Compensation grouting in sand, fractures and compaction

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5.1 Settlement compensation by grouting

Introduction

Fracture grouting has been successfully applied in several projects to compensate for surface settlements induced by for example tunnelling. Fracture grouting uses hydraulic fracturing and/or compaction to get a heave that can compensate the settlement or it densifies the soil to improve its characteristics. Hydraulic fracturing can also be an unwanted phenomenon in tunnelling or horizontal drilling when high pressures can cause a blow-out that starts with a hydraulic fracture.

Compensation grouting is up to now predominantly an empirical procedure. It is qualitatively known that the necessary injection pressure depend on the density of the sand and the properties of the grout. No model is yet available to quantify the various phenomena. Two different processes can occur: fracturing of the sand by the injected grout or densification of the sand by compaction grouting. The latter occurs when a more viscous liquid is injected and needs much higher injection pressures.

Model tests are preformed to acquire knowledge on the mechanism that are of importance for hydraulic fracturing and to get quantitative data on this process.

Tests performed

A circular container with a diameter of 0.9 m was used for the tests (see Figure 1). This container was filled with saturated sand up to 0.9 m height. The injection nozzle is comparable to the system developed for compensation grouting: a pipe with a rubber sleeve. The sleeve will only allow outflow of the grout when the grout pressure is higher than the soil pressure. Injection rate, injection procedure and type of grout were varied during the tests.

Special attention was paid to the measurement of the volumes. The increase in volume due to the injection and the drainage of pore water was measured continuously during the tests. The efficiency of the grouting process depends on the relative density of the sand, see Figure 2. CT scans of the recovered grout showed that bleeding of the grout occurred, see Figure 3.

The results of the tests showed that not all tests lead to fracture grouting. Some tests resulted in compaction grouting with very high injection pressures.

The paper

The paper will describe the test set-up and the results more in detail. The governing mechanisms that determine between fracture grouting and compaction grouting will be discussed as well as the influence of grout properties.

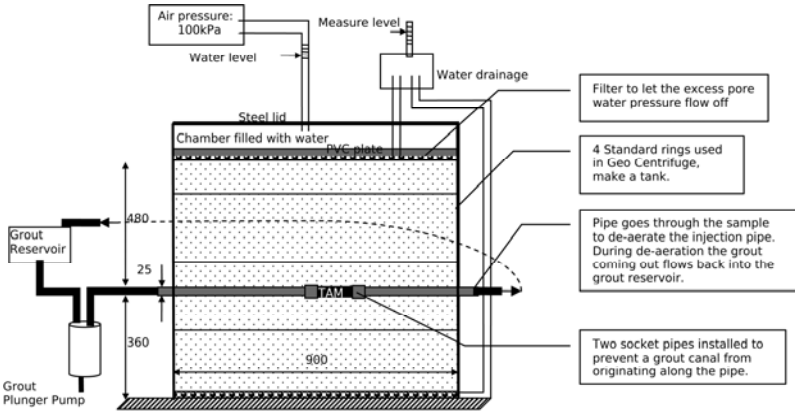

Figure 1: Test set-up, dimensions in mm.

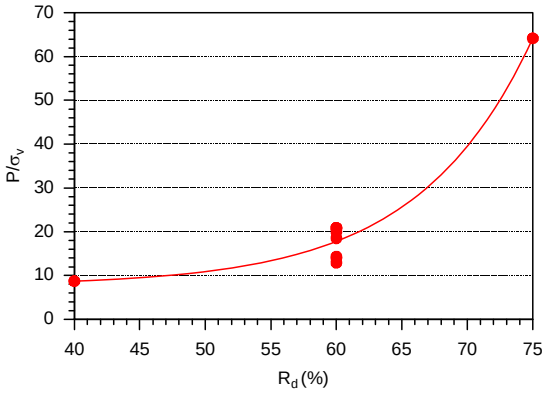

Figure 2: Injection pressure divided by the effective stress as a function of the relative density.

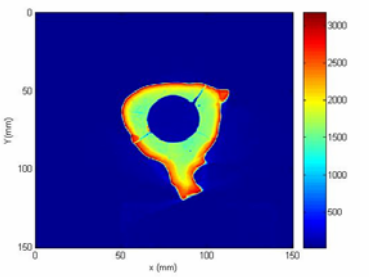

Figure 3: Variation of density in the grout after injection. Results of a CT scan.

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