches maximum, with water-reducing admixture. Concrete placement shall be performed in accordance with Section 502 of the Standard Specifications on concrete materials and with the requirements herein.

Concrete shall be placed as soon as possible after reinforcing steel placement. Concrete placement shall be continuous from the bottom to the top elevation of the shaft. Concrete placement shall continue after the shaft excavation is full until good quality concrete is evident at the top of shaft. Concrete shall be placed either by free fall or through a tremie or concrete pump. The free fall placement shall only be permitted in dry holes. The maximum height of free fall placement shall not exceed 25 feet. Concrete placed by free fall shall fall directly to the base without contacting either the rebar cage or hole side wall. Drop chutes may be used to direct concrete to the base during free fall placement.

The elapsed time from the beginning of concrete placement in the shaft to the completion of the placement shall not exceed 2 hours. Admixtures such as water reducers, plasticizers, and retarders shall

not be used in the concrete mix unless permitted in the contract documents. All admixtures, when approved for use,, shall be adjusted for the conditions encountered on the job so the concrete remains in a workable plastic state throughout the 2 hour placement limit. Prior to concrete placement the Contractor shall provide test results of both a trial mix and a slump loss test conducted by an approved testing laboratory using approved methods to demonstrate that the concrete meets this 2 hour requirement. The Contractor may request a longer placement time provided he supplies a concrete mix that will maintain a slump of 4 inches or greater over the longer placement time as demonstrated by trial mix and slump loss tests. The trial mix and slump loss tests shall be conducted using concrete and ambient temperatures appropriate for site conditions.

501.082 TREMIES

Tremies may be used for concrete placement in either wet or dry holes. Tremies used to place concrete shall consist of a tube of sufficient length, weight, and diameter to discharge concrete at the shaft base elevation. The tremie shall not contain aluminum parts which will have contact with the concrete. The tremie inside diameter shall be at least 6 times the maximum size of aggregate used in the concrete mix but shall not be less than 10 inches. 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 shear bends which restrict concrete pavement.

The tremie used for wet excavation concrete placement shall be watertight. Underwater placement shall not begin until the tremie is placed to the shaft base elevation. Valves, bottom plates or plugs may be used only if concrete discharge can begin within one tremie diameter of the base. Plugs shall either be removed from the excavation or be of material, approved by the Resident, which will not cause a defect if the shaft is 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 be immersed at least 5 feet 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 shaft concrete.

If at any time during the concrete pour, the tremie line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete any necessary side wall removal directed by the Resident and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.

501.083 PUMPED CONCRETE

Concrete pumps and lines may be used for concrete placement in either wet or dry excavations. All pump lines shall have a minimum 4 inches diameter and be constructed with watertight joints. Concrete placement shall not begin until the pump line discharge orifice is at the shaft base elevation.

For wet excavations, 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 Resident, which will not cause a defect in the shaft if not removed.

The discharge orifice shall remain at least 5 feet below the surface of the fluid concrete. When lifting the pump line during concreting, the Contractor shall temporarily reduce the line pressure until the orifice has been repositioned at a higher level in the excavation.

If at any time during the concrete pour, the pump line orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the shaft shall be considered defective. In such case, the Contractor shall remove the reinforcing cage and concrete, complete any necessary side wall removal directed by the Resident, and repour the shaft. All costs of replacement of defective shafts shall be the responsibility of the Contractor.

501.084 DROP CHUTES

Drop chutes may be used to direct placement of free fall concrete in excavations where the maximum depth of water does not exceed 3 inches.

Free fall is not method permitted in wet excavations. Drop chutes shall consist of a smooth tube of either one piece construction or sections which can be added and removed.. Concrete may be placed through either a hopper at the top of the tube or side openings as the drop chute is retrieved during concrete placement. The drop chute is less than 25 feet at all times. If concrete placement causes the shaft excavation to cave or slough, or if the concrete strikes the rebar cage or side wall, the Contractor shall reduce the height of free fall and/or reduce the rate of concrete flow into the excavation. If placement cannot be satisfactorily accomplished by free fall in the opinion of the Resident, the Contractor shall use either tremie or pumping to accomplish the pour.

501.09 SHAFT ROCK EXCAVATION BY BLASTING

Blasting will not be allowed under this contract to excavate the rock for shafts.

501.10 NONDESTRUCTIVE EVALUATION

When called for in the contract documents, specific completed drilled shafts, the number and/or location of which are specified in the contract documents, shall be subject to nondestructive tests to evaluate their structural integrity. Such tests my include (a) downhole tests conducted in access tubes, including crosshole acoustic/sonic tests and backscatter gamma ray tests or (b) sonic echo tests.

At a minimum, crosshole sonic logging (CSL) shall be used on all production drilled shafts.

The testing shall not be conducted until 24 hours after the placement of all concrete in the shaft and must be completed within 45 calendar days after placement on production drilled shafts. The Contractor shall employ a registered professional engineer show has been qualified to perform, evaluate and report the tests. The report on the CSL tests on any given shaft must be submitted to the Resident within 3 working days of the performance of the tests on the shaft. The Resident will evaluate and analyze the results and provide to the Contractor a response regarding the acceptability of the shaft that was tested within 3 working days of receipt of the report.

The Contractor my continue to construct drilled shafts before the receipt of notice of acceptance of the test shaft or shafts by the Resident, however, if the Resident finds the tested shaft(s) to be unacceptable, the Contractor shall be req2uired to repair at the contractor’s expense, the unacceptable shaft to the satisfaction of the Resident and (a) prove to the satisfaction of the Resident, at no expense to the State, the acceptability of all shafts constructed since the unacceptable shaft was constructed and the acceptability of the procedure to be used in constructing future shafts, or (b0 cease all drilled shaft construction until a new construction procedure acceptable to the Department has been proposed by the Contractor and acceptable by the Department. In the latter case, those drilled shafts constructed after the unacceptable shaft will be repaired to the satisfaction of the Department at the Contractors’ expense. If any repair

procedures or revisions to the Contractor's installation procedure are proposed by the Contractor, the Contractor shall submit a written plan to the Resident to repair defects and revise construction procedures. If these plans involve changes to the structural design of the shafts or shaft caps, or to the geometry of the shafts, any redesign proposed in the Contractor's plan to the Resident shall be performed at the Contractor's expense by a registered professional engineer.

The Resident may require that additional shafts be tested. If the testing of the additional shaft(s) indicates the presence of a defect in any additional shaft, the testing cost for that shaft will be borne by the Contractor and the Contractor shall repair the shaft at the Contractor's expense, as above.

501.101 CROSSHOLE SONIC ACCESS TUBES AND TESTING

Crosshole sonic logging (CSL) shall be used on all production drilled shafts. Access tubes for crosshole (acoustic or gamma-gamma) logging shall be placed on each reinforcing cage in the position and at the frequency shown on the plans. The access tubes for CSL acoustic logging shall consist of Schedule 40 steel pipe conforming to ASTM A 53, Grade A or B, Type E, F or S. The inside diameter shall be at least 1.5 inches. Access tube for gamma-gamma tests, if performed, shall consist of Schedule 20 PVC pile with an inside diameter of at least 2.0 inches.

All access tubes shall have a round, regular inside surface free of defects and obstructions, including all pipe joints, in order to permit the free, unobstructed passage of probes to the bottoms of the tubes. The access tubes shall be watertight, free from corrosion and free of deleterious material on the outside that can prevent bonding with the concrete. All access tubes shall be fitted with watertight caps on the bottom and top.

Prior to the beginning of downhole logging, the Contractor shall assure that the test probes can pass through every tube to the bottom. If a tube is obstructed, the Contractor shall, at the Contractor's expense, core a hole within the drilled shaft near the obstructed tube to the depth of the obstructed tube that is large enough to accommodate the probe for the full length of the hole. The coring equipment, coring procedure and location of the core hole shall be approved by the Resident prior to beginning the coring process. The coring method shall provide for complete core recovery and shall minimize abrasion and erosion of the core. The core hole shall be placed at a position in the shaft that will not produce damage to the reinforcing steel in the shaft. The core hole shall be logged, voids or defects indicted on the log and the log submitted to the Resident. Core shall be preserved and made available for inspection by the Resident. The core hole will be treated as an access tube and downhole testing shall then commence. If a defect is observed, the Contractor shall pay for all coring costs and shall repair the shaft at his expense, as above. If a defect is not observed, the Department till pay for al coring costs and compensation for the delay will be granted by an appropriate time extension.

Upon completion of al tests involving access tubes, the access tubes an core holes shall be filled with grout having strength properties equivalent to or better than those of the drilled shaft concrete.

501.102 SONIC ECHO TESTS

Equipment and procedures for sonic echo (pulse-echo) tests shall be capable of detecting defects that occupy no more than 30% of the cross-sectional area of the drilled shaft and are no greater than 6 inches thick, and this resolution shall be indicted in the report of the Contractor's consultant. No access tubes are required to be installed prior to construction of the drilled shaft. If a defect is observed in a sonic echo test, the Contractor shall pay for all testing costs and shall repair the shaft at his expense as described in

Section 501.10. If a defect is not observed, the Department will pay for all coring costs, and compensation for the delay will be granted by an appropriate time extension.

501.11 DRILLED SHAFT LOAD TESTS

Osterberg Cell (O-cell) Load Test of shafts shall be performed to verify design and construction methods. The number and locations shall be shown on the plans or as designated by the Resident. All load tests shall be completed before construction of any production drilled shafts. The Contractor shall allow 5 working days after the last load test for the analysis of the load test data by the Department before estimated drilled shaft tip elevations will be provided for production shafts. The Contractor shall notify the Resident within 10 days of the start of any load test.

The number and locations of load tests shall be as shown on the plans or as designated by the Resident. Unless specified otherwise, the load test shafts shall be loaded to a maximum test load equal to 3 times the test shaft load, or to plunging failure, whichever occurs first. Plunging failure is defined as a deflection of the shaft head equal to 5% of the shaft diameter.

Load testing shall not begin until the concrete has attained a compressive strength of 2550 psi as determining from cylinder breaks. Drilled shafts shall be load tested in the order directed by the Resident. Osterberg Load Cell Tests shall be conducted in accordance with FHWA Publication No. FHWA-SA-94-035, "The Osterberg CELL for Load Testing Drilled Shafts and Driven Piles", February 1995.

The Contractor shall furnish all materials and labor necessary for conducting Osterberg Cell (O-cell) Load Tests and reporting the results. The drilled shafts used for the load test program shall be instrumented by LOADTEST, Inc. (the Osterberg Cell supplier). The Osterberg cell load test shall be conducted by LOADTEST, Inc with the Contractor providing auxiliary equipment and services as detailed herein. The load test is a non-destructive test and the test shafts shall be left in a condition suitable for use as a production shaft in the finished structure.

The first drilled shaft shall be tested as part of this contract. The load cell test shall be completed and the Initial Data Report submitted prior to starting additional shafts so that modifications to the socket lengths (if required) can occur. The test shaft shall be installed as per plan and specification. Upon completion of the tests these shafts shall be incorporated into the permanent structure with a factored axial shaft resistance as shown in the plans with resistance factors and nominal side and tip resistances as shown in the plans or as determined from the load tests.

Location of the Osterberg cell within the drilled shaft depends on which shaft is tested. The Contractor shall inform the Resident which drilled shaft will be constructed first. Personnel from LOADTEST shall work with the Resident to determine the location of the load cell. All costs associated with positioning of the load cell shall not be paid separately but shall be incidental to the Drilled Shaft Osterberg Load Cell Test bid item 501.232.

Load cells will be required to measure applied loads during the drilled shaft load tests. Load cells shall be of adequate size to measure the maximum load applied to the shaft and shall be equipped with an adequate readout device. Before load testing begins, the Contractor shall furnish a certificate of calibration for the load cell from an approved testing laboratory. The calibration shall have been completed for all ranges of proposed loading within the two months preceding the load tests. The certified accuracy of the load cell shall be within 1 percent of the true load.

The Contractor shall obtain the services of an independent, specialty testing firm to supply equipment and personnel to conduct the tests. The testing personnel will include a licensed professional engineer, with satisfactory load test experience, to conduct the test in compliance with these specifications, record all data and furnish reports of the test results to the Resident.

A. Procedure

1. For the drilled shaft(s) selected for testing, the Contractor shall construct the drilled shaft using the approved shaft installation techniques, as contained in this Special Provision, until the drilled shaft excavation has been completed.

2. The reinforcing cage, Osterberg Cell, hydraulic supply lines and other attachments shall be assembled and made ready for installation under the direction of LOADTEST, Inc. and the Resident, in a suitable area, adjacent to the test shaft, to be provided by the Contractor. The Osterberg Cell assembly shall be welded to the bottom of the cage in conjunction with the construction of the cage. The plane of the bottom plate(s) of the O-cell(s) shall be set at right angles to the long axis of the cage

3. When the test shaft excavation has been constructed, inspected and accepted by the Resident, a seating layer of concrete or grout shall be placed, by an approved method as contained in this Special Provision, in the base of the shaft. The Contractor shall then install the Osterberg Cell, reinforcing steel cage assembly in the test shaft (while the concrete or grout is still fluid) under the direction of LOADTEST, Inc. and the Resident so that the Osterberg Cell is resting firmly in the concrete. The Contractor shall use the utmost care in handling the placement/test equipment assembly so as not to damage the instrumentation during installation. The contractor shall limit the deflection of the cage to two (2) feet between pick points while lifting the cage from the horizontal position to vertical. The maximum spacing between pick points shall be 25 feet. The contractor shall provide support bracing, strong backs, etc. to maintain the deflection within the specified tolerance.

4. After seating the Osterberg cell, the drilled shaft shall be concreted by an approved method as contained in these Special Provisions and similar to that utilized for typical production shafts. At least eight (8) concrete compression tests cylinders shall be made from the concrete used in the test shaft. At least one of these test cylinders shall be tested prior to the load test and at least two cylinders shall be tested on the day of the load test. Testing of the shaft shall not begin until the concrete strength has reached 3,200 psi (f'ci=0.80f'c).

5. During the period required to perform the load test, no casings may be vibrated into place in the foundation area near the load test. Drilling, may continue provided, however that it be on shafts approximately 50 feet clear from the work area. If test apparatus shows any signs of negative effects due to construction activities, such activities shall cease immediately.

6. After the completion of the load test, and at the direction of the Resident, the Contractor shall remove any equipment, material, waste, etc. which are not to be a part of the finished structure. The Contractor shall grout the interior of the Osterberg cell and annular space around the outside of the Osterberg cell using grouting techniques approved by the Resident and LOADTEST, Inc. and prepare the shaft for incorporation into the permanent structure as directed by the Resident. Steps to prepare the shaft for incorporation into the permanent structure include, but are not limited to:

a. Removal of hydraulic lines and other test apparatus flush with the top of shaft.
b. Removal of oil, debris and other deleterious materials from the top of the shaft.

B. Post-Test Grouting Procedures for Drilled Shafts Tested with an Osterberg Cell

Osterberg load cell test shafts may be incorporated as production shafts only if the shaft is quantitatively proven to be undamaged by compressive tensile loads and if the shaft length and cross section are adequate. In such a situation, the Contractor shall supply all materials required to return Osterberg load cell test shafts to a condition suitable for use in the finished structure, including the grout required to fill each cell at the completion of the test. During the O-cell test the shaft breaks, on a horizontal plane, separating the upper section above the O-cell (side-shear section) from the lower section below the O-cell (end bearing section.) This creates an annular space, the size of which depends on the amount of expansion of the O-cell. The contractor shall be required to grout the O-cell and the annular space around the O-cell in order to reconnect upper and lower shaft sections.

Post-Test Grouting of Osterberg Cells (O-Cells):

1. The grout shall consist of Portland cement and water only, NO SAND.
2. The grout shall be fluid and pumpable. An initial mix consisting of 4 to 6 gallons of water per 95-lb bag of cement is recommended. Adjust water to obtain desired consistency.
3. The mixing shall be thorough to ensure that there are no lumps of dry cement. Pass the grout through a window screen mesh before pumping.
4. Connect the grout pump outlet to one hydraulic line of the O-cell. Open the other line to allow hydraulic fluid to bleed.
5. Pump the grout through the O-cell hydraulic line while collecting the effluent from the bleed line. Monitor characteristics of effluent material and when it becomes equivalent to the grout being pumped, stop pumping.
6. Take three samples of the grout for compression testing @ 28 days. The 28 day compressive strength shall be a minimum of 4000 psi.
7. The minimum amount of pre-mixed grout for grouting the O-Cell shall be as specified by LOADTEST, Inc.

Post-Test Grouting of Annular Space Around Osterberg Cells (O-Cells):

1. Prepare a fluid grout mix consisting of Portland cement and water only, NO SAND. The mixing procedures should be as outlined for grouting the O-cells. The quantity of grout should be at least three (3) times the theoretical volume required to fill the annular space and grout pipes.
2. Pump water to "blow out" the bottom caps of the provided plastic grout lines (two on each shaft).
3. Pump the fluid grout through one of the PVC pipes until the grout is observed flowing from the second grout pipe or until 1.5 times the theoretical volume has been pumped.
4. If no return of grout is observed from the second grout pipe, transfer the pump to the second pipe and pump grout through it until 1.5 times the theoretical volume has been pumped.

Take three (3) samples of each type of grout for compression testing @ 28 days. The 28 day compressive strength shall be a minimum of 4000 psi.

C. Testing and Reporting

The load testing shall be performed in general compliance with ASTM D-1143 (Quick Test Method).

Initially the loads shall be applied in increments equaling 5% of the anticipated ultimate capacity of the test shaft. The magnitude of the load increments may be increased or decreased depending on actual test shaft capacity.

Direct movement indicator measurements should be made of the following: downward shaft end-bearing movement (min. of 2 indicators required), upward top-of-shaft movement (min. of 2 indicators required), shaft compression (min. of 2 indicators required). Total expansion of the O-cell shall be measured to determine downward end bearing shaft movement.

Loads shall be applied at the prescribed intervals until the ultimate capacity of the shaft is reached in either end bearing or side shear, or until the maximum capacity or maximum stroke of the O-cell is reached, unless otherwise directed by the Resident.

At each load increment, or decrement, movement indicators shall be read at 1.0, 2.0 and 4.0 minute intervals while the load is held constant.

During unloading cycles the load decrement shall be such that at least 4 data points are acquired for the load versus movement curve. Additional cycles of loading and unloading using similar procedures may be required by the Resident following the completion of the initial test cycle.

Dial gages, digital gages, or LVWDT's used to measure end bearing and side shear movement should have a minimum travel of 4 inches and be capable of being read to the nearest 0.001 inch division. End bearing movement may be alternately monitored using LVWDT's capable of measuring the expansion of the Osterberg Cell (6 inches). Dial gages, digital gages or LVWDT's used to measure shaft compression should have a minimum travel of 2 inches and be capable of being read to the nearest 0.0001 inch division.

Unless otherwise specified by the Resident, the Contractor shall supply eight (8) copies of a report of each load test, as prepared by LOADTEST, Inc. or others approved by the Resident. An Initial Data Report containing the load-movement curves and test data shall be provided to the Resident within 7 calendar days of the completion of load testing, to allow evaluation of the test results. A final report on the load testing shall be submitted to the Resident within 30 weeks after completion of all load testing on site.

501.12 METHOD OF MEASUREMENT

DRILLED SHAFTS.

The quantities to be paid shall be the length in feet of the completed concrete drilled shaft of the diameter and containing the reinforcement shown on the plans. The length shall be determined as the difference between the plan top of the shaft elevation and the final bottom of the shaft elevation, not including the length of the rock socket.

DRILLED SHAFT ROCK SOCKET EXCAVATION

The quantity to be paid shall be the length in feet of complete bedrock excavation of the diameter shown on the plans measured in linear feet along the centerline of the rock socket in place, from the bottom of the drilled shaft casing to the final bottom of the rock socket elevation.

EXPLORATORY DRILLING

Soil samples and /or rock cores of the diameter and length required and authorized by the Resident will be paid for at the contract unit price per linear foot for either soil sample or rock core.

O-CELL LOAD TESTS

The quantity to be paid shall be the number of O-cell load test conducted according to the specified loading procedures and of the designated maximum load shown in the plans. The drilled shaft O-cell load test shall include all material, labor, equipment, etc., required to assemble, install, conduct and remove the drilled shaft load test and regrout the cell.

501.13 BASIS OF PAYMENT

DRILLING EQUIPMENT MOBILIZATION

DRILLED SHAFTS

Drilled shafts shall be paid for at the contract unit price per linear foot for accepted lengths of drilled shaft of the diameter specified. Such payment shall include the cost of earth and boulder excavation, concrete, reinforcing steel in the shaft and rock socket, all labor, materials, equipment, temporary casings, permanent casings, crosshole sonic tests, obstruction removal, nondestructive testing, inpection, and other incidentals necessary to complete the drilled shaft. Such payment shall be full compensation for the shaft excavation including removal from the site, and disposal of, excavated material, using special tools, drilling equipment, blasting procedures to excavate the shaft to the depth indicated on the plans.

DRILLED SHAFT, ROCK SOCKET.

Rock socket excavation shall be paid at the contract unit price per linear foot of rock socket of the diameter specified. Such payment shall be full compensation for all labor, materials, and equipment, tools, drilling equipment, blasting procedures to excavate the shafts to the required depths, and furnishing all other labor, materials and equipment necessary to complete the work.

DRILLED SHAFT EXPLORATORY DRILLING

Exploratory drilling authorized by the Resident will be paid for at the contract unit price per linear foot of rock core. Such payment shall be full compensation for drilling, extracting, packaging and classifying the cores, delivering them to the Department, and all other expenses necessary to complete the work.

OSTERBERG CELL LOAD TESTS.

Osterberg Cell Load Tests shall be paid for at the contract unit each, for the load tests, completed and accepted. This shall constitute full compensation for all costs incurred for the procurement, installation, conducting of the test, reporting and subsequent grouting of test apparatus and appurtenances. Drilling the rock socket extension to accommodate the Osterberg Cell test shall also be part of this pay item. Such payment shall include all cost related to the performance of the load test.

No separate payment will be made for non-destructive testing, coring, and repair.

Payment will be made under:

Pay Item		Pay Unit
501.804	Drilling Equipment Mobilization	Lump Sum
501.805	Drilled Shaft (x-in dia.)	Linear Foot
501.806	Drilled Shaft, Rock Socket (x-in dia.)	Linear Foot
501.807	Drilled Shaft Exploratory Drilling	Linear Foot
501.232	Drilled Shaft Osterberg Cell Load Test	Each