ITEM 551.9949NN11 – DRILLED SHAFTS

DESCRIPTION

A. General. This work shall consist of furnishing the materials and installing drilled shafts at the locations and dimensions shown on the contract plans or where ordered by the Engineer and approved by the Deputy Chief Engineer Structures (DCES). This work includes installing casings, excavating shafts, disposing of all excavated material and drilling mud, and placing steel reinforcement. The work also includes furnishing and placing Portland cement concrete meeting the performance requirements defined herein to achieve the strength and durability for the application this concrete is used.

The intent of this work is for the Contractor or subcontractor to provide reinforced concrete shafts in cylindrical excavated holes which extend a sufficient depth into the soil and/or rock to support the structure and all externally applied loads for which it was designed.

The Contractor or subcontractor performing this work must have had prior experience installing drilled shafts, as described in this specification.

B. Definitions. Definitions that apply within this specification are:

Contractor: The contractor or subcontractor performing the work described in this specification.

Casing (Shell): A steel shell used to construct the drilled shaft. The casing can help advance the hole, and supports the sides of the hole. Casing can be permanent, interim or temporary.

Casing Method: A method of shaft construction, consisting of advancing and cleaning a cased hole, placing the reinforcing cage, and concreting the shaft while extracting temporary casing (if used).

Drilling Mud: A slurry made using bentonite or polymers (see Slurry).

Drilled Shaft: A cylindrical structural column transmitting loads to soil and/or rock. The drilled shaft is constructed in a hole with a circular cross section. The hole is filled with concrete and reinforced with steel.

Dry Construction Method: A method of shaft construction consisting of drilling the shaft, removing water and material from the excavation, placing the reinforcing cage, and concreting the shaft in a relatively dry condition.

Interim Casing: A casing that acts as a form, but remains in place permanently. It is not designed to carry structural loads.

Permanent Casing: A casing that acts as a form and remains in place permanently.

Quality Assurance: A test or procedure that acts to verify the quality of the work or product. Quality Assurance procedures would include static load testing, Osterberg cell testing, coring, cross hole sonic logging, and other non-destructive testing.

Rock: Rock is identified in the boring logs. Rock may also be defined at the shaft installation site by a Department Engineering Geologist.

Seat: The act of placing the tip of a casing in intimate contact on rock for its entire circumference.
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Slurry: A mixture of water and bentonite or polymers, which provides hydrostatic pressure that supports the sides and bottom of the hole, lubricates and cools the drill tools, and aids clean-out. Slurry cannot be made from native materials, or material from the excavation.

Surface Casing: Temporary casing installed to prevent sloughing of the surrounding soil near the surface of the shaft excavation.

Temporary Casing: A casing that serves its function during construction of the drilled shafts. It serves no permanent structural function, and is extracted during concreting.

Top of Socket. The highest location of the rock socket that is capable of resisting axial and lateral design loads. At any given location, the top of socket elevation is usually below the top of rock elevation. This distance depends on the type and quality of the rock, and the Contractors drilling methods and equipment.

Tremie. A method to place concrete under water. Refer to Section 555 Structural Concrete.

Wet Construction Method. A method of shaft construction in which slurry is used to maintain stability of the hole while advancing the excavation to the final depth, placing the reinforcing cage, and concreting the shaft.

MATERIALS

Refer to the contract plans to determine which of the following materials will be required. For all steel remaining as a permanent part of the work, all Buy America provisions shall apply.

A. Permanent Casing. Provide continuous permanent casing conforming to the limits shown on the contract plans.

Provide material conforming to the requirements of ASTM A252 Grade 2, unless specified otherwise in the contract plans. Furnish full length shells, consistent with requirements shown in the contract documents. Unless otherwise specified in the contract documents, use of spiral welded casing is not permitted.

If needed, equip casing with an appropriate casing shoe to enable installation of casing to the elevations shown on the contract plans.

B. Interim Casing. Provide interim casing capable of withstanding all handling and installation stresses. If needed, equip casing with an appropriate casing shoe to enable installation of casing to the depths necessary to construct the drilled shaft to the elevations shown on the contract plans.

C. Temporary Casing. Provide temporary casing capable of withstanding all handling and installation and extraction stresses. If needed, equip casing with an appropriate casing shoe to enable installation of casing to the depths necessary to construct the drilled shaft to the elevations shown on the contract plans.
D. **Reinforcing Steel.** Provide bar reinforcement meeting the requirements of §709-01 Bar Reinforcement, Grade 75 ASTM A615 Deformed and Plain Carbon-Steel Bars for Concrete Reinforcing steel that is to be welded shall be Grade 80 in accordance with ASTM A706.

E. **Concrete.** The provisions of §555-2 shall apply, except as modified herein

1. Use materials meeting the requirements of 501-2.02

2. Design a concrete mixture proportioned according to the American Concrete Institute Manual of Concrete Practice, ACI 211.1, Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete. Produce a homogeneous mixture of cement, pozzolan (fly ash or GGBFS), fine aggregate, coarse aggregate, air entraining agent, water-reducing and set-retarding admixture, and water as designed. Other NYSDOT Approved List materials may be used as approved by the Director, Materials Bureau.

3. The designed concrete mixture shall meet the following requirements:
   - Strength: 28 day minimum compressive strength of 6,000 psi.
   - Spread: 18” to 24”
   - Entrained Air: 2 to 5%.
   - Water/Total Cementitious Material Ratio: 0.40 maximum.
   - Use Type I, I/II, or II cement. Use 15% to 35% fly ash or 30% to 70% GGBFS by weight of cementitious materials.
   - Resistivity >21 (kΩ-cm) (AASHTO T358), based on 4”x8” cylinders, or Permeability <2000 Coulombs (AASHTO T 277) at 28 days of age. The time frame may be extended to 56 days moist cure for high pozzolan content mix designs or the Accelerated Moist Curing alternative may be used.

4. Perform mix development testing in accordance with ASTM C143, C231, C192 and C39, to assure all performance criteria can be achieved during production and placement.

5. The maximum aggregate size used in a concrete mixture shall be dependent on the size and shape of the concrete member and on the amount and distribution of reinforcing steel. The Contractor shall select the largest available nominal maximum size of aggregate which does not exceed the following:
   - three-quarters of the clear distance between reinforcing bars and between the reinforcing bars and the forms; and
   - one-third the thickness of the placement.

6. At least 1 month prior to the start of any concrete placement, provide a copy of the proposed mixture design(s) and trial batch test results to the Director, Materials Bureau, submitted through the Regional Materials Engineer, for evaluation. Submit sufficient data to permit the Director to offer an informed evaluation. Include at least the following:
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- Concrete mix proportions.
- Material sources. Also include fineness modulus and specific gravity for all aggregates.
- Air content of plastic concrete.
- Slump of plastic concrete.
- Compressive strength at 7, 14, 28, and 56 days, and at any other age tested or deemed necessary.
- Resistivity or Permeability test data showing results of >21 kΩ-cm (AASHTO T358) or <2000 Coulombs (AASHTO T 277) respectively.

Do not interpret having a valid mixture design as approval of the mixture. Also, resubmit any proposed mixture design change to the Director, Materials Bureau, for evaluation. Multiple mixture designs may be used to address performance and placement issues as deemed necessary by the Contractor. Submit each mixture for evaluation, as indicated above, prior to use.

F. Centralizers. Provide centralizers for properly aligning the steel reinforcement, made of a material that is not detrimental to the reinforcement or the concrete. The type of centralizer utilized must be approved by the DCES.

G. Rebar Cage Feet. Provide cylindrical feet to support the rebar cage at the proper elevation, made of a material that is not detrimental to the reinforcement or concrete. The type of feet utilized must be approved by the DCES.

H. Mineral Slurry. Provide mineral (bentonite) slurry that will remain in suspension, and with sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. Provide a slurry with the percentage and specific gravity of the material used to make the suspension sufficient to maintain the stability of the excavation and to allow proper concrete placement.

The acceptable range of values for mineral slurry is as follows:

<table>
<thead>
<tr>
<th>Property (Units)</th>
<th>Range of Values (68°F)</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (lb/ft³)</td>
<td>64.3 to 69.1</td>
<td>64.3 to 75.0</td>
</tr>
<tr>
<td>Viscosity (seconds/quart)</td>
<td>28 to 45</td>
<td>28 to 45</td>
</tr>
<tr>
<td>pH</td>
<td>8 to 11</td>
<td>8 to 11</td>
</tr>
</tbody>
</table>

Increase density range values by 2 pcf in salt water.

Desand the slurry so that the sand content does not exceed 4 percent (by volume) prior to concrete placement as determined by the American Petroleum Institute sand content test.
I. Polymer Slurry. Provide a polymer slurry with sufficient viscosity and gel characteristics to hold the hole open, and transport excavated material to a suitable screening system.

Polymer slurry may be made from PHPA (emulsified), vinyl (dry), or natural polymers.

Desand the polymer slurry so that the sand content is less than 1 percent (by volume) prior to concrete placement, as determined by the American Petroleum Institute sand content test.

J. Water. Provide water conforming to the requirements of §712-01 Water, except with a pH conforming to the slurry requirements listed above.

CONSTRUCTION DETAILS

A. Prior Experience. Submit proof and details of the following:

1. Two projects in the past 5 years where the Contractor or subcontractor performing the work has successfully installed drilled shafts similar to the size and type on this project.
2. The foreman for this work having supervised the successful installation of drilled shafts on at least two projects in the last 2 years.
3. The drill operators having had at least one year of experience installing drilled shafts with similar diameters and lengths, and in similar conditions.

Include details describing the equipment and methods used, any difficulties encountered and how they were overcome, and the results of any testing performed. Include the name and telephone number of someone for each project cited who can be contacted as a reference. Submit this information to the DCES for review, evaluation, and approval prior to submitting detailed information as stated in this specification under C. Submittals. The DCES will render a decision within 15 working days after the receipt of all information. A Contractor or subcontractor will not be permitted to install drilled shafts without this approval.

All approvals are subject to trial and satisfactory field performance. Departmental approval does not relieve the Contractor or subcontractor of his responsibility to satisfactorily complete the work detailed in the contract documents.

B. General. Provide the equipment and use procedures necessary to install drilled shafts at the locations and to the elevations shown on the contract plans, or as approved by the DCES.

Prior to preparing submittals, fully examine the existing site conditions and subsurface exploration logs.

The construction methods selected are directly related to the method of load transfer assumed in the project design. The type of drilling method, presence of permanent or interim casing, and clean out procedure all affect the drilled shaft load transfer behavior in skin friction and...
end bearing. Construct the drilled shafts using construction methods consistent with the load transfer mechanism shown on the contract plans.

C. Submittals. Submit the proposed procedure and equipment for installing drilled shafts to the DCES for review and approval prior to commencing the work. The DCES will render a decision within 15 working days, measured from the date of receipt of all pertinent information. The submittal should include, but not be limited to, the following information:

1. Method describing how the Contractor will progress through obstructions and rock.
2. Details and method describing how the Contractor will keep the hole for the drilled shaft open.
3. Drawings showing and details describing the proposed sequence of drilled shaft installation. Include the sequence for each shaft, the overall construction sequence, and the sequence of shaft construction in bents or groups.
4. Information describing the type of equipment to be used, including drill rig, cranes, drilling tools, final cleaning equipment, desanding equipment, slurry pumps, sampling equipment, tremie or concrete pumps, casing (including casing dimensions, material and splice details), etc.
5. Proposed method for cleaning out the shaft excavations. Include a description of how the Contractor will perform spoil removal and disposal.
6. Documentation that shows that the Contractor, Driller, and Foreman have the requisite prior experience in installing drilled shafts. Include the name and telephone number of someone for each project cited who can be contacted as a reference.
7. Shaft excavation methods, and final shaft dimensions.
8. If slurry is to be used, indicate the method proposed to mix, circulate, and desand the slurry. Include methods of slurry disposal in the submittal.
9. Method of reinforcement placement, including support and centralization type and methods.
10. Details and method of concrete placement, curing, and protection.
11. If the concrete mix is modified (i.e., retarders), include the new mix design, and test results of cylinder breaks from an independent laboratory. Also, include test results that demonstrate a slump loss versus time relationship.
12. A description and details of the slurry sampling tool to be used. Provide a tool capable of taking a slurry sample at a specific depth, without being contaminated by slurry from another depth.
13. When slurry is used, include an alternate procedure to be used which will secure the shaft in the event of slurry loss.
14. A description of the type of feet to be used to support the rebar cage in the drilled shaft.
15. An emergency construction joint procedure, to be used in the event when concrete placement for the drilled shaft is unexpectedly interrupted.
16. A procedure for filling voids between permanent or interim casing and the soil.
17. A description of equipment and methods to be used for drilled shaft inspection. The Inspector will use these methods and equipment to inspect the drilled shafts. The inspection program must be thorough enough to assure the Department that each drilled shaft meets the requirements contained in this specification.
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Do not begin work until the DCES has issued all approvals.

D. Construction Tolerances

1. The allowable tolerance from plan location is 3 inches at the top of shaft elevation. Measure the as-drilled center of shaft using reference stakes offset from the shaft excavation.
2. The allowable tolerance from the required verticality is 2%. For battered shafts, the allowable tolerance from the required batter is 3%. This tolerance applies for the total length of shaft.
3. Cutoff elevation tolerance is plus 1 inch to minus 3 inches from the top of shaft elevation shown in the contract plans.
4. Rebar stick up elevation tolerance, after all shaft concrete has been placed, is plus or minus 2 inches from the stick up elevation shown in the contract plans.
5. The bottom of the shaft excavation is perpendicular to the axis of the shaft, within a tolerance of ¾ inch per foot of shaft diameter.
6. Tolerances for the diameter are as follows:
   a. The minimum diameter of the drilled shaft is not more than 1 inch less than the diameter shown on the plans.
   b. The maximum shaft diameter is the diameter shown on the plans plus 6 inches. Verify the diameter for the entire length of the shaft using devices constructed of a rigid rod with four 90° offset rods.

Drilled shaft excavations and completed shafts not constructed within the required tolerances are unacceptable. Submit written correction procedures to the DCES through the Engineer for approval prior to correcting the deficiencies. The Contractor is responsible for correcting all unacceptable shaft excavations and completed shafts to the satisfaction of the Engineer at no cost to the State.

E. Drilling and Excavation

1. General. When drilled shafts are to be constructed in conjunction with embankment placement, construct shafts after placement of the fill, unless otherwise shown on the contract plans.

The Contractor is responsible for reviewing all the subsurface and site information, and limitations, for the project.

2. Drilled Shafts. Excavate the holes and dispose of all excavated material for production drilled shafts using the methods approved by the DCES or the Engineer. Do not alter equipment and/or methods without written permission by the DCES or the Engineer.

Progress the holes for the shaft(s) to the required elevation(s) in such a manner so as not to cause disturbance or settlement to the surrounding ground surface or adjacent structures and in-service utilities. If any disturbance occurs, halt operations and modify the equipment and/or procedures so as not to cause any further disturbance. Submit the modified drilled shaft
installation procedure, in writing, to the DCES through the Engineer. After receiving approval from the DCES, repair any damage at no cost to the State, and proceed.

During drilling or excavation of the shaft(s), make frequent checks of the plumbness, alignment, and dimensions of the shaft. Correct any deviations exceeding the allowable tolerances using a procedure approved by the Engineer.

Where drilled shafts are located in open water areas, extend exterior casings (temporary, interim or permanent) from above the water elevation into the ground to protect the shaft concrete from water action during placement and curing of the concrete. Install the exterior casing in such a manner so as to produce a positive seal at the bottom of the casing and prevent piping of water or other materials into or from the shaft excavation.

Do not keep mineral slurry in the holes while drilling rock sockets, as it has a detrimental effect on the concrete-to-rock bond. For wet method of construction, replace the slurry with water.

Dispose of all excavated material in accordance with Section 203.

3. **Dry Construction Method.** This method will only be permitted at sites where all of the following apply:
   a. The groundwater table and site conditions are suitable to permit construction of the shaft in a relatively dry excavation.
   b. Where the sides and bottom of the shaft remain stable without any caving, sloughing, or swelling.
   c. Where the sides and bottom of the shaft can be visually inspected prior to placing the rebar cage and concrete.

A “relatively dry” excavation is one where the infiltration rate does not exceed 12 inches of water in one hour. Perform all operations so that less than 2 inches of water remain at the bottom of the excavation at the time of concreting.

4. **Wet Construction Method.** The wet construction method may be used at sites where a dry excavation cannot be maintained for placement of the shaft concrete. This procedure may require cleaning the slurry, and final cleaning of the excavation by means of a bailing bucket, air lift, submersible pump, or other devices.

Maintain a minimum slurry level of 4 feet above the highest groundwater level encountered on the project.

Provide surface casings to aid shaft alignment and position, and to prevent sloughing of the top of the shaft excavation, unless it is demonstrated to the satisfaction of the Engineer that the surface casing is not required.

5. **Temporary Casing Construction Method.** Use this method at sites where the stability of the excavated hole and/or the effects of groundwater cannot be controlled by other means.
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Install temporary casing using rotating, oscillating, driving, or vibratory methods unless methods are required or limited in the contract plans. Install temporary casing in advance of the excavation to the lower limits of the caving material.

Remove temporary casing while the concrete is still workable. As the casing is withdrawn, maintain a 5 foot minimum head of fresh concrete in the casing so that all fluid trapped behind the casing is displaced upward without contaminating the shaft concrete. Extract the casing at a slow, uniform rate, with the pull in line with the axis of the casing.

6. Interim Casing Construction Method. Use this method at sites where the stability of the excavated hole and/or the effects of groundwater cannot be controlled by other means. Install interim casing using rotating, oscillating, driving, or vibratory methods unless methods are required or limited in the contract plans. If full penetration cannot be attained, the Contractor may either excavate material within the embedded portion of the casing, or excavate a pilot hole ahead of the casing until the casing reaches the desired penetration. Progress the pilot hole centered in the shaft, and no larger than one-half the diameter of the shaft.

Progress the interim casing so that the casing maintains intimate contact with the soil.

7. Permanent Casing Construction Method. This method generally consists of installing the permanent casing to a prescribed elevation prior to excavating. Install permanent casing using rotating, oscillating, driving, or vibratory methods unless methods are required or limited in the contract plans. If full penetration cannot be attained, the Contractor may either excavate material within the embedded portion of the casing, or excavate a pilot hole ahead of the casing until the casing reaches the desired penetration. Progress the pilot hole centered in the shaft, and no larger than one-half the diameter of the shaft.

Progress the permanent casing so that the casing maintains intimate contact with the soil.

8. Slurry. Pre-mix the slurry, and allow adequate time for hydration prior to introduction into the shaft excavation. Provide adequate slurry tanks when specified or required by the Engineer. Do not mix slurry in the hole for the drilled shaft. Slurry pits will not be allowed without written permission from the Engineer.

Provide adequate desanding equipment where required for slurry operations. Take appropriate steps to prevent slurry from “setting up” in the shaft excavation, such as agitation, circulation, and adjusting the properties of the slurry. Do not let the slurry sit unagitated for more than 4 hours. If the slurry is in the hole, unagitated for more than 4 hours, scrape the sides to remove the filter cake before proceeding with the excavation.

Perform control tests on the slurry to determine density, viscosity, and pH before and during shaft excavation to establish a consistent working pattern.
Let the slurry sit for 30 minutes prior to placing the rebar cage and shaft concrete, to allow the excess sand to settle out. Remove any sand and spoil that has accumulated on the bottom.

Immediately prior to placing shaft concrete, take slurry samples from the bottom and 10 feet from the bottom of the drilled shaft excavation using an approved slurry sampling tool. Remove any heavily contaminated slurry and spoil that has accumulated at the bottom of the shaft. Be sure the slurry is within the specification requirements immediately before concrete placement. If it is not, clean the hole and flush it with fresh slurry until subsequent tests reveal that the slurry is within the tolerances contained in this specification.

9. **Excavation Inspection.** Provide equipment for checking the dimensions and alignment of each shaft excavation. Determine the dimensions and alignment under the direction of the Engineer. Measure the final shaft depth after cleaning.

F. **Rock Sockets.** Progress rock sockets to the depth, diameter and elevations shown on the contract plans. If the top of socket elevation varies from that shown on the contract plans by more than 3 feet, notify the Engineer who will contact the DCES for a redesign.

G. **Quality Assurance Equipment Installation.** Install any quality assurance equipment prior to concreting the hole. This includes any pipes for crosshole sonic logging, and any other instrumentation.

H. **Concrete.** The provisions of §555-3 shall apply, except as modified herein:

Prior to placing any concrete required by this specification, perform a trial placement of at least 8 cubic yards using the proposed mixture design(s). This trial placement(s), when approved by the Engineer, may be incorporated into the project as a substitute for the placement of another Class of concrete shown on the plans. If used in another element as a trial placement, the entire placement for that element on the day of the trial must use the same concrete. The Department will make and test concrete cylinders from the trial placement(s) to verify laboratory test results.

The loading limitations of §555-3.10 apply, except that concrete cylinder sets designated for early loading must attain an average compression strength of 6000 psi, or greater, with no individual cylinder less than 5,400 psi.

1. To evaluate 28 day strength of the concrete, the Department will cast cylinders following the requirements and frequency of Materials Method 9.2 for each placement, with a minimum of two (2) 6”x12” cylinders for each day. The results of all test cylinder specimens representing an element placed, or part thereof, on a given day will be averaged to determine the ultimate compressive strength for each placement. The average shall be 6,000 psi with no individual cylinder less than 5,400 psi.
If any strength test falls below the criteria established above, the Engineer will determine if investigation is required. The investigation may consist of, but is not limited to, review of the following:

- Sampling and testing of plastic concrete,
- Handling of cylinders,
- Cylinder curing procedures, or
- Compressive strength testing procedures.

If necessary, coring may be required to determine in-place strength. The contractor shall perform all coring at locations directed by the Engineer.

Make any repairs as per the provisions of §555-3.13, Damaged or Defective Concrete. The Engineer will reject any concrete represented by a 28-day cylinder set with an average compressive strength less than 6,000 psi, or an individual cylinder with a compressive strength less than 5,400 psi. Proposed repairs require Deputy Chief Engineer, Structures approval.

2. To evaluate the Resistivity of the concrete, the Department will cast cylinders at the same frequency and from the same sample(s) of concrete used to cast compressive strength specimens, with a minimum of one (1) set per placement. A set consists of three (3) 4” x 8” cylinders. Test samples shall be cured using the accelerated method (7-day normal cure at 73 degrees F, 21 days wet cure at 100 degrees F). The results of all test cylinder specimens representing an element placed, or part thereof, on a given day will be averaged to determine the Resistivity for each placement. The average shall be \(>37 \text{k}\Omega\cdot \text{cm} \) (AASHTO T358).

Permeability will be considered an alternative method to measure durability and will require only two (2) 4”x8” cylinders sampled at the same frequency as for compressive strength. Test samples shall be cured using the accelerated method (7-day normal cure at 73 degrees F, 21 days wet cure at 100 degrees F). The results of all test cylinder specimens representing an element placed, or part thereof, on a given day will be averaged to determine the Permeability for each placement. The average shall \(<1000 \text{ Coulombs} \) (AASHTO T 277).

If any Resistivity / Permeability test data falls outside the criteria established above, the Engineer will determine if an investigation is required. The investigation may consist of, but is not limited to, review of the following:

- Sampling and testing of plastic concrete,
- Handling of test cylinders,
- Cylinder curing procedures, or
- Permeability testing procedures.

**H. Flash Butt Welded Reinforcing Steel.** The provisions of §556-3 shall apply, except as modified herein:
1. Submittals
   • The qualifications of the testing laboratory, equipment and personnel that is being proposed to perform all testing shall be submitted to the DCES for approval.
   • Mill reports for all heats of reinforcing steel used for qualification and production
   • Welding Procedure Specification for the process to document parameters
   • Qualification tensile test reports
   • Production tensile test reports

2. Qualification of Process
   Before incorporation into the work, ensure that all Flash Butt Welded splices are fabricated in conformance with the following pre-production test requirements:

   • Submit the Weld Procedure Specification
   • Notify the DCES of the qualification testing in advance
   • Make sample welds of 4 bar splices in the presence of the NYSDOT inspector on the designated machine using the same operator and parameters to be used in production. All test bars must be from the same production heat and bent before welding into the same configuration as to be used on the project. Bent bars shall be straightened prior to transport to the lab for tensile testing.
   • Select control 4 sample bars from the same production heat. These will be provided without bending.
   • Perform the following testing for all eight (8) bars in a laboratory approved by the DCES
     - Testing of welded samples to ultimate tensile strength failure per ASTM A370.
     - Testing of control samples to yield and ultimate tensile strength per A370.
     - Testing shall be conducted in the presence of the NYSDOT inspector.
   • Acceptance criteria
     Welded sample bars must fail with visible necking of the bar.
     - Welded samples that fail outside the heat affected zone are acceptable
     - Welded samples that fail within the heat affect zone must exhibit visible necking prior to failure and achieve 95% of the tensile strength of the control samples.

   Qualification will apply to bars for a different heat, provided the carbon equivalent of that heat is less or equal to that used for the qualification tests.

   All weld samples shall pass to qualify the process.

   • Provide qualification test reports for the eight (8) qualification tests (4 welded sample plus 4 control samples) for NYSDOT approval prior to initiating production. Reports to contain:
     - NYSDOT Contract Number
     - Bar Size
     - Test specimen preparation procedures
- Bar heat number and ladle analysis report
- Type of Splice
- Physical Condition of Splice and Control Bar
- Any Notable Defects
- Location of Visible Necking Area
- Ultimate Strength of Each Bar
- Ultimate Strength and 95% of Ultimate Strength for Control Bars
- Actual Yield Strength of Each Control Bar
- Comparison to confirm 95% of the ultimate strength of each control bar and the ultimate strength of its associated welded splice sample
- Signature of technician

3. Quality Control During Production
   • All production welds shall be visually inspected by the operator
   • Welds shall be made in the presence of the NYSDOT inspector as required by the Department.
   • Production welds are to be divided into lots of no greater than 150, all within the same heat number.
   • Tensile tests shall be conducted on a minimum of two (2) production samples, randomly selected by the DOT inspector and tested in his presence, for each lot of 150 or at least two (2) samples tested per shift, whichever number is greater. Tests, acceptance criteria, and reports shall be per 2e through 2g above. Reports to be provided to the NYSDOT inspector within one working day of the tests.
   • All samples within a lot must satisfy the tensile test requirements.

4. Quality Assurance by Post Production Sampling
   • Provide three (3) welded samples and one control sample for each lot of 150 of bars rolled in the same heat. A different heat shall require a separate lot.
   • Samples shall be randomly selected and marked by the NYSDOT inspector, then cut to length, straightened, and separately bundled with the control bar for shipment to NYSDOT at the following address:
     
     New York State DOT Laboratories
     Building 7 – Physical Testing Lab
     1220 Washington Ave.
     Albany, NY  12206

5. Testing Equipment and Testing Personnel
   • Testing equipment, facilities, and personnel with any associated qualifications or certifications shall meet the requirements of all ASTM, AASHTO, or other appropriate test standards to safely complete the testing
   • Tensile test equipment and readouts shall be calibrated within the past year by an independent calibrating agency with measurements traceable to the National Institute of Standards and Technology.
   • Bars shall be marked prior to tensile testing to indicate any slippage of clamps.
J. Rebar and Concrete Placement, and Temporary Casing Removal. Place reinforcing and concrete within 2 hours after the drilled shaft has been excavated, cleaned out, inspected, and accepted by the Engineer.

Completely assemble the reinforcing steel cage, including longitudinal bars, ties, cage stiffener bars, centralizers, concrete feet, and other necessary appurtenances.

Place and center the rebar cage in the hole for the drilled shaft prior to concreting the shaft. Install centralizers at the bottom and along the axial length of the steel reinforcing at sufficient spacing to maintain proper concrete cover (minimum 3 inches), but at a spacing that does not exceed 10 feet. Place approved cylindrical feet (bottom supports) at the bottom of the cage to ensure that the bottom of the cage is maintained at the proper distance above the base.

Immediately prior to concreting, take depth measurements with a weighted tape. Clean out the hole if there is more than 1/2 inch of debris on the bottom for end-bearing shafts, and 2 inches of debris for side-friction shafts. If drilling mud is being used to support the hole, perform slurry contamination tests in accordance with the American Petroleum Institute’s (API’s) test Standard Procedure for Field Testing Drilling Fluids, API RP-13B. Adjust the slurry to meet contract specification requirements.

Check the elevation of the top of the rebar cage before and after placing the shaft concrete. If the rebar cage is not maintained within the specified tolerances, make corrections to the satisfaction of the Engineer. Do not construct additional shafts until the procedure has been modified, to the satisfaction of the Engineer.

For drilled shafts constructed using the Dry Construction Method, place concrete by tremie, pumping, or free-fall. When placing concrete by free-fall, direct the concrete so that it does not strike the sides of the excavation or the reinforcing cage.

For all other drilled shafts, place concrete in accordance with the requirements of §555-3.04 Handling and Placing Concrete and §555-3.05 Depositing Structural Concrete Under Water except place the concrete using the tremie method, by pumping, or by another method approved by the Engineer. Do not place concrete using free fall. Place concrete in one continuous operation to the top of the shaft.

For shafts less than 8 feet in diameter, conduct operations so that the elapsed time from the beginning of concrete placement in the shaft to the completion of placement does not exceed 2 hours, unless an approved shaft concrete retarder is used. Proceed so that the concrete mix remains in a workable plastic state throughout the 2 hour placement limit.

When the top of shaft elevation is above ground, form the portion above ground with a removable form, or with permanent casing when specified.

Temporary casings which become bound during shaft construction and cannot be practically removed are unacceptable unless the Contractor can prove to the Department’s satisfaction that the casing will not adversely affect the performance of the drilled shaft. Submit a procedure for correcting this to the Engineer for approval before conducting further work on the shaft.
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Do not conduct any construction operations which may cause soil movement immediately adjacent (within 5 feet) to the drilled shaft for 24 hours after completing the shaft concrete pour.

Fill any voids between permanent or interim casing and the soil with concrete at least 48 hours after concreting the shaft.

**Pumped Concrete.** All provisions of §555-3.05 *Depositing Structural Concrete Under Water* shall apply.

**K. Quality Assurance.** Provide Quality Assurance as required on the contract plans. In the event the Quality Assurance testing indicates voids or discontinuities in the concrete, which, as determined by the DCES, indicate that the drilled shaft is not structurally adequate, submit a written proposal for correcting the deficiencies and steps to prevent them from recurring to the Engineer for approval by the DCES. Do not continue working on the drilled shaft in question, or any other drilled shaft, until the DCES grants approval. Perform any additional QA verification work (such as full depth shaft coring) and/or corrective work necessary as a result of shaft defects at no additional cost to the State.

**METHOD OF MEASUREMENT**

**Drilled Shafts.** This work will be measured as the number of feet of drilled shaft furnished, installed, and accepted, measured between the cut-off elevation and the tip elevation shown on the contract plans or as changed, in writing, by the Engineer.

**BASIS OF PAYMENT**

The unit price bid for each item shall include the cost of furnishing all labor, material, and any equipment necessary to complete the work not included in the applicable pay item for furnishing equipment for installing drilled shafts. This includes progressing the hole through all soil, rock, and obstructions, placing concrete and reinforcing steel in the drilled shaft, installing temporary, interim and/or permanent casing, and supplying the methods and equipment for drilled shaft inspection. The cost of the concrete mixture design, and laboratory testing for mixture acceptance shall be included in the unit bid price. The cost of the trial placement will be paid for at the unit cost for the material being substituted for.

Note: The “NN” in the Pay Item denotes a serialized pay item. Refer to §101-02 *Definitions of Terms*. The State will make payment for each specified diameter of drilled shaft.

Quality Assurance, including any load testing and non-destructive testing (i.e. crosshole sonic logging), will be paid for under separate items. There will be no payment for additional quality assurance testing (i.e. coring) that is required to verify or quantify anomalies detected by the initial QA testing.

There will be no extra payment for leaving bound temporary casing, deemed acceptable to the Engineer, in place.
ITEM 551.9949NN11 – DRILLED SHAFTS

Pay adjustments will be made for cast-in-place concrete that does not meet specified performance characteristics and shall be computed on the actual quantity of concrete representing an element placed, or part thereof, on a given day. The concrete pay adjustment (CPA) will be made for non-conforming material according to the formulas defined as follows:

For concrete not meeting strength requirement, but allowed to remain in place, the payment representing the quantity of concrete for a given day / element’s placement shall be reduced as follows:

<table>
<thead>
<tr>
<th>Compressive Strength</th>
<th>Pay Factor (PF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;95.0% and &lt;100.0% of $f'_c$</td>
<td>The Department will pay 90.0%</td>
</tr>
<tr>
<td>&gt;90.0% and &lt;95.0% of $f'_c$</td>
<td>The Department will pay 75%</td>
</tr>
<tr>
<td>&lt; 90.0% of $f'_c$</td>
<td>Reject concrete</td>
</tr>
</tbody>
</table>
ITEM 551.9949NN11 – DRILLED SHAFTS

For concrete not meeting resistivity / permeability requirements, but allowed to remain in place, the payment representing the quantity of concrete for a given day / element’s placement shall be reduced as follows:

<table>
<thead>
<tr>
<th>Surface Resistivity (kΩ-cm)</th>
<th>Permeability Coulombs (C)</th>
<th>Pay Factor (PF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;37 and &gt;27</td>
<td>&gt;1000 and &lt;1500</td>
<td>The Department will pay 90.0%</td>
</tr>
<tr>
<td>&lt; 27 and &gt;19</td>
<td>&gt;1500 and &lt;2500</td>
<td>The Department will pay 75%</td>
</tr>
<tr>
<td>&lt;19</td>
<td>&gt;2500</td>
<td>Reject concrete</td>
</tr>
</tbody>
</table>

When a concrete mix contains corrosion inhibitor, all resistivity values will be decreased by 20% or permeability values will be increased by 20%

The total concrete pay adjustment for compressive strength and resistivity for a given day’s placement / element shall be computed as

\[
CPA = [(\text{Compressive strength PF})(0.60)] + [(\text{Resistivity PF})(0.40)]
\]

Payment will be made under:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>551.99490711</td>
<td>Drilled Shafts at Approach Span</td>
<td>Foot</td>
</tr>
<tr>
<td>551.99490811</td>
<td>Drilled Shafts at Main Span</td>
<td>Foot</td>
</tr>
</tbody>
</table>