STANDARD SPECIFICATIONS
FOR
HIGHWAY AND BRIDGE
CONSTRUCTION

NEW MEXICO STATE
DEPARTMENT
OF
TRANSPORTATION

2014 EDITION

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SECTION 502: DRILLED SHAFTS

502.1 DESCRIPTION

This Work consists of constructing drilled shafts. Drilled shaft construction, with or without under-reamed bottoms ("bell bottoms"), includes excavation, bottom hole cleaning, reinforcing steel placement and concrete.

502.1.1 Work Experience

Demonstrate to the State Geotechnical Engineer that the Contractor is able to perform the Work in accordance with the Contract. Provide evidence of two (2) Projects within two (2) years of the Bid date involving drilled shaft construction for the conditions expected and use a Superintendent with experience from one (1) of those Projects who will provide all oversight responsibility of all aspects of drilled shaft construction covered in Section 502. Provide the latest NMDOT drilled shaft inspection form of each drilled shaft element signed by the Drilled Shaft Superintendent indicating drilled shaft construction completed in accordance with Section 502 requirements.

502.1.2 Submittals

Submit construction and field designs to the Project Manager for review and approval by the State Geotechnical Engineer.

502.2 MATERIALS

502.2.1 General

Provide Materials in accordance with Table 502.2.1:1, "Applicable Bearing Pile Standards."

Table 502.2.1:1
Applicable Bearing Pile Standards

Material description	Standard
Portland cement concrete, Class G	Section 510, "Portland Cement Concrete"
Reinforcing steel cage	Section 540, "Steel Structures"
Reinforcing steel HP pile	ASTM A 572, Grade 50
Steel pipe (longitudinal or continuous spiral welded) piles and columns	ASTM A 252, Grade 3

502.2.2 Additional Requirements

502.2.2.1 Concrete

For Class G concrete requirements see Section 509, "Portland Cement Concrete Mix Designs."

502.2.2.2 Temporary Casings

Provide temporary steel casings with an inside diameter equal to or greater than the shaft size in accordance with the Contract. Ensure the casings are smooth, clean, watertight, and of ample strength to withstand both handling and driving stresses, pressures of concrete, and the surrounding soils.

502.2.2.3 Permanent Casings

Provide permanent casing with a wall thickness that is at least the thickness specified for the shaft construction. Provide a greater wall thickness if necessary to withstand handling and installation stresses. The casing dimensions are subject to the American Pipe Institute tolerances applicable to regular steel pipe. If approved by the Project Manager, the Contractor

may use casings larger than specified, at no additional cost to the Department.

502.3 CONSTRUCTION REQUIREMENTS

502.3.1 Equipment

502.3.1.1 Excavation and Drilling Equipment

Use excavation and drilling Equipment that can excavate a hole of the specified diameter 20% deeper than what is shown in the Contract. Use excavation Equipment that can complete a flat shaft bottom. Ensure that the cutting edges are normal to the vertical axis of the Equipment within a tolerance of 0.25 in per foot of diameter. Ensure that under-reaming tools do not allow the base diameter to exceed three (3) times the specified shaft diameter. The Foundation Engineer may approve a change in other under-reaming Plan dimensions to accommodate the Equipment. When the Foundation Engineer requires over-reaming of the shaft sidewall, use an over-reaming bucket, grooving tool, or other approved Equipment. Use an over-reaming tool that over sizes the shaft diameter from 0.5 inch to three (3) inch. If the Contractor cannot drill the material with conventional earth augers, the Contractor shall use special drilling Equipment, such as core barrels, rock tools and other Equipment, as necessary. Blasting is not allowed.

502.3.1.2 Slurry Equipment

Use desanding Equipment to keep the slurry sand content to less than eight percent (8%) by volume for mineral slurry and less than one percent (1%) by volume for polymer slurry. This is required during shaft excavation to maintain mix consistency of the slurry in the shaft. Use slurry tanks for slurry circulation, storage, and treatment. Do not use excavated slurry pits in place of slurry tanks without the written permission of the Project Manager. Use a slurry-sampling tool to conduct the slurry control tests in accordance with Section 502.3.4.1.3.3, “Slurry Control Tests.” Use a slurry sampler capable of sampling slurry from the bottom of the hole and withdrawing the sample without loss or contamination of sample fluid.

502.3.1.3 Concrete Placement Equipment

Depending on the type of shaft construction, place the concrete in the excavated shaft with a rigid tremie pipe, a concrete pump line, or a drop chute.

502.3.1.3.1 Tremies

Use a rigid tremie pipe that can deposit concrete at the shaft bottom. Do not use a tremie with aluminum parts that will have contact with the concrete. Ensure the inside diameter is at least ten (10) inch. Ensure the tremie’s inside and outside surfaces are clean and smooth. Ensure that the tremie is watertight. In slurry displacement shafts use a plug initially placed at the top of the tremie to separate the concrete from the displacement fluid until the concrete is flowing through the orifice. Ensure that plugs left in the shaft concrete are made of material approved by the Project Manager. Construct the discharge end of the tremie to permit the free radial flow of concrete during placement operations.

502.3.1.3.2 Concrete Pumps and Lines

Use watertight pump lines with a diameter of at least five (5) inch. Use schedule-40 steel pipe or heavier. Use plugs in accordance with Section 502.3.1.3.1, “Tremies.”

502.3.1.3.3 Drop Chutes

Use rigid-pipe drop chutes that are either one-piece or sectional. Ensure they can be added and removed from a metal hopper. Do not use flexible trunk line hose.

502.3.2 Submittals

Provide the required drilled shaft submittals to the Project Manager for the State

Geotechnical Engineer's review and approval. The Contractor may use documented Work experience (per Section 502.3.2.1, "Work Experience") and proposed construction procedure submittals (per Section 502.3.2.2, "Proposed Construction Procedure") approved on previous Department Projects of similar size, difficulty, and geology, in lieu of the detailed submittal requirements listed below.

502.3.2.1 Work Experience

Submit documentation verifying the required Work experience in accordance with Section 502.1.1, "Work Experience." Include the names and phone numbers of references that can verify successful completion of the listed Projects.

502.3.2.2 Proposed Construction Procedure

At least 30 Days before the drilled shaft concrete bearing pile Work begins, submit a complete written proposal of the construction procedure. The following information is required:

1. Superintendent name and experience record;
2. List of proposed Equipment including: cranes, drills, augers, bailing buckets, final cleaning Equipment, desanding Equipment, slurry pumps, core sampling Equipment, tremies or concrete pumps, casing, etc.;
3. Description of construction operation sequence;
4. Description of shaft excavation methods;
5. Details of mixing, circulating, and slurry desanding methods;
6. Manufacturer and type of apparatus for testing slurry;
7. Description of methods for cleaning the shaft excavation;
8. Details for placing reinforcement including support and centralization methods; and
9. Details for placing concrete including operational procedures for free fall, tremie or pumping methods.

502.3.2.3 Review and Approval

The State Geotechnical Engineer will evaluate the proposed construction procedure and will notify the Contractor if additional information is required and changes are necessary within 14 Days after receiving the proposed construction procedure. Administrative approvals are subject to field verification of performance.

502.3.3 Construction Preparations

502.3.3.1 Site and Subsurface Conditions

The Department's test results and rock core samples are available for examination upon request.

502.3.3.2 Protection of Existing Structures

If specified, submit a preventative-measures plan to the Project Manager, at least 14 Days before the construction of the shaft.

502.3.3.3 Site Preparation

If footings are present, excavate to the footings' bottom elevation before beginning shaft construction, unless the Contract or Project Manager allows otherwise. If the Contractor drills shafts in conjunction with placing Embankment, drill the shafts after placing the fill, unless the Contract or Project Manager allows otherwise.

502.3.3.4 Proof Drilled Shafts

Construct a proof drilled shaft, when specified, at the location shown in the Contract.

Construct the shaft after the State Geotechnical Engineer approves the Equipment and methods. If specified in the Contract, load test the proof shaft in accordance with the Contract and Section 504, “Load Testing of Bearing Piles.” Drill the shaft to the maximum depth of any production shaft unless otherwise shown in the Contract. Underream the proof shaft to establish the feasibility of under-reaming in a specific soil strata or rock. Fill the proof shaft with concrete in the same way as the production shafts. If the methods and Equipment produce inadequate results as determined in 502.3.7 Acceptance, the Project Manager will require the Contractor to demonstrate acceptable results with another proof shaft. Once the proof shaft is approved, construct production shafts using the same means and methods. Do not change the means or methods without written approval from the State Geotechnical Engineer. Cut off the proof shafts five (5) ft below finished grade and leave in place. Restore the proof shaft sites to their original condition.

502.3.3.5 Safety

Do not allow workers to enter the excavation for any reason.

502.3.4 Construction of Drilled Shafts

502.3.4.1 Construction Methods

502.3.4.1.1 Dry Construction Method

The State Geotechnical Engineer will approve the dry construction method when the following occurs:

1. The shaft accumulates less than 12 inches of water above the base over a one (1) hr period without pumping;
2. The shaft remains stable without caving, sloughing or swelling over a four (4) hr period immediately following excavation;
3. The Contractor can remove loose material and water before inspection and concrete placement; and
4. Use of low strength grout collars to stabilize running sands or unstable zones within the drilled shaft excavation.

Use the slurry-displacement construction method or the casing construction method for shafts that do not meet these requirements.

The dry method consists of the following:

1. Drilling the shaft;
2. Removing accumulated water and loose material from the excavation;
3. Approval of bottom hole conditions by Certified Drilled Shaft Inspector;
4. Placing the reinforcing cage; and
5. Concreting the shaft.

502.3.4.1.2 Casing Construction Method

Use the casing construction method when called for in the Contract or where the dry construction method is inadequate. If necessary, use the casing method combined with the slurry displacement or dry construction method. Place the casing by twisting, driving, or vibrating into the ground before cleaning it out, unless the Contract requires the Contractor to place the casing in a predrilled hole. If the Contractor elects to use casings or shafts larger than those specified the Contractor shall provide the concrete necessary to fill the additional volume, at no additional cost to the Department.

502.3.4.1.2.1 Temporary Casing

The Department will consider subsurface casing to be temporary unless shown as permanent in the Contract. Remove the temporary casing when placing concrete for the

drilled shaft when the concrete is in a fluid state. If the Contractor removes a casing or replaces it with a longer or larger diameter casing through caving soils, the Contractor shall stabilize the excavation with slurry before installing the new casing. Other methods to control the stability of an excavation require approval of the Foundation Engineer. Before withdrawing the casing, ensure that the level of concrete in the casing is at least ten (10) ft above either the hydrostatic water level or the drilling fluid level, whichever is higher. Maintain a concrete level in the casing as it is removed so that fluid trapped behind it is displaced upward and discharged without contaminating or displacing the shaft concrete. Temporary casings that become bound or fouled during shaft construction, and cannot be practically removed, constitute a defect. Repair defective shafts in accordance with 502.3.8 Correction of Defective Drilled Shafts.

502.3.4.1.2.2 Permanent Casing

Make permanent casing continuous from top to bottom. Cut off the permanent casing at the prescribed elevation after installation. Complete the shaft by placing the reinforcing steel and concrete in the casing. If using temporary casings in conjunction with permanent casings, keep the temporary inner casing aligned with the permanent outer casing. Maintain a water-tight seal between the two (2) casings during excavation and concrete placement where an oversized hole or temporary casing is approved by the Project Manager. When approved by the Foundation Engineer to allow drilling an oversize hole to aid in the placement of the permanent casing, post grout the exterior annular space outside of the permanent casing, such that the direct contact between casing and the surrounding soil/rock is created.

502.3.4.1.3 Slurry Displacement Construction Method

Use the slurry displacement method at sites where maintaining a dry excavation is not possible. Use a mineral or polymer slurry, or water to maintain stability around the hole's perimeter while advancing excavating, placing the reinforcing cage, and placing concrete. Displace the slurry during final cleaning of the excavation with a bailing bucket, air lift, or submersible pump. Place concrete with a tremie or concrete pump beginning at the shaft bottom. During construction, keep the slurry level in the shaft excavation high enough to prevent caving and at least five (5) ft above the highest expected piezometric pressure head along the depth of the shaft. If not using permanent casings, provide temporary surface casings to aid shaft alignment and to prevent sloughing, unless otherwise approved by the Foundation Engineer. If the slurry construction method does not produce the necessary results, discontinue operations and make corrective modifications to the procedures and Equipment.

502.3.4.1.3.1 Polymer Slurry Requirements

Use polymer slurry that will stabilize the hole and inhibit the influx of ground water. Table 502.3.4.1.3.1:1, “Polymer Slurry Requirements, Emulsified or Dry Phpa Polymer,” lists acceptable ranges of values for slurry viscosity and gel.

Table 502.3.4.1.3.1:1
Polymer Slurry Requirements, Emulsified or Dry PHPA Polymer

Property (units)	Requirements (at time of introduction or before concreting)	Test Method
Density (pcf)	62.4 – 64.0	Density Balance
Viscosity (seconds/quart)	50–120	Marsh Funnel
pH	8–11.7	pH Paper
Sand Content (% by volume)	0–1	API Method

Note: Perform tests when the slurry temperature is above 40 °F.

Premix the polymer slurry according to the manufacturer’s directions. Prevent the slurry from losing the required viscosity and gel characteristics in the shaft. Neutralize expended

polymer slurry with bleach and remove from Project to a site approved by the Project Manager.

502.3.4.1.3.2 Mineral Slurry Requirements

Use Attapulgite, in lieu of Bentonite, where saline or chemically contaminated groundwater occurs. Use mineral slurry with a grain size that remains in suspension and has sufficient viscosity and gel characteristics to transport excavated material to the screening system. Provide mineral slurry in accordance with Table 502.3.4.1.3.2:1, "Mineral Slurry Requirements, Sodium Bentonite or Attapulgite in Fresh Water."

Table 502.3.4.1.3.2:1
Mineral Slurry Requirements, Sodium Bentonite or Attapulgite in Fresh Water

Property (units)	At time of slurry introduction	In hole at time of concreting	Test method
Density (pcf)	N/A	64.0 – 75.0	Density Balance
Viscosity (seconds/quart)	28–45	N/A	Marsh Cone
PH	8–10	8–10	pH paper
Sand Content	N/A	0–4	API Method

Note: Perform tests when the slurry temperature is above 40 °F.

Premix the slurry according to the manufacturer's directions. Prevent the slurry from "setting up" in the shaft. Dispose of the slurry offsite in accordance with Section 107.14.8, "Disposal of Other Materials and Debris."

502.3.4.1.3.3 Slurry Control Tests

Perform control tests on the mineral slurry to determine density, viscosity, pH, and sand content. Do not place concrete unless the Certified Drilled Shaft Inspector has approved the bottom hole test results and after test results show acceptable values. Provide test reports to the Project Manager upon completion of each drilled shaft.

502.3.4.1.3.3.1 Pre-entry Tests

Perform tests to determine viscosity and pH before pumping the slurry into the excavation. Take at least two (2) sets of tests during the first 8 h of slurry processing. Decrease the testing frequency to one (1) set every eight (8) hours when the results are consistent.

502.3.4.1.3.3.2 Bottom Hole Tests

Test slurry samples taken from the shaft base before placing concrete in any shaft excavation. Test until samples produce acceptable values for density, pH, and sand content.

502.3.4.2 Shaft Excavation

Extend drilled shaft tip elevations when the Foundation Engineer determines that the material encountered during excavation is unsuitable. Dispose of Materials from the shaft excavation as directed by the Project Manager.

When using vibrating casing, do not place adjacent casings or excavate shafts until 48 h after pour completion of an adjacent shaft, or when concrete from the adjacent shaft pour breaks at least 2,000 psi, whichever comes first. This requirement applies to excavating any shaft within four (4) shaft diameters of another.

502.3.4.2.1 Underream and Overream

Use sidewall overreaming when the Foundation Engineer determines the sidewall has: softened due to excavation methods; swelled due to concrete placement Delays; or, degraded

because of slurry cake build-up. The Foundation Engineer will direct the thickness and elevation of sidewall overreaming.

502.3.4.2.2 Obstructions

Remove surface and subsurface obstructions. Obstructions may include manmade Materials, such as old concrete foundations, or natural Materials, such as boulders or nested cobble zones that are not anticipated in the Contract. The Department's *Foundation or Geotechnical Report* includes the soil boring and rock core information, as well as groundwater conditions present at the time of the field investigation. Use this information to anticipate conditions. When obstructions are encountered, notify the Department Certified Drilled Shaft Inspector as shown in Section 502.4.3, "Obstruction Removal."

502.3.4.2.3 Soil Samples and Rock Cores

Take soil samples or rock cores at the locations shown in the Contract or as directed by the Foundation Engineer to determine the character of material directly below the bottom shaft elevation. Perform soil borings before excavating the shafts. Perform rock cores before excavating the shaft from the bottom of an exploration hole at no additional cost to the Department. Extract and ship the core samples in accordance with the Department's *Manual of Highway Structure Foundation Investigation and Subsurface Exploration*. Unless otherwise specified in the Contract, begin bore holes or rock cores at the top of the rock socket elevation to at least ten (10) ft below the bottom of the drilled shaft excavation. Record the rock quality designation, percent recovery, joint orientation and infilling, and joint water from the rock cores extracted. After exploration, fill the core holes with grout, slurry, or mortar having a minimum compressive strength of 3,000 psi at 28 Days. Deliver the geologist's field log cards to the Project Manager after completing the logs. The Department will not require the Contractor's geotechnical consultant to perform Laboratory testing on soil samples or rock cores unless specifically specified in the Contract. The Foundation Engineer will notify the Contractor of the final required shaft depth after receiving the geologist's field log sheets and the lab testing results. This notification may take as long as 48 h from the time the Foundation Engineer receives the field log sheets or the soil and rock samples test results.

502.3.4.2.4 Shaft Excavation Inspection

Measure the final shaft depths. Ensure that at least 50% of each shaft base has less than 1.0 in of sediment when placing the concrete. Ensure that the sediment depth or debris at any place on the shaft base does not exceed 1.5 inches. For dry shafts, ensure that the water depth does not exceed three (3) inches before pouring concrete. Inspect slurry displacement shafts using the methods that the Foundation Engineer deems appropriate. Receive approval of bottom hole conditions from Certified Drilled Shaft Inspector prior to continuing with the Work.

502.3.4.2.4.1 Inspection Procedures

The Project Manager will notify the Contractor which procedures will be used for the shaft inspections. Supply Equipment and labor, the Project Manager will need to inspect the shaft. Inspection procedures may include:

1. Inserting a casing in the shaft excavation temporarily for alignment, cleanliness, and dimension checks;
2. Inserting a rigid rod assembly with several 90° offsets equal to the shaft diameter;
3. Using Department video Equipment; or
4. Using a weighted tape and evaluation of results of desanding and density tests for slurry displacement excavations.

502.3.4.2.4.2 Remedial Work for Substandard Excavation

If the Foundation Engineer determines that a shaft excavation is substandard, develop, propose, and implement corrective measures. Corrective measures may include:

1. Overdrilling to a larger diameter to permit reinforcing steel placement with the required minimum cover;
2. Overreaming sidewalls of the shaft;
3. Increasing steel reinforcement bar number and size; or
4. Enlarging the underream within allowed tolerance.

502.3.4.3 Reinforcing Steel Unit Placement

The reinforcing steel unit consists of longitudinal bars and circular ties or a Structural Steel shape. Place the structural shape or the reinforcing steel cage as a unit immediately after the Certified Drilled Shaft Inspector approves the shaft excavation and before placing concrete. Tie and support the reinforcing steel unit in the shaft so that it remains within allowable tolerances given in Section 502.3.5, "Location and Alignment Tolerances." Use concrete spacers or other approved non-corrosive spacing devices at sufficient intervals, near the bottom and at maximum intervals of ten (10) ft up the shaft, to ensure concentric spacing for the entire reinforcement unit length. Use spacers equal in quality and durability to the concrete specified for the shaft. Inspect the bottom of the shaft immediately before placing of the cage to ensure that there is no sloughing.

Check the top elevation of the reinforcement unit before and after placing the concrete. If the reinforcement unit is not maintained within the specified tolerances, make corrections. Do not construct additional shafts before modifying the reinforcement unit support to the satisfaction of the Project Manager. Maintain the reinforcement unit at the proper elevation and orientation with an approved support mechanism at the ground surface. Place shaft concrete immediately after installing the cage. If more than 24 h elapses between the placement of the cage and concrete placement, remove the cage and inspect the shaft for sloughing or other damage.

502.3.4.4 Concrete Placement

Place concrete in accordance with Section 511, "Concrete Structures." Place concrete as soon as possible after placing reinforcing steel.

Ensure that the time from when the concrete is batched at the plant to placement does not exceed 2 h. The Project Manager may approve a longer time period if the concrete mixture remains workable and plastic. Use admixtures for the job conditions so the concrete remains in a workable plastic state through the approved placement limit.

502.3.4.4.1 Concrete Placement by Free Fall

Use free fall placement in relatively dry holes where the maximum water depth does not exceed three (3) inches. Ensure that free fall-placed concrete falls directly to the base without contacting either the rebar cage or hole sidewall. Use a hopper at the top of the shaft or a rigid pipe extension from the hopper. Ensure that free fall placement does not exceed 60 ft below the bottom of the hopper or the rigid pipe extension. Do not use free fall in slurry displacement shafts. If the Project Manager determines that concrete cannot be placed using the free fall method, use either a tremie or pumping to accomplish the pour.

502.3.4.4.2 Concrete Placement with Tremie or by Pumping

Use rigid tremie pipe or concrete pumps for concrete placement in either dry or slurry displacement shafts. Place plug within tremie or pump line to ensure concrete does not segregate prior to developing concrete pressure head within tremie or pump line and that plug does not discharge from tremie or pump line prior to concrete developing continuous flow. Do not begin underwater placement before placing the tremie or pump line within one (1) tremie or pump line diameter of the shaft base elevation. Remove plugs from the excavation if the Project Manager does not specifically approve them to remain in the shaft. Keep the discharge end continually immersed at least five (5) ft in concrete after starting the flow of concrete. Keep the concrete flow continuous. Maintain the concrete in tremies or pump lines continuously at a positive pressure differential to prevent water or slurry intrusion into the shaft

concrete. When lifting pump lines during concrete placement, 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 orifice is removed from the fluid concrete column and discharges concrete above the rising concrete level, the Department will consider the shaft defective. The Contractor may at its own risk and cost, remove the reinforcing cage and concrete to complete the necessary sidewall removal as directed by the Foundation Engineer. The Department will base final Acceptance in accordance with Section 502.3.7, "Acceptance."

502.3.5 Location and Alignment Tolerances

Adhere to the following construction tolerances unless otherwise stated in the Contract or directed by the Project Manager:

1. Ensure the drilled shaft and the concentric reinforcement steel unit is within three (3) inches of Plan position at the top of the shaft;
2. Do not vary the vertical alignment of a vertical drilled shaft from the Plan alignment by more than 1/4 inch per foot of depth. Do not vary alignment of a battered drilled shaft by more than 0.5 inch per foot of depth from the specified batter;
3. Ensure that the top of the reinforcing steel unit is no more than six (6) inches above and no more than three (3) inches below Plan elevation; and
4. Ensure that the top elevation has a tolerance of +1 inch or −3 inch from the Plan top of shaft elevation.

502.3.6 Load Testing

When the Contract includes load testing, complete the testing before construction of production shafts, unless otherwise approved by the State Geotechnical Engineer. Allow three (3) Working Days after the last load test is completed before receiving tip elevations of the production shafts from the State Geotechnical Engineer and proceeding with the construction of production shafts. After testing is completed, cut off the test shafts and reaction shafts at an elevation of five (5) ft below the finished ground elevation.

502.3.7 Acceptance

502.3.7.1 Concrete Strength

The Department will accept drilled shafts after the 28-Day compressive strength is verified. If the Contractor does not achieve the 28-Day compressive strength, the Department may completely reject the shafts or accept them in place in accordance with subsection 510.3.5.5, "Price Adjustments."

502.3.7.2 Location and Alignment Tolerances

The Department will accept drilled shafts if the construction tolerances are satisfied in accordance with Section 502.3.5, "Location and Alignment Tolerances." If the shafts exceed the location or alignment tolerances, the Department will reject the shafts. If the State Geotechnical Engineer determines that the extent of overloading is not detrimental to the performance of the shaft, the Department will accept the shaft.

502.3.7.3 Shaft Integrity

If applicable, the Department will accept shafts when the pile integrity testing reports verify the structural integrity of the piles. The Department may reject a shaft if integrity testing shows conclusive evidence that a defect exists in the shaft that may result in inadequate or unsafe performance under service loads. If the report is inconclusive, the State Geotechnical Engineer may require the Contractor to drill a core hole in the shaft. If the core hole confirms the defect, the Department will not pay the coring costs. If the core hole does not find a defect, the Department will pay for coring costs, including pressure grouting.

502.3.8 Correction of Defective Drilled Shafts

If the Department determines that a shaft is unacceptable, submit a plan for remedial action to the Project Manager for approval. Provide calculations and Working Drawings, stamped by a New Mexico registered professional Engineer for all foundation elements affected by the proposed corrections. Make corrections to drilled shafts r, at no additional cost to the Department.

502.4 METHOD OF MEASUREMENT

502.4.1 Drilled Shafts

The Department will not measure additional shaft depth or additional shafts used due to defective procedures.

The Department will only measure the first proof shaft constructed in place.

502.4.2 Soil Borings and Rock Cores

The Department will measure *Soil Borings* from the bottom of the exploration hole to existing grade.

The Department will measure Rock Cores from the point at which rock cores are recovered to the bottom of the rock coring.

502.4.3 Obstruction Removal

The Department will measure an obstruction vertically beginning where it is encountered and ending where conventional drilling Equipment adequately advances the hole. To qualify for Obstruction Removal measurement, get the Certified Drilled Shaft Inspector's authorization and meet the following requirements:

1. Hole advancement requires special procedures and tools, such as: chisels; boulder breakers; percussion hammers; core barrels; air tools; hand excavation; temporary casing; or increasing hole diameter; or
2. The rate of auger advancement is decreased to where the drilling rate through the obstruction is less than 50% of the drilling rate above the obstruction.

Obstruction Removal cost will include Delay costs. The Department will not allow additional Contract Time unless the Project Manager approves a detailed schedule analysis establishing the critical path of the additional time required to complete the Obstruction Removal. The Department will not measure *Obstruction Removal* outside the specified shaft diameter.

502.4.4 Certified Drilled Shaft Inspector

Provide a Certified Drilled Shaft Inspector to oversee and inspect all aspects of the drilled shaft construction and sign the NMDOT Drilled Shaft Inspection Reports. Provide certification through NMDOT TTCP or International Association of Foundation Drilling, also identified as ADSC.

502.5 BASIS OF PAYMENT

Pay Item	Pay Unit
Drilled Shaft Foundation____Diameter	Foot
Permanent Casing____Diameter	Foot
Steel Shape Reinforcement	Pound
Soil Borings	Foot
Rock Cores	Foot
Obstruction Removal	Foot

Steel Reinforcement in the drilled shaft is paid for under Section 540 except for overhead sign structures which are address in Section 701.

502.5.1 Work Included in Payment

The following Work and items will be considered as included in the payment for the main item(s) and will not be measured or paid for separately:

A. Methods employed by the Contractor to maintain stability of the shaft, including the use of temporary casings, slurry assisted shaft excavation, or use of grout collars;

B. All Work associated with sidewall overreaming;

C. Drilled shaft concrete required to fill shafts including oversized excavations, underreams, and overreams;

D. Excavation of anticipated Materials shown in the Contract of different densities and character including employment of special tools and procedures necessary to accomplish the excavation through bedrock;

E. Additional wall thickness required for handling and installation of permanent casing;

F. The Equipment and labor required for the shaft inspection procedure; and

G. Certified Drilled Shaft Inspection.

SECTION 505: PILE INTEGRITY TESTING

505.1 DESCRIPTION

505.1.1 General

This Work consists of pile integrity testing for verifying structural integrity and determining the extent and location of pile defects. Defects may include internal voids, necking of the pile's perimeter, transverse cracks, soil intrusions, weak concrete or grout in drilled shaft foundations.

505.1.2 Test Methods

Use crosshole sonic logging (CSL) or low strain integrity (LSI) testing for integrity testing. The Department may require LSI testing to corroborate the results of CSL testing that show potential defects. Only an approved Integrity Testing Consultant or Department personnel will perform CSL or LSI Testing.

505.1.3 Consultant Integrity Testing

If an Integrity Testing Consultant is required, the consultant's qualifications must meet the requirements of the Geotechnical Design Section and the Equipment used must meet the requirements of Section 505.3.1.1, "CSL Testing Equipment," and Section 505.3.1.2, "LSI Testing Equipment." Perform field testing with an experienced technician or Engineer having at least one (1) year of experience with the integrity testing methods. Use a licensed professional Engineer having at least three (3) years of experience in the integrity testing methods performed to interpret the recorded measurements.

505.1.4 Department Integrity Testing

Department personnel will only perform integrity testing when the Contract specifies CSL or LSI Department testing. Department personnel will use Department-owned Equipment to perform testing.

505.1.5 Assistance

Provide additional labor to perform the testing if required by the testing consultant or Department personnel. Provide access to the piles. If required, provide a 110 V, 55 Hz to 60 Hz, AC power supply.

505.2 MATERIALS

505.2.1 CSL Access Tubes

Use two (2) inch internal diameter (ID) access tubes of schedule 40 PVC with a round, regular ID free of defects or obstructions to allow passage of the source and receiver probes. Provide watertight tubes with clean internal and external surfaces to ensure a good bond between the concrete and tubes. Fit the tubes with glued caps at the bottom and threaded caps at the top.

505.3 CONSTRUCTION REQUIREMENTS

505.3.1 Equipment

505.3.1.1 CSL Testing Equipment

Use CSL Equipment in accordance with the following requirements:

1. Use ultrasonic source and receiver probes capable of producing records with strong signal amplitude and energy through uniform, high quality concrete. Use probes with a diameter and cabling that will descend freely through two (2) inch ID pipe for the full pile depth;

2. Record probe depth;
3. Use a microprocessor-based CSL measurement system for analog-digital conversion and data recording, individual record display, receiver response analysis, and log printing;
4. Ensure that the CSL system has filter/amplification of data and cables;
5. Use a CSL system that has a synchronized triggering feature with the ultrasonic pulse for the recording system.

505.3.1.2 LSI Testing Equipment

Use LSI Testing Equipment that meets the following requirements:

1. Use Equipment that has a digital data acquisition system with a dynamic signal analyzer, magnetic disk storage and hardcopy plotting capabilities. Ensure that the analyzer has both signal conditioning and power supply with high signal-to-noise ratios and variable frequency filtering to mitigate steel reinforcing and surface waves vibration noise. Ensure that the data is displayed in the field so that a preliminary data quality evaluation is possible;
2. Provide a receiver that is a suitable velocity transducer or accelerometer and place on the pile head.

505.3.2 CSL Testing Requirements

505.3.2.1 Preparation of CSL Access Tubes

Place access tubes in drilled shafts where the wet-hole construction method was used, or as directed by the State Geotechnical Engineer. Install access tubes as shown in the Plans. Fasten the tubes to the exterior reinforcement cage, so the tube bottoms are six (6) inches above the shaft bottom and the tube tops are 12 inches above the shaft top. Tie the tubes to the cage and glue the tubes together while lowering the cage into the shaft. Immediately after concrete or grout placement, fill the tubes with clean water and cap.

505.3.2.2 CSL Testing Procedure

Before construction of the Substructure above the foundation, direct the CSL consultant to test the completed piles from two (2) Days to ten (10) Days after completing concrete or grout placement. Provide information about the pile's bottom and top elevations, tube lengths and positions, and construction dates to the Integrity Testing Consultant or Department personnel before logging.

Log between each adjacent pair of tubes in the pile. Place the source and receiver probes in the same horizontal plane unless test results indicate potential defects. If potential defects are indicated, evaluate the area further using angled tests with the source and receiver vertically offset in the tubes. Additional testing of other untested tube pair combinations may be required.

Simultaneously pull the probes from the tube bottom of the over the depth wheel or other measuring device, once the slack is taken out of the cables, to provide accurate depth measurements. Take the CSL measurements at 2 3/8 inch intervals or less from the bottom to top of the pile. Report defects indicated by longer pulse arrival times and significantly lower amplitude/energy signals to the State Geotechnical Engineer. The State Geotechnical Engineer may require further tests to evaluate the extent of the defects.

Refill CSL tubes with water after testing the shafts containing defects indicated by the initial CSL testing.

505.3.2.3 CSL Testing Results

Report the results of completed CSL testing at a given Substructure element within 5 Days after testing completion for that element. Provide report copies to the State

Geotechnical Engineer and the Project Manager that contain the following information:

1. CSL logs (indicate defect zones on the CSL logs);
2. Initial pulse arrival time versus depth and pulse amplitude/energy versus depth analyses; and
3. Narrative.

505.3.3 LSI Testing Requirements

505.3.3.1 Pile Head Preparation

Ensure that the pile head is perpendicular to the pile's vertical axis and is made of sound concrete. Remove weak, poor quality, or broken concrete from the pile head to expose sound concrete. Clearly expose the pile head and free it of debris and water. Ground the pile head center impacted by the impulse hammer smooth along with the pile edge area where transducers are attached to provide a flat, horizontal surface for the LSI test.

505.3.3.2 LSI Testing Procedure

Perform LSI testing only when specified or when required by the State Geotechnical Engineer due to potential defects indicated by CSL testing results. Impact the pile head with a hammer that can produce a compression wave capable of being reflected from the pile toe. LSI testing may only be effective to depths of 20 times to 30 times the pile diameter. Take LSI testing measurements in both the time and frequency domains.

Display the motion record (pile top velocity) on a hard copy as a function of time. High soil friction may require velocity signal magnification using integration with exponentially increasing magnitude to enhance the pile toe reflection. Average several consistent records. In addition to the velocity records as a function of time, the amplified and averaged difference between velocity and force may be displayed to provide additional information about the pile top quality, including dynamic stiffness.

Use transient response or impulse response, using hammer force in the frequency domain (mobility) to provide additional defect determination of the pile.

505.3.3.3 LSI Testing Results

Report LSI testing results completed at a given Substructure element within 10 Days after completing testing for that element. Provide report copies to the State Geotechnical Engineer and the Project Manager that contain the following information:

1. Pile length and concrete quality analyses;
2. Pile integrity opinions based on LSI testing;
3. Correlation of potential defects to those indicated by the CSL test results, if performed;
4. Pile head dynamic stiffness;
5. Mobility, a measure of cross-sectional area and concrete quality;
6. Plots of the averaged, amplified velocity and acceleration versus time, and, if required, the mobility versus frequency; and
7. Narrative.

505.3.4 Acceptance and Rejection of Piles

The Department will accept piles if pile integrity testing reports verify the structural integrity of the piles. Pile rejection will require conclusive evidence that a defect exists that may result in inadequate or unsafe performance under service loads. If the report is inconclusive, the State Geotechnical Engineer may require the Contractor to drill a core hole into the defective pile.

The Department will reject shafts where velocities are less than 10,000 ft per second and

the anomalous velocity is less than 25% of the baseline velocity of the CSL record. Such rejection may be due to tubes not being tied in a plumb position and with equal offsets from adjacent tubes.

If a pile is unacceptable, submit a remedial action plan to the State Geotechnical Engineer. Provide calculations and Working Drawings stamped by a registered professional Engineer for foundation elements affected by modifications to the foundation piles and load transfer mechanisms caused by the remedial action.

505.4 METHOD OF MEASUREMENT—Reserved

505.5 BASIS OF PAYMENT

Pay Item	Pay Unit
CSL Consultant Testing	Each
CSL Department Testing	Each
LSI Consultant Testing	Each
LSI Department Testing	Each

505.5.1 Work Included in Payment

The following Work and items will be considered as included in the payment for the main items and no direct payment will be made therefore;

A. Furnishing all Materials, labor, tools and Equipment necessary to complete the Work;

B. Assistance to the consultant or Department personnel necessary to complete the Work;

C. CSL Access tubes; and

D. Calculations and Working Drawings stamped by a registered professional Engineer for all foundation elements requiring remedial action, and all labor and Materials necessary to complete corrections for rejected piles. If a defect is confirmed by coring of the concrete, Materials and labor for coring will be at the expense of the Contractor. If no defects are found, the Department will pay for all coring costs, including pressure grouting of the core holes. The time period allowed to perform testing shall be no less than 48 hours to no more than 10 Days from time of completion of the construction of the pile.