**NOTICE TO USERS**

Borings are necessary to estimate *Compaction Grouting* and *Grout Pipe* pay item quantities as well as the number and depths of holes. For assistance with arranging a subsurface investigation and determining grouting requirements, contact Mike Holmes, Grouting Supervisor with the NCDOT Geotechnical Engineering Unit at (919) 906-9900 or by email at mrholmes@ncdot.gov.

**COMPACTION GROUTING: (1-16-18)**

**Description**

Compaction grouting is a ground improvement method that consists of injecting low mobility grout into the ground to displace and compact the surrounding soil without permeating or fracturing the soil. Grout is pumped through steel sectional casings, i.e., “grout pipes” installed to required depths. As grout pipes are withdrawn, columns of grout “bulbs” are formed below the ground surface. Compaction grouting is required to stabilize subgrades and embankments and prevent future subsidence at locations shown in the plans or as directed. Use a prequalified Subsurface Grouting Contractor to perform compaction grouting.

If a minimum grout replacement ratio is shown in the plans, inject enough grout to achieve this replacement ratio which is defined as the ratio of the injected grout volume to the volume of treated soils. Depending on the compaction grouting results in the field, the Engineer may adjust the grouting requirements shown in the plans which could include more or less holes, revised hole grouting sequence or different hole depths or locations.

**Materials**

Refer to Division 10 of the *Standard Specifications*.

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| **Item** | **Section** |
| Grout | 1003 |

Use Type 5 grout for compaction grouting and Type 3 grout for patching holes in pavements. Provide a Type 5 grout mix with at least 400 lb of cement per cy. In some subsurface conditions, the Engineer may approve grout mix designs that deviate from Type 5 grout requirements in order to improve grout take or pumpability.

**Pregrouting Requirements**

1. **Compaction Grouting Plan**

Submit a PDF copy of a compaction grouting plan at least 14 days before mobilizing to the site. Do not begin grouting until a grouting plan submittal is accepted. Provide detailed project specific information in the compaction grouting plan that includes the following:

1. Overall description and schedule of work and traffic control operations,
2. List of personnel with descriptions of experience and qualifications,
3. Details of drilling and coring, grout pipe installation, hole layout and grouting sequence, equipment and procedures,
4. Methods and equipment for mixing grout and monitoring and recording grout volumes and pressures with calibration certificates dated within 1 year of the submittal date,
5. Detailed description of movement monitoring including device locations, specific things to be monitored and measuring equipment with calibration certificates dated within 1 year of the submittal date,
6. Grout volume and pressure and movement criteria for raising grout pipes,
7. Example of drilling, grouting and monitoring logs,
8. Grout mix design that meets Section 1003 of the *Standard Specifications* and
9. Other information shown in the plans or requested by the Engineer.

If alternate grouting procedures are proposed or necessary, a revised compaction grouting plan submittal may be required. If the work deviates from the accepted submittal without prior approval, the Engineer may suspend compaction grouting until a revised plan is accepted.

1. **Compaction Grouting Equipment**

Mobilize equipment to the site capable of installing grout pipes to the depths required and through whatever pavement and subsurface materials that are encountered including concrete approach and sleeper slabs, asphalt pavements, debris, obstructions, etc. Use equipment capable of drilling round and plumb holes of the required diameter through pavements for grout pipe installation. For concrete slabs, use a core barrel with an outside diameter 1" to 2" larger than the casing outside diameter to core holes completely through concrete and reinforcing steel. Use grout pipes consisting of flush joint steel sectional casing with an inside diameter of at least 2" and sufficient strength to maintain grout holes and withstand pumping, drilling and jacking pressures.

Provide mobile equipment as necessary to transport, proportion, mix and batch materials and pump grout for compaction grouting. A volumetric concrete mixer is required to produce Type 5 grout. Do not use grout from a concrete ready mix or batch plant. Produce grout with volumetric mixer equipment that is certified by the Volumetric Mixer Manufacturers Bureau (VMMB) signified by a VMMB registered rating plate attached to the equipment. Use a mixer that can continuously produce grout with a slump of less than 2" at pressures of up to 1,000 psi and flow rates up to 5 cf per minute. An operator with at least 3 years of experience within the last 5 years operating volumetric mixer equipment for compaction grouting is required.

Use a riser elbow with a radius of at least 1 ft. Provide an elbow and grout hoses with an inside diameter equal to or larger than the inside diameter or the casings. Use hoses of sufficient strength for the pressures anticipated and couplings that do not restrict grout flow. Monitor grout pressures with an in-line calibrated pressure gauge that is protected from grout contamination and mounted near the riser elbow.

1. **Monitoring Equipment**

Monitor ground surface heave with digital electronic devices. For jointed pavements, use devices with the ability to simultaneously detect the movement of two adjacent slabs. Monitor vertical and horizontal movement of nearby structures, drains, utilities and walls with dial gauges on rigid supports. Use monitoring devices and gauges that can measure to the nearest 0.01". For concrete slabs, structures, drains, utilities and walls, take digital pictures of existing cracks or damage and mark the locations of cracks or damage on slabs, structures, drains, utilities and walls. Provide an electronic copy of this photographic information to the Engineer before pumping grout.

1. **Pregrouting Meeting**

Before starting compaction grouting, hold a pregrouting meeting to discuss the grouting, movement monitoring, criteria for raising grout pipes and other aspects of the work. Schedule this meeting onsite and during daylight hours before mobilizing to the site. The District or Bridge Maintenance Engineer, Geotechnical Operations Engineer or Grouting Supervisor and Grouting Contractor Superintendent will attend pregrouting meetings.

**Compaction Grouting Methods**

A Grouting Supervisor or Engineer with at least 3 years of experience within the last 5 years working on compaction grouting projects is required to remain on-site for the duration of the work. Use equipment and methods accepted in the compaction grouting plan or approved by the Engineer. Air temperature restrictions in Article 1003-5 of the *Standard Specifications* do not apply to Type 5 grout for compaction grouting. Do not drill more holes than can be cased or grouted full depth during a single shift.

Install grout pipes as required in the plans or if an alternate plan is approved, follow the compaction grouting plan accepted by the Engineer. Install casings for and grout primary holes before secondary holes. Use methods to drill holes and advance grout pipes that prevent casings from plugging or ejecting during grouting or grout escaping through annular space between the casings and the ground. Install grout pipes within 5$°$ of vertical or the batter accepted in the compaction grouting plan.

Remove oil, rust inhibitors, residual fluids and similar foreign materials from holding tanks/hoppers, mixers, pumps, hoses and all other equipment in contact with grout before use. Discard the first 2 cf of grout produced by the volumetric concrete mixer when grout production begins for each shift. Verify the flow rate initially before grouting and weekly after that by filling a 1 cf container. Take precautions as necessary to prevent grout, drill cuttings and fluids from drilling or equipment from defacing the site.

Continuously monitor and record grout take and pressure near the grout pipe head while injecting grout into the ground through grout pipes. Control pumping so grout injection rate is between 0.25 cf and 5 cf per minute. Inject grout in holes from the bottom up unless otherwise approved by the Engineer. Provide hard copies of logs to the Engineer at the end of each shift and a PDF copy of all logs upon completion of compaction grouting.

Withdraw grout pipes in 1 ft increments unless otherwise approved. At each increment, inject grout until criteria for raising grout pipes in the compaction grouting plan is met or unacceptable or undesirable movements occur in nearby structures, drains, utilities or walls as directed by the Engineer. Limit total ground surface heave from compaction grouting to 1/4".

It is crucial to monitor movement closely to prevent damage to nearby structures, drains, utilities or walls. Take precautions to avoid breaking or cracking concrete slabs. Slabs, structures, drains, utilities and walls will be considered damaged if damage is due to compaction grouting as determined by the Engineer based on crack patterns and locations.

The Contractor is responsible for any damage to slabs, structures, drains, utilities or walls caused by compaction grouting. Acceptance of the compaction grouting plan does not relieve the Contractor of responsibility for damage or liability in accordance with Article 107-11 of the *Standard Specifications*.

If damage occurs, submit a proposed remediation or repair plan for review. Ensure remediation submittals are designed, detailed and sealed by an engineer licensed in the state of North Carolina. Do not begin remediation or repair work until plans are approved. No extension of completion date or time will be allowed for repair of damaged slabs, structures, drains, utilities or walls.

When drilling through existing pavements and the roadway will not be resurfaced or the concrete slab will not be lifted after completing compaction grouting, remove excess grout, drill cuttings and fluids from holes and fill holes with Type 3 grout. Collect and dispose of any debris, waste and excess grout before leaving the site and opening lanes to traffic.

**Measurement and Payment**

*Compaction Grouting* and *Grout Pipes* will be measured and paid in cubic feet and linear feet, respectively. Compaction grouting will be measured as the cubic feet of grout injected into the ground through grout pipes. Grout pipes will be measured as the linear feet of casings installed equal to the maximum casing depth achieved below the ground surface. The contract unit price for *Compaction Grouting* and *Grout Pipes* will be full compensation for submittals, monitoring, logs, labor, tools, equipment, materials, installing grout pipes, mixing and injecting grout, cleanup, patching holes and any incidentals necessary to complete the work.

No additional payment will be made due to changing the number, location or depth of holes or the order for grouting holes. No payment will be made for discarded grout or casing ejected during grouting. No payment will be made for remediation or repair of damaged slabs, structures, drains, utilities or walls.

*Mobilization* will be measured and paid in accordance with Section 800 of the *Standard Specifications*.

Payment will be made under:

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| --- | --- | --- |
| **Pay Item** |  | **Pay Unit** |
| Compaction Grouting | Cubic Foot |
| Grout Pipes | Linear Foot |

**PE SEAL NAME**

**PE #**