Analysis of Seepage and Uplift Pressure for Al-Shamiya Barrage South of Iraq

Dr. Jaafar S. Maatooq
Building and Construction Engineering Department, University of Technology.
Haider Alwash
Building and Construction Engineering Department, University of Technology.
Email:hmalwash@yahoo.com
Hazim Muhammad Al-Khafaji
Building and Construction Engineering Department, University of Technology.

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Abstract:

This study aims to analyze the settlement phenomena of Al-Shamiya barrage located south of Iraq then show if it located within a safety limits. The two-dimensional model based on the finite elements specified software have been used to analyze the seepage and uplift pressure under barrage to conclude if there is a piping and excessive uplift that may be having a responsibility for settlement. The results of analysis illustrate that some default cases at which the barrage are not safe , however at a design stat the barrage is safe . That is refer a seepage pattern doesn't lead to piping phenomena , accordingly excluding its effect on the settlement problem.

تحليل التسرب وضغط الأصعاد لناظم الشامية جنوب العراق

الاخلاصة

تهدف هذه الدراسة الى تحليل الهبوط الحاصل في سدة الشامية جنوب العراق ومقارنته بحدود الأمان، تم استخدام برنامج حاسوبي يعتمد النموذج ثنائي البعد بطريقة العناصر المحددة لتحليل التسرب وضغط الأصعاد تحت أساس الناظم وبيان هل أمكانية حدوث ظاهرة الأنجراف الأنبوبي (piping) أو حدوث ضغوط زائدة تحت المنشأ من مسببات الهبوط . وقد تبين من خلال نتائج التحليل ان القيم المستحصلة تعتبر غير أمينة لبعض الحالات الافتراضية وامينة للحالة التصميمة للناظم. مما يشير الى أن التسرب تحت المنشأ لايعد من الاسباب المؤدية الى هبوط الناظم.

INTRODUCTION

The influence of seepage, uplift pressure and exit gradients, are the aims of the present study to examine if there have a direct influences on settlement . The finite element technique and field measurements have been used simultaneously of barrage for evaluations and, hence, presented a reliable solutions. Two dimensional models have been carried out to evaluate the seepage underneath the barrage by using Geoslope/2007-SEEP/W software .

The analysis procedure can be folded and listed here under:-

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

a- Analyzing the seepage phenomena under barrage for both design state and at a present operation state.

b- Quantitative the exit gradient in different downstream apron joint.(arbitrary failures of an existing joint)

c- The ability of seepage response variations with the different depth of upstream sheet pile, have been analyzed.

d- The reading of piezometers that installed at different location of barrage have been compared for different status such as design state, and a present with damages and cracks state.

Analysis of Seepage and Uplift Pressure

The influence of seepage and uplift pressure have been analyzed by using a 2-D numerical model to examine if it have a responsibility of settlement . The depth of flow extends from the level of floor of barrage at16.00 a.s.l. to the impervious layer located at 14.5 a.s.l. The flow domain extends left and right of the floor for a distance approaching the depth of flow domain (Harr, 1962). According to the recommended methodology for SEEP-FLOW software , four nodal quadrilateral elements were used to idealize the flow domain within a permeable soil underneath Al-Shamiya Barrage with total 3329 elements and 3512 nodes.

Boundary Conditions and Analysis

The maximum upstream water level for actual operation was 21.00 m a.s.l, for fully closed gates and the minimum downstream water level occurred at 18.00 m a.s.l., for this situation, the maximum head difference was 3.0m.

The nodal values of the upstream and downstream are considered as a boundary conditions. The nodal points in the upstream and downstream take a specified value of piezometric head equal to 3.0 m and 0.0m respectively. These boundary values were used to compute the piezometric head for the rest nodes of the flow domain.

This condition have been used to solve the existing problems in Al-Shamiya Barrage. According to the type of soil strata underneath a barrage, where it consist of clayey soil ,the hydraulic conductivity (K) for horizontal and vertical direction are taken 0.05 cm/s and 0.01 cm/s respectively as recommended in a geotechnical tender documents of Sogreah Consulting Engineers, 1983 .

Simulation the Barrage problems

When the barrage operated at a design state , the seepage underneath has been simulated as shown in Figs.2and 3, one arbitrary failure at joint in location 2 is presented to illustrate the seepage pattern and its influence on settlement. Fig.1 , illustrate the locations of pizometers as installed within a barrage .

The problems at hand were analyzed to simulate different proposal of damages in apron and the comparison with actual and design pizometric readings were presented in Table(1). However, in Table(2), the resulting values of exit gradient at all proposed location of damages are listed with the design value 0.061 as recommended for clayey strata by the Sogreah Consulting Engineers (Ref.8) .

Conclusion

Tables (1) and (2) presents the values of pizometric head under barrage for both design and actual flow performance and the exit gradient at different joints for a

proposed damage in apron, the value of exit gradient is calculated by the finite element technique via SEEP/W software . These values have been compared with safe exit gradient value related to the kind of soil strata. The exit gradient practically is the force just equal to the submerged weight of the soil particle when located against exit seepage path this gradient is called a critical exit gradient. According to recommendation were presented by , Garg. 1978 , the safe exit gradients related to the type of soil strata should be taken within 0.2 to 0.25 of the critical exit gradient if this strata consisting clayey loam . Thus, to check the possibility of piping occurrence; the calculated value of the exit gradient have been compared with the safe limits .

The comparison between the value of exit gradient of a proposed states and the safe value of exit gradient (0.2 to 0.25), refer that the barrage does not have the acceptable safety and also it was not safe against piping. However, the safety was accomplished just with the design state (i.e. , location 5) as presented in Table (2). The conclusion of this study and according to an arbitrary proposed damage locations at the existing joints of barrage apron, that , the failure at any of these joints if it occur , having a direct influence on a present settlement of barrage.

However , the calculated piezometric head via SEEP/W under the structure for the four proposed damage location compared with the recorded values shows that the uplift pressure doesn't have an influence on the existing damage and crack problems as visualized and stated for barrage .

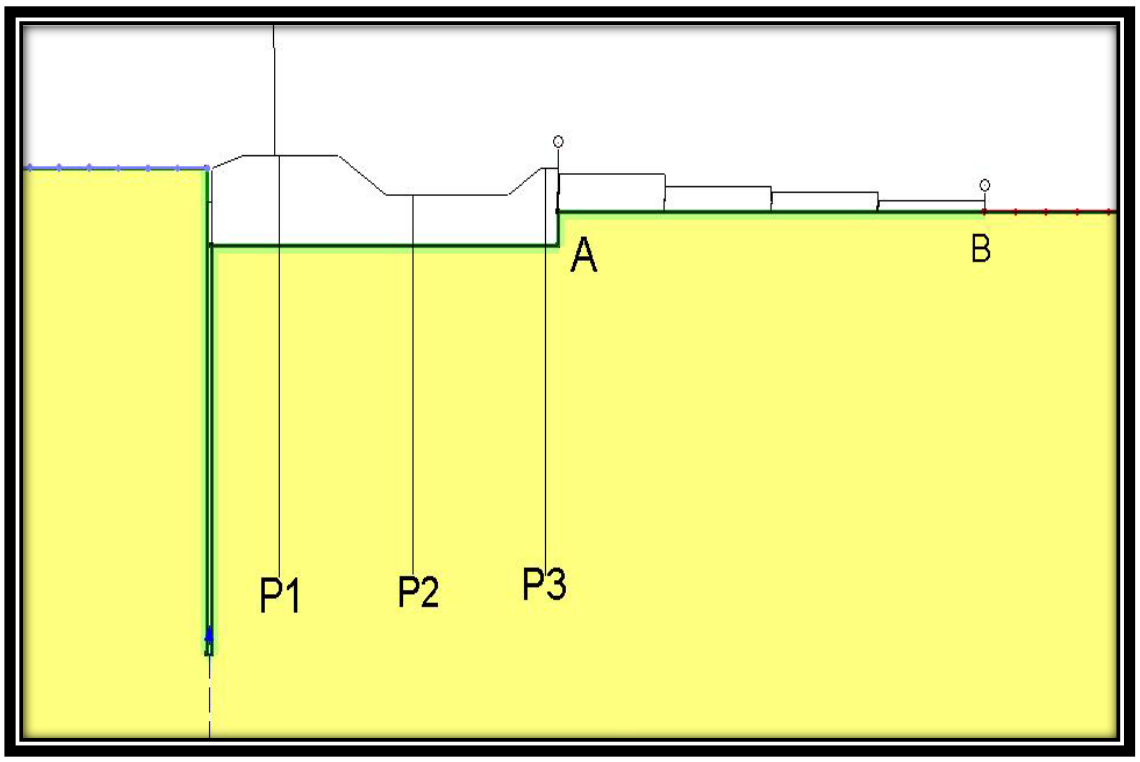

Figure. (1a): profile of allocation the piezometers along the apron

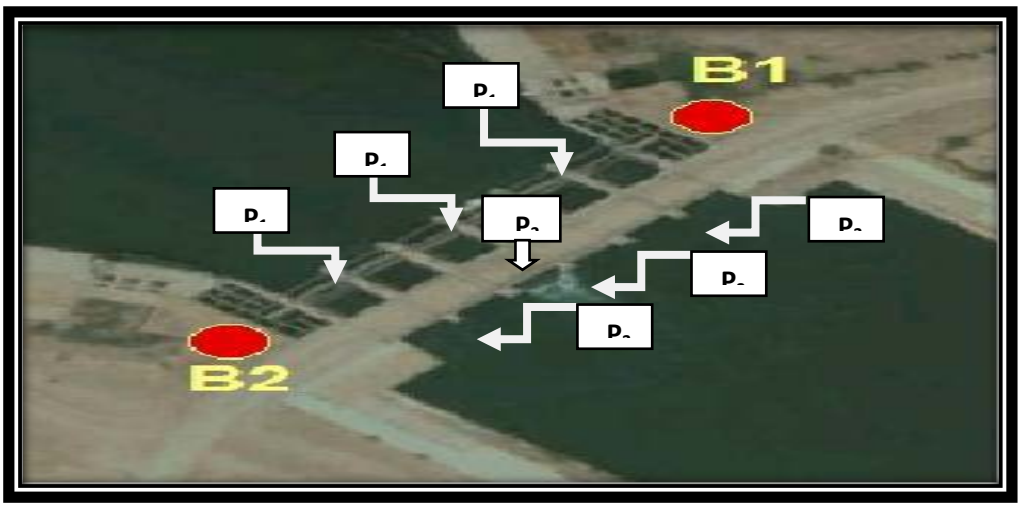

Figure. (1b): locations of the piezometers along the apron (plan view)

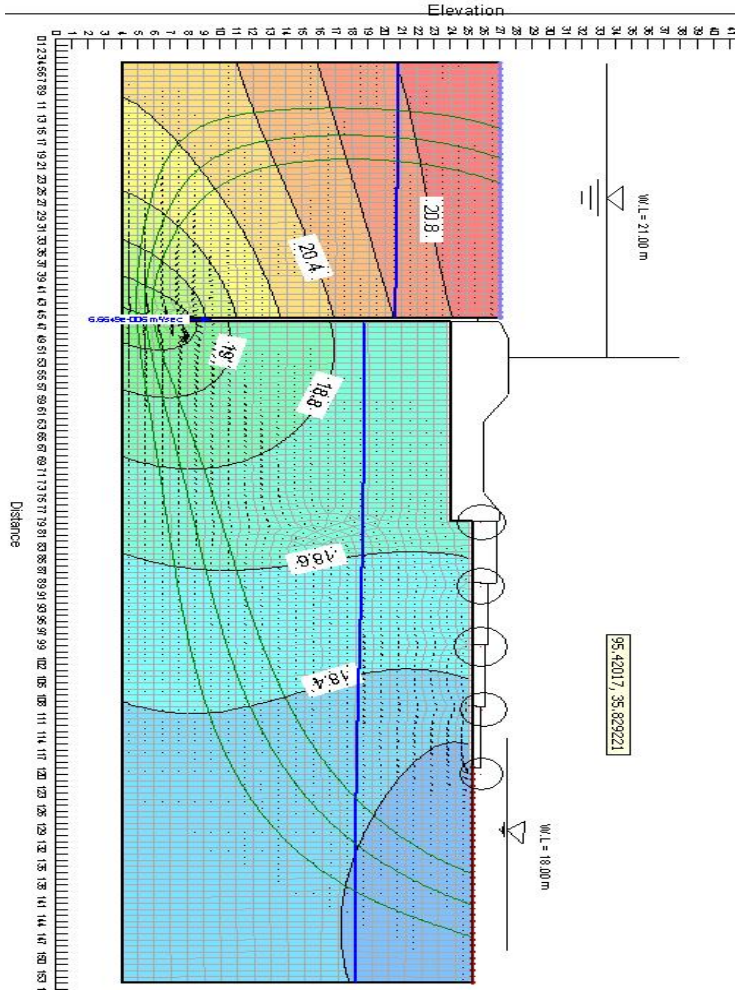

Figure. (2): Analysis the seepage pattern under Al-Shamiya barrage fo operation at design state

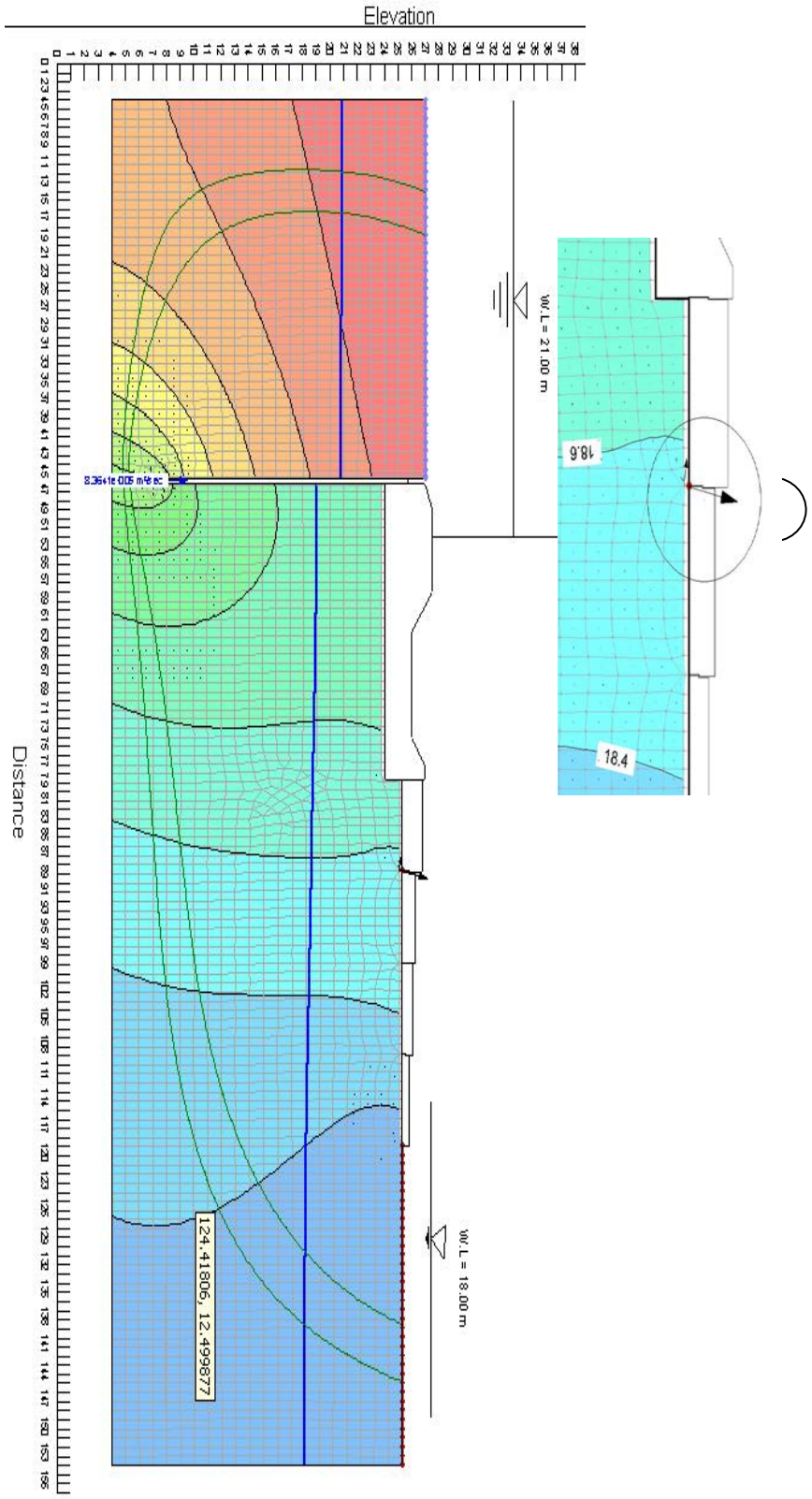

Figure. (3): The seepage pattern if a proposed damage at location No.2

Table (1) the values of piezometric head as recorded and calculated for assumed proposed damages cases.

Measure case	Proposed Problems	Water Level		Piezometeric Head (At present)		
		U/S	D/S	P1	P2	P3
		21.00	18.00			
	Design			19.14	19.12	18.81
Readings for Design at 20-03-2012	Bay (1)			19.03	_	18.88
	Bay (2)			19.14	19.05	19
	Bay (3)			19.18	_	19.06
SEEP/W software results for proposed damage in:	Location 1			18.98	18.85	18.62
	locations1 - 2			18.95	18.82	18.61
	Locations 1-2-3-4			18.93	18.8	18.58
	Location 2			19.03	18.91	18.74
	Locations 2 - 3			19.04	18.89	18.78
	Locations 2 - 4			19.06	18.92	18.71
	Locations 2 - 3 - 4			19.03	18.89	18.68
	Location 3			19.1	19.08	18.75
	Locations 3-4			19.08	18.95	18.71
	Location 4			19.12	18.95	18.75

Table (2) values of exit gradient as calculated for the four proposed damage locations and at end of existing apron

Measure case	Location	Water Level		Exit Gradient				
		U/S	D/S					
		21.00	18.00	1	2	3	4	5
Calculation according SEEP/W program	Design State			-	-	-	-	0.061
	Location 1			0.52	-	-	-	0.049
	Locations1 - 2			0.49	1.23	-	-	0.045
	Locations 1-2-3-4			0.46	1.12	0.9	0.62	0.39
	Location 2			-	1.21	-	-	0.058
	Locations 2 - 3			-	1.49	1.19	-	0.051
	Locations 2 - 4			-	1.62	-	0.81	0.051
	Locations 2 - 3 - 4			-	1.5	1.13	0.76	0.47
	Location 3			-	-	1.81	-	0.053
	Locations 3-4			-	-	1.29	0.85	0.52
	Location 4			-	-	-	1.28	0.059

References

[1].AL-Obaidi ,S.R.R , « Seepage Analysis for Hydraulic Structures Using Different Methods of Analysis ». M.Sc, Thesis , Department of Building and Construction Engineering , University of Technology,pp10-21,2001.

[2].Al-Saadi, A.S.A., « Evaluation of Al-Adhaim Dam Safety », Ph.D., Thesis, Department of Building and Construction Engineering, 2006 .

[3].Garaman, S., « Application Computer Programs on Stability of Dams », Diploma, Thesis, College of Engineering, University of Damascus, and P.P:22-43, 2004, (In Arabic).

[4].Garg, S.K., « Irrigation Engineering and Hydraulic Structures», Knanna Publishers, P.P:67-70, 1987.

[5].Geo-Slope International Ltd., « GEO-SLOPE Office Manual », 2007.

[6].Harr, M.E., and Deen, R.C., " Analysis of Seepage Problems ", Journal of Soil Mechanics and Foundation Division, ASCE, Vol.(87), No.(5), P.P:91-107, 1961**.**

[7].Harr, M.E., " Ground Water and Seepage " **,** McGraw-Hill, P.P: 36,1962.

[8].Sogreah, consulting Engineers, " Scale Model Studies to Find Ways of Improving Hydraulic Performance of the Existing Structure ", Report Ministry of Water Resources, Sogreah, France, Oct. 1983.