

**Section 411**

1 (2) Where the Engineer directs the Contractor to excavate below the original plan  
2 elevation of the bottom of the footing by a distance which is less than 3 feet the  
3 character of the work will not be considered to be materially changed and no additional  
4 compensation will be allowed for the foundation excavation at such location.

5 (3) Where the Engineer directs the Contractor in writing to excavate more than 3 feet  
6 below the original plan elevation of the bottom of the footing, payment for such  
7 excavation will be made as extra work in accordance with Article 104-7.

8 **(C) Furnishing and Hauling Backfill Material**

9 Where it is necessary to provide backfill material from sources other than excavated areas  
10 or borrow sources used in connection with other work in the contract, payment for  
11 furnishing and hauling such backfill material will be paid as extra work in accordance with  
12 Article 104-7. Placing and compacting such backfill material is not extra work but is  
13 incidental to the work being performed.

14 When the Contractor has been directed by the Engineer to drill in the vicinity of a footing  
15 to obtain subsurface information, such drilling in excess of a 5 foot depth will be paid as  
16 extra work in accordance with Article 104-7.

17 When so used, no additional payment will be made for use of the material under other pay  
18 items or for stockpiling the material for use under other pay items.

19 Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Foundation Excavation	Cubic Yard
Foundation Excavation for Bent No. ____ at Station ____	Lump Sum
Foundation Excavation for End Bent No. ____ at Station ____	Lump Sum

20 **SECTION 411**  
21 **DRILLED PIERS**

22 **411-1 DESCRIPTION**

23 Construct drilled piers consisting of CIP reinforced concrete cylindrical sections in excavated  
24 holes typically stabilized with casings or slurry. Provide permanent casings, standard  
25 penetration tests, integrity testing and assistance with the shaft inspection device as noted in the  
26 plans. Construct drilled piers with the required resistances and dimensions in accordance with  
27 the contract and accepted submittals. Use a prequalified Drilled Pier Contractor to construct  
28 drilled piers.

29 Define “excavation” and “hole” as a drilled pier excavation and “pier” as a drilled pier. Define  
30 “permanent casing” as a casing that remains in the excavation and acts as a form for Drilled  
31 Pier concrete and “temporary casing” as any casing that is not permanent. Define “rock” as a  
32 continuous intact natural material with a standard penetration resistance of 0.1 foot or less per  
33 60 blows or a rock auger penetration rate of less than 2 inches per 5 minutes of drilling at full  
34 crowd force or as determined by the Engineer when rock is not encountered as expected based  
35 on these criteria. This definition excludes discontinuous loose natural materials such as  
36 boulders and man-made materials such as concrete, steel, timber, etc. and is not for  
37 measurement and payment purposes. See Article 411-7 for measurement and payment of  
38 drilled piers.

1 **411-2 MATERIALS**

2 Refer to Division 10.

<b>Item</b>	<b>Section</b>
Grout, Type 2	1003
Portland Cement Concrete, Class Drilled Pier	1000
Reinforcing Steel	1070

3 Provide Type 3 material certifications in accordance with Article 106-3 for permanent casings  
 4 and roller, chair, steel pipe and cap materials. Store steel materials on blocking at least  
 5 12 inches above the ground and protect it at all times from damage; and when placing in the  
 6 work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign  
 7 materials. Load, transport, unload and store drilled pier materials so materials are kept clean  
 8 and free of damage.

9 **(A) Steel Casing**

10 Define "casing" as a temporary or permanent casing. If permanent casing is required for  
 11 an excavation, the largest diameter casing in the hole is the permanent casing. This does  
 12 not apply to working casings around permanent casings as approved by the Engineer. Use  
 13 smooth non-corrugated clean watertight steel casings of ample strength to withstand  
 14 handling and installation stresses and pressures imposed by concrete, earth, backfill and  
 15 fluids.

## 16 (1) Temporary Casings

17 Provide temporary casings with a nominal wall thickness of at least 0.375 inch and an  
 18 outside diameter equal to or larger than the design pier diameter for which temporary  
 19 casing is used.

## 20 (2) Permanent Casings

21 Use permanent casings with a yield strength of at least 36 ksi and a nominal wall  
 22 thickness that meets Table 411-1.

<b>TABLE 411-1 MINIMUM PERMANENT CASING WALL THICKNESS</b>	
<b>Casing Diameter</b>	<b>Nominal Wall Thickness</b>
< 48"	0.375"
48" - 78"	0.500"
> 78"	0.625"

23 Provide permanent casings with an outside diameter equal to the design pier diameter  
 24 for which permanent casing is used unless larger diameter permanent casings are  
 25 approved.

26 **(B) Slurry**

27 Define "slurry" as bentonite or polymer slurry. Mix bentonite clay or synthetic polymer  
 28 with water to make bentonite or polymer slurry.

## 29 (1) Bentonite Slurry

30 Provide bentonite slurry that meets Table 411-2.

**Section 411**

<b>TABLE 411-2 BENTONITE SLURRY REQUIREMENTS<sup>A</sup></b>		
<b>Property</b>	<b>ANSI/API RP<sup>B</sup> 13B-1</b>	<b>Requirement</b>
Density <sup>C</sup> (Mud Weight)	Section 4 Mud Balance	64.3 - 72.0 lb/cf
Viscosity	Section 6.2 Marsh Funnel	28 - 50 sec/qt
Sand Content	Section 9	≤ 4 % <sup>D</sup> ≤ 2 % <sup>E</sup>
pH	Section 11 Glass Electrode pH Meter <sup>F</sup>	8 - 11

- 1        **A.** Slurry temperature of at least 40°F required.
- 2        **B.** American National Standards Institute/American Petroleum Institute
- 3        Recommended Practice,
- 4        **C.** Increase density requirements by 2 lb/cf in saltwater,
- 5        **D.** In tanks before pumping slurry into excavations,
- 6        **E.** In excavations immediately before placing concrete,
- 7        **F.** pH paper is also acceptable for measuring pH,

8        (2) Polymer Slurry

9        Use polymer slurry products qualified by the Department. Provide polymer slurry  
10       with density, viscosity, sand content and pH properties that meet the product  
11       requirements. The polymer slurry QPL with the property requirements for each  
12       qualified polymer slurry product is available on the Geotechnical Engineer Unit’s  
13       website.

14       **(C) Rollers and Chairs**

15       Use rollers and chairs that are non-metallic and resistant to corrosion and degradation.  
16       Provide rollers with the necessary dimensions to maintain the minimum required concrete  
17       cover shown in the plans and center rebar cages within excavations. Use chairs of sufficient  
18       strength to support rebar cages in excavations and of the size necessary to raise cages off  
19       bottom of holes to maintain the minimum required distance shown in the plans.

20       **(D) Steel Pipes and Caps**

21       Use Schedule 40 black steel pipes for access tubes for crosshole sonic logging (CSL).  
22       Provide CSL tubes with an inside diameter of at least 1.5 inches. Use CSL tubes with a  
23       round, regular inside diameter free of defects and obstructions, including any pipe joints,  
24       in order to permit free, unobstructed passage of probes for CSL testing. Provide watertight  
25       CSL tubes free of corrosion with clean internal and external faces to ensure a good bond  
26       between concrete and tubes. Fit CSL tubes with watertight plastic caps on the bottom and  
27       removable caps on top.

28       **411-3 PRECONSTRUCTION REQUIREMENTS**

29       **(A) Drilled Pier Construction Plan**

30       Submit the proposed drilled pier construction plan for all drilled piers for acceptance.  
31       Provide 2 copies of this plan at least 30 days before starting drilled pier construction. Do  
32       not begin drilled pier construction until a construction plan is accepted. Provide detailed  
33       project specific information in the drilled pier construction plan that includes the following:

- 34       (1) Overall description and sequence of drilled pier construction;
- 35       (2) List and sizes of equipment including cranes, drill rigs, vibratory and downhole  
36       hammers, Kelly bars, augers, core barrels, casings (diameters, thicknesses and  
37       lengths), cleanout buckets, air lifts, pumps, slurry equipment, tremies, pump pipes and  
38       other equipment;

- 1 (3) Procedures for casing installation and temporary casing removal including how  
2 telescoping temporary casings will be removed;
- 3 (4) If applicable, details of slurry testing and use including intended purpose, product  
4 information and additives, manufacturer’s recommendations for use, name and contact  
5 information for slurry manufacturer’s technical representative, mixing and handling  
6 procedures and how slurry level will be maintained above the highest piezometric  
7 head;
- 8 (5) Methods for drilling and cleaning holes including how cores will be removed and  
9 drilling spoils and slurry will be handled and disposed of;
- 10 (6) Details of CSL tubes, caps and joints including pipe size and how tubes will be  
11 attached to reinforcing steel;
- 12 (7) Procedures for lifting and setting reinforcing steel including how rebar cages will be  
13 supported and centralized;
- 14 (8) Procedures for placing concrete including how tremies and pump pipes will be  
15 controlled and contaminated concrete will be contained;
- 16 (9) Concrete mix design that meets Section 1000;
- 17 (10) Approved packaged grout or grout mix design that meets Section 1003;
- 18 (11) CSL Consultant including Field and Project Engineer; and
- 19 (12) Other information shown in the plans or requested by the Engineer.

20 If alternate construction procedures are proposed or necessary, a revised drilled pier  
21 construction plan submittal may be required. If the work deviates from the accepted  
22 submittal without prior approval, the Engineer may suspend drilled pier construction until  
23 a revised plan is accepted.

24 **(B) Preconstruction Meeting**

25 Before starting drilled pier construction, hold a preconstruction meeting to discuss the  
26 installation, monitoring and inspection of the drilled piers. Schedule this meeting after the  
27 Drilled Pier Contractor mobilizes to the site. If this meeting occurs before all drilled pier  
28 submittals have been accepted, additional preconstruction meetings may be required before  
29 beginning construction of drilled piers without accepted submittals. The Resident or Bridge  
30 Maintenance Engineer, Bridge Construction Engineer, Geotechnical Operations Engineer,  
31 Contractor and Drilled Pier Contractor Superintendent will attend preconstruction  
32 meetings.

33 **411-4 CONSTRUCTION METHODS**

34 Do not excavate holes, install piles or allow equipment loads or vibrations within 20 feet of  
35 completed piers until 16 hours after drilled pier concrete reaches initial set.

36 When drilling from a barge, use a fixed template that maintains hole position and alignment  
37 during drilled pier construction. Do not use floating templates or templates attached to barges.

38 Check for correct drilled pier alignment and location before beginning drilling. Check  
39 plumbness of Kelly bars before beginning and frequently during drilling.

40 For drilled piers constructed with slurry or permanent casings, the pier diameter may be 2 inches  
41 less than the design pier diameter shown in the plans. For all other drilled piers, construct piers  
42 with the minimum required diameters shown in the plans except for portions of drilled piers in  
43 rock with may be 2 inches less than the design pier diameter.

44 Install drilled piers with tip elevations no higher than shown in the plans or approved by the  
45 Engineer. Provide piers with the minimum required tip resistance and, when noted in the plans,  
46 penetration into rock.

## Section 411

### 1 (A) Excavation

2 Excavate holes with equipment of the sizes required to construct drilled piers. Use  
3 equipment and methods accepted in the drilled pier construction plan or approved by the  
4 Engineer. Inform the Engineer of any deviations from the accepted plan.

5 Use drill rigs with sufficient capacity to drill through soil, rock, boulders, timbers, man-  
6 made objects and any other materials encountered and drill 20 feet deeper or 20% longer  
7 than the maximum drilled pier length shown in the plans, whichever is greater. Drilling  
8 below pier tip elevations shown in the plans may be required to attain sufficient resistance.

9 Do not use blasting to advance drilled pier excavations. Blasting for core removal is only  
10 permitted when approved by the Engineer. See Articles 107-11 and 107-12 for protection  
11 of public and private property and control of siltation, dust and air and water pollution from  
12 blasting, drilling and excavating with down-the-hole hammers. Contain and dispose of  
13 drilling spoils and waste concrete as directed and in accordance with Section 802. Drilling  
14 spoils consist of all materials and fluids removed from excavations.

15 Stabilize excavations with only casings or slurry and casings except, as approved by the  
16 Engineer, portions of excavations in rock. Use casings or slurry in rock if unstable material  
17 is anticipated or encountered. Stabilize excavations from beginning of drilling through  
18 concrete placement. If excavations become unstable, the Engineer may suspend drilling  
19 and require a revised drilled pier construction plan. If it becomes necessary to replace a  
20 casing during drilling, backfill the excavation, insert a larger casing around the casing to  
21 be replaced or stabilize the excavation with slurry before removing the casing.

22 When noted in the plans, do not dewater drilled pier excavations. Otherwise, if excavations  
23 are in rock, dewater excavations to the satisfaction of the Engineer.

### 24 (B) Casings

25 Provide temporary casings to stabilize holes and protect personnel entering excavations.  
26 Permanent casings may be required as noted in the plans. Install permanent casings with  
27 tip elevations no deeper than shown in the plans or approved by the Engineer. Additional  
28 drilled pier length and reinforcing steel may be required if permanent casings are installed  
29 below elevations noted in the plans.

30 Install casings in continuous sections. Overlap telescoping casings at least 24 inches.  
31 Remove portions of permanent casings above the ground line or top of piers, whichever is  
32 higher, after placing concrete. Do not cut off permanent casings until Drilled Pier concrete  
33 attains a compressive strength of at least 3,000 psi.

34 When using slurry construction without permanent casings, temporary casings at least  
35 10 feet long are required at top of excavations. Maintain top of casings at least 12 inches  
36 above the ground line.

### 37 (C) Slurry Construction

38 Unless noted otherwise in the plans, slurry construction or polymer slurry is at the  
39 Contractor's option.

40 Use slurry and additives to stabilize holes in accordance with the manufacturer's  
41 recommendations. Provide a technical representative employed by the slurry manufacturer  
42 to assist and guide the Drilled Pier Contractor onsite during the construction of the first  
43 drilled pier. If problems are encountered during drilled pier construction, the Engineer may  
44 require the technical representative to return to the site.

45 Provide documentation that mixing water is suitable for slurry. Use slurry equipment that  
46 is sufficient for mixing, agitating, circulating and storing slurry. Thoroughly premix slurry  
47 with water in tanks before pumping into excavations. Allow bentonite slurry to hydrate at  
48 least 24 hours in tanks before use.

1 Pump slurry into excavations before encountering water. Maintain slurry level at least  
2 5 feet or one pier diameter, whichever is greater, above the highest piezometric head along  
3 the drilled pier length. The highest piezometric head is anticipated to be the static water or  
4 groundwater elevation. However, the Drilled Pier Contractor is responsible for  
5 determining the highest piezometric head for each pier.

6 Maintain the required slurry properties at all times except for sand content. Desand or  
7 replace slurry as needed to meet the required sand content in tanks before pumping slurry  
8 into excavations and in excavations immediately before placing concrete.

9 (1) Time

10 Agitate bentonite slurry in holes at least every 4 hours. If this 4-hour time limit is  
11 exceeded, the Engineer may require holes to be overreamed at least 1 inch and no more  
12 than 3 inches below casings. Overream holes with grooving tools, overreaming  
13 buckets or other approved methods.

14 Construct drilled piers so the maximum time slurry is in contact with uncased portions  
15 of holes from drilling through concrete placement does not exceed 36 hours. If this  
16 36 hour time limit is exceeded, the Engineer may require the hole diameter to be  
17 enlarged at least 6 inches. If the enlarged hole diameter is greater than the permanent  
18 casing diameter, replace casing with a larger permanent casing with an outside  
19 diameter equal to the diameter of the enlarged hole.

20 (2) Slurry Testing

21 Define a "sample set" as slurry samples collected from mid-height and within 2 feet  
22 of the bottom of slurry tanks or holes. Take a sample set from slurry tanks to test  
23 slurry before beginning drilling. Do not pump slurry into excavations until both slurry  
24 samples from tanks meet the required slurry properties. Take sample sets from  
25 excavations to test slurry at least every 4 hours and immediately before placing  
26 concrete. Do not place Drilled Pier concrete until both slurry samples from  
27 an excavation meet the required slurry properties. If any slurry test results do not meet  
28 the requirements, the Engineer may suspend drilling until both samples from a sample  
29 set meet the required slurry properties.

30 Sign, date and submit slurry test reports upon completion of each pier. The  
31 Department reserves the right to perform comparison slurry tests at any time.

32 (3) Disposal

33 Comply with all Federal, State and local regulations, as well as the project permits and  
34 commitments, when disposing of slurry and drilling spoils mixed with slurry. Contain  
35 slurry and drilling spoils and keep out of water at all times.

36 **(D) Cleaning and Inspection**

37 Provide clean holes with level bottoms so elevations within bottom of holes do not vary by  
38 more than 12 inches. Remove soft and loose material from bottom of holes using methods  
39 accepted in the drilled pier construction plan or approved by the Engineer. When bottom  
40 of holes are not hand cleaned, remove sediment from holes with cleanout buckets, air lifts  
41 or pumps.

42 After cleaning is complete, provide all equipment, personnel and assistance required for  
43 the Engineer to visually inspect holes from above or by entering excavations. Remove all  
44 cleaning and drilling equipment from holes during inspections and do not interfere with  
45 inspections.

## Section 411

### 1 (1) Tip Resistance

2 If the Engineer determines that the material below an excavation does not provide the  
3 minimum required tip resistance, increase the drilled pier length and lengthen  
4 reinforcing steel as directed. One of the following methods may be required to check  
5 the conditions and continuity of material below excavations.

#### 6 (a) Test Hole

7 If excavations are in rock, drill a 1.5 inch diameter test hole at least 6 feet below  
8 bottom of holes for the Engineer to determine the continuity of rock below holes.

#### 9 (b) Standard Penetration Test

10 Standard penetration tests (SPT) may be required as noted in the plans. When  
11 required, drive a split-barrel sampler 18 inches below bottom of holes or to refusal  
12 in accordance with ASTM D1586. Perform SPT in holes at least 12 inches away  
13 from casing walls and support drill rods so rods remain vertical and straight.  
14 Report the number of blows applied in each 6 inch increment and provide  
15 recovered samples to the Engineer. The Engineer will determine the standard  
16 penetration resistance required.

### 17 (2) Bottom Cleanliness

18 Holes are clean if at least 50% of bottom of holes has less than 0.5 inch of sediment  
19 and no portions of bottom of holes have more than 1.5 inches of sediment. If bottom  
20 of holes does not meet this cleanliness criteria, remove sediment from holes until the  
21 Engineer determines holes are clean. One or more of the following methods may be  
22 required to inspect the bottom cleanliness of holes.

#### 23 (a) Steel Probe

24 If drilled pier excavations are not dewatered or as directed, provide a #10 rebar  
25 steel probe that is 24 inches long with a flat tip on one end and a non-stretch cable  
26 connected to the other end. Provide a cable long enough to lower the steel probe  
27 to the bottom of holes for the Engineer to determine the amount of sediment in  
28 holes.

#### 29 (b) Shaft Inspection Device

30 The Engineer may use the shaft inspection device (SID) as noted in the plans. The  
31 Engineer provides the SID and personnel to operate it. Notify the Engineer at  
32 least 2 days before finishing holes that will be inspected with the SID.

33 Assist the Engineer in handling the SID and associated equipment and supporting  
34 the SID during inspections. Provide working areas large enough for the SID,  
35 associated equipment and SID personnel within reach of the SID cables and clear  
36 view of holes being inspected. If necessary, provide a secure location to store the  
37 SID and associated equipment onsite overnight.

38 Approximately one hour is required to inspect a hole with the SID after the SID  
39 and associated equipment are set up. The Engineer will use the SID to measure  
40 the amount of sediment at 5 locations around the bottom of holes.

### 41 (E) Reinforcing Steel and Concrete

42 Assemble rebar cages consisting of bar and spiral reinforcing steel shown in the plans.  
43 Securely cross tie reinforcing steel at each intersection with double wire. Attach a chair  
44 under each reinforcing bar and rollers near the top and bottom of rebar cages and every  
45 10 feet along cages in between. The number of rollers required at each location along rebar  
46 cages is one roller per foot of design pier diameter with at least 4 rollers per location. Space  
47 rollers equally around rebar cages at each location. Attach rollers so rollers are supported

1 across 2 adjacent reinforcing bars and will freely rotate when rebar cages are lowered into  
2 excavations.

3 If CSL tubes are required, securely attach CSL tubes to spiral reinforcing steel on the inside  
4 of rebar cages with at least 3 inches of clearance to reinforcing bars. Extend CSL tubes  
5 from 6 inches above pier tip elevations to at least 2 feet above the ground line or top of  
6 permanent casings, whichever is greater. The number of CSL tubes required for each  
7 drilled pier is one tube per foot of design pier diameter with at least 4 tubes per pier. Space  
8 CSL tubes equally around rebar cages so distances between tubes measured around spiral  
9 reinforcing steel are uniform. Install CSL tubes as straight and parallel to each other as  
10 possible. Fit caps on top and bottom of CSL tubes.

11 After the Engineer determines that the material below excavations provides the minimum  
12 required tip resistance and holes are clean, place rebar cages and then concrete in  
13 excavations. Do not rack or distort rebar cages and CSL tubes when lifting and handling  
14 cages. Set rebar cages directly on bottom of holes or, as approved by the Engineer, hang  
15 cages from permanent casings. When hanging rebar cages, leave devices supporting cages  
16 in place until Drilled Pier concrete attains a compressive strength of at least 3,000 psi.

17 Do not delay placing cages or concrete unless excavations are cased to rock or otherwise  
18 approved. If delays occur, the Engineer may require removal of rebar cages to reinspect  
19 bottom cleanliness of holes. If bottom of holes does not meet the cleanliness criteria in  
20 Subarticle 411-4(D)(2), remove sediment from holes until the Engineer determines holes  
21 are clean before resetting rebar cages.

22 After placing rebar cages with CSL tubes, remove top caps, fill tubes with clean water and  
23 reinstall caps before placing concrete. Check for correct cage position before placing  
24 concrete and keep rebar cages plumb during concrete placement. Maintain cage position  
25 so rebar cages do not move vertically more than 6 inches and columns or footings have the  
26 minimum required concrete cover shown in the plans.

27 Remove all temporary casings during concrete placement. Do not twist, move or otherwise  
28 disturb temporary casings until the concrete depth inside casings is at least 10 feet or half  
29 the head, whichever is greater, above the bottom of casing being disturbed. Define "head"  
30 as the difference between the highest piezometric head along the drilled pier length and the  
31 static water elevation inside the excavation.

32 When removing temporary casings, maintain the required concrete depth above the bottom  
33 of casing being removed except when the concrete level is at or above top of piers. Sustain  
34 sufficient concrete depths to overcome pressures imposed by earth, backfill and fluids. As  
35 temporary casings are withdrawn, ensure fluids trapped behind casings is displaced upward  
36 and discharged out of excavations without contaminating or displacing concrete.

37 Pour concrete in excavations to form uniform jointless monolithic drilled piers. Do not  
38 trap soil, air, fluids or other contaminants in concrete. Remove contaminated concrete from  
39 top of piers at time of concrete placement.

40 Inform the Engineer of the volume of concrete placed for each pier. For piers constructed  
41 with slurry or as directed, record a graphical plot of depth versus theoretical and actual  
42 concrete volumes.

43 Dry or wet placement of concrete is at the Contractor's option for piers constructed with  
44 only casings if the water inflow rate into excavations is less than 6 inches per half hour  
45 after removing any pumps from holes. Wet placement of concrete is required for all other  
46 drilled pier construction.

#### 47 (1) Dry Placement

48 If holes are filling with water for dry placement of concrete, dewater excavations as  
49 much as possible before placing concrete. For drilled piers less than 80 feet long, pour  
50 concrete down the center of excavations so concrete does not hit reinforcing steel or



## Section 411

1 excavation sidewalls. For piers longer than 80 feet, place concrete with a tremie or  
2 pump pipe down the center of excavations so length of free fall is less than 80 feet.

### 3 (2) Wet Placement

4 For wet placement of concrete, maintain static water or slurry levels in holes before  
5 placing concrete. Place concrete through steel tremies or pump pipes. Use tremies  
6 with watertight joints and a diameter of at least 10 inches. Pump concrete in  
7 accordance with Article 420-5. Use approved devices to prevent contaminating  
8 concrete when tremies or pump pipes are initially placed in excavations. Extend  
9 tremies or pump pipes into concrete at least 5 feet at all times except when the concrete  
10 is initially placed.

11 When the concrete level reaches the static water elevation inside the excavation, dry  
12 placement of concrete is permitted. Before changing to dry placement, pump water or  
13 slurry out of holes and remove contaminated concrete from the exposed concrete  
14 surface.

## 15 411-5 INTEGRITY TESTING

16 Define “integrity testing” as crosshole sonic logging (CSL) and pile integrity testing (PIT).  
17 Integrity testing may be required as noted in the plans or by the Engineer. The Engineer will  
18 determine how many and which drilled piers require integrity testing. Do not test piers until  
19 Drilled Pier concrete cures for at least 7 days and attains a compressive strength of at least 3,000  
20 psi.

### 21 (A) Crosshole Sonic Logging

22 If CSL testing is required, use a prequalified CSL Consultant to perform CSL testing and  
23 provide CSL reports. Use a CSL Operator approved as a Field Engineer (key person) for  
24 the CSL Consultant. Provide CSL reports sealed by an engineer approved as a Project  
25 Engineer (key person) for the same CSL Consultant.

#### 26 (1) CSL Testing

27 Perform CSL testing in accordance with ASTM D6760. If probes for CSL testing will  
28 not pass through to the bottom of CSL tubes, the Engineer may require coring to  
29 replace inaccessible tubes. Do not begin coring until core hole size and locations are  
30 approved. Core at least 1.5 inches diameter holes the full length of piers. Upon  
31 completion of coring, fill holes with clean water and cover to keep out debris. Perform  
32 CSL testing in core holes instead of inaccessible tubes.

33 For piers with 4 or 5 CSL tubes, test all tube pairs. For piers with 6 or more CSL tubes,  
34 test all adjacent tube pairs around spiral reinforcing steel and at least 50% of remaining  
35 tube pairs selected by the Engineer. Record CSL data at depth intervals of 2.5 inches  
36 or less from the bottom of CSL tubes to top of piers.

#### 37 (2) CSL Reports

38 Submit 2 copies of each CSL report within 7 days of completing CSL testing. Include  
39 the following in CSL reports:

##### 40 (a) Title Sheet

- 41 (i) Department’s TIP number and WBS element number
- 42 (ii) Project description
- 43 (iii) County
- 44 (iv) Bridge station number
- 45 (v) Pier location
- 46 (vi) Personnel
- 47 (vii) Report date

- 1 (b) Introduction
- 2 (c) Site and Subsurface Conditions (including water table elevation)
- 3 (d) Pier Details
- 4 (i) Pier and casing diameters, lengths and elevations
- 5 (ii) Drilled Pier concrete compressive strength
- 6 (iii) Installation methods including use of casings, slurry, pumps, tremies, dry or
- 7 wet placement of concrete, etc.
- 8 (e) CSL Results
- 9 (i) Logs with plots of signal arrival times and energy vs. depth for all tube pairs
- 10 tested
- 11 (f) Summary/Conclusions
- 12 (i) Table of velocity reductions with corresponding locations (tube pair and
- 13 depth) for all tube pairs tested
- 14 (ii) List of suspected anomalies with corresponding locations (tube pair(s) and
- 15 depth range)
- 16 (g) Attachments
- 17 (i) Boring log(s)
- 18 (ii) Field inspection forms and concrete curves (from Engineer)
- 19 (iii) CSL tube locations, elevations, lengths and identifications
- 20 (iv) CSL hardware model and software version information
- 21 (v) PDF copy of all CSL data

22 **(B) Pile Integrity Testing**

23 If required, the Engineer will perform PIT. Provide access to and prepare top of piers for

24 PIT as directed. See ASTM D5882 for PIT details.

25 **(C) Further Investigation**

26 Define “further investigation” as any additional testing, excavation or coring following

27 initial integrity testing. Based on concrete placement and initial integrity testing results,

28 the Engineer will determine if drilled piers are questionable and require further

29 investigation within 7 days of receiving CSL reports or completing PIT. For initial CSL

30 testing, the Engineer will typically determine whether further investigation is required

31 based on Table 411-3.

<b>TABLE 411-3 DRILLED PIER FURTHER INVESTIGATION CRITERIA (For Initial CSL Testing)</b>	
<b>Velocity Reductions</b>	<b>Further Investigation Required?</b>
< 20%	No
20 - 30%	As Determined by the Engineer
> 30%	Yes

32 If further investigation is necessary, the Engineer will typically require one or more of the

33 following methods to investigate questionable piers.

34 (1) CSL Testing

35 If required, use CSL testing as described above to retest questionable piers and as

36 directed, perform testing with probes vertically offset in CSL tubes. CSL offset data

37 will typically be required for all locations (tube pair and depth) with velocity

38 reductions greater than 30% and at other locations as directed. Record offset data at

39 depths, intervals and angles needed to completely delineate anomalies.

## Section 411

1 Provide CSL reports that meet Subarticle 411-5(A)(2). When CSL offset data is  
2 required, perform tomographic analysis and provide 3 dimensional color coded  
3 tomographic images of piers showing locations and sizes of anomalies.

### 4 (2) Excavation

5 If required, excavate around questionable piers and remove permanent casing as  
6 needed to expose Drilled Pier concrete. Do not damage piers when excavating or  
7 removing casings. The Engineer will determine the portions of piers to expose.

### 8 (3) Coring

9 If required, core questionable piers and provide PQ size cores that meet ASTM D2113.  
10 The Engineer will determine the number, location and depth of core holes required.  
11 Handle, log and store concrete cores in accordance with ASTM D5079. Provide cores  
12 to the Engineer for evaluation and testing. Sign, date and submit core logs upon  
13 completion of each core hole.

### 14 (D) Defective Piers

15 For questionable piers that are exposed or cored, the Engineer will determine if piers are  
16 defective based on the results of excavation or coring. For questionable piers that are not  
17 exposed or cored, the Engineer will determine if piers are defective based on the results of  
18 integrity testing. Questionable piers with only CSL testing will be considered defective if  
19 any velocity reductions between any tube pairs are greater than 30%.

## 20 411-6 DRILLED PIER ACCEPTANCE

21 Drilled pier acceptance is based in part on the following criteria:

22 (A) Temporary casings and drilling tools are removed from the drilled pier excavation or the  
23 Engineer determines that a temporary casing may remain in the excavation.

24 (B) Drilled Pier concrete is properly placed and does not have any evidence of segregation,  
25 intrusions, contamination, structural damage or inadequate consolidation (honeycombing).

26 (C) Center of pier is within 3 inches of plan location and 2% of plumb. Top of pier is within  
27 1 inch above and 3 inches below the elevation shown in the plans or approved by the  
28 Engineer.

29 (D) Rebar cage is properly placed and top and center of cage is within tolerances for center of  
30 pier. Tip of permanent casing does not extend below the elevation noted in the plans or  
31 approved by the Engineer.

32 (E) Drilled pier is not defective or the Engineer determines the defective pier is satisfactory.  
33 A pier will be considered defective based on Subarticle 411-5(D).

34 Do not grout CSL tubes or core holes, backfill around a pier or perform any work on a drilled  
35 pier until the Engineer accepts the pier. If the drilled pier is accepted, dewater and grout  
36 CSL tubes and core holes, and backfill around the pier with approved material to finished grade.  
37 If the Engineer determines a pier is unacceptable, remediation is required. Remediation may  
38 include, but is not limited to grouting, removing part or all of unacceptable piers, modifying  
39 pier designs or providing replacement or additional piers or piles. Submit working drawings  
40 and design calculations for acceptance in accordance with Article 105-2. Ensure remediation  
41 submittals are designed, detailed and sealed by an engineer licensed by the State of North  
42 Carolina. Do not begin remediation work until remediation plans are approved. When repairing  
43 unacceptable piers, perform post repair testing to gauge success of the repair. No extension of  
44 completion date or time will be allowed for remediation of unacceptable drilled piers or post  
45 repair testing.

**411-7 MEASUREMENT AND PAYMENT**

\_\_\_\_ *Dia. Drilled Piers in Soil*, \_\_\_\_ *Dia. Drilled Piers Not in Soil* and \_\_\_\_ *Dia. Drill Piers* will be measured and paid in linear feet. Acceptable drilled piers will be measured as the difference between the specified top of pier and pier tip elevations or revised elevations approved by the Engineer.

For bents with a not in soil pay item shown in the plans, drilled piers will be paid as \_\_\_\_ *Dia. Drilled Piers in Soil* and \_\_\_\_ *Dia. Drilled Piers Not in Soil*. Define “not in soil” as material with a rock auger penetration rate of less than 2 inches per 5 minutes of drilling at full crowd force. When not in soil is encountered, seams, voids and weathered rock less than 3 feet thick with a rock auger penetration rate of greater than 2 inches per 5 minutes of drilling at full crowd force will be paid at the contract unit price for \_\_\_\_ *Dia. Drilled Piers Not in Soil*. Seams, voids and weathered rock greater than 3 feet thick will be paid at the contract unit price for \_\_\_\_ *Dia. Drilled Piers in Soil* where not in soil is no longer encountered. For bents with a not in soil pay item shown in the plans, drilled piers through air or water will be paid at the contract unit price for \_\_\_\_ *Dia. Drilled Piers in Soil*.

For bents without a not in soil pay item shown in the plans, drilled piers will be paid as \_\_\_\_ *Dia. Drill Piers*. The contract unit price for \_\_\_\_ *Dia. Drilled Piers* will be full compensation for drilling through any materials encountered.

The contract unit prices for \_\_\_\_ *Dia. Drilled Piers in Soil*, \_\_\_\_ *Dia. Drilled Piers Not in Soil* and \_\_\_\_ *Dia. Drill Piers* will also be full compensation for spoils and slurry containment and disposal, slurry construction including a slurry manufacturer representative and overreaming and enlarging piers and any concrete removal, miscellaneous grading and excavation. No additional payment will be made for excess Drilled Pier concrete due to caving or sloughing holes or telescoping casings.

Reinforcing steel will be measured and paid in accordance with Article 425-6.

*Permanent Steel Casing for \_\_\_\_ Dia. Drilled Pier* will be measured and paid in linear feet. Permanent casings will only be paid for when required by the Engineer or shown in the plans. Permanent casings will be measured as the difference between the ground line or specified top of pier elevation, whichever is higher, and the specified permanent casing tip elevation or revised elevation approved by the Engineer. If a permanent casing cannot be installed to the tip elevation shown in the plans, up to 3 feet of casing cut-off will be paid at the contract unit price for *Permanent Steel Casing for \_\_\_\_ Dia. Drilled Pier*.

*SID Inspections* will be measured and paid in units of each. *SID Inspections* will be measured as one per pier. The contract unit price for *SID Inspections* will be full compensation for inspecting holes with the SID the first time. No additional payment will be made for subsequent inspections of the same hole.

The Contractor is responsible for any damage to the SID equipment due to the Contractor’s fault or negligence. Replace any damaged equipment at no additional cost to the Department.

*SPT Testing* will be measured and paid in units of each. *SPT Testing* will be measured as the number of standard penetration tests performed except no payment will be made for *SPT Testing* to determine if temporary casing is necessary.

*CSL Testing* will be measured and paid in units of each. *CSL Testing* will be measured as one per pier. The contract unit price for *CSL Testing* will be full compensation for performing initial CSL testing and providing CSL reports. Subsequent CSL testing of and CSL reports for the same pier will be considered further investigation. No separate payment will be made for CSL tubes. CSL tubes including coring for inaccessible tubes and grouting will be incidental to the contract unit prices for drilled piers.

No payment will be made for stuck temporary casings that cannot be removed from drilled pier excavations or additional drilled pier length and reinforcing steel required due to temporary casings that remain in excavations. No payment will be made for PIT. No payment will be

## Section 412

1 made for further investigation of defective piers. Further investigation of piers that are not  
2 defective will be paid as extra work in accordance with Article 104-7. No payment will be  
3 made for remediation of unacceptable drilled piers or post repair testing.

4 Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
____ Dia. Drilled Piers in Soil	Linear Foot
____ Dia. Drilled Piers Not in Soil	Linear Foot
____ Dia. Drilled Piers	Linear Foot
Permanent Steel Casing for ____ Dia. Drilled Piers	Linear Foot
SID Inspections	Each
SPT Testing	Each
CSL Testing	Each

## SECTION 412

### UNCLASSIFIED STRUCTURE EXCAVATION

#### 412-1 DESCRIPTION

8 Excavate any material not classified as foundation excavation, box culvert excavation or  
9 channel excavation whose removal is required for the construction of bridges, retaining walls  
10 of reinforced concrete or reinforced masonry, arch culverts and box culverts without floor slabs,  
11 and which is classified as unclassified structure excavation in the plans, in accordance with the  
12 contract or as directed. Excavate, blast, brace, shore, provide sheeting and cribbing, backfill,  
13 haul and dispose of materials.

14 Do not deposit excavated materials, nor construct earth dikes or other temporary earth  
15 structures, in rivers, streams or impoundment or so near to such waters that they are carried into  
16 any river, stream or impoundment by stream flow or surface runoff.

17 Dispose of all timber, stumps and debris in accordance with Article 200-6.

#### 412-2 PRESERVATION OF CHANNEL

19 Unless otherwise required by the contract, do not excavate in stream channels. Do not disturb  
20 the natural stream bed adjacent to the structure without permission.

21 Do not place material in a stream without approval. Remove materials placed within the stream  
22 area and leave the stream in its original condition, unless otherwise permitted.

#### 412-3 UTILIZATION OF EXCAVATED MATERIAL

24 Use and place suitable excavated material in accordance with Articles 410-7 and 410-8.

25 Notify the Engineer a sufficient time before beginning the excavation so measurements may be  
26 taken of the undisturbed ground.

#### 412-4 MEASUREMENT AND PAYMENT

28 The price and payment below will be full compensation for all items required to complete  
29 unclassified structure excavation including, but not limited to, those items contained in  
30 Article 412-1.

31 *Unclassified Structure Excavation at Station \_\_\_\_* will be paid at the contract lump sum price.

32 Payment will be made under:

<b>Pay Item</b>	<b>Pay Unit</b>
Unclassified Structure Excavation at Station ____	Lump Sum