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Section 19-11. Use for compaction grouting.

There are two options for compaction grouting.

Option 1 – The Department lays out the grout holes and delineates treatment zones on the plans.

Include paragraph 8, which allows the contractor to submit alternative compaction grouting plan and method. The pay items' quantities are the total length of grout holes and the volume of grout.

For Option 1, use bid items:

19xxxxA - Compaction Grouting Hole

19xxxxA - Grout (Compaction Grouting)

Option 2 – The Contractor lays out the grout holes, spacing and pattern; the plans show the area and upper and lower elevations of the treatment zone. Delete paragraph 8. The pay item quantity is the volume of the treatment zone.

For Option 2, use bid item 19xxxxA - Compaction Grouting

Replace section 19-11 with:

19-11 COMPACTION GROUTING

## 19-11.01 GENERAL

### 19-11.01A Summary

1

Section 19-11 includes specifications for performing compaction grouting to densify subsurface materials in the delineated treatment zones.

### 19-11.01B Definitions

2

**treatment zone:** Space bounded by the upper and lower surface limits of the delineated treatment zone.

### 19-11.01C Submittals

#### 19-11.01C(1) General

3

Not Used

#### 19-11.01C(2) Contractor Qualifications

4

Submit:

1. Summary of the Contractor's experience that demonstrates compliance with section 19-11.01D(2)

2. List of at least 3 projects completed in the last 3 years that demonstrate the compaction grouting subcontractor's ability to perform compaction grouting with similar conditions to this job. For each project include:

2.1. Project description

2.2. Name, email address, and phone number of the owner

2.3. Project completion date

3. List of at least 2 personnel who will perform the work. Each personnel must have completed at least 3 compaction grouting projects in the last 3 years that are similar to this job. For each personnel include:

3.1. Project list and description

3.2. Name, email address, and phone number of the owner

3.3. Project completion date

#### 19-11.01C(3) Shop Drawings

##### 19-11.01C(3)(a) General

5

Submit 5 copies of shop drawings. After review, submit from 6 to 12 copies, as requested, for authorization and use during construction.

6

Shop drawings and calculations must be stamped and signed by an engineer who is registered as a civil engineer in the State.

7

Shop drawings must include:

1. Your name, address, telephone number, and email address.

2. Plans showing the proposed layout of grout injection holes, hole diameter, and depth. Show perimeter, primary, and secondary grout injection holes. Layout the primary and secondary holes using split-spacing method. Layout the secondary holes midway between the primary holes.

3. Proposed construction method and sequence that will densify the subsurface materials and achieve the minimum requirements of densification criteria based on cone penetration test (CPT).

4. Grout mix design and test procedures, including material specifications, grain size distribution, plasticity index, and hydrometer test results of the aggregate.

5. Description of drilling methods and equipment.

6. Description of grouting methods and equipment, including mixers, grout pumps, delivery lines, and appurtenances. Provide the make, model, year, and general condition of each item.

7. Description of the casing and casing withdrawal system.

8. Methods and equipment for calibrating, measuring, and recording the proportioning of the grout constituents.

9. Methods and equipment for calibrating, measuring, and recording grout quantity pumped, pumping pressure, and pumping rate.

10. Certified calibration chart for each pump and pressure gauge.

11. Description of grout injection operations.

12. Samples of drilling and grouting logs.

8. Delete when Option 2 is used. The plans must not show the layout of the grout holes.

You may submit an alternative compaction grouting plan and method for densifying subsurface materials of the treatment zone to specified requirements.

##### 19-11.01C(3)(b) Displacement Monitoring Plan

9

Displacement monitoring plan must include:

1. Description and layout of monitoring instruments that monitor displacement of the ground surface and structures within a 30 feet distance from any hole being grouted.

2. Description of and manufacturer's product data for instruments for monitoring displacement of pavement, ground surface, adjacent structures, storm drains, and utility conduits during compaction grouting.

3. Method and schedule to monitor and record data.

4. Sample forms of monitoring logs.

#### 19-11.01C(4) Compaction Grouting Records

10

Submit daily compaction grouting record in electronic and hardcopy format before the start of work the following day, for holes completed the previous day. The record must include the following for each hole:

1. Hole identification and location

2. Date and time the hole was drilled

3. Hole diameter

4. Elevation at the top and bottom of the hole

5. Date and time when grouting of the hole started and ended

6. Grout pressure measured at the top of casing and at the pump

7. Volume of grout pumped per linear foot of each hole

8. Unusual conditions encountered

9. Displacement monitoring records that identify location and magnitude of any uplift or displacement of pavement, ground surface, adjacent structures, storm drains, and utility conduits during compaction grouting

#### 19-11.01C(5) Test Results

11

Submit CPT results in electronic and hardcopy format within 24 hours of test completion. Data in the electronic format must be in comma-separated or tab-separated values format.

#### 19-11.01C(6) Supplemental Shop Drawings

12

For subsurface materials in the treated zone that do not meet the acceptance criteria, submit supplemental shop drawings that show limits of the failed zones and revised construction method.

### 19-11.01D Quality Assurance

#### 19-11.01D(1) General

13

Not Used

#### 19-11.01D(2) Contractor Qualifications

14

The contractor must have:

1. Experience performing compaction grouting

2. Successfully completed at least 3 compaction grouting projects in the past 3 years

3. At least 2 personnel, full-time on site, who each have completed at least 3 compaction grouting projects in the past 3 years

#### 19-11.01D(3) Quality Control

15

The displacement monitoring instruments must be accurate to ±0.05 inch.

#### 19-11.01D(4) Department Acceptance

##### 19-11.01D(4)(a) General

16

Perform verification and proof tests using CPT to verify the compacted density of the subsurface materials within the treatment zone.

17

Provide CPT equipment that can penetrate the soil to the required maximum compaction grouting depth. Measure cone tip resistance (qc), sleeve friction (fs), and pore water pressure (u), at 2-inch depth increments. Perform CPT under ASTM D5778.

##### 19-11.01D(4)(b) Verification Testing

18. Verification test area must be provided by Geotechnical Services and must be shown on the plans.

Perform verification test at locations shown and as follows:

1. At each verification test area, perform 2 CPT soundings.

2. Perform compaction grouting in the verification test area using the proposed construction method and equipment described in the shop drawings.

3. After compaction grouting in the verification test area, perform 3 CPT soundings at the center of a grout-hole pattern and at locations determined by the Engineer.

19

Perform verification test in the Engineer's presence.

20

Verification tests that fail to comply with the acceptance criteria are rejected. Submit revised shop drawings.

21

Perform additional verification compaction grouting in the area selected by the Engineer. Perform additional verification tests until the verification tests demonstrate the revised compaction grouting layout and construction method can densify the subsurface materials to the density that meets the acceptance criteria.

##### 19-11.01D(4)(c) Proof Test

22

Perform one proof test per 800 square feet of treatment area. Perform proof test at the center of a grout-hole pattern and at locations determined by the Engineer. Perform proof test in the Engineer's presence.

23

Densification of subsurface materials by compaction grouting must be represented by proof tests within a designated treatment zone.

24

Subsurface materials represented by proof tests that fail to comply with the acceptance criteria, are rejected.

##### 19-11.01D(4)(d) Acceptance Criteria

###### 19-11.01D(4)(d)(i) General

25

Not Used

###### 19-11.01D(4)(d)(ii) Density of Treatment Zone

26. Refer to Geotechnical Report for the minimum (default at 80 ksf) and average (default at 100 ksf) corrected cone tip resistances.

The subsurface materials in the treatment zones tested by CPT soundings must have:

1. Minimum corrected cone tip resistance values greater than 80 ksf

2. Average corrected cone tip resistance greater than 100 ksf for each 12-inch-depth interval

27

If the CPT sounding encounters refusal above the bottom of the compaction grouting treatment zone, perform additional CPT sounding at a location selected by the Engineer.

28

If CPT soundings indicate that the density of the subsurface materials in the treatment zone has not met the acceptance criteria, perform at least 4 additional CPT soundings to determine the limits of the failed zones.

29

Perform additional compaction grouting in the failed zone under supplemental shop drawings. Perform 2 additional proof tests per failed zone if the area of the failed zone is less than 800 square feet.

###### 19-11.01D(4)(d)(iii) Pavement Grade

30

Pavement grade must be within 0.1 inch of original grade.

## 19-11.02 MATERIALS

### 19-11.02A General

31

Not Used

### 19-11.02B Grout

32

Grout must comply with section 49-3.02B(5). The aggregate must have less than 5 percent passing no. 200 sieve. The portion of aggregate passing no. 40 sieve must have a plasticity index less than 15 under ASTM D4318.

33

Do not use additives such as pumping aids, gums, gelling agents, high-plasticity clay, organic matter, or similar materials.

34

The slump must be less than 1.5 inches under ASTM C143.

## 19-11.03 CONSTRUCTION

### 19-11.03A General

35

Start construction activities after acceptance of verification test results.

36

Perform compaction grouting in the treatment areas and to the depths shown.

37

Survey and mark on the ground the exterior limits of all underground facilities, including conduits, irrigation systems, and storm drains shown and within 10 feet from the limits of the treatment zone.

38

Perform compaction grouting in the following sequence:

1. Perimeter holes

2. Primary holes on or near downslope of the treatment zone, or near a retaining wall or structure foundation

3. Remaining primary holes

4. Secondary holes

39

Do not perform grouting at any hole within 12 feet of a hole grouted within the previous 12 hours.

40

Water or grout from compaction grouting must not:

1. Fall on traffic

2. Flow across shoulders or lanes occupied by traffic

3. Flow into landscaping, gutters, or other drainage facilities

4. Be left on the surface of the pavement or embankment

### 19-11.03B Equipment

#### 19-11.03B(1) General

41

Not Used

#### 19-11.03B(2) Drilling Equipment

42

Drilling equipment must produce straight, clean holes. Drilling equipment must be capable of advancing the grout holes to the required depth through the existing soil and rock materials and buried man-made objects.

43

Drilling equipment must be capable of coring through concrete and asphalt concrete pavement for compaction grouting on paved surfaces.

#### 19-11.03B(3) Mixer

44

Grout mixer must be an automatic, volumetric, proportioning, and mixing system complying with ASTM C885. The mixing system must be capable of continuously proportioning and mixing the grout in sufficient quantity without interruption. The mixing system must be calibrated in the presence of the Engineer before grout injection.

#### 19-11.03B(4) Pump

45

Use a positive displacement piston pump with a piston no more than 4 inches in diameter. The pump must have the capacity to pump grout from 0.2 to 2 cubic feet per minute at continuous pressure up to 1,500 psi. Short-stroking of the pump is not allowed.

46

Pumping system must be equipped and calibrated to continuously measure, display, and electronically record volume of grout pumped and grout pressure measured at the top of grout casing and at the grout pump. Calibrate the grout volume measuring system each day of pumping at the beginning of work. Pressure range of the pressure gauges must be less than 150 percent of the anticipated maximum grout pressure.

#### 19-11.03B(5) Grout Delivery Line and Casing

47

Grout delivery line must be watertight and no more than 2 inches in diameter.

48

Grout casing must be from 1-3/4 to 3 inches in diameter. Grout casing must have flush joints on the interior and exterior surfaces.

### 19-11.03C Establishing Grout Holes

49

Core highway pavement within 1 day before beginning of compaction grouting. Do not keep the drilled holes open whenever the National Weather Service predicts at least a 50 percent probability of precipitation within the following 24 hours.

50

Drill grout holes and install grout casing to the specified depth of grouting. The casing must be in tight, intimate contact with the surrounding soil of the resulting hole so that it is firmly held in place and resistant to ejection from the grout pressure or leakage of grout around the perimeter.

51

Confirm depth of the grout hole before connecting the grout delivery line.

### 19-11.03D Grouting

52

Perform grouting of a hole in one continuous operation. If grouting is terminated for any reason before the full depth is grouted, that grout column is rejected.

53

Perform grouting in ascending stages starting from the bottom. Individual stage length must be from 1 to 2 feet.

54

Maintain grout injection rate between 0.5 and 2.0 cubic feet per minute, with the average injection rate less than 1.5 cubic feet per minute for each hole. Injection rate must not be greater than 2.0 cubic feet per minute at any time.

55

If a grouting stage is within 10 feet of a pipe, culvert, or tunnel, grout pressure must be less than 250 psi.

56

Terminate a compaction grouting stage when:

1. Pumping at a pressure of 1,000 psi or more measured at the casing top for a period of 3 minutes

2. Sustained pumping at a pressure of 500 psi or greater measured at the casing top

3. Displacement of adjacent structure is greater than 0.1 inch, or pavement heave occurs

### 19-11.03E Finishing

57

After grouting, remove grout from drilled holes to at least 4 inches below the pavement surface. Clean the holes and fill with mortar. Mortar must be a prepackaged fast-setting mortar that complies with ASTM C928. Finish filled holes flush with the pavement surface.

58

If the pavement elevation is higher than the original grade by more than 0.1 inch but equal to or less than 1 inch or 25 percent of the pavement thickness, whichever is less, grind the noncompliant concrete pavement surface under section 42-3 and asphalt concrete pavement surface under 39-2.01C(16) to within 0.1 inch of original grade.

59

If the pavement elevation is higher than the original grade by more than 1 inch or 25 percent of the pavement thickness, whichever is less, remove and replace the noncompliant concrete pavement slabs under section 41-9 and the noncompliant asphalt concrete pavement under section 39-3.02.

### 19-11.03F Displacement Monitoring

60

Provide dedicated personnel to monitor the instruments during construction to prevent damage to the site, pavement, and structures.

## 19-11.04 PAYMENT

61-62. Use for Option 1. Delete paragraph 63.

The payment quantity for compaction grouting hole is the length of drilled grout hole and installed grout casing measured end to end. Payment for the grout used to construct the compaction grouting is not included in the payment for compaction grouting hole.

62

The payment quantity for grout (compaction grouting) is the volume of the grout.

63. Use for Option 2. Delete paragraphs 61 and 62.

The payment quantity for compaction grouting is the volume of the treatment zone shown.