SECTION 436 – DRILLED SHAFTS FOR SIGN STRUCTURE FOUNDATIONS

436.01 DESCRIPTION

This work shall consist of the construction of drilled cast-in-place concrete shafts for Sign Structure foundation where indicated on plans. The work shall include furnishing all equipment, materials and labor necessary for constructing drilled shafts in accordance with these specifications and as directed by the Engineer. The work shall include excavation, installing and removing temporary casing, drilling slurry, soil and rock drilling to penetrate whatever the materials and obstructions encountered, installing reinforcement, concrete, finished shaft top preparation and disposal of excavated soils.

436.02 MATERIALS

Materials shall conform to the following Sections and Subsections:

Admixtures and Curing Materials 906
Portland Cement Concrete.....905.05
Reinforcement Steel for Structures 908.01
Structural Steel (casings) 909.01

Casings (if required) shall be smooth, non-corrugated, clean, be of watertight steel, and of ample strength to withstand both handling and driving stresses, pressures of concrete, pressure of fluids and of the surrounding earth materials. Casings shall have inside diameters not less than indicated shaft sizes.

436.03 SHOP DRAWINGS

Shop, erection, and other drawings necessary for the fabrication and erection of sign support structures shall be furnished in accordance with Subsection 104.08. As a minimum, the following items shall be submitted to the Engineer for approval:

1. A summary of the Contractor's or his specialized drilled shaft subcontractor's experience on projects of a similar nature and scope. The specialty subcontractor shall be selected by the Contractor and be approved by the Engineer. Approval will be based on qualifications and previous experience on similar projects.
2. List and size of proposed equipment including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, concrete pumps, temporary steel casing, slurry sampling and testing equipment.
3. Details of equipment and procedures for drilled shaft installation, including drawings showing consecutive steps of drilled shaft installation and drawings with measurements showing that the proposed equipment can perform the specified work. Included in the drawings shall be shown the areas that are planned to be used

for staging, layout drawings showing the proposed sequence of drilled shaft installation, details of placement, splicing, and centering devices for steel reinforcing.
4. Mix design for the concrete and documentation from an independent laboratory showing that the mix design conforms to the submitted mix and meets the strength requirements set by the Engineer. The mix design and documentation should be submitted for approval at least 30 calendar days prior to use.
5. Details of slurry including proposed methods of mixing, placing and circulating.
6. Details of shaft excavation methods.
7. Details of proposed methods to clean shaft after initial excavation.
8. Procedures for control and removal of spoils.
9. Details of shaft reinforcement, including methods to ensure centering/required cover, cage integrity during placement, placement procedures, and cage support.
10. Details of concrete placement including proposed operational procedures for concrete pump or tremie including initial placement, raising during placement, and overfilling of the shaft concrete, and provisions to prepare the completed shaft top at its final shaft top elevation.

Actual drilled shaft location data shall be submitted to the Engineer within one working day after a drilled shaft is installed. Drilled shaft subcontractor shall provide the Engineer's on-site representative with written tabulations of the following information:

1. Drilled shaft location.
2. Elevation of top of drilled shaft measured to the nearest 10 millimeters.
3. Deviation from design plan location measured to the nearest 5 millimeters.
4. Plumbness (deviation from vertical).

Within seven working days after the completion of installation of all the drilled shafts, and before removing the drilled shaft installation equipment from the site, the Contractor shall provide the Engineer with a plan certified by a land surveyor registered in the State of New Jersey showing the as-installed location of all drilled shafts installed to the tolerances indicated in these specifications and as shown on the plans.

436.04 INSTALLATION OF DRILLED SHAFTS

The following requirements shall apply to all installations of Drilled Shafts for Sign Structures:

(A) EQUIPMENT.

Drilled shafts shall be installed with approved drilling equipment. The proposed drilled shaft installation equipment and methods shall be subject to the approval of the Engineer and approval shall be secured before mobilization. Approval by the Engineer shall not relieve the Contractor or drilled shaft subcontractor of his responsibility to provide equipment with sufficient power, downward thrust and torque, materials, and methods to adequately perform the work in a safe, timely, workmanlike manner. Approval shall not be reason to hold the Authority and/or the Engineer responsible for the Contractor's or drilled shaft subcontractor's failure to perform the work.

Drilled shaft installation equipment shall be capable of installing drilled shafts with the use of temporary casing. Wet rotary drilling using the slurry displacement method shall employ sufficient fluid pressure to provide complete removal of the cuttings from the hole. The Contractor shall provide a weighted bar with slender tip and attached to a thin

cable with calibrated depth marker, metal tape, or other approved equipment suitable for confirming the completeness of the final cleaning operations.

The Contractor or his specialized subcontractor shall provide all equipment, including concrete pumps or tremie pipes required for the placement of concrete into the drilled shafts in accordance with the plans and specifications. The minimum inside diameter of concrete pump lines or the tremie pipe shall be greater than six times the maximum aggregate size.

(B) SHAFT DRILLING.

The Contractor shall perform the excavations required for the shafts through whatever materials are encountered, to the dimensions and elevations shown in the plans or otherwise required by these specifications. The Contractor's methods and equipment shall be suitable for the intended purpose and whatever the materials encountered. The Contractor shall provide equipment capable of constructing shafts to a depth equal to the deepest shaft shown in the plans plus 15 feet or plus three times the shaft diameter, whichever is greater, except when the plans instruct the Contractor to provide equipment capable of constructing shafts to a greater depth.

An approved fixed template, adequate to maintain shaft position and alignment during all excavation and concreting operations, shall be provided for all drilled shafts.

The Contractor shall install a suitable temporary casing for the full depth of the drilled shaft. All drilled shafts shall meet construction tolerance criteria and be installed in accordance with the dimensions as shown on the plans, or as directed by the Engineer.

The top center of each drilled shaft shall not vary from the plan location by more than 3 inches. At the top of the drilled shaft, reinforcing bars shall not vary in plan distance from the plan shaft by more than 1 inch. The drilled shaft shall not vary from the vertical by more than one percent of its length, as measured above ground and shall not be out of the required position at the top by more than 3 inches. The plumbness shall be checked by plumbing the Contractor's extended Kelly bar with a full size drill bucket when it is down to the bottom of the drilled shaft with an accurate carpenter's level placed against the exposed part of the Kelly bar, followed by measurements of offset from the Kelly bar to the permanent casing in four compass directions.

The Contractor or his specialized subcontractor shall protect existing utilities to remain within the drilled shaft installation work zone in accordance with the requirements of authorities having jurisdiction over same. The Contractor shall repair or replace any construction-induced damage to the satisfaction of the governing authority at the Contractor's expense.

The Contractor or his specialized subcontractor shall employ within his contract bid price, a licensed registered Land Surveyor, experienced in this type of work, who shall establish lines and grades. The Contractor shall be responsible for the correct location of drilled shafts and keeping a record of drilled shafts installed.

Drilled shafts shall be located and staked by the Contractor and prior to the start of installation work. The Contractor shall maintain all location stakes and shall establish all elevations required.

Unless the accuracy and precision of other methods are demonstrated to the satisfaction of the Engineer, the plan position of the center of each shaft shall be determined by

optical survey measurements to a minimum of four points arranged around the shaft casing perimeter at the four compass directions. These measurements are to be geometrically averaged to calculate the best-fit mathematical center of the shaft at the measurement elevation. Then the calculated center of the shaft at the measurement level shall be reduced to calculate the mathematical center of the shaft at the proposed final shaft top elevation by adjustment using the shaft plumbness measurement information.

(C) PLACING CONCRETE.

The handling, measuring, proportioning, mixing, and placing of concrete shall conform to Section 401 and this section. Concrete shall be placed only in the presence of the Engineer.

Concrete shall be placed using concrete pump or a tremie pipe from the bottom of the excavation upward so as to avoid segregation. Concrete shall not be allowed to fall freely. Neither air, water, nor slurry shall be injected into the shaft concrete during placement. A disposable foam or rubber plug shall be used in the concrete pump line or tremie pipe to separate the fresh concrete from the slurry at the start of concrete placement. The plug shall be inserted so that the first flow of concrete pushes the plug out of the pipe and prevents slurry mixing and contamination as the concrete placement commences. The concrete pump line or tremie shall consist of a tube constructed in section having flanged couplings fitted with gaskets. The means of supporting the concrete pump line or tremie shall be such as to permit free movement of the discharge end over the entire top of the concrete and to permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie, if used, shall be filled by a method that prevents washing of the concrete. The discharge end shall be completely submerged in concrete at all times after initiation of concrete placement flow and the concrete line shall contain sufficient concrete to prevent any water entry. Maintain the concrete level at the top of the drilled shaft until the concrete has set.

If concrete flow is halted and the concrete line's discharge end is for any reason raised out of the shaft concrete, flow shall be reinitiated only after fully recharging the concrete line with fresh concrete by 1) inserting a foam or rubber plug or pig into the concrete line at the concrete hopper end, 2) placing the discharge end approximately 6 inches above the top of the shaft concrete, 3) resuming concrete flow, recharging the pump or tremie line and depositing what will be classified as waste concrete on the top of the previously placed shaft concrete, 4) discharging waste concrete until the line is fully recharged with fresh concrete and the pig is pushed completely through the line, 5) without halting the flow of fresh concrete plunging the discharge end of the concrete line into the shaft concrete to within 6 inches or less of the shaft bottom or to a level as directed by the Engineer, 6) continuing concrete placement without further interruption, and 7) placing a final volume of additional concrete in the shaft no less than the volume of waste concrete placed to recharge the line in the process of resuming concrete flow. This procedure shall be applied without exception as necessary to avoid injecting any air, any water, any slurry, or any concrete that has flowed through a line filled with air, water, or slurry into the shaft concrete.

Final concrete placement elevation details shall be as specified herein for shaft top preparation. A hole shall not be progressed within five drilled shaft diameters of a previously installed drilled shaft until the concrete has been in place for a minimum of 2 days.

(D) SHAFT CONSTRUCTION TIMING.

Every effort shall be made by the Contractor in planning, coordinating, and carrying out the work to minimize the time between the start of excavation and completion of shaft concrete placement. Each step in the process of initially drilling, satisfactorily cleaning the shaft bottom, placing reinforcing steel, and completing concrete placement shall be coordinated to avoid delays during or between each work step. In general, the time between shaft excavation and completion of concrete placement is expected to be eight (8) continuous hours or less.

For cases where two (2) or more continuous hours elapse between completion of excavation and commencement of concrete placement, any reinforcing steel already placed in the shaft shall be removed, the shaft bottom shall be satisfactorily cleaned, reinforcing steel immediately placed in the shaft, and concrete placement immediately commenced.

(E) SHAFT REINFORCING STEEL.

Where shafts are extended at the direction of the Engineer to final authorized tip elevations lower than the estimated minimum tip elevations, no fewer than one-half of the vertical reinforcing steel bars (every other bar around the circumference) shall be extended to the authorized tip elevation by lap splicing or mechanical splicing. Lap splices shall be tied firmly enough to support the full weight of the reinforcing cage above the lap zone. Horizontal reinforcing bands shall be added in the bottom extension zone at a vertical spacing no more than 6 inches center to center.

(F) SHAFT TOP PREPARATION.

If tremie concrete is used, the top-most concrete placed in the shaft shall be considered waste concrete and shall be either: (A) pushed upward and ejected completely out of the top of the casing and wasted as final concrete is placed or, alternatively, or (B) pumped upward to a level at least 2 feet clear distance above the plan shaft top level and allowed to cure in place for removal later. Waste concrete shall be considered to be the top 2 feet of initial concrete placed, plus the height of any additional volume of waste concrete deposited in the shaft where concrete placement was halted and restarted, plus any additional amount necessary to produce full strength concrete, non-segregated concrete at the plan shaft top level.

Where waste concrete alternative (A) is selected, waste concrete must be allowed to evenly overflow the full top circumference of the casing, and may not be channeled or bleed off by notches or holes cut in the casing top. Any fresh concrete in the casing at a level above the plan shaft top level after ejecting all waste concrete may be dipped or pumped out to the plan top elevation while still plastic by methods and equipment approved by the Engineer, or allowed to cure in place for removal later.

Final shaft top preparation may commence only once the drilled shaft concrete obtains an average unconfined compression strength of at least 2466 psi, or, in lieu of concrete strength testing, beginning seven (7) full days after completion of concrete placement. Final top preparation steps shall consist of (A) cutting off any extra casing above the top of casing elevation, (B) cutting off any cured over-pour concrete to the plan shaft top elevation by approved methods, (C) dressing the final shaft top surface, (D) verification by the Engineer that the exposed concrete consists of full strength concrete with a typical, non-segregated mortar and aggregate distribution, (E) approved non-destructive strength testing by the Contractor where required by the Engineer to verify that concrete has full design strength, (F) removal of additional concrete below the plan shaft top level

as necessary to reach full-strength, non-segregated concrete, and (G) preparation of the shaft top key recess.

(G) SHAFT ACCEPTANCE

A comparison of the computed volume of the excavation (theoretical) with the volume of concrete placed (actual) shall be made. A plot of depth versus volume shall be computed. The contractor shall provide cooperation and whatever assistance necessary to accurately monitor the volume of concrete placed at all times during the pour.

Unaccepted drilled shafts are drilled shafts that are rejected by the Engineer because of damage, failure to advance through obstructions, mislocation, misalignment, or failure to install the drilled shaft to the proper bearing stratum, or the results of the CSL testing indicate defects. Rejection of a shaft based on the shaft integrity testing shall require conclusive evidence that a defect exists in the shaft which will result in inadequate or unsafe performance under service loads. If the CSL records are complex or inconclusive, the Engineer may require additional testing to confirm the location of the defect. The Engineer may also require coring or excavation of the shaft to verify shaft conditions.

The Contractor shall submit a written plan of action to the Engineer for approval, showing how to correct the problem and prevent its reoccurrence. The drilled shaft shall be repaired, augmented or replaced to the satisfaction of the Engineer. To mitigate and/or to remedy unaccepted drilled shafts, the Contractor may be required to provide additional drilled shafts or supplement drilled shafts to meet specified requirements at no cost to the Authority.

When otherwise acceptably installed drilled shafts exceed the specified tolerances, the drilled shaft subcontractor shall provide an accurate as-built survey to the Design Engineer. The Design Engineer will then analyze the total loads on individual drilled shaft based on the survey data. If the load on any drilled shaft exceeds 10 percent of the specified load capacity, corrections shall be made in accordance with a design provided by the Design Engineer.

436.05 CROSSHOLE SONIC LOGGING OF DRILLED SHAFTS

The nondestructive testing method called Crosshole Sonic Logging (CSL) shall be used on all production and demonstration drilled shafts forty-eight hours after the placement of all concrete in a shaft and must be completed within 20 calendar days after the concrete placement. The Engineer may specify a longer minimum time if concrete mix designs or other factors result in slower setting concrete. The CSL tests shall be conducted by an experienced independent testing Consultant approved by the Engineer prior to testing.

(A) Preparation for Testing

A number of tubes shall be installed in each shaft to permit access for CSL. The number of tubes installed shall be the greater of 3 or the nearest integer value of the diameter of the drilled shaft measured in feet. The tubes shall be 1.5 inch to 2.0 inch inside diameter schedule 40 steel pipe. The pipes shall have a round, regular internal diameter free of defects or obstructions, including any at pipe joints, in order to permit the free, unobstructed passage of a 1.3 inch 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 and a good bond between the concrete and the tubes.

The pipes shall each be fitted with a watertight shoe on the bottom and a removable cap on the top. The pipes shall be securely attached to the interior of the reinforcement cage. The tubes shall be installed in each shaft in a regular, symmetric pattern such that each tube is equally spaced from the others around the perimeter of the cage. The Contractor shall submit to the testing organization his selection of tube size, along with his proposed method to install the tubes, prior to construction. The tubes shall be as near to parallel as possible.

The tubes shall extend from 6 inches above the shaft bottoms to at least 3 feet above the shaft tops. Any joints required to achieve full-length tubes shall be made watertight. Care shall be taken during reinforcement installation operations in the drilled shaft hole so as not to damage the tubes. After placement of the reinforcement cage, the tubes shall be filled with clean water as soon as possible. After the tubes are filled with water, the tube tops shall be capped or sealed to keep debris out of the tubes prior to concrete placement. The pipe caps or plugs shall not be removed until the concrete in the shaft has set. Care shall be exercised in the removal of caps or plugs from the pipes after installation so as not to apply excess torque, hammering, or other stresses which could break the bond between the tubes and the concrete.

(B) CSL Testing

CSL tests shall be conducted between pairs of tubes. The approved testing organization shall test two principle diagonals through the center and between each tube pair around the perimeter of all tested shafts. Additional logs shall be conducted at no additional cost in the event anomalies are detected. The CSL tests shall be carried out with the source and receiver probes in the same horizontal plane unless test results indicate potential defects in which case the questionable zone may be further evaluated with angled tests (source and receiver vertically offset in the tubes).

CSL measurements shall be made at depth intervals of 0.2 feet or less, and shall be done from the bottom of the tubes to the top of each shaft. The probes shall be pulled simultaneously, starting from the bottoms of the tubes, over a depth measuring device. Any slack shall be removed from the cables prior to pulling to provide for accurate depth measurements of the CSL records. Any defects indicated by longer pulse arrival times and significantly lower amplitude/energy signals shall be reported to the Engineer and further tests shall be conducted as required to evaluate the extent of such defects.

(C) CSL Test Results

The CSL results shall be presented to the Engineer in a report. The report shall include recommendations as to the acceptability, unacceptability, soundness, etc., of the drilled shaft. The report shall be checked, stamped approved, and signed by a Professional Engineer registered in New Jersey. The report shall be submitted directly to the Engineer. The test results shall include CSL logs with analyses of:

a. Initial pulse arrival time versus depth
b. Pulse energy/amplitude versus depth

A CSL log shall be presented for each tube pair tested with any defect zones indicated on the logs and discussed in the test report as appropriate.

(D) Evaluation of CSL Test Results

The Engineer will evaluate the CSL test results and determine whether or not the drilled shaft construction is acceptable. If the Engineer determines that the drilled shaft is

acceptable, the CSL tubes shall be dewatered and grouted. The grout shall be of the same strength or higher than the strength of the concrete used in the original drilled shaft. The Contractor's grout mix shall not include calcium chloride based additives. If the Engineer determines that the drilled shaft is unacceptable, the shaft shall be cored to allow further evaluation of the shaft. Cores shall be taken without additional compensation.

(E) Further Evaluation

If the CSL records are inconclusive or show an anomaly, the Engineer may require coring or the performance of Crosshole Tomography to verify the shaft condition. The details of the Crosshole Tomography, if directed by the Engineer, shall be submitted for review and approval. The Crosshole Tomography analysis shall include the development of three dimensional volumetric images for the entire shaft. This shall be presented in color and coded to indicate variations in sonic velocity. The images and complete discussion of the data shall be presented in the report by the testing firm.

436.06 MEASUREMENT

Drilled shafts will be measured by the linear feet. The limits for payment for drilled shafts will be as shown on the plans. Furnishing equipment, mobilization for drilled shaft installation, CSL testing or any further evaluation will not be measured, and all costs shall be included in drilled shaft.

436.07 PAYMENT

Payment will be made under:

PAY ITEM	*PAY UNIT*
Drilled shaft for Sign Structures……	Linear Feet

No separate payment will be made for reinforcement steel, steel pipe for CSL testing, and concrete within the drilled shaft limits shown on plans. The costs thereof shall be included in the above drilled shaft pay item.

No separate payment will be made for obstructions, rock material, or whatever the material is encountered, the payment will be made for one item as soil.

No separate payment will be made for CSL testing and/or further evaluation associated with determining the integrity of the drilled shaft.

The contract items and unit price bids set forth in the bid schedules shall include all services, permits, labor, equipment, transportation, materials, testing, and supplies for the complete work, including, without limitation, mobilization and demobilization for completion of the work. No payment will be made for drilled shafts abandoned because of defects in the work or other fault of the Contractor or his drilled shaft subcontractor.