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Research Paper

The effect of sheet pile location on uplift pressure under hydraulic structures

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Abstract -In this study, the finite elements method was used in computer programs (GEOSTUDIO) to show the effect uplift pressure on hydraulic structure with different locations for sheet pile (or cutoffs). Five cases are used for this study sheet pile beginning of the dam, middle of dam, dam end, and sheet pile in middle of dam inclined by 45^0 by direction the beginning of dam and sheet pile inclined by 45^0 by direction the end dam. All cases solved and compared with standard case without sheet pile to find best location of sheet pile in the dam.

Keyword: sheet pile, hydraulic structures, finite elements, uplift pressure.

I. Introduction

Hydraulic structures are one of the types of engineering structures as dams, bridges, regulators, weirs ...etc designed and implemented to control and distribute water sources, Studying design problems is an important step, studying the stability and maintenance of these structures.

Hydraulic structures can be built on impermeable soil or impermeable to water When they are built on impermeable soil, the water level in front of the dam and behind the dam is different, the water seeping below the base of the dam will be through this soil, and the water seeping at the bottom of the dam has a danger to its collapse. The water seeping at the bottom of the dam Causes to raise the soil particles from the water exit at the end of the dam and continuously will lead to cavitation of the soil at the bottom of the dam base and lead to the collapse of the structure this problem occurs when the hydraulic gradient is greater than the critical value.

This paper discussed the effect of location sheet pile under concrete dam on uplift pressure then studied different cases for location of sheet pile and effect on foundation of the dam.

II. Uplift Pressure

Uplift pressure is defined as upward pressure on the base of the hydraulic structure and it occurs as a result of water seepage into the soil below the structure.

The lifting pressure reaches its maximum value when the front of the dam is full of water and the back of the dam is free of water. Therefore, hydraulic structures must be efficiently designed against uplifting pressure, and the safety factor should be taken in suitable amount, in general, the floor must be provided by a sufficient length and also sufficient thickness must be provided in different points of the floor.

There are several methods for calculating the uplifting pressure whose value is necessary for the design of the structure such as approximate graphic flow net, flow tank, electrical analogy method, Bligh's creep method, Khosla method, Lane's method. Also, the other methods like Finite Element Method, Finite Difference Method.

III. Uplift Pressure Calculation

Computer program (GEOSTUDIO) has been used to solve this problem and calculate uplift pressure by assuming steady state flow and the permeability of soil was similar in three dimensions (kx =ky =kz).

The seepage area under foundation of the dam will be equal to three times of base dam (first part is before the dam and second part is base of dam and third part is after the base of dam) and depth of seepage equal to 1.5 times of the length of floor and convert the seepage area to mesh with nodes as shown in Figure 1. The shape of mesh is depend upon the shape of seepage area. So, the flow assumed in two directions and the area of seepage was rectangle for that use rectangular or square mesh.

The uplifting pressure is constant at some points and the worst case is used when the water level was at its maximum in upstream and minimum in downstream, the pressure of all points before the dam will be equal to the head pressure at upstream and the pressure of the points after the dam will be zero. And all other points under the base of dam has average pressure between upstream and downstream.

IV. CONDITIONS OF SHEET PILE USED

In order to decrease the uplift pressure to minimum value on foundation hydraulic structure with safety against piping, in this paper horizontal floor used sheet pile at the beginning of the dam, middle of the dam, dam end, and sheet pile in middle of dam inclined by 45^0 in direction of the beginning of the dam and sheet pile inclined by 45^0 in direction of the end the dam as shown in figure 1.

Depth of sheet pile in all cases is 3m, and soil assumed anisotropic with permeability equal to 10-5 m/s , the problem has been analyzed by computer program (GEOSTUDIO)2D.

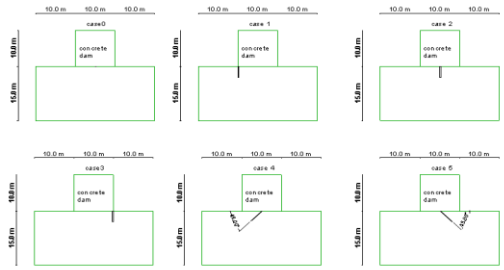


Fig. 1. *studied cases*

V. RESULTS AND DISCUSSION

All cases have been analyzed by the computer program to calculate uplift pressure and choose best position of sheet pile in dam floor. Figure (2) shows the distribution of uplift pressure with distance of the dam floor for all cases.

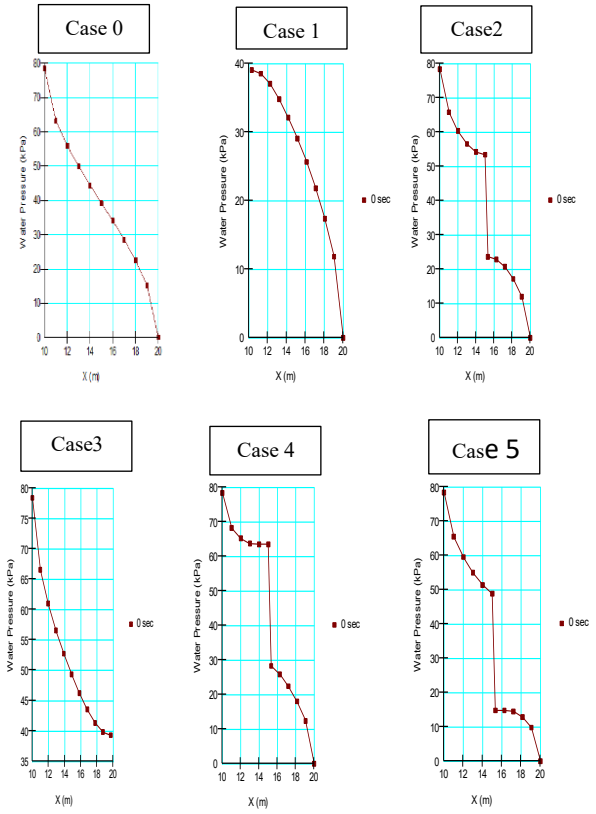


Fig.2. *Uplift pressure distribution with distance of the dam floor*

We note in all cases studied that the amount of water pressure was maximum at upstream and gradually decreases until it becomes minimum at downstream, also note that there is a drop in the water pressure value of cases 2,4 and 5 at the middle of the dam as a result of the effect of sheet pile.

The comparison of the value of total water pressure for all cases, shows that the total water pressure of case 1 decreased by 29.4% of total water pressure of case 0 (standard case) and for case 2 increased by 0.5% of case 0, for case 3 increased by 29.1% of case 0 and case 4 decreased by 10.5% from case 0 and case 5 decreased by 7.8%.

Table I. TOTAL WATER PRESSURE FOR ALL CASE

No. of cases	details	Total water pressure
0	***without sheet pile***	***392.4***
1	***sheet pile at the beginning of the dam***	***277.8***
2	***Sheet pile at the middle of the dam***	***394.6***
3	***Sheet pile at the end of the dam***	***506.8***
4	***sheet pile at the middle of dam inclined by 45^0 by direction the beginning of the dam***	***433.8***
5	***sheet pile at the middle of the dam inclined by 45^0 by direction of the dam end***	***361.6***

VI. CONCLUSIONS

The finite element method has been used to analyze the results in this study for all cases studied by the computer program, and this method was suitable for analysis, from this study, we can summarize some conclusions. The first is that the position and inclination of the sheet pile affects the value of the total water pressure, and the second is in cases 1 and 5 in which the total water pressure is less than the value of the total water pressure for the standard case, while cases 2, 3 and 4 have the value of the total water pressure greater than the standard case in different percentages.

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