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Shirin darreh dam condition of stability and maintenance

Babak Hagdoust[1], G. Akbari[2]

Abstract. Measurements of tension and deformation in final step of the construction was found significantly important in design of earth dam. The results show that the application of the Mohr–Coulomb model has appropriate accuracy where sinking the vertical core takes place. The results indicated vertical movement and upward trend of the dam was slower in the upper shell due to the presence of drain. Also the total tension in the dam's body was slowly upward during the first operations over a decade. Dewatering transferred a low-level inside the core to lower-level in the middle of the core. Comprehensive measurements were carried out through dam body showed that after construction and initial operation pore water pressure reached at 370 kPa including the middle core. Pore pressure for the whole dam after completion of the construction was monitored as 96 cm in the middle and one-third of the core level as well.

Key words. Pore pressure, critical condition, precision measurements, elastic modulus, Poisson's ratio, adhesion, friction expansion angle.

1. Introduction

Despite of considerable progress in engineering science and its decisive role advancing in civilization the urgent attention to heterogeneous and unpredictable construct of the rock mass in nature and human errors in design, implementation and correct operation of dams, led to instability and breaking of dams [1–3]. The unpleasant experience of dams instability and causalities and economic losses indicates that many of these cases deal with their effective factor which are predictable. Maintenance of dams is associated with certain complications. The stability control and dams safety at all stages of design, implementation and operation, should be maintained. According to reports of the International Committee on Large Dams, 1105 (5.7 %) cases of 14700 dams that were studied had serious damage and 107 (0.7 %) of them were destroyed or could be destroyed [2, 3]. Referring to Fig 1, it can be seen that the majority (about 74 %) built dams are earth or rockfills which face to de-

[1]MSc. Civil Engineering, Hydraulic Structures University of Sistan-Baluchistan, Iran

[2]Assoc. Prof. Civil Engineering, University of Bojnord, Iran

struction compared with concrete dams, this can reveal the necessity of monitoring and surveillance of earth dams.

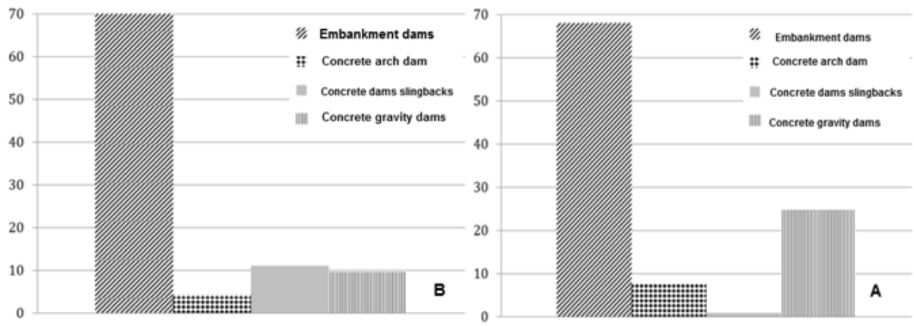

Fig. 1. Left–ratio of existing dams, right–ratio of destroyed dams

Nevertheless, to control behavior and performance of dam as well as control and verification of design assumptions, instrumentation and systems for measuring parameters affect the stability of dams [4, 5]. Thus pore water pressure, effective tensions, tension distribution, horizontal movements, and sedimentation are investigated. In this study, a comparison of figures obtained from the results of instrumentation and numerical analysis suggests that there is a good agreement between measured data by the electrical piezometers and software resulted in the clavy cored dam and we can be sure about the exude in dam.

2. FLAC design procedures

2.1. In field investigation of the model

Shirindarreh dam is in 65 km of northwest of the Bojnord city, in northern latitude of "6" 37 and east longitude of 43 "28" 6 57, which is established on the northern branch of the Atrak. The aim of the construction of the dam was supplying water of agriculture in the 6300 meters from the river bed, a crest length of 483 meters and storage of 91/5MCM water and 68/5MCM annually adjustable water. The dam with +801/25crest level above sea level, the height of 75/65 meters under core, crest length of 483 meters, crest width of 12 meters and the reservoir volume of about 91/5 million cubic meters. It is a soil type with vertical clay core, that is located on alluvial foundation at the deepest point with 36 meters deep. After completion of the body construction, water level in the reservoir was at the level of 760/29+ equal to 24/54 meters depth of water.

Body and dam foundation of Shirindarreh dam is composed of different areas. Figure 2 shows various regions and constituent materials of the dam and foundation. In the figure, areas related to materials are indexed by numbers: 1. Coarse foundation, 2. Coarse grained foundation, 3. Medium grained foundation, 4. Seal, 5. 2 kilometers (one of the source), 6. Core, 7. Qarnas (one of the sources), 8. Atrak (one of the sources), 9. Shirindarreh (one of the sources), 10. Rock fill, 11. Drain,

12. Filter.

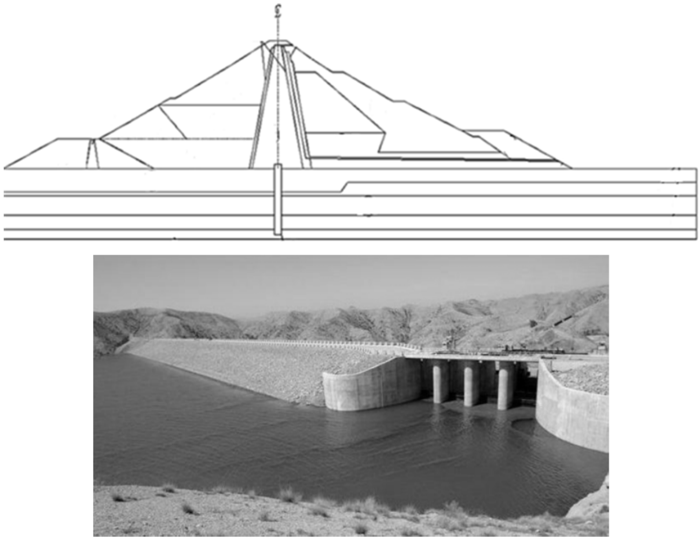

Fig. 2. A view of the Shirindarreh dam and various parts of the body and foundation

Instrumentation of Shirindarreh dam is conducted in 3 of 10 cross sections using foundation electric piezometer, electric piezometer of embankment (EPE), Casagrande piezometers, observable wells, total pressure cells (TPC), the mapping of geodesy, combined turnkey (INC) and measuring Sediment (MS). In reviewing the results of the analysis,the results returned from the utility electric piezometers of embankment (EPE), total pressure cells (TPC), turnkey (INC) and measuring sediment (MS) installed in the section with maximum height are used. The number of tools used in the different sections and position of locating instrument used in Shirindarreh dam are presented in in Table 1 and Fig. 2, top part.

Table 1. The instruments used in different sections

Sections of investment			Instrument	No.
3-3	5-5	7-7		
15	21	15	Electrical piezometer	1
6	9	6	Casagrande piezometer	2
8	9	8	Pressure cell	3
2	2	2	Deviation meter–subside	4

3. Results

Finite element software Abaqus/CAE6.11-1 and FLAC were used for modeling special feature accompanied with all abilities of the processor at the time of analysis. The unique features of this software compared to similar softwares such as PLAXIS exhibit a significant reduction in time.

3.1. Pore water pressure in the dam's body

To investigate the pore water pressure in the body and foundation of Shirindarreh dam, electrical piezometers of vibrating string and stand pipe are used. Electric piezometers are installed at the core and downstream embankment of dams on three levels and at the upstream and downstream foundation of water curtain on 2 or 3 levels. Graph of pore water pressure changes of piezometers EPE3-7– EPE 3-6 EPE3-5- EPE3-8 which are from upstream to downstream at levels of 5/741, are shown in Figs. 3, 4, and 5 respectively. Water level of reservoir has downward trend that indicates the proper functioning of clay core of the dam. At this point and zero values of pore water pressure in EPE3-8 piezometer installed above a horizontal drain also approve this. Parameters in different parts of the body foundation by inverse method of analysis is calculated which are presented in Table 2.

Table 2. Parameters calculated in different parts of the body foundation by inverse method of analysis

Material	Y (kN/m^2)	E (kN/m^2)	ν (-)	C (K)	φ (deg)	ψ deg	K_x (m/s)	K_z (m/s)	e (-)
Seal	21.5	1.0E+5	0.3	-	-	-	1.0E-10	1.0E-10	0.2
2 Km	19.5	4.0E+4	0.3	24	33	3	3.0E-04	3.0E-04	0.4
Core	19	6.0E+3	0.4	160	0	0	2.0E-10	1.0E-10	0.5
Qarnas	21	3.5E+4	0.3	5	30	0	0.4	0.4	0.4
Atrak	21.5	8.5E+4	0.3	68	42	12	1	1	0.4
Shirindar	21	4.5E+4	0.3	4	35	5	0.7	0.7	0.4
Rockfill	20.5	8.0E+4	0.3	0	41	11	0.5	0.5	0.4
Drain	20	3.5E+4	0.3	0	35	5	0.5	0.5	0.4
Filter	20	3.5E+4	0.3	0	36	6	0.2	0.2	0.4

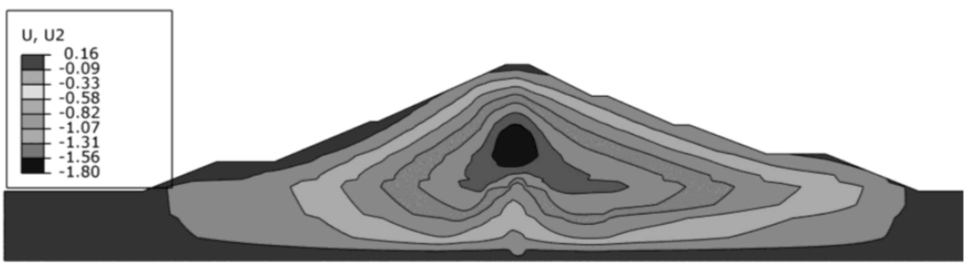

Fig. 3. Vertical deformation.using Mohr–Coulomb model

This reduction amount of pore water from EPE3-1 pizometer to the pizometers EPE3-2 and EPE3-3 which are installed in upstream and downstream of sealing curtains respectively, also implies the proper functioning of the blankets so that a

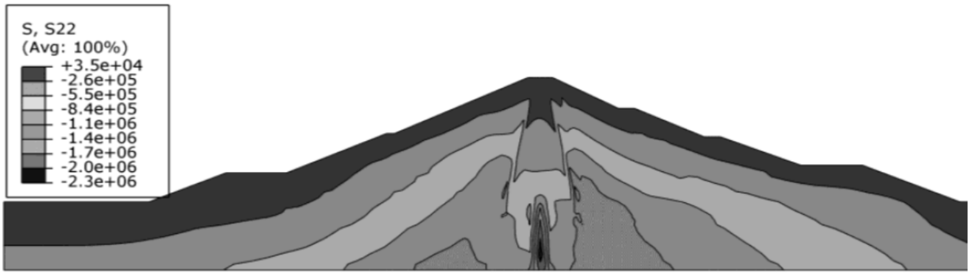

Fig. 4. Vertical effective pressure using Mohr–Coulomb

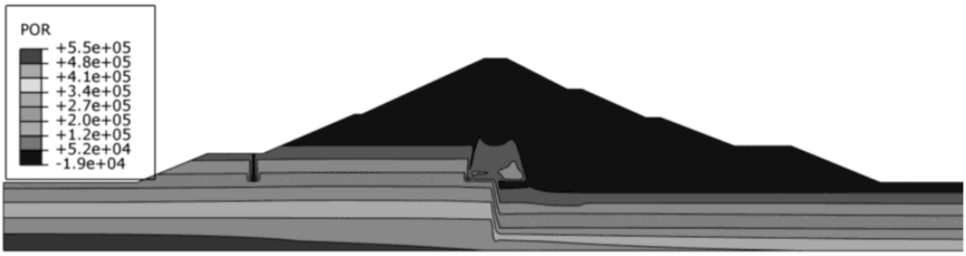

Fig. 5. Pore water pressure using Mohr–Coulomb

2X increases in drained upstream piezometers has led to an only 40 % increase in pore water pressure of downstream piezometers blanket (Fig. 6).

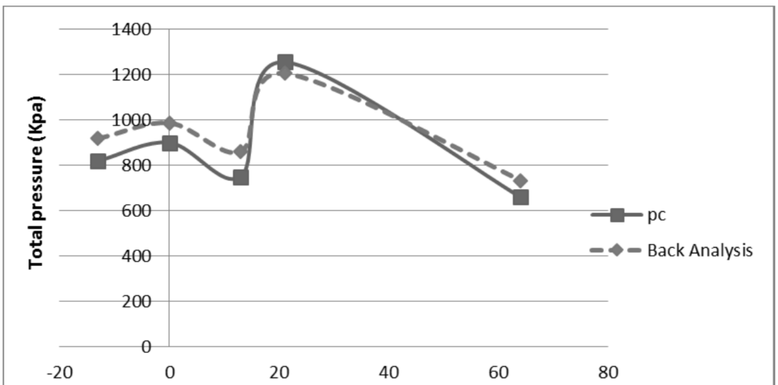

Fig. 6. Pore pressure changes by Piezometers for body at 799 m core elevation

This trend is also sensible in the section and as observations from the above figures, Pore water pressure values is significantly decreased from EPE5-7to EPE5-9, EPE5-8 and EPE5-10 and there is no pore water pressure in EPE5-9, EPE5-8 and EPE5-10 which are On top of horizontal drain.However, at a distance about 7 meters of EPE5-8piezometer upstream, which is in EPE5-7, the Pore water pressure has reached around 190KPa (Fig. 7).

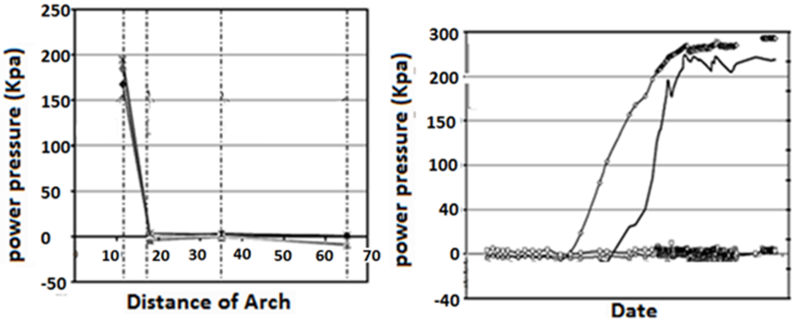

Fig. 7. Pore water pressure changes in Piezometers of the body in section of 5-5

In the electric piezometers installed in foundation section 5-5, pore water pressure is decreased from piezometers EPF5-1 and EPF5-3 installed in the upstream of water curtain to the downstream piezometers EPF5-6, EPF5-5, EPF5-4 and EPF5-2, and the values read from Casagrande Pizometers in water curtain downstream also prove this point.

4. Conclusion

Evaluation of pore water pressures in electrical and Casagrande piezometers installed in the upstream and downstream of a drain blanket, indicates the proper function in reducing the hydraulic gradient. The main drawback of this program is low speed and convergence of models on consolidation issues. In general, the most important results of tension distribution in this study include:

1. Effective tension level of initial water filling until the end of the first ten years was increased, but from begin of the second ten years from had a downward trend.

2. The process of total tension in body of dam had slow upward trend which from first water filling to end of first ten years, is transferred from low level of core side to low level of middle of the core.

3. The vertical movements in Shirindarreh dam has slow upward trend that the process is slower in the upstream shell comparing the downstream due to the presence of water.

4. Horizontal movements in Shirindarreh dam as well as the vertical, has upward trend but the speed in downstream is more than upstream due to the lake water.

References

[1] A. K. Chopra, L. Zhang: *Earthquake-induced base sliding of concrete gravity dams.* Journal of Structural Engineering *117* (1991), No. 12, 3698–3719.

[2] M. Azmi, P. Paultre: *Three-dimensional analysis of concrete dams including contraction joint non-linearity.* Engineering Structures *24* (2002), No. 6, 757–771.

[3] R. A. Mir, C. A. Taylor: *An investigation into the base sliding response of rigid concrete gravity dams to dynamic loading.* Earthquake Engineering & Structural Dynamics *25* (1996), No. 1, 79–98.

[4] J. Dunnicliff: *Geotechnical instrumentation for monitoring field performance.* John Wiley & Sons, Inc (1994).

[5] L. Pagano, S. Sica, A. Desideri: *Representativeness of measurements in the interpretation of earth dam behaviour.* Canadian Geotechnical Journal *43* (2006), No. 1, 87–99.

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