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Return Analysis of Tabarakabad Dam using Instrumentation Data

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Abstract— **To control the safety and behavior of Tabarakabad dam during exploitation, monitoring and returned analysis, utilizing happened by performance of the instrumentation inf¬ormation installed on dam fuselage. Monitoring means to evaluate the performance of structure during construction and exploitation phase and matching it with the predictions of design time. This -review requires having the right information from all of the dam construction duration. By monitoring the results and studying the tolerant trend of the instrumentation data, it can be possible to reveale the probable phenomena that are eroding and undermining dam to prevent or reduce the damages. The amount of cohesion in core has been achieved about two times higher than the predicted values in dam design and the internal friction angle is slightly less than the primary value. This could be due to the conservative conditions included in dam designing, which in any case is for insure. Also in the return analysis elasticity modulus, values are less than the predicted values except for the core. The existence of a downtrend process in the consolidation settlement of the dam core accordance with the indicated trend by the tools. This topic demonstrates the natural behavior in the settlement and pore water pressure changes in dam core.**

Keywords— **Tabarakabad dam, returned analysis, Limited components, behavior control**

I. Introduction

In order to achieve the main goals of dam construction, and achieve national and regional economic development plans, also avoid irreparable life-threatening and fiscal casualties and damages caused by the failure of the dam, safety control operations and dams stability during exploitation, on a regular basis, according to the most appropriate method, is essential [1]. Also in this case Icold [2] says "as generally this principle is accepted that dam safety not only depends on proper design and construction, but actual performance monitoring of the dam, during the first few years of activity and the entire operation time is also very effective.

"Therefore to control and safety behavior of Tabarakabad dam during operation, monitoring and returned analysis was don utilizes the information of instrumentation that was installed in the dam fuselage. Monitoring meant to evaluate the performance of a structure during construction and the operation phase that accommodated with the predictions of the designed time. It requires having the right information at all times, construction which requires collection of information and instrumentation readership to process them. Also the accuracy of the instrument should be checked to ensure information accuracy. With monitoring results and research of innovation process in the instrumentation data, can be possible phenomena being eroded, undermining the dam appearance and to provide the ability to prevent or reduce damages.

II. Specifications Of Tabarakabad Dam

Tabarakabad is a Pebbly- earth reservoir dam that located 25 kilometers northeast of Ghoochan city at 1/5 kilometers downstream of Tabarakabad village on Tabarakabad river that is one of the sub-branches of Atrak river[3]. A summary of the main specifications of Tabarakabad dam is shown in (Table. 1).

The main components of dam fuselage contains the core, crust, filter and drainage. Tabarakabad dam has a clay core, with almost 10-9 m/s permeability. The analyzed Core is located in the middle of the dam. The dam shell is the stability and protection factor of the core. Therefore, precise control of parameters that will be mentioned in the analysis are essential. Drainage system of dam fuselage consists of a vertical and horizontal drains.

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TABLE 1
SPECIFICATIONS OF TABARAKABAD DAM

Dam type	gravely soily with clay core
Start year	1372
project completion time	1383
The first year of operation	1383
crown width	10 m
crown length	198 m
crown level	1521.5 m from see level
height from floor	50 m
height from foundation	74 m
normal level from sea level	1513.5 m

III. METHOD OF ANALYSIS

The performed analysis contains investigating of stress and strain changes, during the dams life time and comparison with data from instrumentation. Analysis of stress and strain in different periods of the dam life, was performed by the static forces using finite element method [4]. This analysis has been done to evaluate the interaction of inside areas of the dam fuselage.

Stress-strain analysis method at the end of construction, impounding and operation time periods has been done in effective stress method by consider the capabilities of the GeoStudio software, to analyze the stress and strain in the dam core, using the Elasto-Plastic model [5].

Analytical purposes, in any time period, is to control of the settlement, stress and pore water pressure created in dam and compare with the results of the instrumentation data. Intended geometry specification for dam modeling, ia according to the plans before construction. upstream slope of 1:1/8 and the downstream slope 1:1/65. The crest level at 1520/3 meters and a height of the dam core is about 76 meters. In the following, the different periods of the dam's life time will be analyzed.

Construction period

Construction of Tabarakabad dam in Ghoochan began on February 1381 and was completed on October 1383. In total, construction period duration has been about 620 days, which is less than the initial forecast that was around 730 days. Analysis of the dam during construction, should be done in stages by taking 16 steps embankment, during the period of 20 to 60 days for each layer. The purpose of consider the embankment stages is analysis conditions to be closer to the reality, consider the consolidation factor and in pore water pressure changes.The Performed layering on the the program, has been shown in Figure 1.

Different parts of the dam in this analysis includes the core, shell, filter, drainage, embankment and the dam foundation. At the beginning of analysis, the initial parameters that design have been done by them can be used, this parameters are shown in table 2 [6, 7].

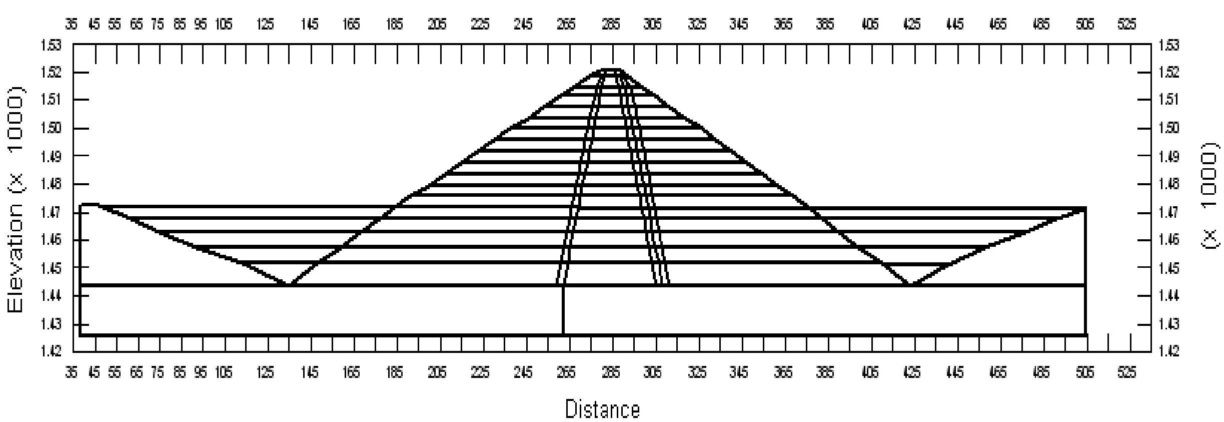

Figure 1. Designed model in software

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TABLE 2
THE INITIAL PARAMETERS OF DAM MATERI

parameter / aggregate	permeability Coefficient (cm/s)	elasticity modulus (Mpa)	Poisson coefficient	angle of internal friction (degree)	adhesion (KPa)	specific weight of saturated (KN/m^3)	dry specific weight (KN/m^3)
core	1×10^{-7}	10	0.35	29	10	20	17
crust	1×10^{-2}	54	0.30	44	0-	22	21
filter	1×10^{-5}	28	0.25	28	-0	21	17.5
drain	1×10^{-5}	28	0.25	28	-0	21	17.5
foundation	1×10^{-9}	250	0.25	25	100	22.5	21

Stress analysis of dam fuselage

In analyzing the problem by numerical models, supplay elements way, definition of boundary conditions and backrest conditions of problem, each of them plays a specific and effective role in results analysis. Anyway find the true parameters of the model and its introduction to the program, is the main part of the numerical modeling. In Elasto-plastic behavioral model, the formulation of stress-strain curve is like a hyperbolic shape and soil modulus is a function of confining pressure and shear stress that soil experience. Elasticity modulus changes in the height of the core of the dam have been considered by Duncan & Chang (1970) method [8]. Material behavior model in other parts of the Linear elastic dam, have been considered in drained conditions.

After making the model geometry and import the initial parameters of materials, the primary analysis and then return analysis can be done. Since the main objective of return analysis is achive to the actual parameters of materials used in the construction of the dam, so some primary parameters input to the software must be changed where as almost similar to the actual behavior of the dam (obtained from the instrument) is create in the model.

For this purpose, numerous analyzes performed in different stages and all the main affecting parameters has been changed separately with logical trend until all the parameters to be corrected with actual values it should be noted that this is a complex task because almost all parameters influence each other and by changing one of them the other parameters will change for this reason, in every analysis, only one parameter is changed logically to observe its effect on other parameters, accordingly the need for change next parameter and its range should be determine.

Changeable parameters can be roughly divided into two categories, effective parameters in the pore water pressure and effective parameters on deformation of the dam fuselage. In Figure 2 pore water pressure values of the core dam obtained from instrument has been compared with software analysis at the end of the construction time.

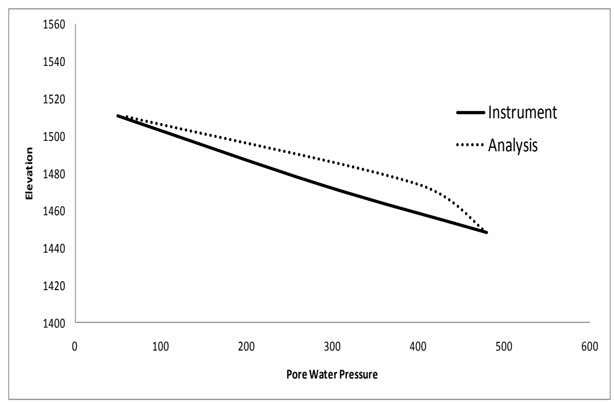

Figure 2. A comparison between pore water pressure values obtained from instrument and software analysis

During construction of the dam fuselage, due upper layers reloading, pore pressure create inside the core. This additional pore water pressure during construction and thereafter be amortized gradually and proportional to it, consolidation settlement will be created in core. Hence the aim of the analysis, to determine remaining pore pressure in the core after the completion of the dam building and its involvement in dam structural stability during final analysis of construction. Status and values of settlement contours in dam fuselage and comparison beetween the values obtained from the instrument and software analysis has been shown in Figures 3 and 4.

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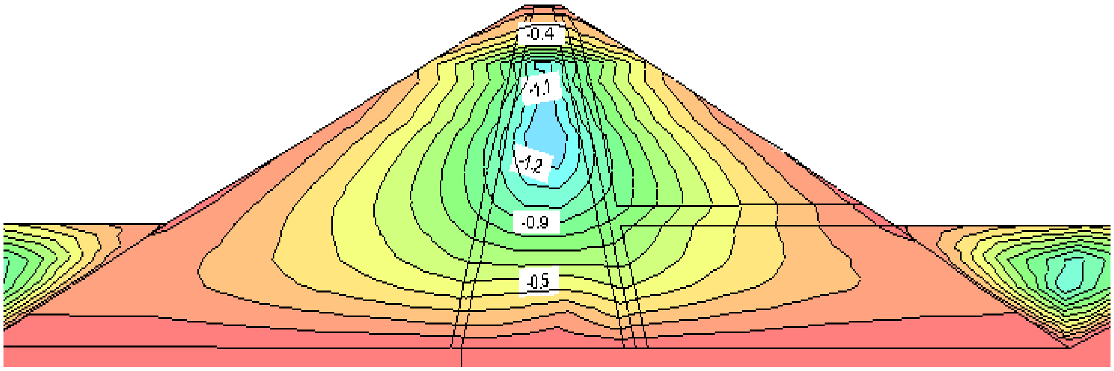

Figure3. Status and values of settlement contours in the dam fuselage

(numbers are settlement amounts in meters)

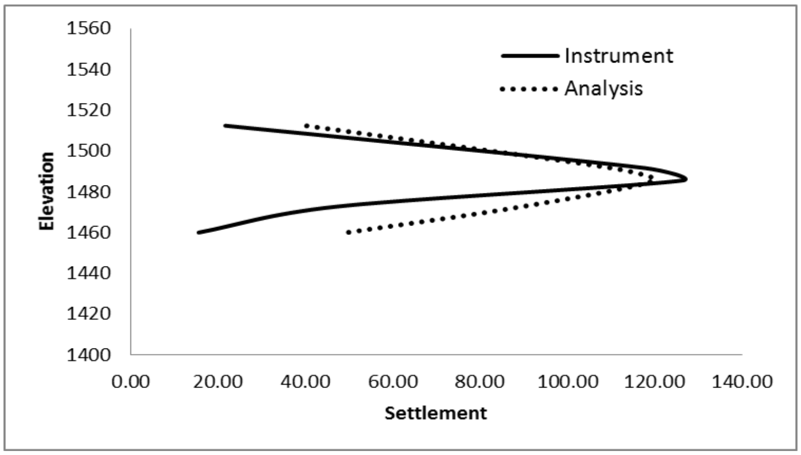

Figure 4: A Comparison between the values obtained from the instrument and software analysis

IV. DAM DEHYDRATION STAGE

Study on stability and deformation of embankment dams during the first dehydration has considerable importance. Shell areas in rockfill dams slam dry often. In the first dehydration, the presence of water reduce the resistance between the rock grains and eventually slip and displacement of grains in the upstream shell [9]. In This analysis dam dehydration have been considered for six months in three stages (each stage takes two months). The maximum water level at various stages of dehydration are listed in Table 3.

Condition of pore water pressure in three stages of dehydration has been shown in Figures 5 to 7. A comparison between pore water pressure changes in dam core has been shown in Figure 8.

TABLE 3
WATER LEVEL IN VARIOUS STAGES OF DEHYDRATION

water level of reservoir	dehydration stage
1479.5 m	first stage
1478.7 m	second stage
1502 m	third stage

Settlement evaluation caused by stress at the core of dam under the influence of dehydration has changed as shown in Figure "9". Since the manometer tools installed on the dam core, commenting about stress values has been done at this point of the dam fuselage. To assess of the dam core,the SD-9-2 instrumen data have been used. Dam settlement contours are shown in Figure 10.

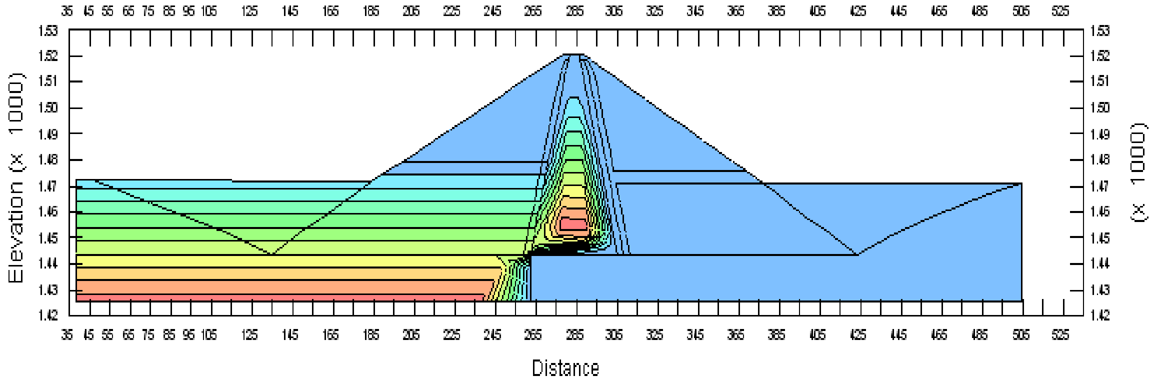

Figure 5. Condition of pore water pressure in the first stage of reservoir dehydration

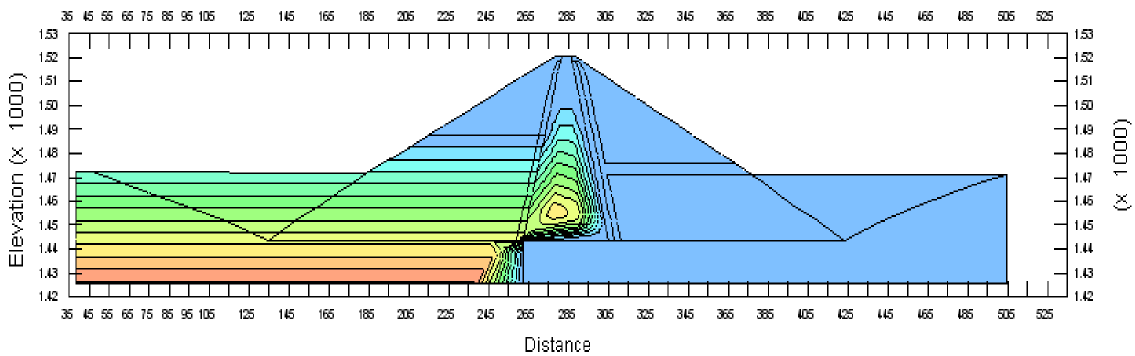

Figure 6. Condition of pore water pressure in the second stage of reservoir dehydration

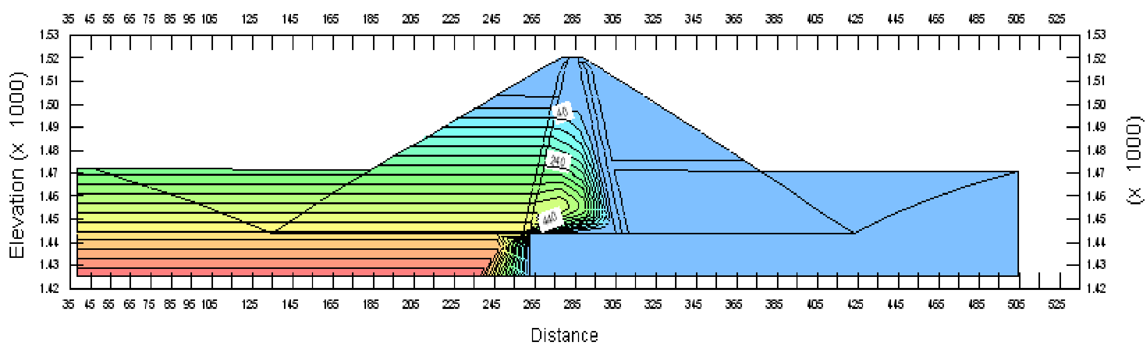

Figure 7. Condition of pore water pressure in the third stage of reservoir dehydration

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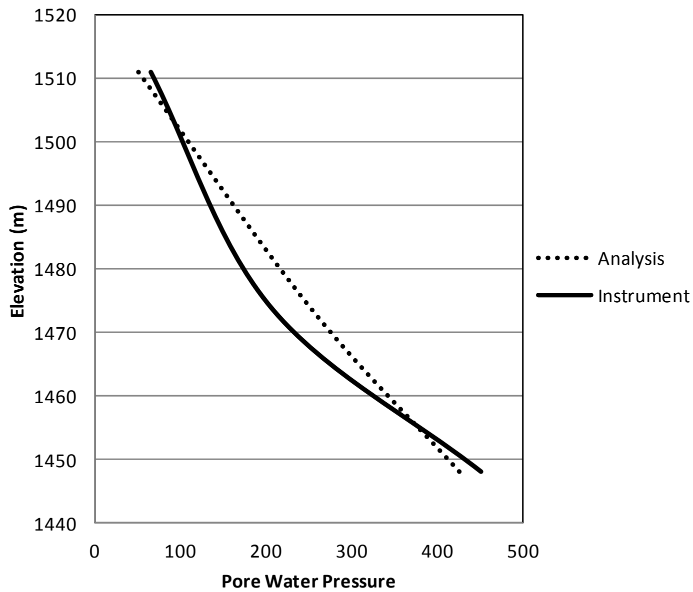

Figure 8. A comparison between pore water pressure changes in the dam core

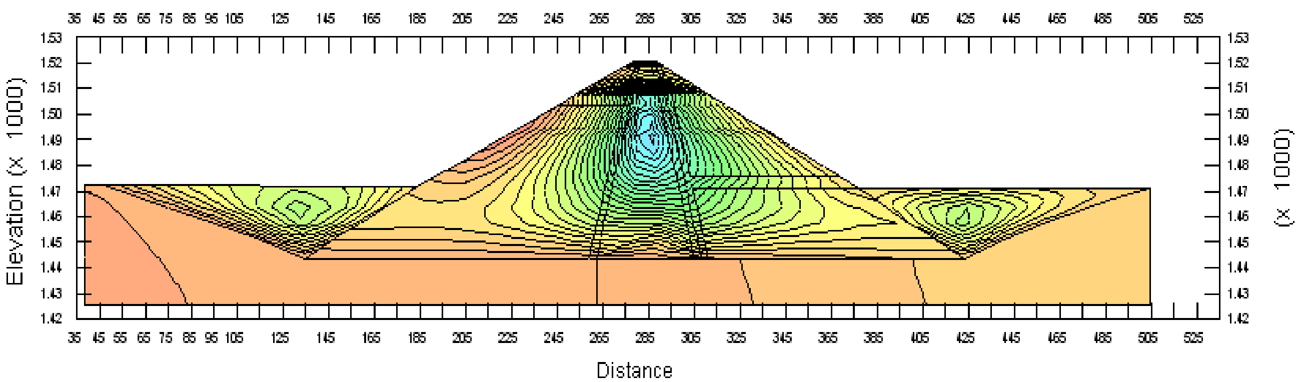

Figure 9. Settlement condition at the end of dehydration (the numbers shown are settlement values in meters)

Stress values at the core of the dam has changed under the influence of dehydration as shown in Figure 11. Since the manometer tools installed on the dam core, commenting about stress values has been done at this point of the dam fuselage.

The stress distribution at the end of dehydration has been shown in Figure 12.

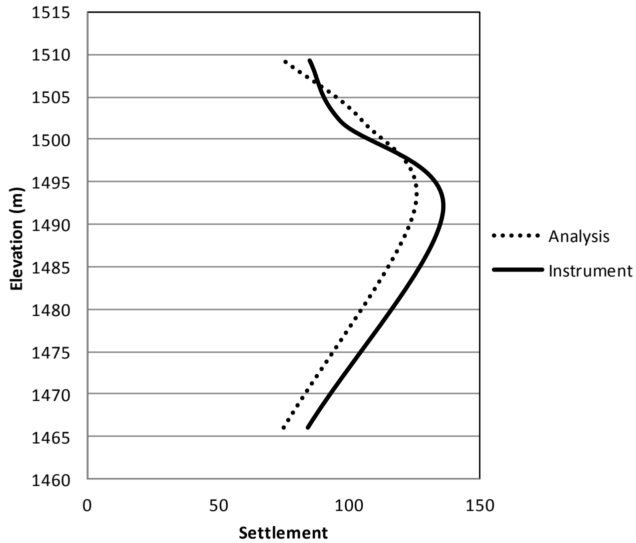

Figure 10. Compare the settlement changes in the core center of the dam

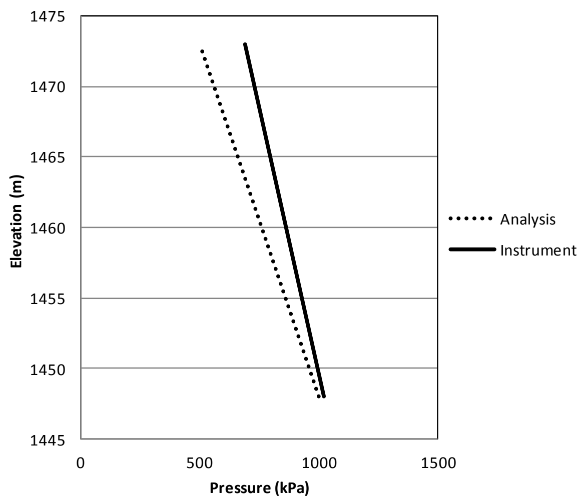

Figure 11. Compare changes recorded by instrument and software analysis

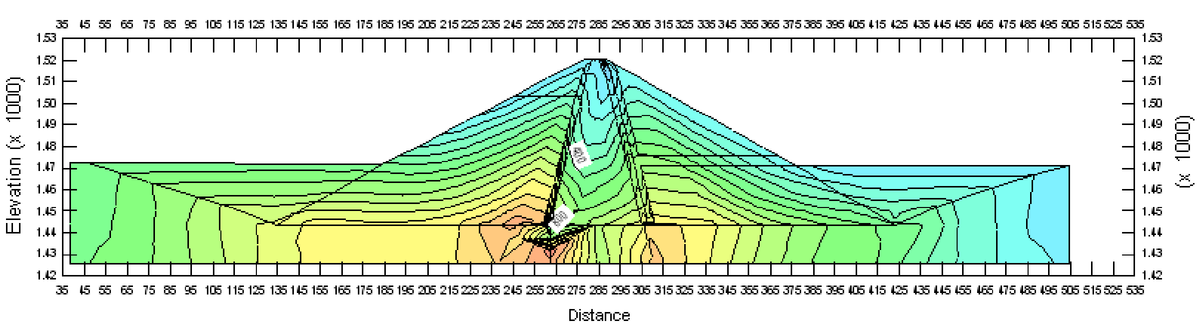

Figure 12. The stress distribution at the end of dehydration

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V. CURRENT CONDITIONS

Analysis of the dam current conditions has been don, on date 2013/02/19, according to the instrumentation data. Reservoir water level have been considered at 1502 meters.

Following the results of the software analysis were compared with data from the instrumentation.

According to the SD-9-2 instrument data in the center of dam core and software analysis (Figures 13 and 14) values obtained for the settlement on dam Current conditions compared.

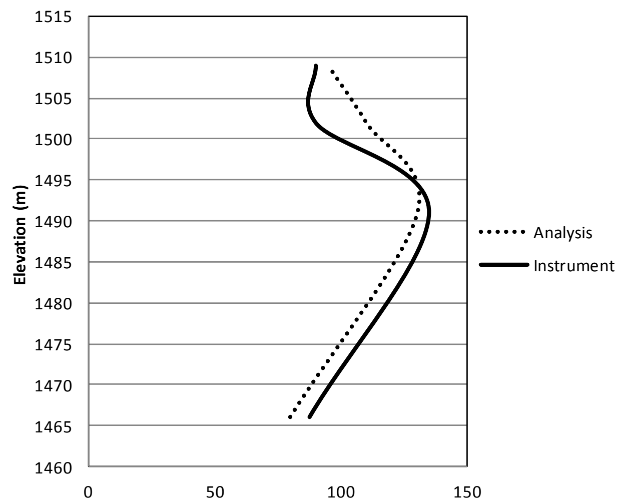

Figure 13. comparison between changes recorded by instrument and software analysis

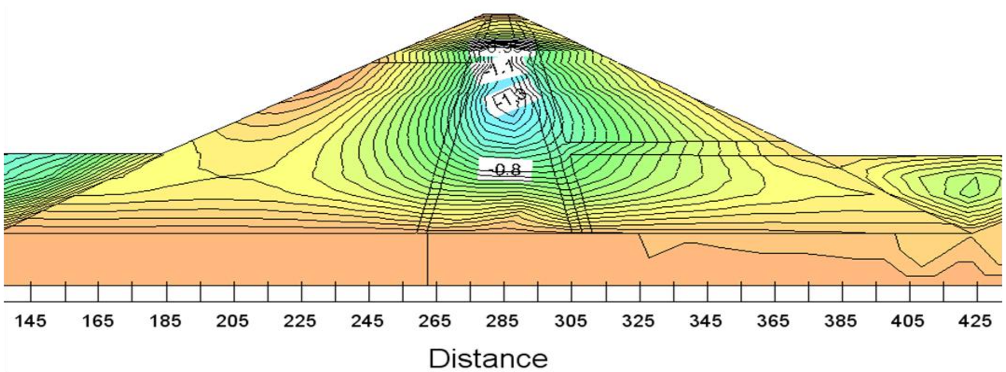

Figure 14. Settlement Conditions in core related to the current conditions of dam

Almost all the strength and deformation parameters are effective on each other somehow So that by changing one of the parameters the other will change. By approximate coincidence of stress and deformation values in the core [10] and critical section of the dam, dewatering of the dam started in three stages, which corresponded with the results of instruments.

Finally by exerting the dam operation time, the final values of the parameters of the fuselage dam has been achieved. Primary and secondary parameters have been compared in Table 4. (the primary parameters are shown with gray in the table4).

TABLE 4
A COMPARISON BETWEEN THE FINAL AND PRIMARY PARAMETERS OF THE DAM FUSELAGE

parameter / Aggregate	Permeability Coefficient (cm/s)	Elasticity modulus (Mpa)	Poisson coefficient	Angle of internal friction (degree)	Adhesion (KPa)	Specific weight of saturated (KN/m^3)	Dry specific weight (KN/m^3)
Core	1.15e-7	N=0.25 K=15	0.3	22	22	20	17.5
	1×10-7	10	0.35	29	10	20	17
Crust	1e-3	30	0.3	44	-	22	21
	1×10-2	54	0.3	44	-	22	21
Filter	1e-4	16	0.334	35	-	21	17.5
	1×10-5	28	0.25	28	-	22	17.5
Drain	1e-4	16	0.35	35	-	20	17.5
	1×10-5	28	0.25	28	-	22	17.5
Foundation	5e-6	30	0.3	25	-	22	21
	1×10-9	25	0.25	25	100	22.5	21

VI. CONCLUSIONS

In this study, software analysis is done by examining stress – strain changes during dam's life time and comparison with the data from the instrumentation. Consider the dam embankment stages has been done in order to analyze the consolidation settlement changes and pore water pressure measurement. To analyze the stress and strain on dam core, Elasto-Plastic behavioral model is used. Obviously, the stress and strain parameters are effective on each other somehow. So that by changing one of the parameters the other will change. By approximate coincidence of stress and deformation in the core and critical section of the dam, the final values of the dam parameters has been achieved (Table 4).

The amount of cohesion in core has been achieved about two times higher than the predicted values in dam design and the internal friction angle is slightly less than the primary value. This could be due consideration of the conservatively conditions at dam's design time which in any case is for insure. Elasticity modulus values is less than the predicted values except for the core.

Consolidation settlement downtrend in dam core is accordance with the indicated trend by the tools. Since Tabarakabad dam always been exploited between half to one-third the normal level this issue demonstrates the natural trend in the settlement and pore water pressure changes in dam core. In software analysis pore water pressure ratio always have been less than 0.5.

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