Eng. & Technology, Vol.24, No.9, 2005

Effect of Seepage Below Hydraulic Structures on The Scouring

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Received on: 27/12/2003
Accepted on: 8/5/2005

Abstract

This paper describes the results of experimental investigation on flow behavior below hydraulic structures on pervious soil layers.

The pressure acting on the bottom of the structure during under- flow and the quantity of seepage discharge were measured.

The present paper provides more evidence, which support the previous work based on the difference of scour hole depth at the bottom, and at the soil surface behind the aprons.

Laboratory experiments have been carried out to investigate, critical case of flow behavior below the hydraulic structures, the effect on the stability of the hydraulic structures, and identity the length of protection works. The pressure data were analyzed in detail as curves drawn for each depth of water level. It was noticed that maximum danger of scour lies at the exit of the hydraulic structures

تأثير التسرب اسفل المنشآت الهيدروليكية على عملية التعرية

الخلاصة

يستعرض هذا البحث نتائج مختبريه عن سلوك التسرب تحت المنشآت الهيدروليكية المستندة على تربة نفاذه .تم قياس الضغوط على قاع المنشا وكمية المياه المتسربة إثناء التدفق.واعتمادا على تغير عمق حفرة التعرية عند قاع المنشأ وعند السطح الخارجي للتربة، تم استنباط خاصية لتمييز الحالات الحرجة الممكنة لسلوك التدفق تحت المنشأ ، من حيث تأثيره علي توازن واستقرار المنشأ الهيدروليكي وتحديد طول الحماية المطلوبة.

تم رسم بيانات الضغوط بشكل مفصل ولكل عمق من المياه وتبين أن اخطر حفرة تعرية تقع بعد المنشأ مباشرة.

Introduction

The scour is a phenomenon, which damage the system work of the hydraulic structures. The scour phenomenon is a problem way like the dry conditions, floods and soil salination…etc.

The holes form from the loss of the soil surface. Holes are regards an unfavorable condition as regards to the stability of the hydraulic structures.

Weirs are commonly used for flow regulation and measurement in a variety of hydraulic structures. Because there is a difference in water level between upstream and downstream, there is under- flow and the pulsations in flow underneath the structures is the major cause for the stability of the hydraulic structures [1], [2].

These pulsations are the result of flow problem from the upstream edge to the end of the structures and subsequent reattachment at a certain downstream location.

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https://doi.org/10.30684/etj.24.9A.3
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The difference between up-stream water level and down-stream water level, causes many problems, one of these problem is seepage. The seepage water causes the uplift pressure underneath the structure and piping phenomenon.

Therefore, the study of the pressure distribution, hydraulic gradient and depth of the scour hole assume importance for understanding the dynamic behavior below the structure. For hydraulic structures with under -flow, the seepage and scouring hole at the bottom plays an important role in the design. It is therefore necessary to examine this flow pattern in more detail.

For high values of flow depth, It is known that the depth of the scour hole is primarily a function of soil characteristics, climatology, the difference in piezometric head, shape of the soil particles and depth of water at downstream of the structure [3 to7].

In the present case the under flow is with free water surface upstream of the hydraulic structures, eventually the boundaries are determined by the upstream water level, the water level at the piezometers.

Thus in some cases, the uplift pressure may go clearly to the bottom and eventually lift the concrete floor level, if the thickness of the concrete floor is not adequate this causes failure to the structure.

On the other hand, in some other cases it may cause a scour hole to the soil and reattach the concrete floor [8].

If the scour hole is reattaching the concrete floor, the reattachment is considered unstable.

The unstable condition is important for the design of the bottom of the hydraulic structures. In this paper, it was decided to classify the uplift pressure, scour hole and the quantity of seepage water into different classes, based on the upstream water level.

Experimental Set - Up

The experiments were conducted in rectangular flume; 180 cm long, 15 cm wide and 70 cm deep, having glass walls and steel floor.

Water depth was accurately measured by means of the rule, and the seepage discharge beneath the model was calculated by measuring the volume of water with time.

The model of the weir is rectangular cross section made of fine plastic coated with a material preventing any leakage of the water. The length of the model is 60 cm with five piezometers put at equal distances, in order to read the uplift pressures as shown in Fig.1.

Most of the sample of the soil was taken from Basrah (Karmat Ali). Ten experimental runs were performed. In each run the model was put on a compacted soil with depth equal to 40 cm ... In each run, the ratio between the floor length and the depth of sheet-pile was held constant with a variable head of water.

The pressure measurements were obtained from the water levels in the piezometers and were read to an accuracy of 1 mm.

Before the start of each run of the experiments, a great care had been taken to see that the piezometric tubing was free from air bubbles.

This precaution was followed in all the run of experiments performed in this work.

Uniform flow was achieved when both the water and scour hole depths became constant along major portion of the flumes length.

In each run, the upstream water level, the uplift pressure, quantity of the seepage water, and the scour depth were measured. After the collection of pertinent data, the experimental was stopped, the soil cleared out completely and the flume was set ready for another run.

Discussion of Results

As mentioned before many series of tests were carried out. The purpose of these series tests was to obtain the uplift pressure, scour hole depth, its distance, and the quantity of the seepage water at which the bed become unstable and the bed was washed away. During under- flow, the uplift pressure at the bottom of the floor and scour hole depth subsequent reattachment at downstream increases with the depth of water upstream. With an impervious base, the flow lines tend to be horizontal and are directed outward towards the downstream.

The boundary level of water changes according to a depth of scour. The depth of scour hole and magnitude of pressure on the bottom of the floor are dependent on the velocity of the water (the difference between up-stream water level and down-stream water level) and the degree of the permeability of the soil.

The results of the experimental data were obtained in similar manner. [9 to 11] Figure (2) shows the relation between the piezometric head along the floor and the length of the bed for different depths of water at upstream. From this figure, it can be clearly seen that if a water depth at upstream increases the piezometric head increases. As well, with time, scour hole will be developed at different distances, and at different locations Figs (3), (4) were plotted showing the location of the scour hole. At the first, the scour hole will be developed at the exit. Scour hole depth and the quantity of the seepage water were recorded. The test was allowed long enough to ensure that the scour hole and the quantity of the seepage water did not change at that setting. At this depth of the scour hole, the structure found to be unstable. There is a fail. The seconed run of the experiment, and at the same depth of water level at up-stream, and in order to a void the scour hole at the exit. I recommend to cover the down-stream layer with a very large boulders as a protection work. After we put this layer, the scour hole will be developed under the floor as shown in figs. (3), (4). Decreasing the length of the protection works, in order to demonstrate how much length of the protection works along the down-stream is sufficient. Scour hole will be developed at B/5 from the exit as shown in figs. (3), (4). The results showed that the length of the protection works beyoned B/5 after the exit, there is no change either failure of the hydraulic structures. The data for other depth of water were obtained in similar manner. Using all the data, Figs. 5, 6 and 7 were plotted showing the influence of the piezometeric head along the floor on the scour hole location. It can be clearly seen that if the scour hole lies at the exit, it was give the sign of the hydraulic gradient and its relationship with the piping phenomenon which is dangerous to the hydraulic structure for the stability.

The quantity of the seepage water, scour hole depth and its location are shown in Table 1. From this table, it is found that if the scour hole lies at a distance B/5 from the exit, where B is the length of floor, the structure is stable. The mount of protection works is required at the downstream side of the structure at a distance equals to B/5.

Conclusions

1. Based on the upstream water level, the pressure distribution at the bottom of the structure has been developed.
2. The scour hole is located at downstream edge of the bottom floor, at the end of the floor, and at a distance 1/5 B from the end of the floor.
3. It has been found that the scour hole at the end of the floor is much larger for the case of unstable in comparison with the scour hole at different distances of the hydraulic structure.
4. For the design and construction of satisfactory and economical submerged weirs, the cost factor is the most important consideration, it has been found from this paper that the length of the protection works equals to B/5.

Table 1 Quantity of the seepage water, scour hole depth, and location for different upstream water level.

Upstream water level (cm)	Depth of the scour hole (cm)	Location of the scour hole (cm)	Quantity of the seepage water (l/sec)
15	0	0	0.0032
20	0	0	0.0072
	3.6	Under the floor	0.0114
	3.5	B/5 from the exit	0.0098
	3.8	Exit	0.036
25	0	0	0.0093
	4.6	Under the floor	0.0178
	4.3	B/5 from the exit	0.0165
	5.1	Exit	0.038
30	0	0	0.015
	5.8	Under the floor	0.028
	4	B/5 from the exit	0.024
	6	Exit	0.097

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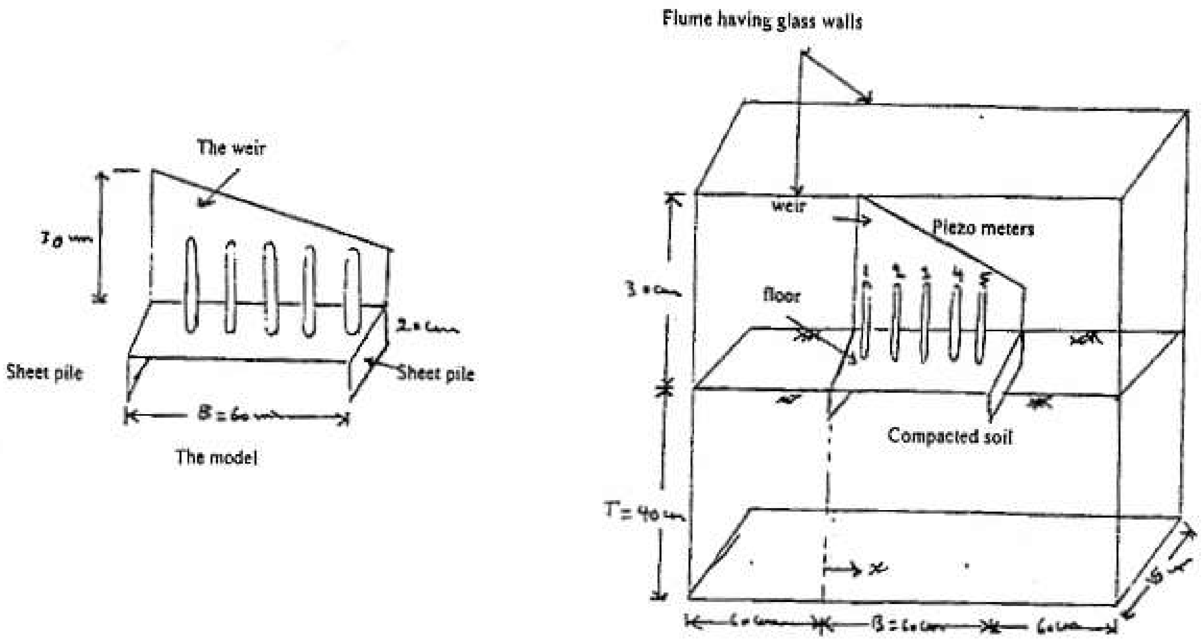


Figure (1) Experimental set - up

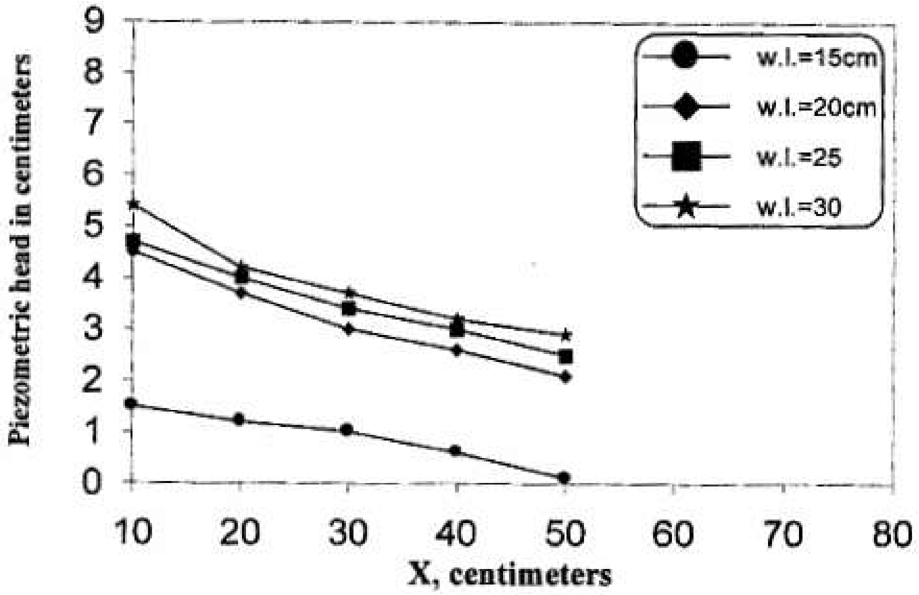
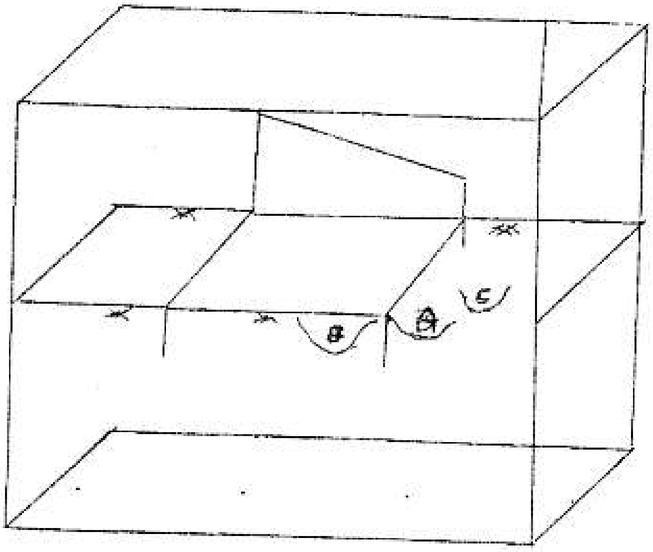


Figure (2) Piezometric Head along the Floor

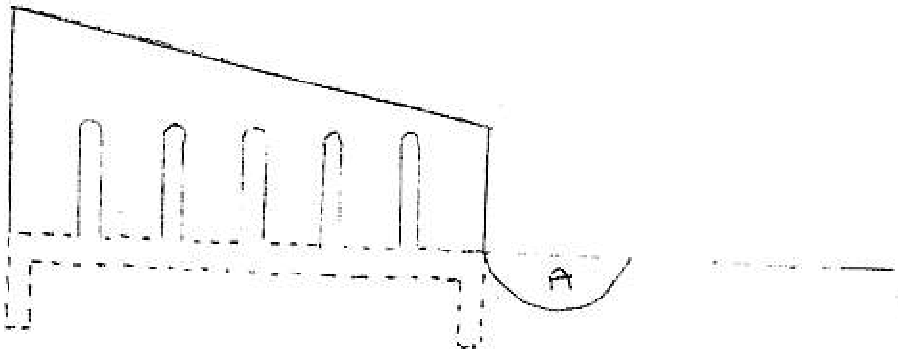


hole B under the floor

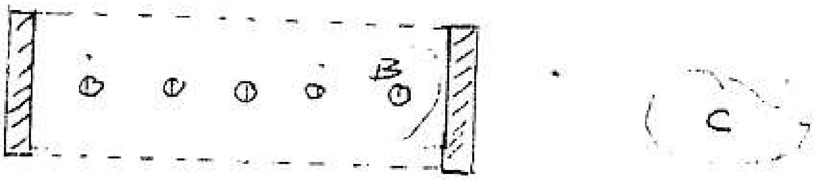
hole A at the exit

hole C at B/5 from the exit

Figure (3) The locations of the scour hole



Section of the scour hole



Section of the scour hole

Figure (4) Horizontal sections about the scour hole

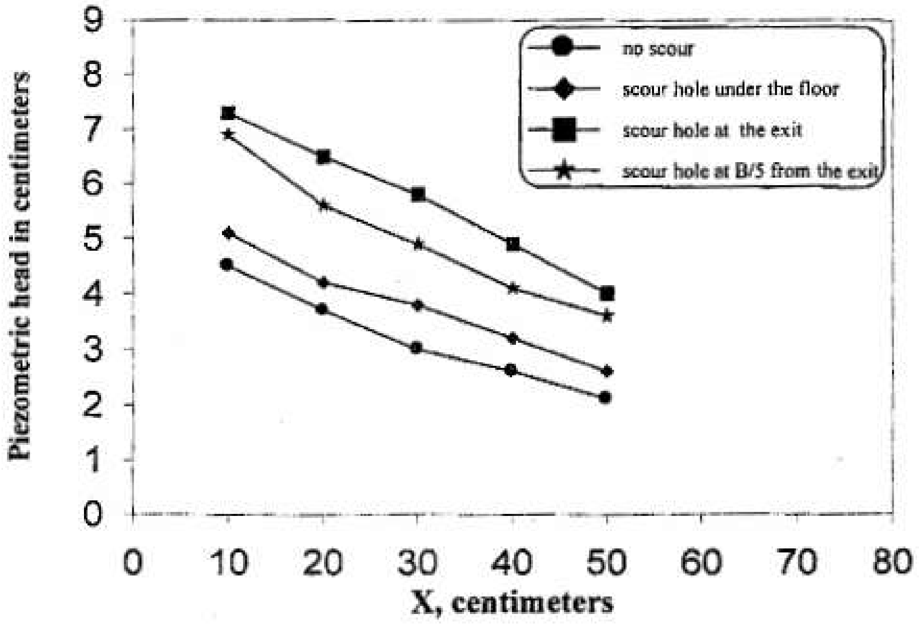


Figure (5) Piezometric Head along the Floor
When w.l.=20cm

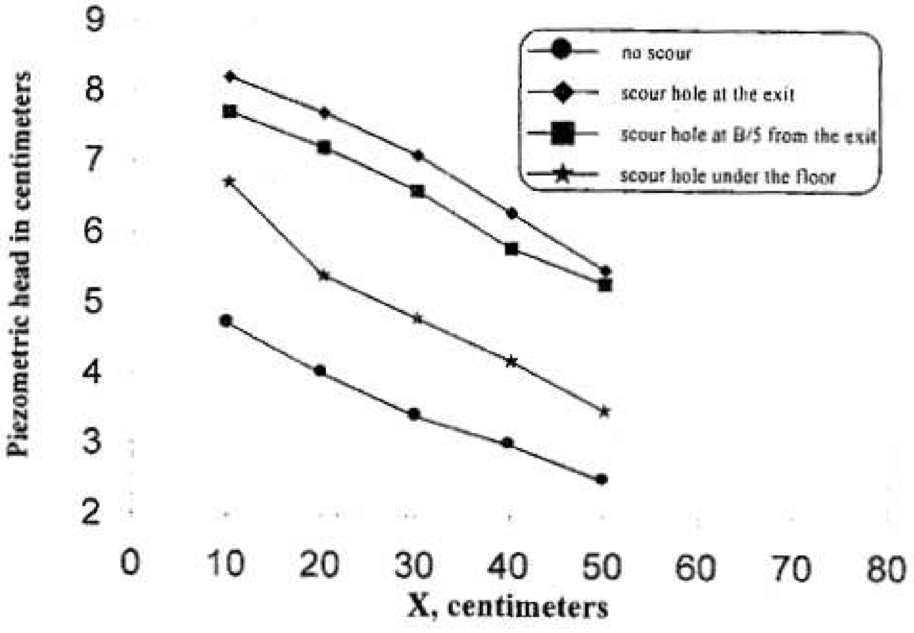


Figure (6) Piezometric Head along the Floor
When w.l.=25cm

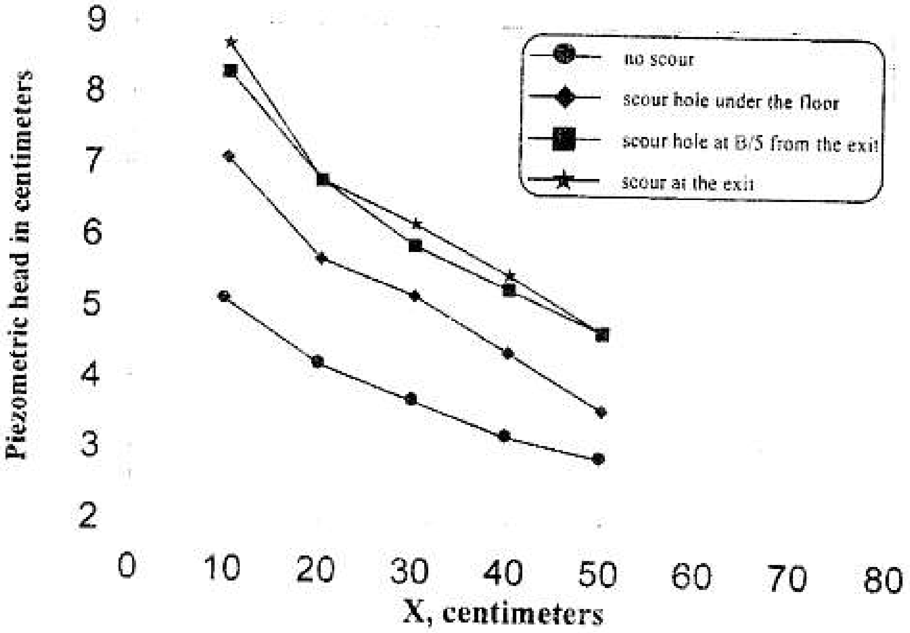


Figure (7) Piezometric Head along the Floor
When w.l.=30cm