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Finite Difference Modelling of Seepage in a Region of the Foundation Rock Below a Concrete Gravity Dam Wall

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High seepage values were recorded, post-construction, in a region of the foundation rock below a concrete gravity dam wall in South Africa. These seepage values were attributed to a prominent pegmatite vein running through the foundation rock. As such, this research aims to simulate flow through this feature with the use of numerical modelling methods based upon descriptors of the pegmatite vein obtained during joint line surveys of the foundation during the construction process.

A Finite Difference method was employed for the modelling process, and was conducted through MatLab®. The pegmatite vein was modelled directly from descriptors and geometrical data obtained from the joint line surveys conducted on the exposed rock mass before the placement of concrete. The modelling method incorporated the determination of the hydraulic head distribution through numerical flow net analysis, along with the incorporation of a number of flow equations including the Cubic law and Darcy's law.

Due to the lack of input data, the seepage results obtained varied significantly based on the range of assumptions made. As a result, comparing the numerically modelled seepage values to the measured discharge values from two relief wells intercepting the pegmatite vein, yielded questionable results. However, the seepage results obtained from the most plausible hydraulic conductivity assumed, yielded seepages within a single order of magnitude of that of the measured discharge.

In addition to the pegmatite vein seepage modelling, a grout scenario simulation was developed so as to assist in determining the most economical grouting location within a given fracture network. This entailed generating a theoretical heterogeneous network of fractures, simulating a number of grouting scenarios at different locations, and subsequently determining the reduction in seepage for each scenario. This however, required the development of a numerical flow net analysis method capable of determining the hydraulic head distribution within a network of planes along with heterogeneous conditions.

The results obtained for the seepage improvements in the various grouting scenarios were very promising as they conformed to expectations based on the geometry and properties of the fracture network. As a result, the grouting scenario simulation method developed in this paper could be of potential value in development of grouting procedures aimed at reducing seepage through a rock mass.