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Investigation the effect of clay core in seepage from non-homogenous earth dams using SEEP/W Model

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Abstract: One of the dams, homogenous dams is that in its body used of soil materials with different grading. One of Important issues in dams design is seepage problem that according to extensive studies have been done before dam construction, always cannot predicted hydraulic behavior of the dam body or nearby geological formations. In this context, many soft wares had been prepared to predict and calculate the seepage rate that need to time and cost less than laboratory models for analysis of seepage, before the earth dam construction. In this study, Survey effect of the clay core in seepage from nonhomogeneous earth dams whit using SEEP/W, Was studied the software suite Geo studio. Then analysis was the data obtained by dimensional analysis using SPSS software and respectively the relationship between seepage through the dam in a homogenous, with a coefficient of $R2 = 0.988$. The results of this relationship were compared with the results of dimensional analysis .Finally, by comparing the values of dimensional analysis with Excel software, was investigated the effect of each of the clay core characteristics the seepage of the homogenous soil dams.

Key words: Non homogeneous earth dams; Clay core; See page; Seep/W

1. Introduction

Homogenous earth dam was with a variety of materials that most of these cases, the core is implemented in stone dams that relevant materials are more than the aggregate to prevent water penetration.

One of the most important and effective of the dam degradation factors is leaking from of the dam different parts. leakage phenomenon check and water seepage model produced in porous media which is the situation closest to the reality , Is the most important issues in the design and control of water drainage in the earth dams body and Foundation. Hence, the use of computer models as cheap and fast method, yet with sufficient accuracy in the study and flow simulation in porous media is considered by many experts.

leakage obtaining, allowing the designer to predict the leakage problems and obtain the desired flow characteristics and less time to design and make quickly decide optimum and done optimum design, with less time and decide quickly.

Usually permeability coefficient of the nonhomogeneous earth dams, there is a minimum in the vertical direction Kz and usually this ratio is maximum in the direction of horizontal Kx. Since the permeability of the dams in different layers is different, after determining the equal permeability with continuity respect to the leakage flow rate can be obtained using the following equation.

$$k = \sqrt{k_x k_z} \quad (1)$$

Equivalent permeability

$$q = ki \sin^2\beta \quad (2)$$

Adverse effects of leakage can be named as follows:

- Waste of stored water in the behind the earthen structures
- Create pore pressure in porous media and Reducing the effective stress between the soil particles and as a result reducing the shear strength
- Apply lifting pressure on impervious structures (such as concrete structure , steel, etc.) environment
- The testicles move soil particles and Create internal erosion in the environment
- Leakage power applied on the soil mass in the direction of flow.

The core design of earth dams should consider the following three issues:

A: selection of suitable materials: in selecting suitable materials for the core of earth dams, be considered two factors quantity and quality, as well as the removal of materials (Source bonds).

B: determining the thickness of the core: generally, the core material has a lot of fine silt and clay particles will, therefore, have lower shear strength than the shell material.

Pore pressure existence in the type of materials (Due to very low water feature) reduces the shear strength above it. Also, the executive, the core material should be compacted in thinner layers and more precise control of moisture and density. User of

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thicker cores is economical only if they are economical.

C: core geometry can be constructed as the vertical and sloped in the earth dam section.

D: the relative permeability of the core: according to the research, whatever core permeability is lower than downstream permeability of the shell, in the shell leak line is in the lower position and vice versa. Therefore, the location of the leak line in the downstream shell is pulled off effectively, it is necessary that permeability's to have at least several hundred equal core permeability.

Syed M. Morandi and colleagues (1383), with the evaluation of the Nvmrvf analytical model in the seepage control of the earth dams homogeneous and isotropic and Comparing the results with the developed model by software seep / w found that Increase the through leakage rate of the dam body increases with increasing downstream slope angle and water height of the dam behind to dam height $(\frac{h}{H})$ and Nvmrvf model is not a good approximation of the flow passage and have not enough accurate to calculate the flow rate through of the dam body.

Amir Malekpour and colleagues (1390), investigations effect of different aggregate materials in the seepage control the body of the earth dam using Software seep/w found that a large percentage existence of silt in the aggregate is not a good barrier against leakage current, and on the other hand, if it is more clay aggregate, the core is able to further reduce the leakage current of silt grains.

Mirzaee Zainab and colleagues (1392), the study estimates the rate of leakage from the body of earth dams with limited software seep / w arrived the following equation which provides a quick estimate of the general leak, from different embankments and using finite element and numerical method proposed equations to estimate the leakage of stone earth dams.

$$\frac{Q}{K} = -0.0517(\frac{\Delta H^2}{L})^2 + 1.1563(\frac{\Delta H^2}{L}) \quad (3)$$

Q= Discharge

ΔH= height

L= during drainage

K= Hydraulic conductivity

2. Materials and methods

2.1. The equations governing the flow

Govern the many of hydraulic phenomena cannot be obtained directly from the rules governing fluid motion and existing theories, such as the conservation laws of mass, momentum and energy. In such cases, to try to extract mathematical equation governing such phenomena, first, identify all the variables involved in the creation of the phenomenon.

The general equation contains 11 variables that were obtained below equation after the dimensional analysis method Buckingham.

$$f\left(\frac{q}{\sqrt{g h_1^{1.5}}}, \frac{h_2}{h_1}, \frac{t_f}{h_1}, \frac{t_c}{h_1}, \frac{k_f}{\sqrt{g h_1}}, \frac{k_c}{\sqrt{g h_1}}, R_e, F_r\right) = 0 \quad (2)$$

Table 1: Parameters of effect dimensional analysis in this project

Variable introducing	Dimensions mounting	Variable dimensions
Upstream water height	L	h_1
Downstream water height	L	h_2
Discharge	L^3T^{-1}	Q
Average velocity outflow downstream	LT^{-1}	V
Mass per unit volume	ML^{-3}	ρ
Gravity	LT^{-2}	g
Dynamic viscosity	$ML^{-1}T^{-1}$	μ
Filter thickness	L	t_f
Core thickness	L	t_c
Filter permeability	LT^{-1}	k_f
Core permeability	LT^{-1}	k_c

2.2. Software model

Seep / w software is subset of Geo studio software. This part of the software is to investigate the leak and flow of water in the soil. The capabilities of this section of program is drawn water balance through of the soil and quickly brothers and drawing streamlines and potential and calculate the flow rate for certain sections of soil. As well this program has the ability to analyze the steady-state flow conditions.

Examined the effect of clay core characteristics of the flow through the dam by changing conditions such as core and filter permeability, ore and filter thickness, core deformation, changes in hydraulic conditions upstream and downstream of the filter in the presence or absence of homogenous embankment dam. Changed hydraulic conditions upstream and downstream of each of these cases, we model the software seep/w, flow rate obtained in different conditions and examined the interaction of each of these changes on the rate of flow.

Table 2: Model materials

Material	Permeability (m/s)
Core	10[illegible]
Filter	10[illegible]
Upstream	10[illegible]
Down stream	10[illegible]
foundation	10[illegible]

2.3. Modeling of earth dam in SEEP/W

We modeled the project according to the defined specifications for homogenous earth dam with help software seep/w.

Table 3: Boundary points coordinates of the dam

Points	Coordinate X(m)	Coordinate Y (m)		Points	Coordinate X (m)	Coordinate Y (m)
Point 1	0	0		Point 10	136	38
Point 2	166	0		Point 11	166	38
Point 3	0	35		Point 12	39	53
Point 4	30	35		Point 13	43	53
Point 5	49	35		Point 14	81	100
Point 6	73	35		Point 15	87	100
Point 7	75	30		Point 16	82	100
Point 8	93	30		Point 17	86	100
Point 9	123	30				

- Set the worksheet, scales, axes and grids,
- define the type of analysis to be steady stable,
- Definition permeability different parts of the dam and allocation of the permeability dam materials,
- define boundary Condition,
- drawing model geometry,
- assign material properties defined for different areas of the dam
- select the mesh barrier with combination elements of square, rectangular and triangular,
- Boundary conditions on the model geometry,
- determining the level of the dam that passes the discharge of its. The software calculates the flow rate to the desired level, the velocity of water passing through cross-sectional area specified and designed.
- Program analysis and evaluation.

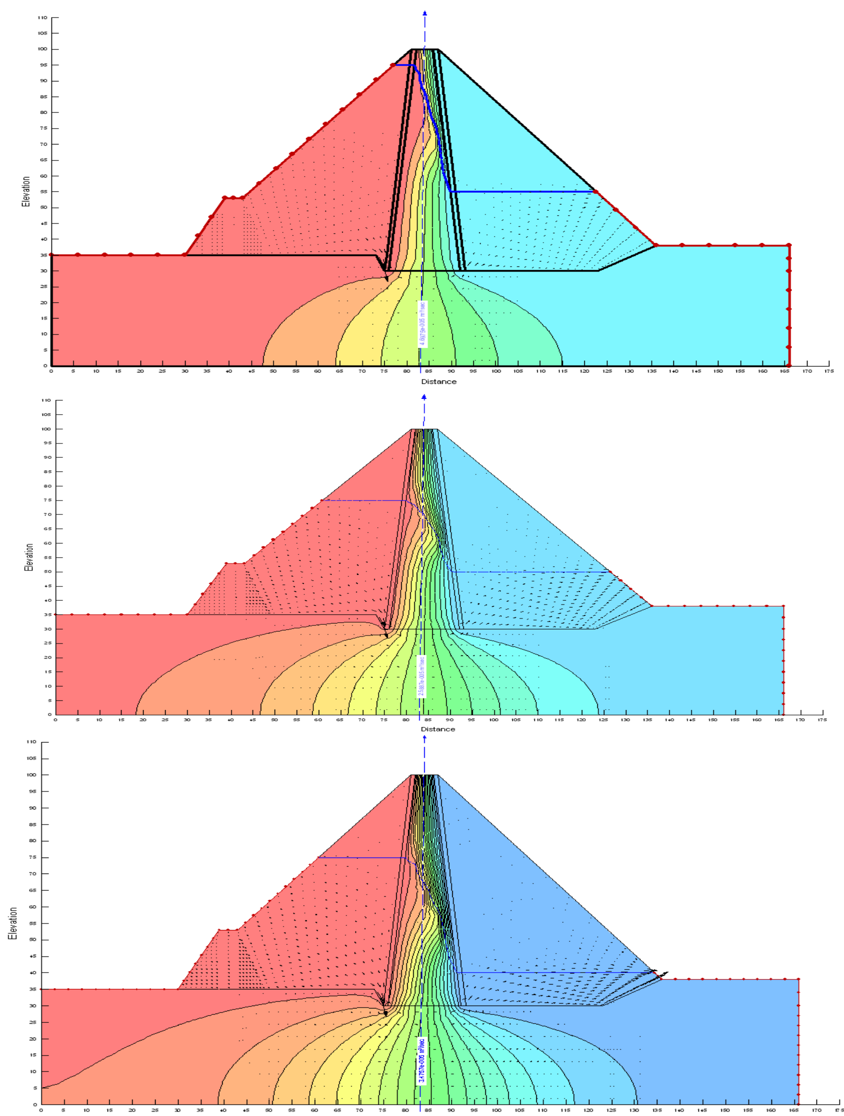
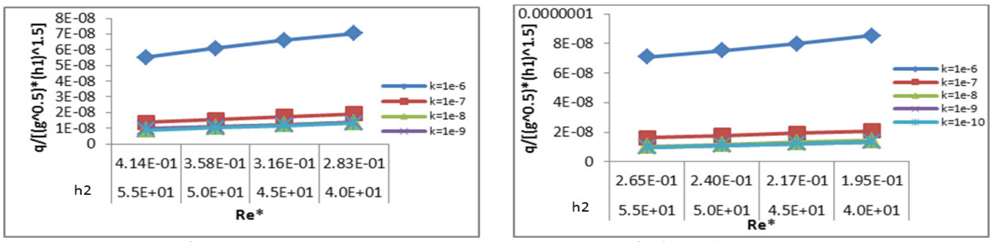


Fig. 1: Analysis of models for different hydraulic conditions

3. Data analyze using Excel software:

Excel software was used to determine the values of the dimensionless. Next, a comparison was made between the data are expressed as linear below.



a: h1=85m b: h1=95m

Fig 2: Ratio $\frac{q}{\sqrt{g}h_1^{1.5}}$ to the R_e^* by changing of the core permeability in *a*: h1=85m, b: h1=95m

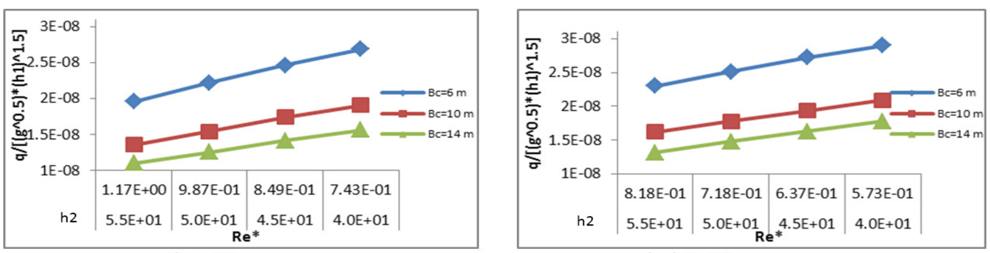
According to Fig. 1, were obtained the following results:

1- The flow rate increases with increasing upstream head and decreases with increasing flow rate through the downstream head.

2- Leakage rate has been reduced to a level 93.27 equal to the core permeability of the 10^{-6} m/s to 10^{-10} m/s . According to Fig. 1 remains constant flow rate of leakage the permeability of less than 10^{-8} m/s.

3- Leakage rate decreases with increasing Re^*.

4- The maximum flow leak rate is 8.52E-08 $\frac{m^2}{s}$ at a height of 95 meters upstream and 40 meters downstream and with core permeability coefficient $k = 10^{-6}$ m/s and the minimum flow leak rate is 4.36E-09 $\frac{m^2}{s}$ at a height of 65 meters upstream and 55 meters downstream and with core permeability coefficient $k = 10^{-10}$ m/s.



a: h1=85m b: h1=95m

Fig. 3: Ratio $\frac{q}{\sqrt{g}h_1^{1.5}}$ to the R_e^* by changing of the core thickness in *a*: h1=85m, b: h1=95m

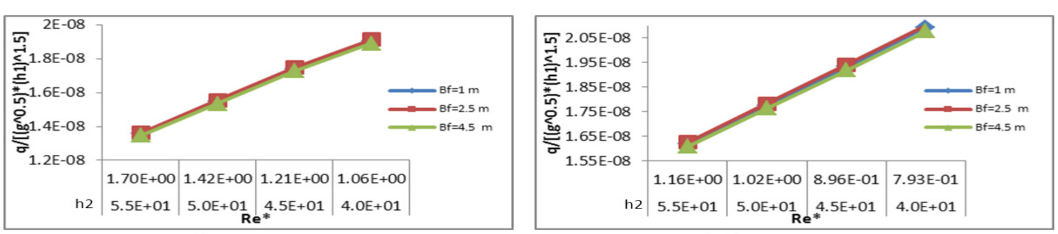
According to the Fig. 3 obtained the following results:

1- The flow rate increases with increasing upstream head and decreases with increasing flow rate through the downstream head.

2- With 2.33 equal to core thickness, the leakage rate has been reduced to the level of 57.14%.

3- Leakage rate decreases with increasing Re^*.

4- the maximum flow leak rate is 2.9E-08 $\frac{m^2}{s}$ at a height of 95 meters upstream and 40 meters downstream and with core thickness Bc=6m and the minimum flow leak rate is 5.01E-09 $\frac{m^2}{s}$ at a height of 65 meters upstream and 55 meters downstream and with core thickness Bc=14.



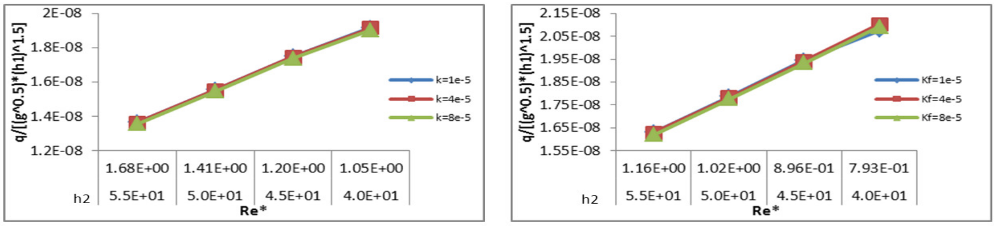
a: h1=85m b: h1=95m

Fig. 4: Ratio $\frac{q}{\sqrt{g}h_1^{1.5}}$ to the R_e^* by changing of the filter thickness in *a*: h1=85m, b: h1=95m

According to the Fig 4:

1- With 4.5 equal the filter thickness, is decreased the leakage rate to 0.74 percent rate.

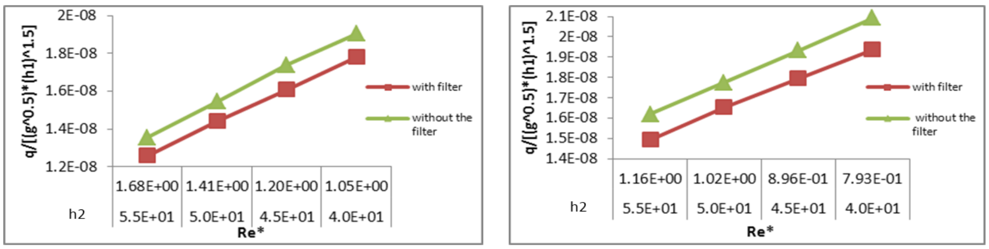
2- Changes in hydraulic conditions influence the leakage flow rate. The flow rate increases with increasing upstream head and decreases with increasing flow rate through the downstream head.



a: h1=85m b: h1=95m

Fig 5: Ratio $\frac{q}{\sqrt{g}h^{1.5}}$ to the R_e^* by changing of the filter permeability in *a:* h1=85m, b: h1=95m

According to Fig. 5, with 8 equal the filter permeability is increased flow rate about 0.62%.



a: h1=85m b: h1=95m

Fig. 6: Ratio $\frac{q}{\sqrt{g}h^{1.5}}$ to the R_e^* with and without filter in *a:* h1=85m, b: h1=95m

According to Fig. 6: 1- Changes in hydraulic conditions influence the leakage flow rate. The flow rate increases with increasing upstream head and decreases with increasing flow rate through the downstream head.

2- Leakage flow rate was increased to a value of 92.28%, in the dam has a filter compared with no filter dam. This is due to changes in core permeability of the filter permeability.

3.1. Analysis software SPSS

Given the number of variables used linear regression, the estimated values of the dependent variable from the values of the independent variables. Several of the models were used to obtain the best relationship with the least error. In the end, we got to (5) with 0.988 = R2.

$$\left(\frac{q}{\sqrt{g}h^{1.5}}\right)'' = -1.439 \times 10^{-7} \sin(0.003 R_e^*) + 1.507 \times 10^{-6} \sin\left(-0.011 \frac{B_f}{h_1}\right) 3.021 \times 10^{-6} \sin\left(0.001 \frac{B_c}{h_1}\right) -0.012 \sin\left(0.010 \frac{k_f}{\sqrt{gh_1}}\right) - 0.003 \sin\left(-3.206 \frac{k_c}{\sqrt{gh_1}}\right) - 0.569(-0.031\, Fr) \quad (5)$$

Leakage flow values obtained by equation (5) and according to the Fig. 7 and finally, we compare the rate of leakage from dimensional analysis and to the conclusion that there are a range of defined functions by dimensional analysis with SPSS software and low error rate it. Therefore, we can use the function (5) with a variable $\frac{k_f}{\sqrt{gh_1}}$, R_e^*, $\frac{B_f}{h_1}$, $\frac{B_c}{h_1}$, $\frac{k_c}{\sqrt{gh_1}}$, Fr instead of $\frac{q}{\sqrt{g}h^{1.5}}$ in respect of dimensional analysis.

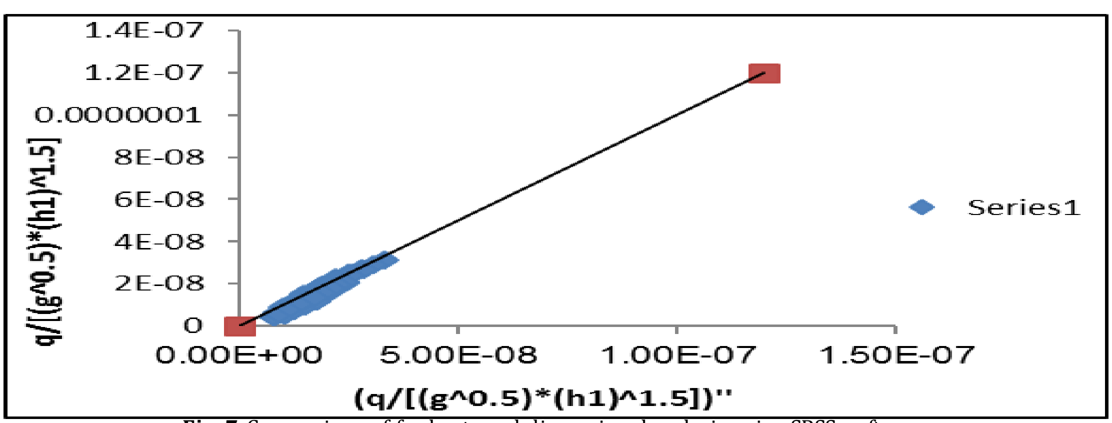


Fig. 7: Comparison of feed rate and dimensional analysis using SPSS software

4. Conclusion

Data analysis software model seep / w, dimensional analysis and software SPSS found that: The flow rate increases with increasing upstream head and decreases with increasing flow rate through the downstream head. Leakage rate has been reduced to a level 93.72 equal to the core permeability of the $10^{-8} m/s$ to $10^{-10} m/s$. According to Fig 1 remains constant flow rate of leakage the permeability of less than $10^{-8} m/s$. Leakage rate decreases with increasing Re^*. With 2.33 equal to core thickness, the leakage rate has been reduced to the level of 57.14%. With 4.5 equal the filter thickness, is decreased the leakage rate to 0.74 percent rate. With 8 equal the filter permeability is increased flow rate about 0.62%. Leakage flow rate was increased to a value of 92.28%, in the dam has a filter compared with no filter dam. This is due to changes in core permeability of the filter permeability. With height increasing and outflow increasing from the dam, increased the number Fr. The results show that the rate is a function of parameters $\frac{k_f}{\sqrt{gh_1}}$, R_e^* , $\frac{B_f}{h_1}$, $\frac{B_c}{h_1}$, $\frac{k_c}{\sqrt{gh_1}}$, Fr.

$$\left(\frac{q}{\sqrt{g}h^{1.5}}\right)^{*} = 1.139 \cdot 10^{[illegible]} \sin(0.003 R_e^*) + 1.507 \cdot 10^{[illegible]} \sin\left(0.011 \frac{B_f}{h_1}\right) 3.021 \cdot 10^{[illegible]} \sin\left(0.001 \frac{B_c}{h_1}\right) - 0.012 \sin\left(0.018 \frac{k_f}{\sqrt{gh_1}}\right) - 0.003 \sin\left(-3.286 \frac{k_c}{\sqrt{gh_1}}\right) - 0.569(-0.831\, Fr) \quad (6)$$

This equation shows the leakage through the dam with clay core in a homogenous and coefficient R^2 = 0.988. Providing a software model seep / w and dimensions analysis and spss proved the importance and value of using a clay core for leakage control in designing the homogenous earth dams. For desired conclusion of the software seep / w in fact, the right should be given to all the initial and boundary conditions. If the boundary conditions and the values of the model are not based on fact, not be expected to achieve real results.

References

Amyn Javaheri, A.r, Pak nyat, A. (1388). Static and dynamic analysis of the earth dams using software Geo studio. Tehran: Civil science. Second Edition.

Braja, MS-DOS (1386). principles of Geotechnical Engineering Soil. Translation: Shapur Tahvny. Tehran: the Forums Code of .chap XV.

Jabari, M.m. (1390). Dam engineering principles. Received from www.spowpowerplant.blogfa.com

Khargani, S. (1389). Earth Dams engineering. Tehran: University of martyr Abbaspoor utilities industry. First Edition.

Koros Kiplangat Vincent, Mutua Nicholas Muthama ,Sakayo Nicodemus Muoki,Darcy's Law Equation with Application to Underground Seepage in Earth Dams in Calculation of the Amount of Seepage,American Journal of Applied Mathematics and Statistics ,2014 ,Vol.2 ,No.3 ,143-149

Malekpour, A. (1390). Materials with different grain size effect in controlling leakage from the dam body. Tenth Conference of hydraulics.

Marandi, M. (1383). Evaluation of the analytical model Nvmrvf control dams Waterproofing homogeneous and isotropic. First National Congress on Civil Engineering.

Mohamed Abd El-Razek M.Rezk,Abd El-Aziz Ahmed Ali Senoon-Analytical solution of seepage through earth dam with an internal core , Alexandria Engineering Journal(2011)50 ,111-115.

Myrzayy, Z. (1392). Estimate the rate of leakage from the earth dam body with the help of finite element software Seep / w. Second National Conference on sustainable development of agriculture and a healthy environment.

Qasemzadeh, H. (1389). Seepage in saturated and unsaturated soils. Tehran University Press KNToosi. First Edition

Rahimi, H. (1385).Earth Dams. Tehran: Tehran University. Second Edition.

Shafaei Bajestan, M. (1389). Principles and Applications of physical models of hydraulic .ahvaz: martyr Chamran University Press, second Ahvaz.chap

Vfayyan, M. (1380). Earth Dams. Isfahan: Isfahan University Jihad publications. Second Edition.

Vfayyan, M. (1385). Administrative information about the Earth dams. Isfahan: organs publication. Second Edition