

**SECTION 411  
DRILLED PIERS**

**411-1 DESCRIPTION**

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

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

**411-2 MATERIALS**

Refer to Division 10.

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

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

**(A) Steel Casing**

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

**(1) Temporary Casings**

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

**(2) Permanent Casings**

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

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

1 Provide permanent casings with an outside diameter equal to the design pier diameter  
2 for which permanent casing is used unless larger diameter permanent casings are  
3 approved by the Engineer.

#### 4 (B) Slurry

5 Define "slurry" as bentonite or polymer slurry. Mix bentonite clay or synthetic polymer  
6 with water to make bentonite or polymer slurry.

##### 7 (1) Bentonite Slurry

8 Provide bentonite slurry that meets Table 411-2.

TABLE 411-2 BENTONITE SLURRY REQUIREMENTS <sup>A</sup>		
Property	ANSI/API RP <sup>B</sup> 13B-1	Requirement
Density <sup>C</sup> (Mud Weight)	Section 4 Mud Balance	64.3 - 72.0 pcf
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

9 **A.** Slurry temperature of at least 40°F required.

10 **B.** American National Standards Institute/American Petroleum Institute  
11 Recommended Practice,

12 **C.** Increase density requirements by 2 pcf in saltwater,

13 **D.** In tanks before pumping slurry into excavations,

14 **E.** In excavations immediately before placing concrete,

15 **F.** pH paper is also acceptable for measuring pH,

##### 16 (2) Polymer Slurry

17 Use polymer slurry products qualified by the Department. Provide polymer slurry  
18 with density, viscosity, sand content and pH properties that meet the product  
19 requirements. The polymer slurry QPL with the property requirements for each  
20 qualified polymer slurry product is available on the Geotechnical Engineering Unit's  
21 website.

#### 22 (C) Rollers and Chairs

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

#### 28 (D) Steel Pipes and Caps

29 Use Schedule 40 black steel pipes for access tubes for crosshole sonic logging (CSL).  
30 Provide CSL tubes with an inside diameter of at least 1.5 inches. Use CSL tubes with a  
31 round, regular inside diameter free of defects and obstructions, including any pipe joints,

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1 in order to permit free, unobstructed passage of probes for CSL testing. Provide watertight  
2 CSL tubes free of corrosion with clean internal and external faces to ensure a good bond  
3 between concrete and tubes. Fit CSL tubes with watertight plastic caps on the bottom and  
4 removable caps on top.

### 5 **411-3 PRECONSTRUCTION REQUIREMENTS**

#### 6 **(A) Drilled Pier Construction Plan**

7 Submit the proposed drilled pier construction plan for all drilled piers for acceptance by  
8 the Engineer. Provide an electronic copy of this plan at least 30 days before starting drilled  
9 pier construction. Do not begin drilled pier construction until a construction plan is  
10 accepted by the Engineer. Provide detailed project specific information in the drilled pier  
11 construction plan that includes the following:

- 12 (1) Overall description and sequence of drilled pier construction;
- 13 (2) List and sizes of equipment including cranes, drill rigs, vibratory and downhole  
14 hammers, Kelly bars, augers, core barrels, casings (diameters, thicknesses and  
15 lengths), cleanout buckets, air lifts, pumps, slurry equipment, tremies, pump pipes and  
16 other equipment;
- 17 (3) Procedures for casing installation and temporary casing removal including how  
18 telescoping temporary casings will be removed;
- 19 (4) If applicable, details of slurry testing and use including intended purpose, product  
20 information and additives, manufacturer's recommendations for use, name and contact  
21 information for slurry manufacturer's technical representative, mixing and handling  
22 procedures and how slurry level will be maintained above the highest piezometric  
23 head;
- 24 (5) Methods for drilling and cleaning holes including how cores will be removed and  
25 drilling spoils and slurry will be handled and disposed of;
- 26 (6) Details of CSL tubes, caps and joints including pipe size and how tubes will be  
27 attached to reinforcing steel;
- 28 (7) Procedures for lifting and setting reinforcing steel including how rebar cages will be  
29 supported and centralized;
- 30 (8) Procedures for placing concrete including how tremies and pump pipes will be  
31 controlled and contaminated concrete will be contained;
- 32 (9) Concrete mix design that meets Section 1000;
- 33 (10) Approved packaged grout or grout mix design that meets Section 1003;
- 34 (11) CSL Consultant including Field and Project Engineer; and
- 35 (12) Other information shown in the plans or requested by the Engineer.

36 If alternate construction procedures are proposed or necessary, a revised drilled pier  
37 construction plan submittal may be required. If the work deviates from the accepted  
38 submittal without prior approval, the Engineer may suspend drilled pier construction until  
39 a revised plan is accepted by the Engineer.

#### 40 **(B) Preconstruction Meeting**

41 Before starting drilled pier construction, hold a preconstruction meeting to discuss the  
42 installation, monitoring and inspection of the drilled piers. Schedule this meeting with the  
43 Engineer after the Drilled Pier Contractor mobilizes to the site. If this meeting occurs  
44 before all drilled pier submittals have been accepted, additional preconstruction meetings  
45 may be required before beginning construction of drilled piers without accepted submittals.

1 The Prime Contractor and Drilled Pier Contractor Superintendent shall attend  
2 preconstruction meetings.

### 3 **411-4 CONSTRUCTION METHODS**

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

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

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

10 For drilled piers constructed with slurry or permanent casings, the pier diameter may be 2 inches  
11 less than the design pier diameter shown in the plans. For all other drilled piers, construct piers  
12 with the minimum required diameters shown in the plans except for portions of drilled piers in  
13 rock which may be 2 inches less than the design pier diameter.

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

#### 17 **(A) Excavation**

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

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

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

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

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

#### 40 **(B) Casings**

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

46 Install casings in continuous sections. Overlap telescoping casings at least 24 inches.  
47 Remove portions of permanent casings above the ground line or top of piers, whichever is

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1 higher, after placing concrete. Do not cut off permanent casings until Drilled Pier concrete  
2 attains a compressive strength of at least 3,000 psi.

3 When using slurry construction without permanent casings, temporary casings at least  
4 10 feet long are required at top of excavations. Maintain top of casings at least 12 inches  
5 above the ground line.

### 6 (C) Slurry Construction

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

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

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

18 Pump slurry into excavations before encountering water. Maintain slurry level at least  
19 5 feet or one pier diameter, whichever is greater, above the highest piezometric head along  
20 the drilled pier length. The highest piezometric head is anticipated to be the static water or  
21 groundwater elevation. However, the Drilled Pier Contractor is responsible for  
22 determining the highest piezometric head for each pier.

23 Maintain the required slurry properties at all times. Desand or replace slurry as needed to  
24 meet the required sand content in tanks before pumping slurry into excavations and in  
25 excavations immediately before placing concrete.

#### 26 (1) Time

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

31 Construct drilled piers so the maximum time slurry is in contact with uncased portions  
32 of holes from drilling through concrete placement does not exceed 36 hours. If this  
33 36 hour time limit is exceeded, the Engineer may require the hole diameter to be  
34 enlarged at least 6 inches. If the enlarged hole diameter is greater than the permanent  
35 casing diameter, replace casing with a larger permanent casing with an outside  
36 diameter equal to the diameter of the enlarged hole.

#### 37 (2) Slurry Testing

38 Define a "sample set" as slurry samples collected from mid-height and within 2 feet  
39 of the bottom of slurry tanks or holes. Take a sample set from slurry tanks to test  
40 slurry before beginning drilling. Do not pump slurry into excavations until both slurry  
41 samples from tanks meet the required slurry properties. Take sample sets from  
42 excavations to test slurry at least every 4 hours and immediately before placing  
43 concrete. Do not place Drilled Pier concrete until both slurry samples from  
44 an excavation meet the required slurry properties. If any slurry test results do not meet  
45 the requirements, the Engineer may suspend drilling until both samples from a sample  
46 set meet the required slurry properties.

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

1 (3) Disposal

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

5 **(D) Cleaning and Inspection**

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

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

15 (1) Tip Resistance

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

20 (a) Test Hole

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

23 (b) Standard Penetration Test

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

31 (2) Bottom Cleanliness

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

37 (a) Steel Probe

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

43 (b) Shaft Inspection Device

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

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

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

### 9 **(E) Reinforcing Steel and Concrete**

10 Assemble rebar cages consisting of bar and spiral reinforcing steel shown in the plans.  
11 Securely cross tie reinforcing steel at each intersection with double wire. Attach a chair  
12 under each reinforcing bar and rollers near the top and bottom of rebar cages and every  
13 10 feet along cages in between. The number of rollers required at each location along rebar  
14 cages is one roller per foot of design pier diameter with at least 4 rollers per location. Space  
15 rollers equally around rebar cages at each location. Attach rollers so rollers are supported  
16 across 2 adjacent reinforcing bars and will freely rotate when rebar cages are lowered into  
17 excavations.

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

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

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

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

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

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

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

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

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

#### 11 (1) Dry Placement

12 If holes are filling with water for dry placement of concrete, dewater excavations as  
 13 much as possible before placing concrete. For drilled piers less than 80 feet long, pour  
 14 concrete down the center of excavations so concrete does not hit reinforcing steel or  
 15 excavation sidewalls. For piers longer than 80 feet, place concrete with a tremie or  
 16 pump pipe down the center of excavations so length of free fall is less than 80 feet.

#### 17 (2) Wet Placement

18 For wet placement of concrete, maintain static water or slurry levels in holes before  
 19 placing concrete. Place concrete through steel tremies or pump pipes. Use tremies  
 20 with watertight joints and a diameter of at least 10 inches. Pump concrete in  
 21 accordance with Article 420-5. Use approved devices to prevent contaminating  
 22 concrete when tremies or pump pipes are initially placed in excavations. Keep tremies  
 23 or pump pipes embedded into concrete at least 5 feet at all times except when the  
 24 concrete is initially placed.

25 When the concrete level reaches the static water elevation inside the excavation, dry  
 26 placement of concrete is permitted. Before changing to dry placement, pump water or  
 27 slurry out of holes and remove contaminated concrete from the exposed concrete  
 28 surface.

### 29 **411-5 INTEGRITY TESTING**

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

#### 35 **(A) Crosshole Sonic Logging**

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

#### 40 (1) CSL Testing

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

47 For piers with 4 or 5 CSL tubes, test all tube pairs. For piers with 6 or more CSL tubes,  
 48 test all adjacent tube pairs around spiral reinforcing steel and at least 50% of remaining



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1 tube pairs selected by the Engineer. Record CSL data at depth intervals of 2.5 inches  
2 or less from the bottom of CSL tubes to top of piers.

### 3 (2) CSL Reports

4 Submit each CSL report within 7 days of completing CSL testing. Include the  
5 following in CSL reports:

#### 6 (a) Title Sheet

7 (i) Department's TIP number and WBS element number

8 (ii) Project description

9 (iii) County

10 (iv) Bridge station number

11 (v) Pier location

12 (vi) Personnel

13 (vii) Report date

#### 14 (b) Introduction

#### 15 (c) Site and Subsurface Conditions (including water table elevation)

#### 16 (d) Pier Details

17 (i) Pier and casing diameters, lengths and elevations

18 (ii) Drilled Pier concrete compressive strength

19 (iii) Installation methods including use of casings, slurry, pumps, tremies, dry or  
20 wet placement of concrete, etc.

#### 21 (e) CSL Results

22 (i) Logs with plots of signal arrival times and energy vs. depth for all tube pairs  
23 tested

#### 24 (f) Summary/Conclusions

25 (i) Table of velocity reductions with corresponding locations (tube pair and  
26 depth) for all tube pairs tested

27 (ii) List of suspected anomalies with corresponding locations (tube pair(s) and  
28 depth range)

#### 29 (g) Attachments

30 (i) Boring log(s)

31 (ii) Field inspection forms and concrete curves (from Engineer)

32 (iii) CSL tube locations, elevations, lengths and identifications

33 (iv) CSL hardware model and software version information

34 (v) PDF copy of all CSL data

### 35 (B) Pile Integrity Testing

36 If required, the Engineer will perform PIT. Provide access to and prepare top of piers for  
37 PIT as directed by the Engineer. See ASTM D5882 for PIT details.

### 38 (C) Further Investigation

39 Define "further investigation" as any additional testing, excavation or coring following  
40 initial integrity testing. Based on concrete placement and initial integrity testing results,  
41 the Engineer will determine if drilled piers are questionable and require further  
42 investigation within 7 days of receiving CSL reports or completing PIT. For initial CSL  
43 testing, the Engineer will typically determine whether further investigation is required  
44 based on Table 411-3.

**TABLE 411-3  
DRILLED PIER FURTHER INVESTIGATION CRITERIA  
(For Initial CSL Testing)**

Velocity Reductions	Further Investigation Required?
< 20%	No
20 - 30%	As Determined by the Engineer
> 30%	Yes

If further investigation is necessary, the Engineer will typically require one or more of the following methods to investigate questionable piers.

(1) CSL Testing

If required, use CSL testing as described above to retest questionable piers and as directed by the Engineer, perform testing with probes vertically offset in CSL tubes. CSL offset data will typically be required for all locations (tube pair and depth) with velocity reductions greater than 30% and at other locations as directed by the Engineer. Record offset data at depths, intervals and angles needed to completely delineate anomalies.

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

(2) Excavation

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

(3) Coring

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

**(D) Defective Piers**

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

**411-6 DRILLED PIER ACCEPTANCE**

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

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

**(B)** Drilled Pier concrete is properly placed and does not have any evidence of segregation, intrusions, contamination, structural damage or inadequate consolidation (honeycombing) and meets compressive strength required in Table 1000-1.

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

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

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

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

### 18 411-7 MEASUREMENT AND PAYMENT

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

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

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

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

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

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

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

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

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

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

16 No payment will be made for stuck temporary casings that cannot be removed from drilled pier  
 17 excavations or additional drilled pier length and reinforcing steel required due to temporary  
 18 casings that remain in excavations. No payment will be made for PIT. No payment will be  
 19 made for further investigation of defective piers. Further investigation of piers that are not  
 20 defective will be paid as extra work in accordance with Article 104-7. No payment will be  
 21 made for remediation of unacceptable drilled piers or post repair testing.

22 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

23 **SECTION 412**  
 24 **UNCLASSIFIED STRUCTURE EXCAVATION**

25 **412-1 DESCRIPTION**

26 Excavate any material not classified as foundation excavation, box culvert excavation or  
 27 channel excavation whose removal is required for the construction of bridges, retaining walls  
 28 of reinforced concrete or reinforced masonry, arch culverts and box culverts without floor slabs,  
 29 and which is classified as unclassified structure excavation in the plans, in accordance with the  
 30 contract or as directed by the Engineer. Excavate, blast, brace, shore, provide sheeting and  
 31 cribbing, backfill, haul and dispose of materials.

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

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

36 **412-2 PRESERVATION OF CHANNEL**

37 Unless otherwise required by the contract, do not excavate in stream channels. Do not disturb  
 38 the natural streambed adjacent to the structure without permission from the Engineer.