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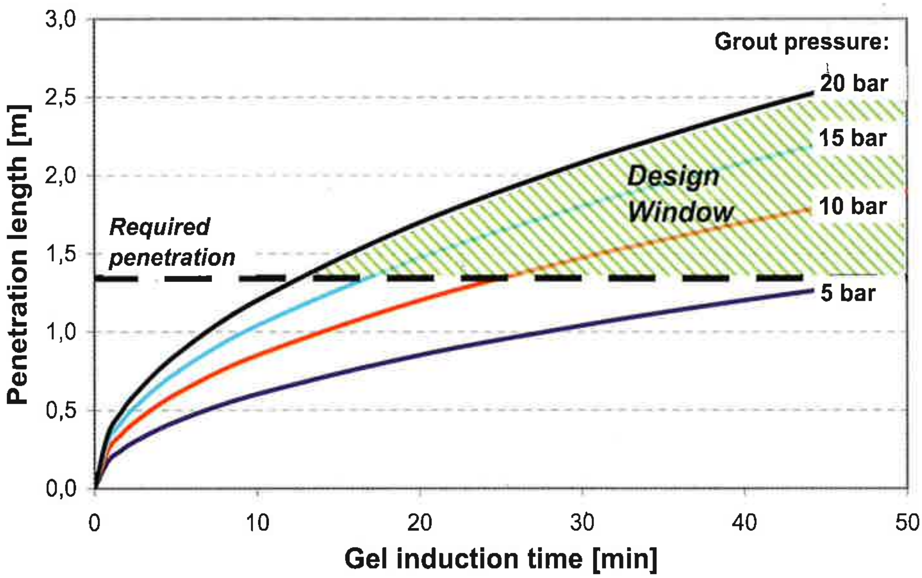

Grouting of Fractured Rock with Silica Sol

Grouting design based on penetration length

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ABSTRACT
Recent grouting projects in Sweden have concentrated on the grout itself. The only grout normally used in Sweden is cement-based. During the past 10 years, the acceptable flow of water into tunnels has been reduced significantly. The current requirements mean that an average fracture aperture of around 0.05 mm must be sealed. Chemical grouts generally have a low initial viscosity and the absence of particles means that they can penetrate narrow fractures. Recently, the environmental impact of non-cement grouts has become an important issue. Silica sol is a material that seems to fulfil both requirements, as it is non-hazardous and capable of penetrating narrow fractures.

The main objectives of this study are to investigate the basic concepts of how rheology affects penetration and to develop models for calculating penetration length. Other aims are to analyse the need for sealing narrow fractures and to find out how the grouting design can be linked to the characterisation of the rock mass. The papers deal with the grouting procedure with silica sol and analyse a concept for evaluating sealing efficiency and penetration length.

In two laboratory studies conducted in a sand-column and pipes, parameters affecting the penetration length were studied. In both studies the aim was to equate the penetration length of the sand and in pipes with that in a slit. For the pipe, the equivalent aperture involves only the radius of the pipe and for the sand the aperture is proportional only to the porosity and calculated specific surface of the sand itself.

The five papers outline the grouting procedure with silica sol and suggest a simple grouting model as well as a concept for evaluating the sealing efficiency and penetration length. The grouting design was based on the characterisation of the rock mass and the grouting parameters. A new design criterion for the grouting time was tested and evaluated to obtain a desired penetration length. The grouting time is strongly connected to the gel-time of the grout. The grout used was silica sol, a gelling liquid consisting of amorphous silica particles suspended in water. To initiate and accelerate the gelling process, salt solutions were used.

Models were developed to calculate the grout penetration in both one and two dimensions. An interesting feature is that the penetration length calculated in 1-D is about twice as long as that for 2-D, which is verified partially by two field studies. The final penetration is the same as the penetration calculated using the analytical model with a grouting time equal to gel induction time, t_G. Since the penetration models are based on the grout properties, the proposed calculations can be applied to most types of gelling liquids, provided the basics of the rheology are taken into account.

Keywords: Grouting, gelling liquids, silica sol, colloidal silica, penetration length, hydraulic test, transmissivity, field study, sand column, pipe flow, aperture, propagation, rheology

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