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Monitoring of Masjed Soleyman Dam Based on Instrumentation Data

Saeedeh Hossein [1], Mahin Etemadifar [2] Iman Aghamolaie [3*]

[1] Lecturer, Department of Geology, Payame Noor University, PC 19395-3697,Tehran, Iran

[2] Masters of Geological Engineering Abpouy consulting engineering company

[3] Masters of Geological Engineering

*Imaneng189@gmail.com

Abstract

In order to control and for the safety of Masjed Soleyman dam on the construction and operation period, dam monitoring is performed utilizing data of the instrumentations installed on the dam's body. Monitoring means the investigation of a structure's performance on construction and operation period and its comparison with the design-related predictions. This investigation needs correct information from the dam's whole construction period which requires instrumentation data reading, compilation and processing. Robustness of the instrumentation should be controlled as well to ensure the robustness of the data. Using the monitoring data and studying the trend of the instrumentation data variations, probable events which could wear, weaken and deteriorate the dam can be revealed and thereby it is possible to reduce or prevent losses or damages.

Keywords: *Instrumentation Data, Masjed Soleyman, Ahvaz.*

1. Introduction

Stress condition is one of the most important parameters investigated in earth dams for the evaluation of the dam safety [1,2,3,4,5,6]. These parameters are important in dam construction stage for embankment control and selecting the optimized speed and in the operation period, for investigation and transition of stresses resulted from the embankment to the dam foundation [1,8.9]. In heterogeneous dams, stress condition analysis is more important due to deformability difference between the core and the shell. In these dams, some parts of the core are suspended from the shell due to the lesser settlement of the shell in compare with the core and the resulted stress from the embankment layers will not be completely transferred to the beneath parts and the foundation. The result of such a process is a phenomenon known as sagging or arching in which stress reduces in inner parts and hence the conditions for fracturing deformations are provided. If pore pressure dominates over the governing stresses, there is more possibility of cracking, hydraulic fracture and thereby more scouring of the core. In this regard, it is necessary to investigate the stress conditions on the earth dam body.

Masjed Soleyman dam (Godar-e Landar plan) was constructed and operated with the purpose of 3700 million KWh production of energy per year. With respect to the initial design, the dam has about 165 m height and is a rock-fill structure with a clay-core [7].

2. Research Method and Discussion

The barometer used in Masjed Soleyman is a triple some cluster. Placement locations of these barometer cells are shown in figure 1. This instruments are located on four sections of 360, 260, 160 and 430 in the dam. Location of every instrument is shown in table 1. Registered data in all of the barometers are uttermost till 5/9/2009.

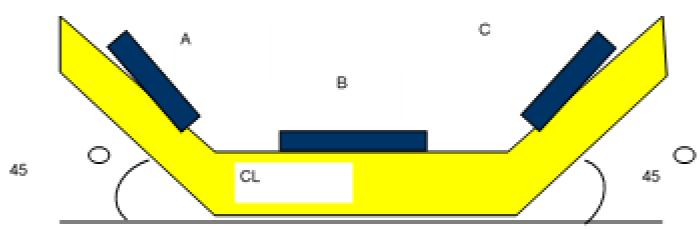

Fig. 1installation locations of stress cells in barometer cluster

Table 1.location of instrument installation on the dam body

Installation location	Sign
Upstream of the core	U/C
Center of the core	CL
downstream of the core	D/C
Upstream filter	U/Filter
Downstream filter	D/Filter
Upstream shell	U/Shell
Downstream shell	D/Shell

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2.1 Section 260

In this section, 19 clusters have been considered. Among them, there are 7 clusters that are without registered data.

2.1.1Level 230 m

Long term variations of the total stress for EP-2103, EP-2104, EP-2105, EP2106 and EP-2107 instruments at level 230 m are shown in figure 2. In instrument EP-2016 (on downstream of the dam), cell C is registered without data since 16/4/2008 figure3. It can be understood from the diagram that cells A and B in cluster EP-2016 have data almost below 100 kPa and negative since 2005. With respect to about 90 m soil height above the instruments, the registered figures seem abnormal. At the same time according to the diagram, apparent performance of other instruments seems robust and analyzable.

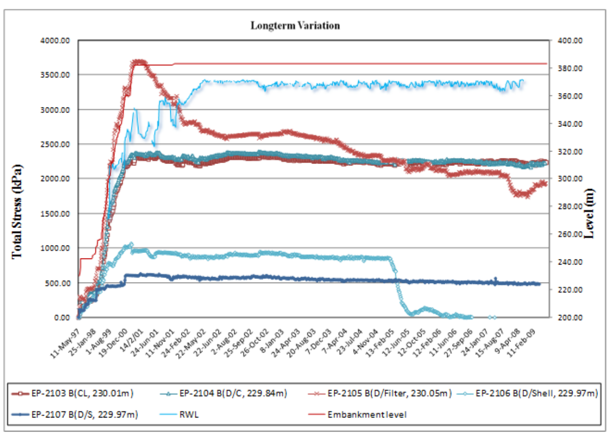

Fig. 2 Longterm variations of total stress for level 230 EPs (cell B).

Instruments EP-2103 and EP-2104 are at the center of the core and downstream of the core respectively. There is not much difference between the registered data of pressure from these two instruments. This issue shows the low possibility of arching. Arching ratios at this level are shown in figure 4. All arching ratios are above the acceptable value of 0.6 and stress condition appears to be acceptable. In this figure instrument EP-2106 have no analyzable data.

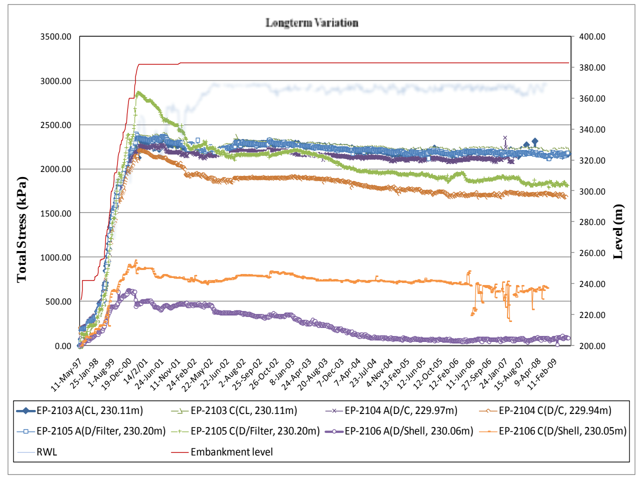

Fig. 3 Longterm variations of total stress for level 230 EPs (cells A and C)

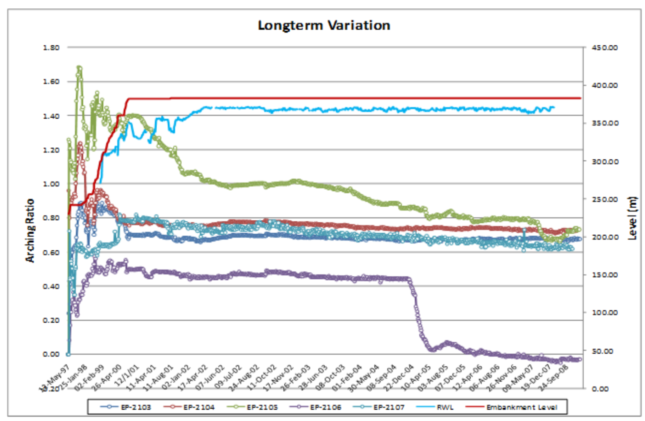

Fig. 4 arching ratios

2.1.2. Level 270 m

In figure 5, longterm variations of the total stress for instruments EP-2202, EP-2203, EP-2204 and EP-2205 are shown at level 270 m. In instrument EP-2202, cell B since 12/14/2005 figure 6 and cell A since 1/4/2004 are without registered data. In instrument EP-2204, cell B is without registered data since 11/19/2003.

The registered data by instruments EP-2203 and EP-2205 (on the downstream core and shell respectively), are close to the theoretical values resulted from the in situ soil height. With respect to the lack of registered data from instrument EP-2204 on the downstream core, it is not possible to compare it with the registered data from instrument EP-2205 in the filter at the same level. Arching ratios are shown in figure 7. All the arching ratios for the dam core are 0.6 and within the acceptable limit.

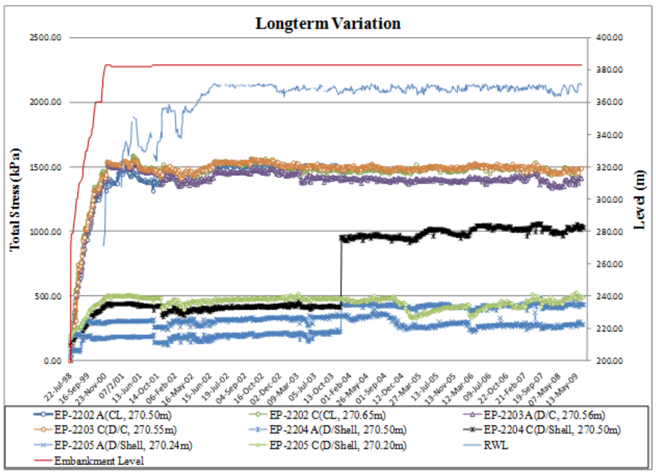

Fig 5 Longterm variations of total stress for level 270 EPs (cells A and C).

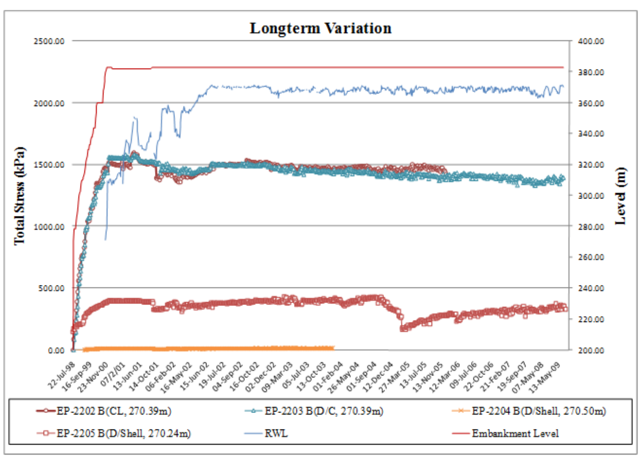

Fig. 6 Longterm variations of total stress for level 270 EPs (cell B)

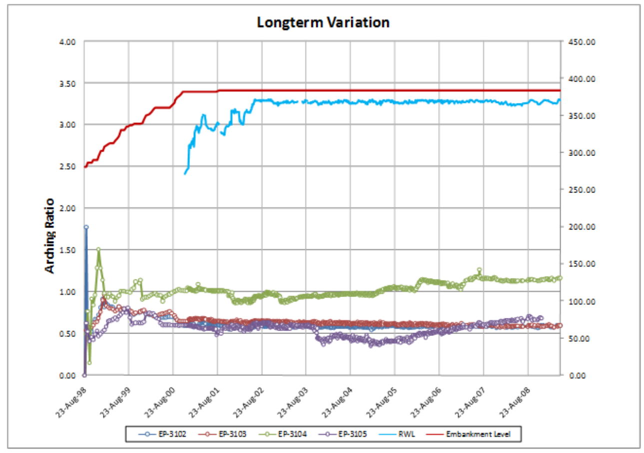

Fig. 7Arching Ratios

2.1.3. Level 310 m

In figure 8, long term variations of the total stress for instruments EP-3204, EP-3205 and EP-3206 are shown at level 310 m. Investigation of the diagram shows the apparent robustness of the instruments under the influence of the water level and embankment level variations. The latest registered values by instruments EP-3204 and EP-3205 (on the downstream core and filter respectively) are close to each other which appear to be acceptable with respect to the soil height above. Instrument EP-3206 on the downstream shell shows that pressure values are acceptable figures 19 and 10.

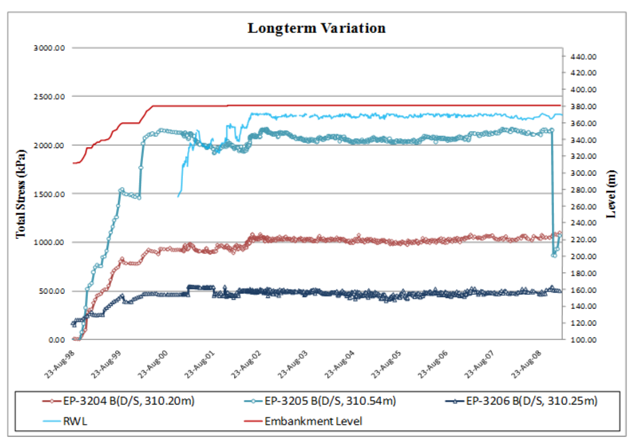

Fig. 8 Longterm variations of total stress for level 310 EPs (cell B).

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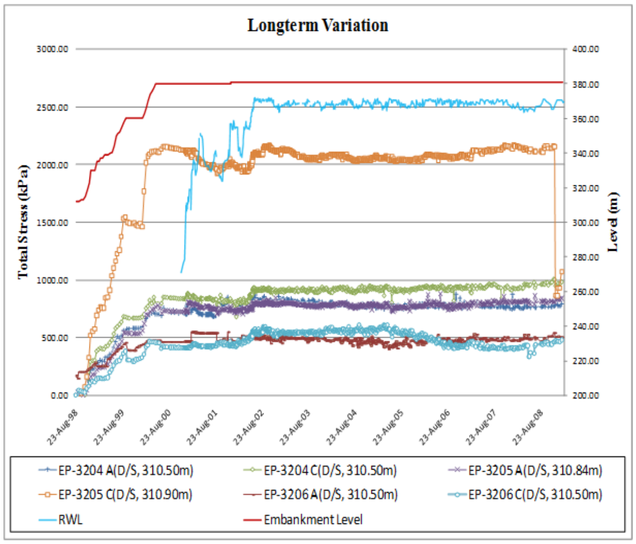

Fig. 9 Longterm variations of total stress for level 310 EPs (cells A and C).

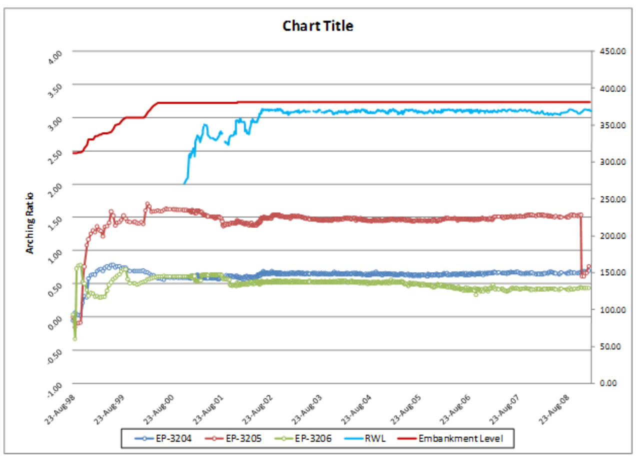

Fig.10 arching ratios

Hydraulic fracturing which leads to core inner corrosion and creation of concentrated run off is the result of a condition in which the created pore pressure at a point inside the dam is more than the created stress from the soil weight or at least is more than the minimum total stress at that point. In this condition, pore pressure dominates over soil tensile strength (which is often inconsiderable) and leads to the inner cracks of the soil. Accordingly, for determining the three principal stresses especially the minimum stress at sensitive points of the dam, a set of total stress cell are used in which every one of these PCs are installed with an special angle. Installation angles of these cells are horizontal, 45 degrees oblique to the upstream, 45 degrees oblique to the upstream. Therefore it is possible to determine the minimum and maximum stresses in the 2D stress plane perpendicular to the dam axis. Value of the calculated stresses should be compared with the measured pore pressure at every point as well. This comparison is performed by the calculation of the effective stress. The effective stress reduction to values lesser than zero shows the formation of tensile stress inside the body and the possibility of hydraulic fracture. Besides the minimum and maximum principal stresses, the calculation of rotation angle history of the main axes due to dam impounding is possible as well. Calculations are performed in such a way that positive rotation angle means the rotation of the principal axes toward the upstream and negative rotation angle means rotation toward the downstream.

2.1.4. EP-2202

the figures 11 and 12 shows stress condition variations in compare with failure criterion for the location of the barometer instrument EP-2202 and piezometer PPE22 (center of the core) at level 270 m. in this instrument, cell B since 12/14/2005 and cell A since 1/4/2004 are without any registered data. Registered data shows the failure occurrence at the core on these coordinates of the dam. Stress direction is also 10 degrees toward upstream. It appears that the investigation of the failure condition and stress direction shows a plastic region incidence on these coordinates of the dam.

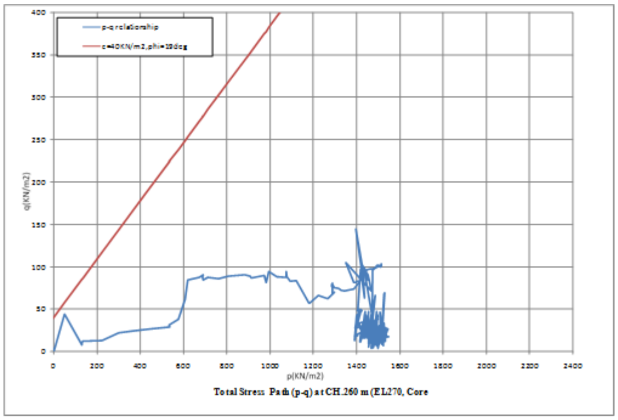

Fig. 11 investigation of plastic condition based on the total stress for instrument EP-2202

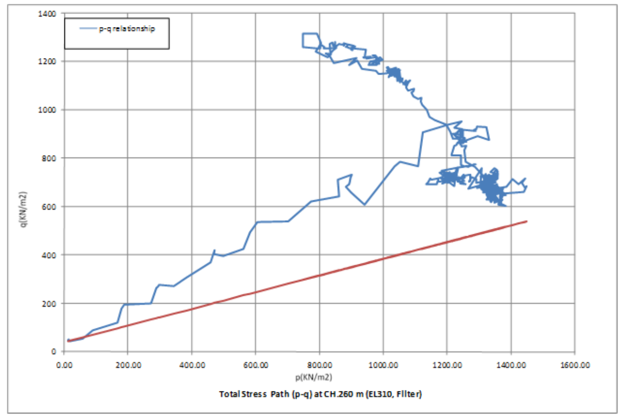

Fig. 13 investigation of plastic region based on the total stress for instrument EP-2305.

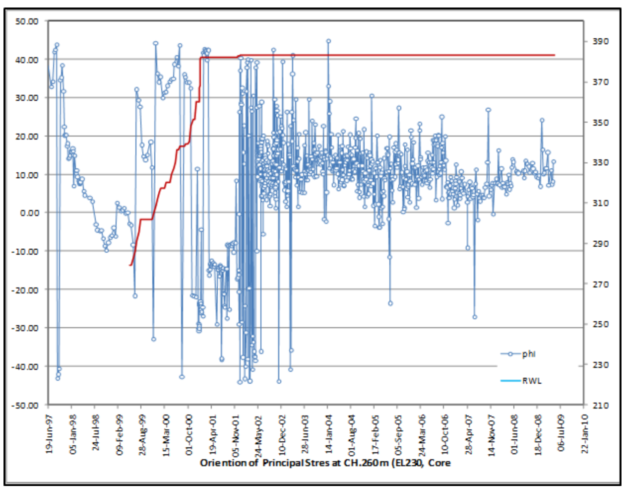

Fig. 12 principal stresses direction of EP-2202

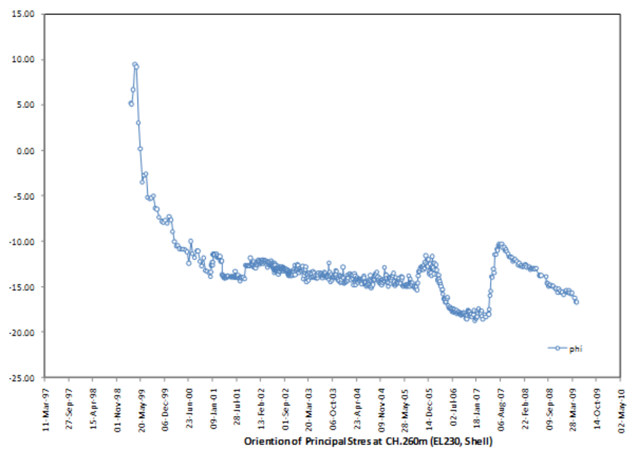

Fig. 14 principal stress direction for EP-2305

2.1.5. EP-2305

In the figures 13 and 14, variations of the stress condition in compare with the failure criterion are shown for instrument EP-2305 (downstream filter) at level 310. Registered data show the failure occurrence of the body material at these coordinates of the dam. The stress direction diagram seems to have a problem. There is a possibility for the drawn stress variation diagram to have problems as well.

Conclusions

As the latest date for the registered data is about 4 years ago i.e. 5/13/2009, it's not possible to reach an appropriate outcome about the current condition of the dam. It is worth noticing that all the upstream instruments along with some middle and downstream instruments are defective. And due to lack of access to data related to piezometers of H-PPE, it's not possible to calculate the effective stress based on data of barometer instruments (EP). At the same time, dam stability investigation based on the existing data shows the presence of plastic conditions at some part of the dam body. In the lateral section no. 160, it seems that in the downstream core (near the filter) at level 280 and in the lateral section no. 430 of the downstream core (near the filter) at level 310 there is a plastic condition. In section 360 of the downstream core (near the filter) and at level 310 of the downstream filter, plastic condition has occurred.

Finally, it seems that most of the plastic region has occurred in section no 260. At the downstream core location (near the filter) and downstream shell of level 230m, there is a more possibility of the formation of plastic region. Either it seems that there is a possibility of the plastic region formation at the center of the core, downstream of the core and the shell downstream of the level 280 m of this section. With regard to the very low rate of pore water pressure in the core (especially at the middle section), it should be noted that this issue have led to the reduction of the effective stress at the dam core. Hence the soil resistance has reduced and plastic condition has occurred. This issue can lead to the formation of the inner cracks and hydraulic fracturing at the core.

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