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EXTENDED ABSTRACT

Evaluation of the Material Permeability Ratio of Earthen Dam with Clay Core Using By 3D Seepage Modelling (Case Study: Sattarkhan Dam)

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Seepage, Sattarkhan dam, Permeability, Pore water pressure, Flac3D software.

1. Introduction

One of the most important issues in the design of earth dams is the analysis of dam body and foundation seepages. Seepage problems may be caused by the characteristics of the foundation, support, floor and walls of the reservoir or dam body materials. Therefore, one of the determining parameter in the stability evaluations of earth dams is seepage analysis. In this study, seepage analysis of Sattarkhan dam is located in East Azarbaijan province, has been done by using the finite difference method, Flac3D software. The behavior of the seepage analysis model has been investigated and compared in two and three-dimensional case. The results of the analysis have been compared and validated with the pore water pressure measured by piezometers installed in the core and have been in good agreement. The main variable in the seepage analysis of dam is the permeability coefficient of the material. The role of this coefficient in the results of the seepage analysis of the dam body has been investigated by sensitivity analysis.In general, it can be said that in the mentioned dam, the water flow vector parallel to the dam axis is not decisive, and the pore water pressure production process complies the two-dimensional model approach. Also, the results show that the permeability ratio of the shell related to the core is effective in its seepage behavior, and in the design of the earth dam body s, it will be necessary to check this ratio according to the property of the borrow mines located in the dam construction area.

2. Methodology

2.1. Case study

The seepage flows have been evaluated according to the different properties of materials in Sattarkhan dam by using FLAC3D software. The type of this dam is an earthen dam with a vertical clay core. According to the monitoring report of this dam, the Sattarkhan reservoir dam is located in East Azerbaijan with crest height is 78 meters and the length of the crest is 350 meters (Regional Water Company of East Azerbaijan, 2011).

The main objectives of the construction of this dam were included controlling and regulating the surface flows of the Ahar River and supplying the water needed for part of the agricultural lands of upstream and the water of Ahar city. The summary of the important characteristics of the materials used in the body and foundation of Sattarkhan dam is according to Table (1).

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Table.1. Summary of dam body and foundation properties of Sattarkhan dam (EARWO, 2011)

Material property	Upstream shell	Clay core	Downstream shell	Filter	foundation	bedrock
Cohesion (kpa)	0	45	0	0	0	750
Friction angle	40	20	40	36	35	50
Elasticity modulus (Mpa)	100	20	100	40	100	2000
Saturation Density(kg/m^3)	2308	2305	2308	1971	2239	2450
Permeability coefficient (cm/s)	1x10^{-2}	1x10^{-6}	1x10^{-4}	1x10^{-3}	1x10^{-4}	impermeable

2.2. FE modeling

Fig. 1 shows the general view of the dam and its prepared 3D model by Flac3D software. The properties of the dam body and foundation materials according to Table 1. The constitutive model of Mohr-coulomb were considered.

The simulation periods of the model included the important periods of an earthen dam (Rahimi, 2013), the construction, the dewatering, and finally the permanent seepage (up to the reservoir water level of 1430 according to the monitoring report (RWCEA2011). Also, sensitivity analysis has been done on the permeability ratio of core and shell materials.

Fig. 2. General view of Sattarkhan Dam and its3D modeling

3. Results and discussion

3.1. Validation

The results of numerical analysis for the piezometers located in the highest cross-section of the dam and the deepest location installation have been determined, which is consistent with the measurements. The pore water pressure changes were followed to the reservoir water level and proportional loss caused by the distance. For example, the results of piezometers 208 and 207 located in the highest cross section of the dam were presented in Fig. 2.

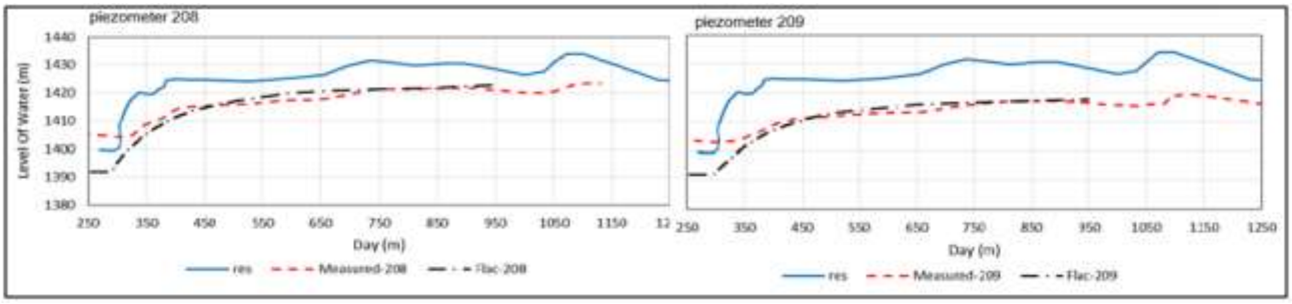

Fig. 2. Comparison between model results and measured results

Here is a good match between the results of the three and two dimensional models. Anyway, according to technical literature such as research results (Eslamian et al., 2021) by considering the significant length of this dam, which is more than 4 times the height of the dam, therefore the water flow vector parallel to the axis of the dam is negligible.

3.2. Sensivity analysis

In the sensitivity analysis study, the effect of the permeability ratio of the dam materials (core and shell), as the most important influencing variable in seepage, was studied in five cases. For example, by reducing the permeability of the core to one-tenth of the existing permeability, the results according to Fig. 3 are obtained for the deepest piezometers installed at the highest section of the dam with significant changes in the pore water pressure results (model K1). This shows the sensitivity of the analysis to the permeability of core material. While by reducing the permeability of the shell to one-tenth of the existing permeability of the shell material (modelK2), no significant changes were observed in the distribution of pore water pressure inside the core.

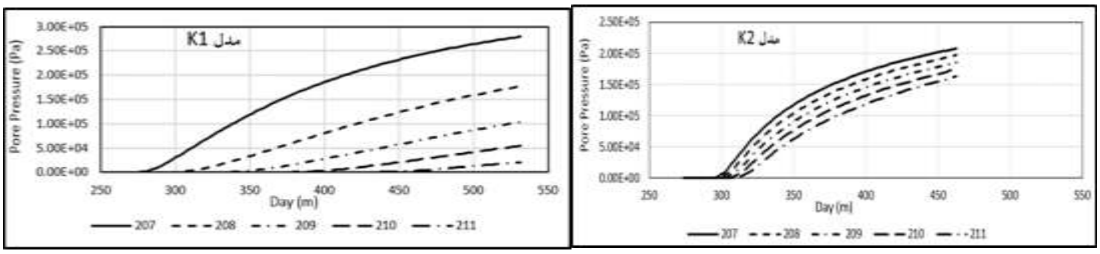

Fig.3. Pore water pressure changes with decreasing permeability in piezometers 207-211(core K1, shell K2)

In general, by reducing the permeability of the shell, dam behavior becomes similar to the homogeneous dams. When the permeability of together the core and the shell had been reduced, more time was needed to form the pattern without creating a noticeable change in the pore water pressure distribution pattern. Also, by increasing the permeability of the core compared to the shell, the pattern of water penetration was similar to a dam with a homogeneous body. In this case, a significant head loss did not occur in the core due to the greater permeability of the materials.

4. Conclusions

The results of numerical analysis of the three-dimensional seepage model for Sattarkhan Dam were compared with the results of piezometers and showed a good agreement. The water flow vector parallel to the dam axis has less effect on the results in the analysis of seepage by considering the geometry of this dam. The main variable in dam seepage analysis is the permeability coefficient of the material. The results of sensitivity analysis were showed that with increasing in the ratio of the difference between the permeability coefficient of core and shell materials, non-uniform behavior was occurred in seepage. In this case, needed time for analysis were increased. The analysis results were more dependent on the permeability of core materials. By reducing the ratio of the permeability difference between the core and the shell, the seepage behavior of the body becomes similar to a homogeneous dam. Also, if the permeability ratio of core and shell were remained constantly, the seepage pattern in the body would not changed. The time of occurrence of produced pore water pressure changes. In the design of the body of earthen dams, it will be necessary to study the ratio of the permeability coefficients of the core and the shell according to the characteristics of the borrow resources located in the site of the dam construction.

5. References

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