

## **SPECIFICATION FOR JET GROUTING**

### **1.0 GENERAL**

The Specialist Contractor shall construct jet grout columns of nominal diameter and spacing as specified in the drawing(s) to the requirements of the Contract.

The objective of the jet grouting is to improve the soil mass. Due to the specialised nature of the work, jet grouting shall be carried out by a reputed Specialist Contractor.

### **2.0 SCOPE OF WORK**

The Work shall consist of installation, monitoring and testing of jet grouting to meet the acceptance criteria stated in this specification.

The Specialist Contractor shall provide all labour, materials and equipment to accomplish the Work in connection with the work programme.

It shall be the Specialist Contractor's responsibility to determine and implement the systems and criteria to ensure that specified improvement is achieved.

### **3.0 STANDARDS AND REFERENCES**

All materials and workmanship shall be in accordance with the current British Standard BS EN 12716:2001 except where the requirements of British Standards are in conflict with this specification, the latter shall take precedence.

### **4.0 SUBMITTALS**

The following shall be submitted by the Specialist Contractor with the tender documents:-

- (a) A list of at least five, previously completed projects of similar scope and purpose. The list shall include a description of the project, relative size, and contact person with phone number.

The following shall be submitted by the Specialist Contractor one week prior to the commencement of the Work:-

- (a) Resumes of the management, supervisory and key personnel for approval of the Engineer.
- (b) A ground movement monitoring plan.
- (c) A mix design for the project indicating sources and types of grout materials, with volumetric proportions, and field test data from previous projects indicating compressive strength achieved. If the Specialist Contractor intends to deviate from the material provided, it shall submit, with the bid, evidence of satisfactory use of the proposed material from past projects with similar soil conditions.
- (d) Work procedures, sequence, and control criteria (including parameters for each stage).
- (e) A general Work Procedures Plan outlining the spacing, location, depth and quantity of grout to achieve the specified criteria of this specification. Grout hole locations shall be dimensionally referenced to the contract drawings.

The following shall be submitted by the Specialist Contractor during the Work:-

- (a) Accurate daily records of all jet grouting locations, depths of treatment, start and stop times, all jetting parameters, and grout injected for each location.
- (b) Any change in the predetermined grouting program necessitated by a change in the subsurface conditions.

## **5.0 SITE INVESTIGATION AND TRIAL**

### **5.1 Provision**

All factual site investigation information and all interpretative reports relevant to the design of jet grouting works, including assessments of any soil contamination, shall be made available to the Specialist Contractor at the tender stage.

The Specialist Contractor shall ensure that the soil information is adequate to characterize the ground to be treated, including made ground, and all physical and geotechnical properties required for jet grouting works e.g. particle size distribution, density, organic content, strength characteristics and groundwater level.

Jet grouting is typically very effective in cohesionless soil and cohesive soil of low plasticity. Highly plastic soil requires special consideration.

### **5.2 Hazard Assessment**

All information relevant to the safe implementation of the proposed grouting works, including the location of all known buried and over-site services and the nature, proximity and condition of adjacent structures, shall be obtained by the Specialist Contractor before work commencement. If underground utilities are anticipated, a thorough investigation may be necessary to ensure location, condition, and protection requirements. If a building in distress is involved, a relevant building survey shall be carried out by the Contractor prior initiating work.

### **5.3 Trial Columns**

An appropriate preliminary field trial section shall be constructed to verify the jet grouting system (double or triple tube systems) and the design grouting parameters. Trial section location will be agreed upon by the Engineer within the treatment area. A trial section shall consist of a single module comprised of at least three jet grout columns. The quality of jet grout columns shall conform to the design requirements and to be verified using the appropriate testing method. Tests will be performed at the center of the module prior to and after grouting. Where excavation is possible, assessment of the geometric and mechanical characteristics of the jet grout column should be made by visual inspection. Laboratory tests on samples recovered by coring or excavation can be made.

Prior to commencement of production grouting, trial section shall be performed. If the pre-production trial sections indicate that the required ground improvement has not been achieved, the Specialist Contractor shall revise the Work Procedure Plan and re-test.

## **6.0 SPECIALIST CONTRACTORS**

The execution of jet grouting shall be carried out by Specialist Contractors equal to the task. The specialist Contractor shall have the following experience and personnel:-

- (a) Executed previous jet grouting work locally for similar nature and scale using the method specified in this specification;
- (b) Possess adequate equipment and instruments which are proven and recognised locally and internationally for the execution of jet grouting works and for quality assurance plan as required in this specification;
- (c) Personnel experienced in the design, supervision and execution of jet grouting works.

## **7.0 TOLERANCE**

### **7.1 Setting Out**

Setting out shall be carried out from reference lines and points shown in the drawings. Immediately before commencement of jet grouting works, the jet grout column positions shall be marked with suitable identifiable pins or markers.

### **7.2 Position**

The maximum permissible deviation of the centre of each grouting point from the correct centre point as shown in the setting out drawing shall be 150 mm in any direction unless otherwise specified by the Engineer.

### **7.3 Verticality**

Jet grouting for vertical borehole shall be carried out as near vertical as possible. The drilling rod shall not deviate by more than 1 in 100 during drilling.

### **7.4 Personnel**

The Specialist Contractor shall employ only personnel experienced in jet grouting for this part of the Works.

## **8.0 LENGTH, DIAMETER AND SPACING OF THE JET GROUT COLUMNS**

The length, diameter and spacing of the jet grout columns shown on the drawings are indicative only and shall be adjusted to suit site conditions when deemed necessary.

## **9.0 COMPRESSIVE STRENGTH**

The average unconfined compressive strength of the selected working columns shall be minimum 1.0 MPa. This shall be confirmed through laboratory tests on samples collected from backflow on site.

## **10.0 GROUTING EQUIPMENT**

The jet grouting equipment shall be specialized equipment and sufficiently powerful to ensure a properly formed soil-cement column for treatment area.

- i) Drilling rig shall be capable of drilling down to the required depth.
- ii) The cement grout batching plant shall include all storage cribs, weather proof shelter, pumps, automatic mixers, agitator and regulating devices required to continuously

- measure and mix cement grout.
- iii) Cement grouting plant shall be capable of effectively batching, automatically mixing and maintaining grout mixtures in suspension and of delivering grout into jet grouting system in a continuous flow at required pressure.
  - iv) The cement grout mixer shall be a high speed colloidal type and capable to operate up to 1,500 rpm.
  - v) High pressure pumps shall be able to produce high pressurized jet at variable pressures to cut and mix the in-situ soil.
  - vi) The jet grouting equipment shall be able to provide at least 400 bar at nozzle for water jetting. The equipment shall provide for continuous positive return flow during jet grouting operation.
  - vii) The jet grouting system shall be able to operate at different rotation and withdrawal rates within the required range in order to complete the work and produce the required jet grout columns.
  - viii) Real time measuring and recording devices shall be provided throughout the drilling and jet grouting operation e.g. column number, time, depth, pressures, flow rates, rotation speed etc.

Spare parts and equipment shall be available on site to maintain jet grouting equipment in satisfactory operation condition at all times during execution of the jet grouting work.

## **11.0 OBSTRUCTIONS**

In the event of obstructions preventing the drilling, the Specialist Contractor shall inform the S. O. immediately. Remedial options will include: -

- i) Reposition the grouting point a short distance from the original position.
- ii) Additional grouting point(s) around the obstructions.
- iii) Excavate, remove the obstruction, backfill and compact to the requirements of the Earthworks Specification and reinstall the jet grout column.

## **12.0 SPOIL RETURN**

Spoil return is the most important quality control indicator on the site. During jet grouting, a visual observation of the flow and features of the spoil shall be maintained. An unexpected reduction in spoil return shall be investigated and dealt with immediately. If there is negligible spoil return, it should be ensured that there is no clogging of the borehole annulus and the jetting parameters may have to be revised. Three cube samples shall be collected from spoil return during jetting at different levels of each column for subsequent laboratory tests.

During jet grouting, spoil return shall be channelled to silting pond, tank or other collection structures. The Contractor shall regularly dispose all waste materials in accordance with the regulations of the appropriate Authorities.

## **13.0 EXECUTION OF JET GROUTING**

### **13.1 Pre-treatment**

Working platforms shall be designed, prepared and maintained in a manner suitable for the safe movement and working of the grouting equipment. Material used to provide working platforms shall be suitable for the ground conditions on which it is placed and shall not prevent drilling operation.

Site working levels for the treatment shall be provided and maintained throughout the duration

of the grouting works.

### **13.2 Treatment**

Before starting the jet grouting works, a method statement should be submitted including grouting parameters, sequence of execution and quality control procedures. The procedure for jet grouting shall generally be as described hereunder to be confirmed by the S. O. on site. Typical ranges of jet grouting parameters are given in Annex B of BS EN 12716:2001.

Unless otherwise specified, drilling of 120mm to 140mm diameter shall be carried out to the required depth. Once at the designated depth, the in-situ soil will be eroded by highly pressurized water or cement grout jet and cement grout will be injected and mixed with the in-situ soil through grout nozzle(s) at the monitor. The monitor is rotated and lifted at required constant speed to achieve a continuous jet grout column.

If the jet grouting operation is interrupted for any reason, to ensure continuity of the column, re-drilling and re-grouting, may be required upon confirmation from the Engineer on site.

The Contractor shall furnish sufficient equipment, material and labour necessary to carry out the jet grouting works in accordance to the Programme.

The Contractor shall adjust the mix design and working parameters, if necessary, throughout the course of the work in order to achieve the requirement for the jet grout columns.

### **13.3 Supervision**

Execution shall be full-time supervised by trained and experienced personnel.

### **14.0 MATERIALS**

The cement grout shall be of Portland cement, water and occasionally, bentonite or additives as approved by the Engineer. Trial mixes shall be tested prior to commencement of work.

The quality as well as the suitability of the fresh grout shall be constantly assured by measuring its density using a hydrometer.

### **15.0 DRILLING AND GROUTING RECORDS**

Comprehensive records shall be kept. At the end of each day, 2 copies of the completed records for each grout hole shall be submitted to the Engineer (Both soft & hardcopy). The record shall include the following information:

- (i) Contract, section.
- (ii) Grout hole reference number.
- (iii) Water-cement ratio.
- (iv) Pressures during jet grouting.
- (v) Flow rates.
- (vi) Withdrawal rate.
- (vii) Rotation speed.
- (viii) Time for drilling, jet grouting and overcoming obstructions.
- (ix) Details of constructions, delays and unusual ground.
- (x) Features of spoil return i.e. colour, quantity and density.
- (xi) Presence of ground deformation (plus estimate if detected) monitored using precise level.
- (xii) Any other information as may be required by the S.O.

## **16.0 QUALITY CONTROL**

The following quality control measures shall be implemented for each grout hole:

- i) Evaluation of the continuously drilling and grouting records from computer output.
- ii) Grout and spoil density tests (daily).
- iii) Grout cube tests (weekly).
- iv) Ground deformation monitoring (where specified).

Any jet grout hole lost or damaged as the result of mechanical failure of equipment, inadequacy of grout, air, or water supplies, or improper drilling or injection procedures shall be backfilled with cement grout and replaced by another hole, drilled and injected by the Specialist Contractor at no additional cost.

Equipment for mixing, holding, and pumping grout shall be in a secure location and shall be operated to minimize spillage of material. No material will be allowed to enter storm drains or other drainage courses.

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