

SPECIFICATION FOR CAVITY AND SLUMPZONE PROBING AND COMPACTION GROUT TREATMENT

1.0 GENERAL REQUIREMENTS

This specification is to be read in conjunction with the contract, the general specification and all other specifications and drawings. The Contractor shall design and carry out compaction grouting of slumpzone, soft or loose soils and voids, above and between rock layers to ensure that the areas and depths specified for such treatment shall be so treated as to comply with the Criteria of Acceptance.

In the event that the provisions of other specification clauses cause ambiguity or conflict with the requirements of this specification, the latter shall take precedence unless otherwise approved by the Engineer.

Where works are ordered to be performed by the Contractor, but are not specified in these specifications, the Contractor shall carry them out with full diligence and expedience as are expected for works of this nature.

2.0 CODES AND STANDARDS

The design and construction where relevant shall be carried out in accordance with good engineering practice and shall comply with the latest applicable Malaysian, British or ASTM Standards and generally including the following:

BS 8004 : 1986	-	Code of Practice for Foundations
BS 5930 : 1981	-	Code of Practice for Site Investigation
BS 8110 : 1985	-	Code of Practice for Structural Use of Concrete
MS 522 : 1979	-	Specification for Portland Cement
ASTM: D2113 – 83 : 1987	-	Diamond Drilling for Soil Investigation

In the event when conflicting requirements occur in different Standards, the most stringent standard shall take precedence.

3.0 SUBMITTALS

Before commencement of the work, the Contractor shall submit to the Engineer for his approval legible points of shop drawing, method statement and design calculations of the proposed treatment. The method statement should include detailed procedures for probing, treatment and full descriptions of the procedures, equipment and materials to be used.

After completion of works at site, the Contractor shall submit complete reports (6 copies) of the probing and treatment that include actual locations of cavity/slump zone, summary of drilling records with rate of drilling, anomalies and full details of materials used, pumping pressure and other relevant information listed in Section 17.0.

4.0 CAVITY AND SLUMPZONE PROBING

The Contractor should propose the drilling method to the Engineer for approval prior to work at site. The drilling method proposed must have minimum effect of the surrounding soil and will not cause subsidence and loosening of the adjacent subsoil. The drillhole shall be stabilised

with drilling fluid of bentonite or polymer slurry unless otherwise agreed by the Engineer. The head of the drilling fluid shall be kept at a level high enough to ensure sufficient stabilising capacity in the cased or uncased drillholes.

The depth of probing into limestone bedrock shall be a minimum of 10m if no cavity is encountered and 10m below the last cavity encountered unless otherwise directed by the Engineer. The boring of soil below cavity roof or overhang shall be considered as boring in soil and shall not be considered as coring in rock. Standard penetration tests (SPT) shall be carried out in all cavities with soil at interval of 1m until the next layer of rock is encountered. The Contractor will only be allowed not to carry out SPT in cavity if the drilling and treatment is to be carried out simultaneously using method and equipment approved by the Engineer.

The penetration speed of the cavity probing shall be recorded in every 1.0m penetration intervals starting from the ground level. The occurrence of slumpzone above rock or cavities within the limestone strata will be determined upon a sudden increase of penetration speed. The Engineer will decide whether to treat the slumpzone or cavities based on the penetration speed records submitted by the Contractor. The Contractor shall plot the penetration speed versus depth and submit or fax the plot together with the data to the Engineer immediately after drilling so that the Engineer can decide on the treatment. If the penetration speed are not properly recorded and submitted to the Engineer in time for his decision on treatment, the Engineer can reject the hole and a replacement hole has to be carried out by the Contractor with no claim of extension of time and addition cost.

The diameter of the drillhole shall be large enough to allow compaction grout to be carried out immediately after reaching the required level without having to redrill the hole after probing of cavities. The diameter of the drillhole shall be proposed by the Contractor and approved by the Engineer. If treatment of slumpzone and cavity is not required, the drill hole shall be properly backfilled with cement-grout ($W/C = 0.6$) or low strength sand-cement mortar to the existing ground level.

5.0 SPECIALIST SUBCONTRACTOR

Compactions grouting shall be carried out by experienced specialist subcontractors who have previously carried out this treatment successfully and to the agreement of the Engineer. The Specialist Subcontractor shall

- (i) have successfully carried out compaction grouting of a similar nature previously;
- (ii) possess equipment for cavity probing and compaction grouting required in this contract.

6.0 PERSONNEL

The Specialist Subcontractor shall employ sufficient of experience personnel who are familiar with the type of cavity probing and compaction grouting described in this contract. All personnel shall be to the agreement of the Engineer.

7.0 CRITERIA FOR ACCEPTANCE

Each treatment location shall be advanced by rotary wash boring through the zone designated for treatment 7 days after completion of grouting unless otherwise directed by the Engineer. Standard Penetration Test (SPT) shall be carried out in soil, and rotary drilling in accordance with ASTM: D2113 - 707 "Diamond Drilling for Soil Investigation" shall be carried out to recover grout cores.

Compaction grouting shall only be deemed to have been successfully completed if:

- (i) For soils within the treatment zone, the individual SPT'N' values at any point

is not less than 20 and the average SPT'N' value is not less than 25; unless otherwise agreed by the Engineer.

- (ii) No void is encountered; and
- (iii) Unconfined compression strengths of the cores are in excess of 2 N/mm².

Grouting shall be repeated until compliance with the Criteria of Acceptance. Provisions have been made in the Bills of Quantities for the boreholes constituting the first check for compliance with the Criteria of Acceptance. Subsequent boreholes after subsequent grouting due to the Contractor's inability to comply with the Criteria of Acceptance shall be at his own cost.

All boreholes shall be grouted to the satisfaction of the Engineer immediately on completion.

8.0 MORTAR MATERIAL

The Contractor shall submit his proposed mortar material for the agreement of the Engineer. Generally and unless demonstrated by field trials that the Criteria of Acceptance may otherwise be achieved, the grain size distribution of the mortar material shall comply with the grading limits given in Table 1.

British Standard Sieve Size	Percentage Passing
5mm	100%
2mm	90 to 100%
600µm	55 to 85%
75µm	7 to 15%
2µm	<1%

Table 1

9.0 MORTAR MIX

The Contractor shall submit his proposed mortar mix design for the agreement of the Engineer. Generally and unless demonstrated by field trials that the Criteria for Acceptance may otherwise be achieved, the mortar mix shall comply with the limits given in Table 2. Chemicals like retarder have to be used if the injection time will be long and to prevent clogging of pipe during injection. However, any other chemicals to be used shall be agreed by the Engineer.

Material	Range
Mortar Material	1000 to 1500 kg
Portland Cement	360 to 500 kg

Table 2

The Contractor shall carry out trial mix at site to justify the workability and strength of the proposed mortar mix.

10.0 SLUMP

The Contractor shall submit his proposed slump for the agreement of the Engineer. Slump shall be in the range of 50 to 110mm and shall be tested on site for each batch of mix.

11.0 MORTAR INJECTION RATES

Generally the Contractor shall adopt slower pumping rates in order to maximise mortar intake and to ensure against occurrence of hydraulic fracturing. Subject to site trials demonstrating that the Criteria of Acceptance otherwise be achieved, the pumping or mortar injection rate shall be less than 0.03 m³ per minute or other approved rate. However, the Contractor should make sure that the mortar would not set in the pumping pipe before completing the injection into slumpzone or cavity.

12.0 LIMIT PUMP IN PRESSURES

The Contractor shall submit the proposed limit pressure for the agreement of the Engineer. Unless directed by the Engineer, the minimum limit pump-in pressures shall be 3.0Mpa (30 bar)

13.0 MORTAR INJECTION SEQUENCE

The Contractor shall submit his proposals for sequencing the pumping process.

Generally mortar injection shall commence around the perimeter of the treatment zone and then proceeding toward the center. Each hole shall be drilled and grouted before moving to the next hole.

In the case of multiple cavities or multiple limestone layers in any drill hole, treatment shall proceed from the lowest cavity and completed for that cavity before proceeding to the next higher cavity.

14.0 CRITERIA FOR TERMINATING OF TREATMENT AT ANY POINT

The Contractor shall submit for the Engineer's agreement his proposal for terminating treatment at any point.

15.0 EQUIPMENT

Equipment shall be such as to enable the anticipated high pressures and injection rates.

- Pumps shall be capable of delivering pressures of not less than 7 MPa.
- Stroke counters are to be provided to enable accurate measurement of mortar injection volume.
- All grout pipes and connections are to withstand the anticipated high pressures with adequate factors of safety.
- Workers are to be equipped with appropriate eye protection devices and other safety device.
- Pressure gauges are to be protected and checked frequently.

16.0 SURFACE MONITORING

The Contractor shall undertake continuous surface monitoring for settlement or heave over the designated treatment area and beyond over the period of drilling and treatment.

17.0 RECORDS

2 copies of completed records for grouting at each location shall be submitted to the Engineer. The record shall include the following information:

- (i) Grouting location or coordinates ;
- (ii) Length of bore;
- (iii) Mortar mix;
- (iv) Mortar injection pressure;
- (v) Volume of mortar;
- (vi) Dates bored;
- (vii) Date and times of grouting;
- (viii) Mortar test cube results;
- (ix) Reduced level of the ground;
- (x) SPT'N' values;
- (xi) Rate of drilling;
- (xii) Soil description;
- (xiii) Any other information required by the Engineer.



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