Utveckling av dynamisk injektering, etapp 1

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Summary:

A major concern in any underground infrastructure is to provide and maintain the sealing required, first during the construction phase, and then during the service life of the project. In the construction phase, the water ingress into the construction area increases the duration and the costs of the project and in some occasions leads to environmental issues such as lowering the groundwater tables, settlement of the surface structures, and destruction of the vegetation. It can sometimes be even harmful to the human life. A typical example for that can be the icicle falls on passing vehicles in the road tunnels in the winter. The other related disadvantages can of course be decrease of the duration of the life cycle of the projects and increase of the maintenance costs. To provide the required sealing, one of the most significant factors is to obtain enough spread of grout in the fractures surrounding the facility. This can be achieved using cement-based grouting, which is probably the most frequently used technique in the industry due to the lowest costs and environmental issues. However, in the cement-based grouting, the spread of grout in fractures is disrupted due to the filtration of the cement particles at the constrictions especially in constrictions smaller than 100 µm. This leads to inadequate spread of grout in such fractures and consequently insufficient sealing.

The presented report is a summary of the laboratory investigation conducted in collaboration between RISE CBI Betonginstitutet and Division of Soil and Rock Mechanics, Royal Institute of Technology (KTH) during 2017-2018 with the aim to improve the grout spread in rock fractures using dynamic grouting technique. The dynamic grouting, which has been developed to improve the spread of grout in rock fractures, has been studied in both the lab and the field since 1985. The focus of all the previous investigations was however on application of high-frequency oscillating pressure to reduce the grout viscosity by destructing the grout internal structure and reconstructing to a lower viscosity suspension. Even though some improvements were reported in the corresponding literatures, the major remaining issue was yet quick dissipation of the oscillations along the fractures and consequently inadequate spread of grout.

Recent investigation of the authors, presented in BeFo-Report-149, illustrated a significant improvement (up to 11 times) in the total volume of grout passed through the apertures smaller than 70 µm in a short slot by applying low-frequency rectangular pressure impulses compared to the static pressure. In this study, the mechanism of improvement of the grout spread was interpreted as successive erosion of the produced filter cakes due to the variation in flow pattern at the constrictions caused by the pressure change in consecutive cycles. However, since the laboratory experiments conducted in this study were carried out using a short slot, the dissipation length of the applied pressure impulses along a longer fracture was yet questionable.

Accordingly, the present study first aimed to investigate the dissipation of the dynamic pressure impulses along a much longer artificial fracture, so-called varying aperture long slot (VALS). This happened by applying two choices of the peak/rest periods and in two steps. In each step, the
extent of the improvement of the grout spread was also examined in different pressure conditions. The main difference between the two steps was the pressure source. A high-pressure gas tank and a screw pump were the two variants of the pressure source that were used in step 1 and step 2, respectively. Even though the project was a limited study based only on the laboratory experiments, the results obtained in terms of both the extent of improvement of the grout spread and the extent of dissipation along a fracture were promising showing the potential of the method. Finally, the study suggests further development of the method to full scale field tests, to demonstrate the capacity of the new technique to the stakeholders in industry.

Fig. 1 Schematic view of the test set-up: 1) Gas tank, 2) pressure regulator, 3) load cell, 4) grout tank, 5) pressure sensor, 6) DAQ-data acquisition system, 7) 3 coupled asymmetrical recycler timers, 8) 2 two-way ball-valves with pneumatic actuators, and solenoid valves, 9) VALS
Fig. 2 Schematic view of the test apparatus used in step 2: 1) Screw pump, 2) Pressure control valve, 3) Pressure sensor, 4) Grout tank, 5) DAQ system, 6) Asymmetrical recycler timers, 7, 71) Two Two-way ball-valves with pneumatic actuators, and solenoid valves, 8) VALS, 9) Inlet from the grout tank to the pump, 10) Bypass from the pressure control valve to the grout tank, 11) Outlet from the pump to the VALS, and finally 12) Backflow from the VALS to the grout tank.

Fig. 3 Dissipation of dynamic impulses along the VALS registered by P1, P2 and P3 in test group D1 (with 2s/2s peak/rest period)