Study the Effect of Sheet Pile Under The Floor of Kufa Barrage In Iraq by Using the Finite Element Software (ANSYS)

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ISSN 2229-5518
Abstract: In this research, a finite element software (ANSYS) has been used to simulate one of the important problems of most hydraulic structures which is seepage and piping under Kufa barrage in Iraq. A Sheet pile would be used to control it and would discuss several cases for location and number of sheet piles under floor of structure. After simulation, the cases of sheet piles and analysis by ANSYS was measured uplift pressure and exit gradient. In the case of no sheet pile provided, the uplift pressure is =6.072 Kn/m, the thickness of impervious floor to equivalent uplift pressure is=4.89 m, exit gradient=0.283. In the case of one sheet pile provided at upstream, the uplift pressure, thickness of floor and exit gradient would be reduced by 50%, 51% and 47.7% respectively. In the case of two sheet piles provided at upstream and downstream, the uplift pressure and thickness of floor would be increased by 43.9% and 43% and exit gradient would be reduced by 36.8%. In the case of three sheet piles provided at upstream, intermediate and downstream, the uplift pressure and thickness of floor would be increased by 3.67% and 2.8% and exit gradient would not change considerably. The last case of four sheet piles one at both of upstream and downstream and two at intermediate, the changes would not be considerable in the uplift pressure, thickness of floor and exit gradient. According to the results, Using of one sheet pile under floor for Kufa regulator will be the perfect case.

Keywords: Barrages, sheet piles, seepage control under barrages, ANSYS analysis, uplift pressure, Kufa Barrage

1- Introduction

The difference in the head of water between upstream and downstream in Barrages and other hydraulic structure. Makes water to seep from the higher head to lower one through the permeable soil. That generates a piping phenomenon [1]

the effect of layers of soil on the properties of seepage with no sheet pile provided was studied and discussed with numerical solution, the result is that the uplift pressure increasing when the lower sub layer of soil's permeability decreasing [2]

By using a Software FORTRAN90, sheet pile's affection place and inclining angle of on controlled seepage beneath floor of dam was studied. In addition, a determination of nodal point uplift pressure and exit gradients and seepage after cutoff walls were carried out [3]

Seepage under the hydraulic structure through the permeable soil layers subjects a pressure on the hydraulic structure and causes a soil washing under it. This phenomena is considered as the main cause of the stability and failure of the hydraulic structure. [4]

The effect of the configuration of sheet pile on seepage under the hydraulic structures, the uplift reactions on downstream of floor and the exit gradient was studied by using the finite element method on the fixed mesh approach which was used to determine the water free surface [5]

The use of moderate sheet pile decreases the uplift pressure below the hydraulic structures. The decreasing ratio of uplift pressure increases when the moderate sheet pile take a position approach to the downstream [6]

The using of sheet pile at the foundation toe decreases the uplift pressure below the hydraulic structure base. When the sheet pile is not provided, uplift pressure raises in the first half section and lowering in the second one with the increasing of soil permeability. [7]

2- Cases and results

Five case have been studied shown in table (2-1) and figure (2-1):

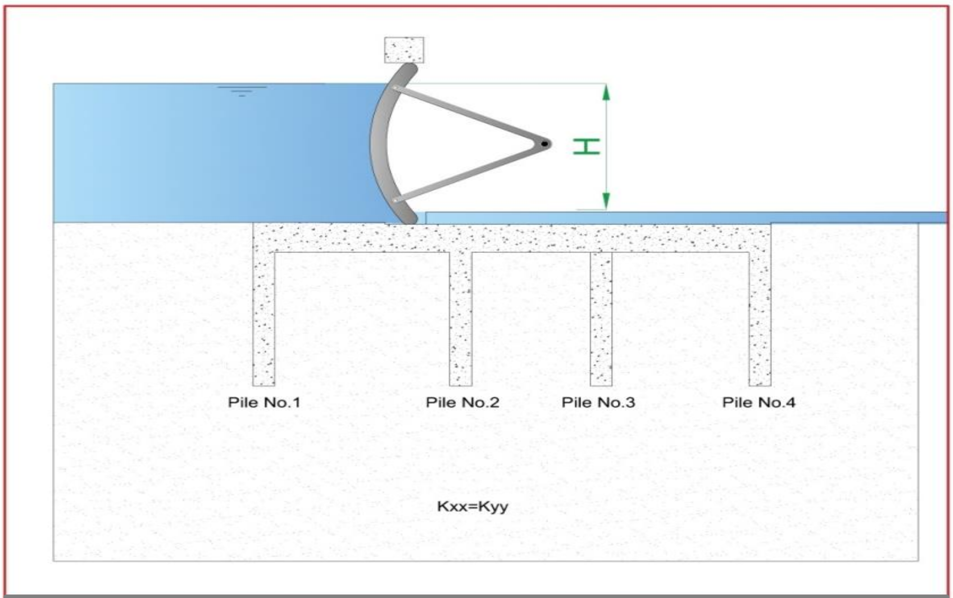

Fig (2-1) distribution of sheet piles under hydraulic structure

Table (2-1) Cases of sheet pile

Case	Pile No.1	Pile No.2	Pile No.3	Pile No.4
1	Not active	Not active	Not active	Not active
2	Active	Not active	Not active	Not active
3	Active	Not active	Not active	Active
4	Active	Active	Not active	Active
5	Active	Active	Active	Active

Case 1: No Sheet pile provided

The uplift pressure contour line shown in Fig (2-2), the distribution of uplift pressure under the floor is shown in Fig. (2-3) and the maximum exit gradient shown in Fig. (2.4).

The max. Uplift pressure is = 6.072 Kn/m2

The Exit gradient at end of floor is = 0.283

The thickness of impervious floor to equivalent up lift pressure that shown in Table (2.2).

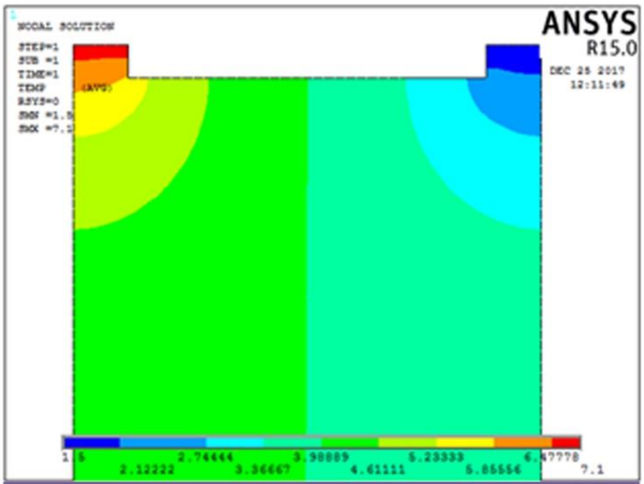

Fig (2-2) uplift pressure by ANSYS Case No. 1

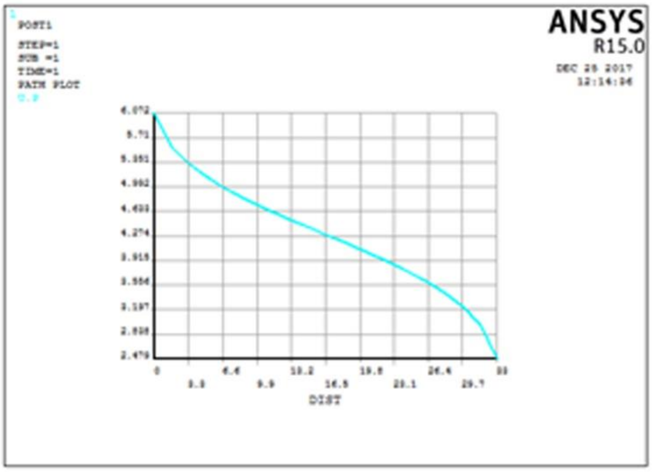

Fig (2-3) Distribution of the uplift pressure for case No.1

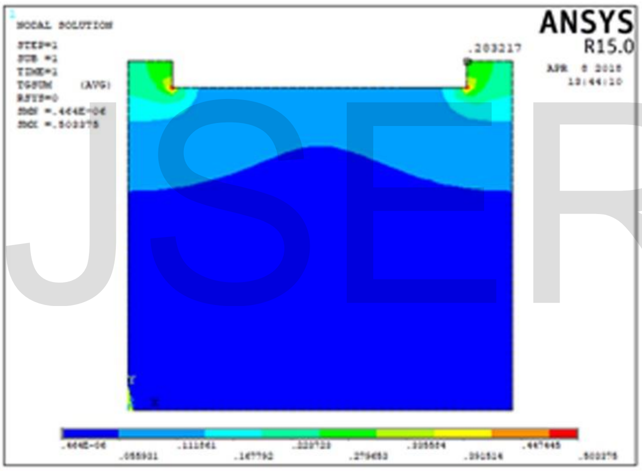

Fig (2-3) Exit gradient at the end for case No. 1

Table (2-2) The thickness of floor					
Distance(m)	0	6.6	16.5	26.4	33
u.p(KN/m)	6.072	4.992	4.274	3.556	2.479
Thickness(m)	4.89	4.02	3.46	2.89	1.99

ISSN 2229-5518

Case 2: No Sheet pile was provided at the upstream

The uplift pressure contour line shown in Fig (2-5), the distribution of uplift pressure under the floor is shown in Fig. (2-6) and the maximum exit gradient shown in Fig. (2.7)

The max. Uplift pressure is = 3.026 Kn/m^2

The Exit gradient at end of floor is = 0.14817

The thickness of impervious floor to equivalent up lift pressure that shown in Table (2.3)

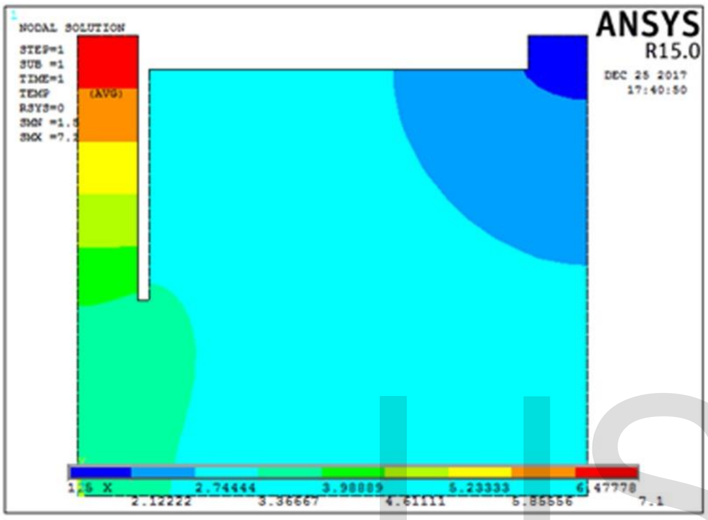

Fig (2-5) The uplift pressure by ANSYS Case No. 2

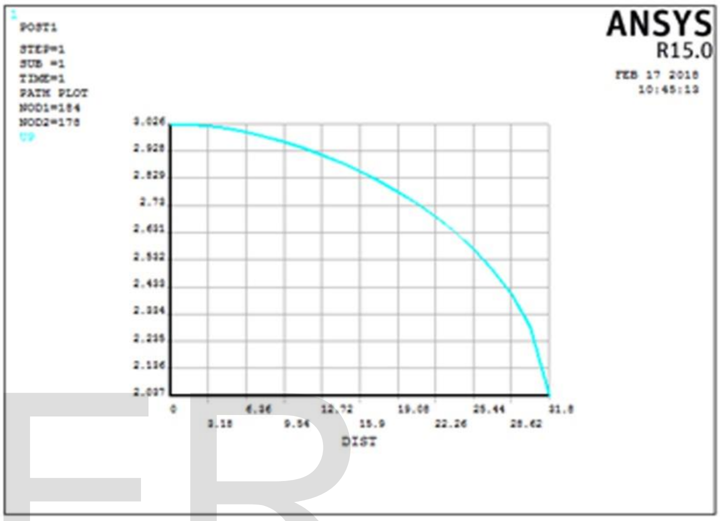

Fig (2-6) Distribution the up lift pressure for case No.2

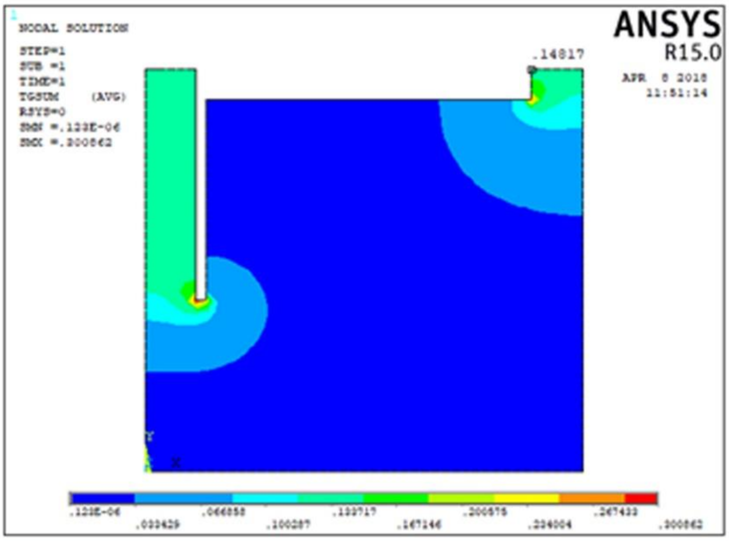

Fig (2-7) Exit gradient at the end for case No.2

Table (2-3) The thickness of floor					
Distance(m)	0	6.36	15.9	25.44	31.8
u.p(KN/m)	3.026	2.9972	2.855	2.573	2.037
Thickness(m)	2.44	2.42	2.30	2.07	1.64

Case 3: Two Sheet piles provided at the upstream and the downstream

The uplift pressure contour line shown in Fig (2-8), the distribution of uplift pressure under the floor is shown in Fig. (2-9) and the maximum exit gradient shown in Fig. (2.10).

The max. Uplift pressure is = 4.357 Kn/m^2

The Exit gradient at end of floor is = 0.0935

The thickness of impervious floor to equivalent up lift pressure that shown in Table (2.4)

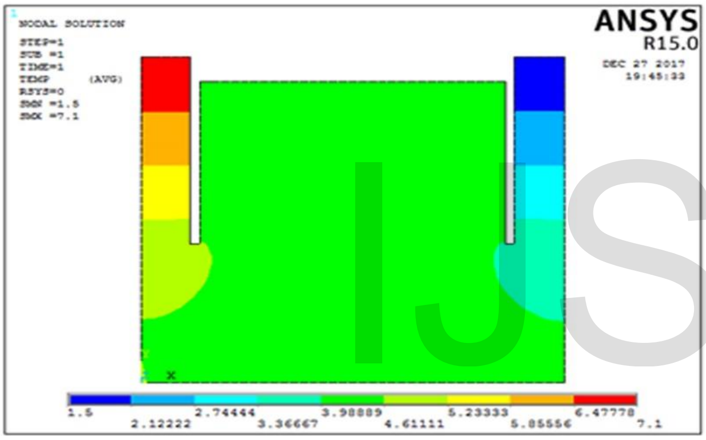

Fig (2-8) uplift pressure by ANSYS Case No. 3

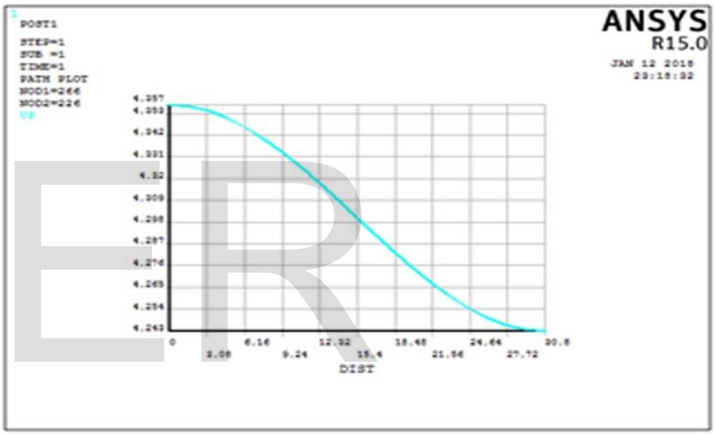

Fig (2-9) Distribution the up lift pressure for case No.3

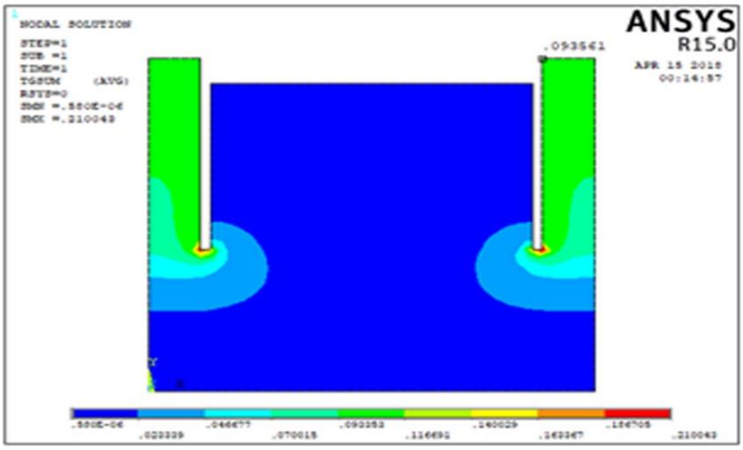

Fig (2-10) Exit gradient at end for case No.3

Table (2-4) The thickness of floor					
Distance(m)	0	6.16	15.4	24.64	30.8
u.p(KN/m)	4.357	4.3461	4.3001	4.254	4.248
Thickness(m)	3.51	3.50	3.47	3.43	3.42

Case 4: Three Sheet piles provided, at the upstream and the downstream and at the intermediate

The uplift pressure contour line shown in Fig (2-11), the distribution of uplift pressure under the floor is shown in Fig. (2-12) and (2-13) and the maximum exit gradient shown in Fig. (2.14).

The max. Uplift pressure is = 4.5173 Kn/m^2

The Exit gradient at end of floor is = 0.0913

The thickness of impervious floor to equivalent up lift pressure that shown in Table (2.5)

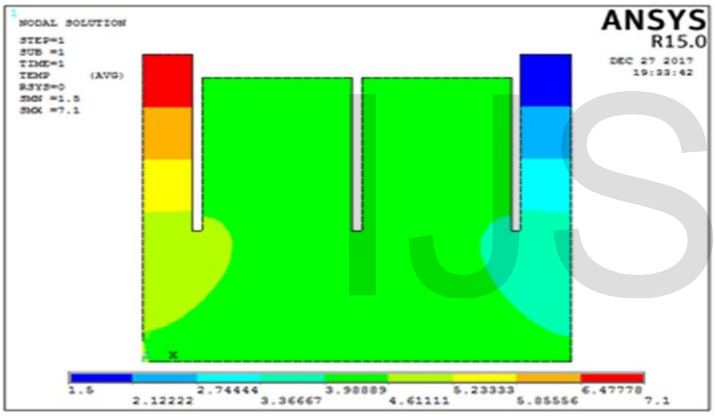

Fig (2-11) uplift pressure by ANSYS Case No. 4

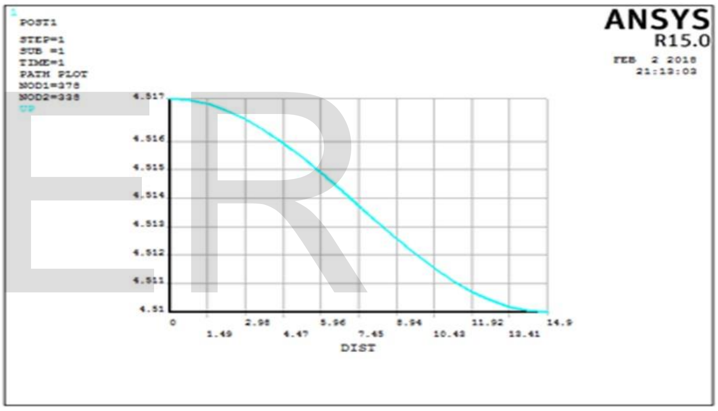

Fig (2-12) Distribution the up lift between pile 1 and pile 2 for case no. 4

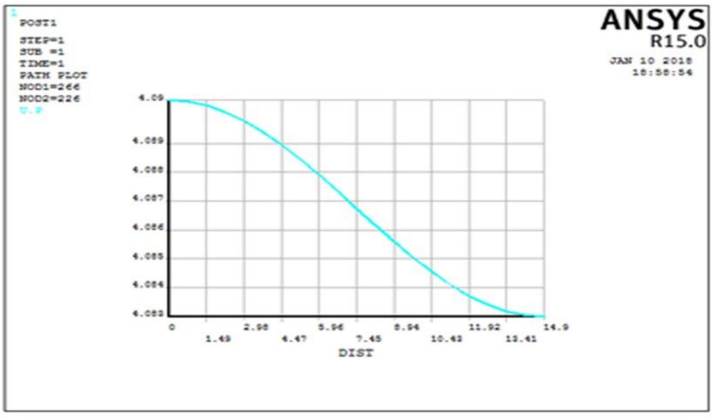

Fig (2-13) Distribution the uplift pressure between pile 3 and pile 4 for case No.4

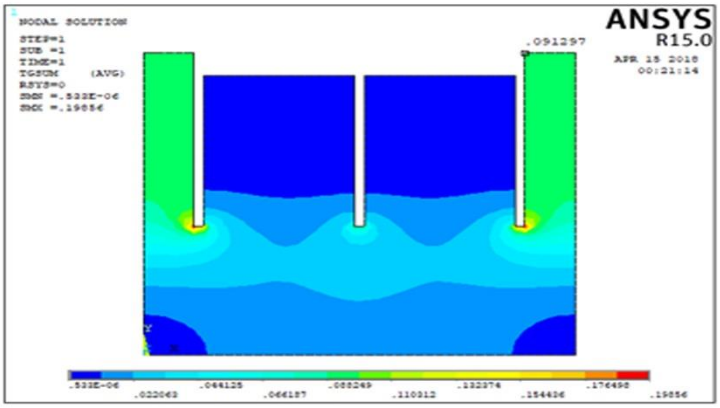

Fig (2-14) Exit gradient at the end for case No.4

Table (2-5) The thickness of floor					
Distance(m)	0	6.705	16.645	24.84	30.8
u.p(KN/m)	4.5173	4.5141	4.0903	4.0855	4.0829
Thickness(m)	3.64	3.64	3.29	3.29	3.29

Case 5: Four Sheet piles provided, at the upstream and the downstream and two at the intermediate

The uplift pressure contour line shown in Fig (2-15), the distribution of uplift pressure under the floor is shown in Fig. (2-16), (2-17) and (2-18) and the maximum exit gradient shown in Fig. (2-19).

The max. Uplift pressure is = 4.5977 Kn/m^2

The Exit gradient at end of floor is = 0.0902

The thickness of impervious floor to equivalent up lift pressure that shown in Table (2-6)

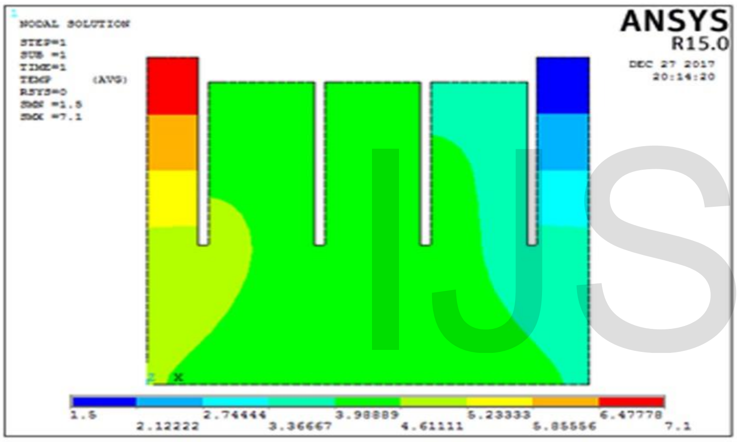

Fig (2-15) uplift pressure by ANSYS Case No. 5

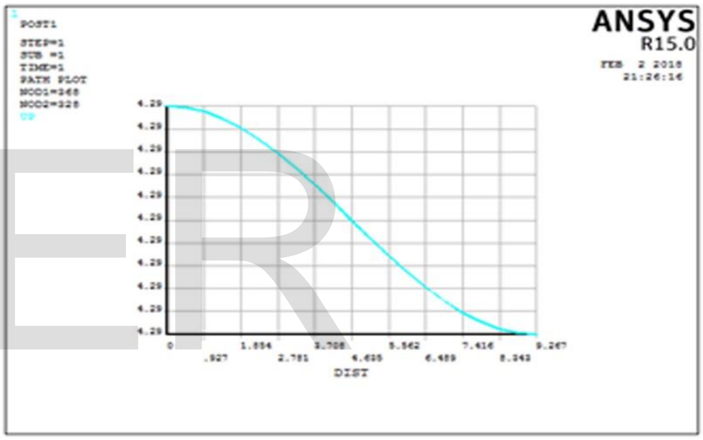

Fig (2-16) Distribution the up lift between pile 1 and pile 2 pressure for case No.5

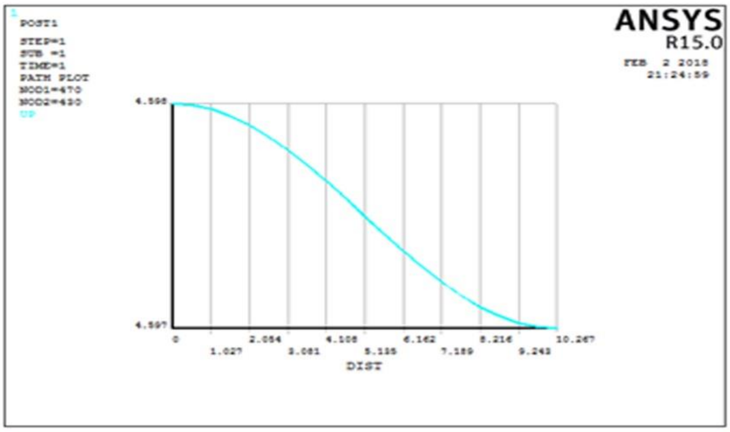

Fig (2-17) Distribution the up lift pressure between pile 2 and pile 3 for case No.5

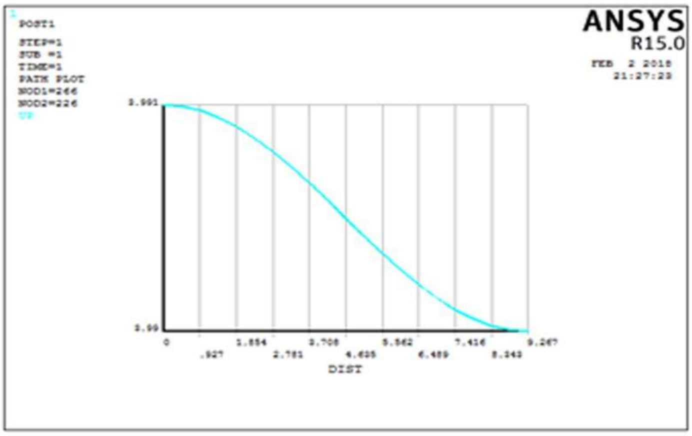

Fig (2-18) Distribution the up lift between pile 3 and pile 4 pressure for case No.5

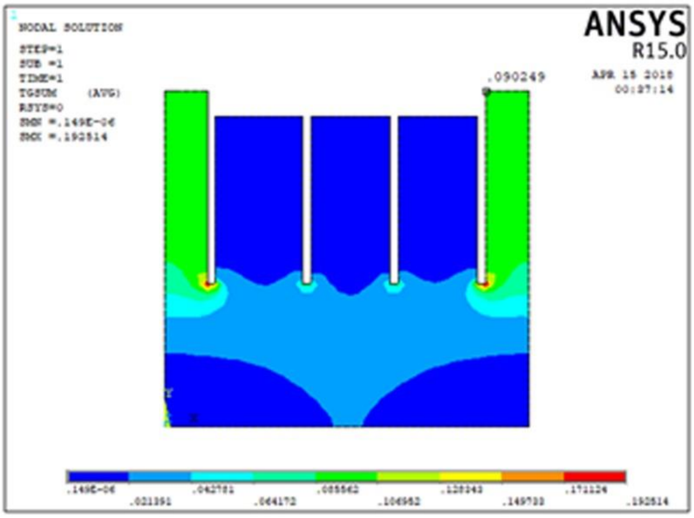

Fig (2-19) Exit gradient at the end for case No.5

Table (2-6) The thickness of floor					
Distance (m)	0	6.6734	16.9134	26.6395	31.2592
u.p(KN/m)	4.5977	4.5971	4.2899	3.9905	3.9903
Thickness(m)	3.71	3.71	3.46	3.22	3.22

3- Results and Conclusions

Due to El-Sayed "The finite element result of up lift pressure was given good agreement with experimental result" After the studying of the five cases, the first case "[2]

After studying the five cases, it is shown that:

For the case no. 1 (only impervious floor without adding a sheet pile), the maximum uplift pressure is (6.072 Kn/m^2), maximum exit gradient at the end is (0.283) and the thickness of impervious floor to equivalent up lift pressure is (4.89, 4.02, 3.46, 2.89, 1.99) m.

For the case no. 2 (one sheet pile (20.2m depth) at upstream has been used), the maximum uplift pressure is (3.026 Kn/m^2, The up lift pressure has reduced by 50.16 % in comparing of case no. 1), maximum exit gradient at the end is (0.1481, The exit gradient has reduced by 47.64% in comparing of case no. 1) and the thickness of impervious floor to equivalent up lift pressure is (2.44, 2.3, 2, 1.6)m (The thickness has reduced by 50.1 % in comparing of case no.1)

For the case no. 3 (two sheet piles of (20.2m depth) at upstream and at downstream has been used). The maximum uplift pressure is (4.357 Kn/m^2, The up lift pressure has reduced by 28.24% in comparing of case no. 1), maximum exit gradient at the end is (0.0935, The exit gradient has reduced by 66.96 %) and the thickness of impervious floor to equivalent up lift pressure is (3.51, 3.5, 3.47, 3.43, 3.42) m (The thickness has reduced by 28.22 % in comparing of case no.1)

For the case no. 4 (three sheet piles of (20.2m depth) at upstream, downstream and at intermediate has been used). The maximum uplift pressure is (4.5173 Kn/m^2, the up lift pressure has reduced by 25.6% in comparing of case no. 1), maximum exit gradient at the end is (0.0913, The exit gradient has reduced by 67.74 %) and the thickness of impervious floor to equivalent up lift pressure is (3.64, 3.64, 3.29, 3.29, 3.29) m (The thickness has reduced by 25.56 % in comparing of case no.1)

For case No.5 (Four sheet piles (20.2m depth) at upstream, downstream and two at intermediate has been used). The maximum uplift pressure is (4.5977 Kn/m^2, the up lift pressure has reduced by 24.28% in comparing of case no. 1), maximum exit gradient at the end is (0.0902, The exit gradient has reduced by 68.13 %) and the thickness of impervious floor to equivalent up lift pressure is (3.71, 3.71, 3.46, 3.22, 3.22) m (The thickness has reduced by 24.13 % in comparing of case no.1)

It is shown the highest value of uplift pressure, exit gradient and thickness of floor are at their maximum value at case no.1 because there is no sheet pile exist to resist the flow. While, the maximum reduction of uplift pressure and the thickness of floor is at case no.2. The decreasing of the rate of reduction of uplift pressure in the cases no.3, no.4 and no.5 is because of the mutual interference between the sheet piles.

As a result, we can conclude that case no. 2 (using one sheet pile (20.2m depth) at upstream) is best case for the Barrage.

4- References

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