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EXTENDED ABSTRACT

Evaluation of the Effect of Drainage Geometry on the Behavior of Homogeneous Embankment Dams (Case Study: Kalan Dam of Malayer)

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1. Introduction

Embankment dams are one of the essential structures in civil engineering, and it is important to examine their various dimensions. In addition to affecting the water discharge process, drainage geometry also plays an important role in the after-filling behavior of embankment dams. In general, the safety of the dam is not only related to its design and construction, but it also depends on behavioral record of its performance in the first period of dewatering and operation, as well as regular service throughout the life of the dam (Ghareh and Nowroozzade, 2019, Komasi and Beiranvand, 2020). In These years, many modeling based on limiting equilibrium methods using different software has been performed. However, a broad view of the effect of drainage geometry on the behavior of homogeneous earth dams has not been done. Accordingly, this study investigates the stability of earth dams with a particular focus on drainage geometry. For accurate evaluation in this research, the Malayer dam has been studied.

2. Methodology

2.1. Introduction of Malayer Dam

Malayer Dam is located 30 km away from the south of Malayer city in Hamedan province and 1100 meters away from downstream and north of Patieh village. This Dam has been constructed to provide drinking water for Malayer city (18 million cubic meters per year) and improve and develop irrigation in the lands south of Malayer city. Malayer Dam is a homogeneous soil dam with a central chimney drain, and it has 47 meters in height from the natural river bed. The maximum final level of the dam crest is 1920 meters (Malayer Geological Report, 2000). The position of the dam is shown in Fig. 1. the cross-section and other characteristics of the Malayer dam are shown in Fig. 2.

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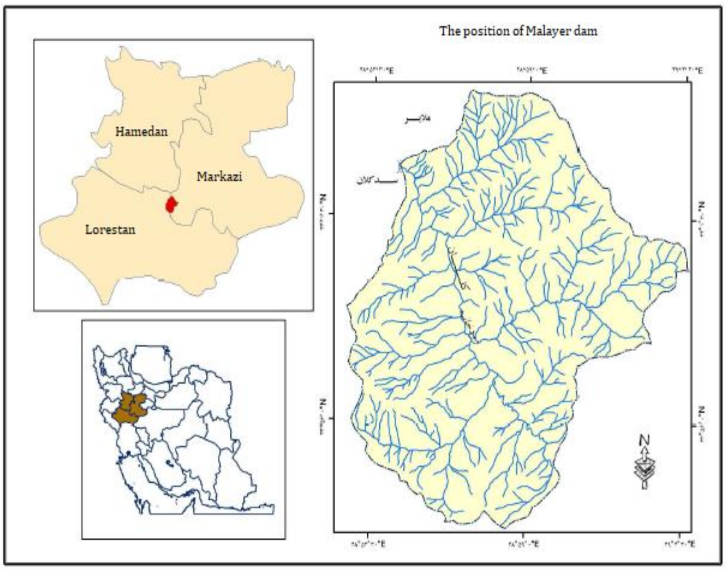

Fig. 1. The position of the Malayer dam

2.2. FLAC modeling

In the first stage of modeling, a suitable meshing for the problem should be defined; therefore, the number of elements in the model is determined. In FLAC software, the desired meshing model is determined according to the priorities (stresses and displacements), and the elements are determined with appropriate dimensions (Itasca, 2000).

Mohr-Coulomb and Cam clay behavioral models have been used for behavioral modeling of body materials and foundations of Malayer Dam in the construction stage. The parameters considered for different materials of the dam body are presented based on the design assumption and experiments in the design reports in Table 1. (Malayer Geological Report, 2000).

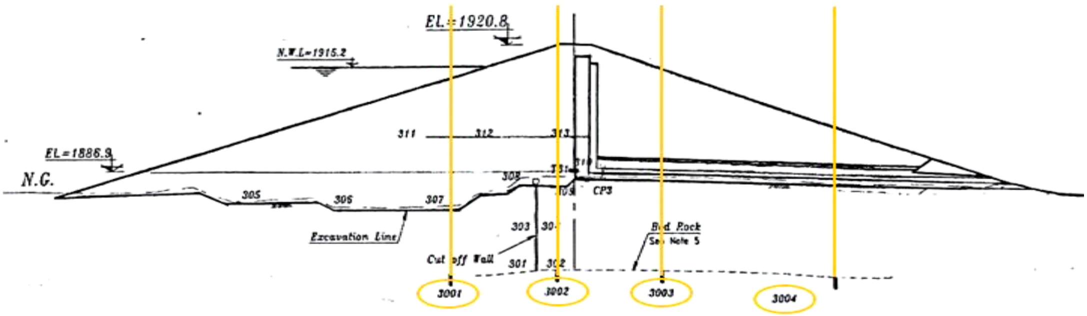

Fig. 2. The cross-section of the Malayer dam

Table. 1. Mohr-Coulomb behavioral model parameters for body materials and dam foundation (Malayer Geological Report, 2000)

Material	ϕ (deg)	C (kN/m^2)	E (kN/m^2)	ν	γ (kN/m^3)
Homogeneous dam	9	70	2×10^4	0.35	21.2
Filter and Drain	38	0	4×10^4	0.3	21.5
The First fine-grained layer of foundation (0-10m)	20	20	1.5×10^4	0.4	20
Coarse-grained interlayer (10-15m)	30	10	2.5×10^4	0.3	20.5
The Second fine-grained layer of foundation (15-25m)	20	20	1.75×10^4	0.3	20

3. Results and discussion

3.1. Effect of chimney drainage angle on dam response after dewatering

To investigate the effect of drainage geometry, the drainage angle has been changed by keeping other dam properties constant. In determining the studied angles, it has been tried to cover the typical range between horizontal and vertical drainage angles, which includes angles of 90, 100, and 110 degrees.

In Fig. 3. the distribution of shear strains for three drainage states with angles of 90, 100, and 110 degrees is shown. Based on the presented results, it can be observed that the distribution of shear strains is such that it relates the rupture wedge in the dam, the distribution of shear strain downstream, from the crest of the dam, in line with the slope of the drainage, advances toward the dam toe.

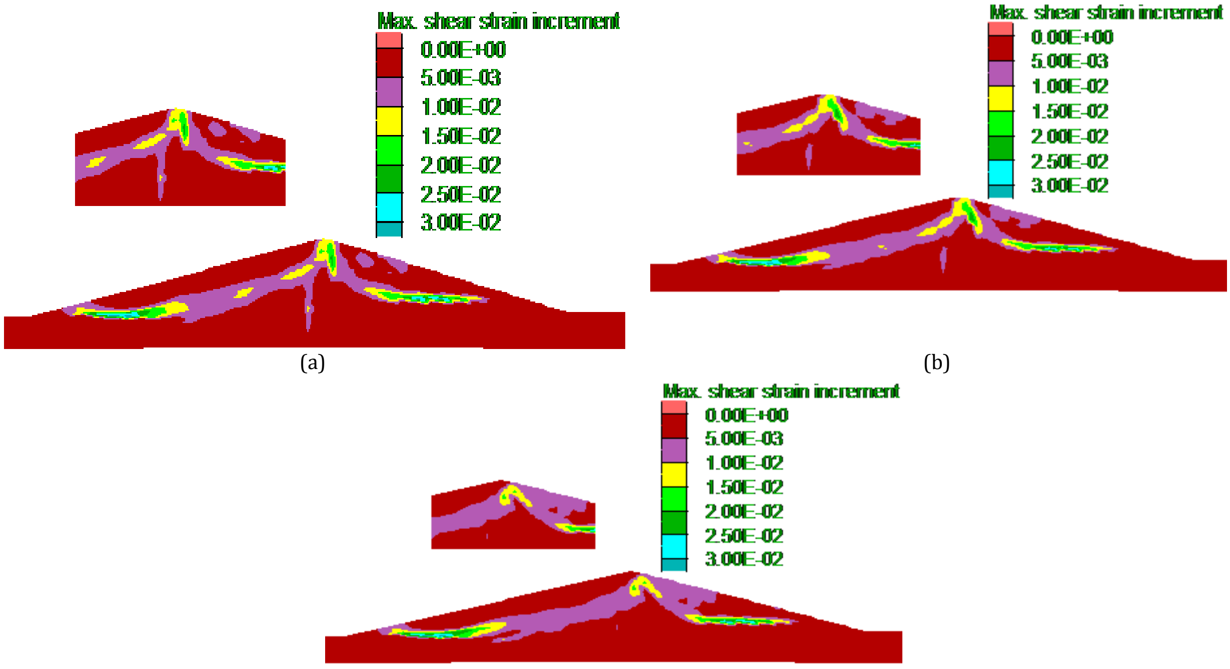

Fig. 3. Shear strain zone whit: a) angle of 90 degrees, b) angle of 100 degrees, c) angle of 110 degrees

In Fig. 4. In three drainage angles, the maximum settlement is at 12 meters in the height of the dam. The amount of settlement at 12 meters in the dam's height for three drainage angles of 90, 100 and, 110 degrees is 1150, 1250 and, 1350 mm, respectively.

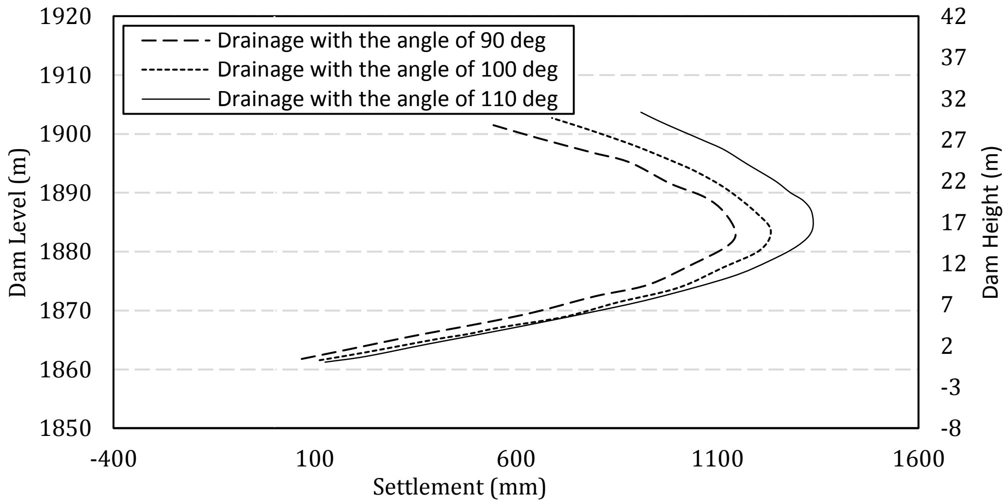

Fig. 4. Settlement Changes against the height of the dam for different drainage angles on the I3001 axis

4. Conclusions

In this paper, we have tried to investigate the behavior of the Malayer Homogeneous Dam; in this way, using the construction and dewatering instrumentation stage results has led to the validation of the performance and results of the computational code. The following points and results can be presented according to the research conducted, including review studies and numerical analyses conducted on Malayer Dam.

1. The results of modeling in the construction and dewatering phase of the dam showed that the low-overall model is more under the instrumentation results than the Mohr-Coulomb model. the Cam clay model errors are less than 5%.
2. The settlement rate upstream and downstream of the dam in the use of drainage at the angle of 110 degrees is higher than angles of 100 degrees and 90 degrees. Vertical drainage with a slight difference compared to drainage with an angle of 100 degrees has the lowest sitting compared to drains with angles of 100 and 110 degrees downstream and upstream.

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