

Evaluation of Grout Curtain Performance in Seepage Control from Rock Formations by 3D Analysis

(A Case Study of Haigher RCC Dam)

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ABSTRACT

The issue of water seepage from foundations and abutments is one of the main challenges related to the design and construction of dams. One of the most important parameters in dam design in the study of seepage is to determine the permeability of the dam site, especially in rock formations. In this study, first, the permeability of Haigher roller compacted concrete dam site, located in Fars province, was determined through extensive Lugeon tests before and after the grout curtain. Then, using PLAXIS 3D FEM software, the site topography was modeled in three dimensions and three-dimensional dam seepage analysis was performed. The efficiency of the grout curtain was evaluated using numerical analysis. The results show that the total seepage discharge in the Haigher dam construction site without grout curtain is $1.075 * 10^{-2}$ m³/s and after the construction of the grout curtain is reduced to $2.305 * 10^{-3}$ m³/s, which indicates a reduction of about 80% seepage discharge. The results of the parametric study showed that with increasing the depth of the grout curtain, the seepage flow decreases and with increasing the reservoir water level, the seepage flow rate from the dam increases linearly.

KEYWORDS

Haigher RCC dam, Seepage, Lugeon test, Grout curtain, PLAXIS 3D.

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1. Introduction

Dam construction as one of the most important engineering activities and one of the most complex construction activities. The most important issue in the design and construction of dams is the water seepage from foundations and abutments. The main parameter in the seepage analyses is the permeability of the construction site. In dams, escape and loss of water from the joints and cracks of rocks occurs due to hydraulic pressures of water behind the dam [1].

Moghimi et al. investigated and calculated the seepage rate from the grout curtain of Seymareh dam using the results of water pressure test before and after injection and concluded that the implementation of the grout curtain reduces the seepage discharge by 62% [2].

Saleh (2018) studied the phenomenon of seepage under the concrete dam by numerical modeling by SEEP/W software and concluded that the seepage flow rate calculated from the software is 6.2667×10^{-6} m³/s [3].

Hanyu Li et al. performed numerical analyses using Abaqus and SEEP/W to simulate the seepage change level of the Chinese Shiziyeh rock fill dam. The seepage current of rockfill dam in both software is equal to 4.74×10^{-3} m³/s [4].

Dhawan et al. investigated the grout curtain of Hidkal dam using MIDAS-GTS software. The amount of seepage in the study before the injection was 6.2×10^{-5} m³/s and after the injection was 2.4×10^{-6} m³/s, which indicates that the injection was successful in reducing the seepage [5].

The present study aims to evaluate the efficiency of the grout curtain in Haigher RCC dam, constructed in rock formation by using PLAXIS 3D. For the construction of the grouting curtain, eight series of boreholes have been used for injection. In this study, the permeability of the dam site was obtained indirectly from Lugeon test. 208 boreholes including 4829 water pressure test sections [6] were used to evaluate the performance of the grout curtain.

2. Methodology

Haigher Dam with a crest length of 230 meters, a width of 6 meters, a height of 90 meters from the riverbed and a reservoir volume of 227 million cubic meters is located at the Firoozabad of Fars province.

The laboratory model of Yousefi et al. [7] was used for validation of the numerical model. The specifications of the laboratory model were

considered for validation including a flume with a length of 2.2, width of 0.4, depth of 0.8 m, thickness of 0.4 m of sand and its permeability of 3.25×10^{-6} m/s.

To construct a 3D topographic surface, the survey mapping curves were imported into Rhinoceros software (Rhinoceros 7.0) to eventually create a complete surface of dam site. The built-in surface is imported into the PLAXIS to make a more realistic model of the dam and the surrounding topography. Figure 1 shows the soil layering with actual geometry and the position of the dam relative to the abutments from the upstream view.

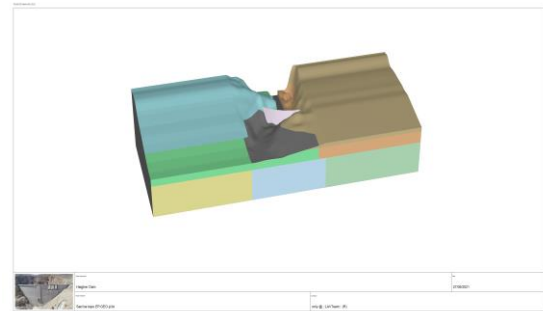


Figure 1: Soil layering with real geometry from the upstream view

3. Discussion and Results

In this section, complete evaluation and analysis of seepage results in the conditions before and after the implementation of the grout curtain was performed. The value of total seepage flow without considering the grout curtain was 0.01075 m³/s and with the grout curtain was 2.305×10^{-3} m³/s, which shows that the grout curtain reduces the seepage flow by 78%.

In this model, six grout curtain depths (0, 0.065, 0.306, 0.555, 0.815 and 1) have been used to compare the results. Figure 2 shows the effect of grout curtain depth on seepage discharge rate. As seen, as the depth of the grout curtain is increased, the quantity of the seepage is decreased. Also, as presented in Figure 3, by increasing the reservoir level, the discharge quantity increased linearly.

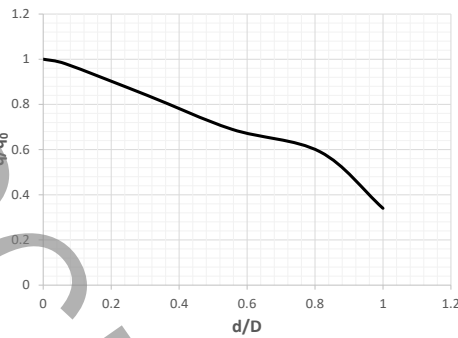


Figure 2: Effect of grout curtain depth on Seepage discharge rate

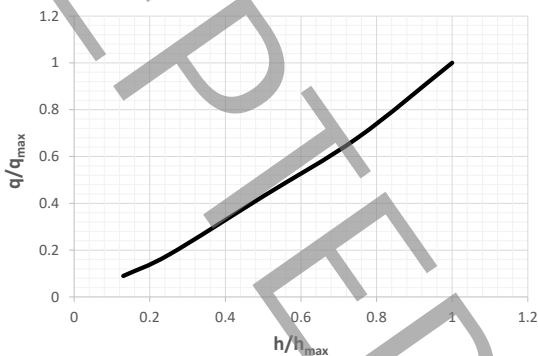


Figure 3: Effect of reservoir water level on Seepage the discharge rate

4. Conclusion

In this research, the efficiency of grout curtain in reducing seepage from Haigher RCC dam, which is located on a completely Rock formation, has been investigated. The most important results of the present study are as follows:

- The implementation of grout curtains reduces seepage discharge by about 80%, which is acceptable compared to the similar projects.
- Implementation of the grout curtain in Haigher dam, prevents about 270000 m³ amount in water loss.
- It was observed that the highest flow rate is occurred from the left abutment, which is due to weathering of rock masses located in the injection gallery of the dam crest.
- By increasing the depth of the grout curtain, the seepage flow decreases, which according to the amount of seepage flow obtained in the final depth of the grout curtain, it is determined that the considered depth is the optimal depth.
- With increasing the water level in the reservoir, the amount of seepage from the whole site increases linearly.

5. References

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