Research Paper Engineering

Construction and Validation of Operative Weir Model

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ABSTRACT

In this experimental work, a trial is made to prepare a physical model resembling to a weir founded on permeable soil with sheet piles. With number of attempts a working model is prepared in such a way that the real flow of water, seepage propagation within the soil mass and uplift pressure heads at key points with reference to water level on upstream side can be observed and measured.

Keywords : Model, weir, sheet piles, uplift pressure, Weir model

INTRODUCTION

It has been established that seepage of water takes place beneath hydraulic structures constructed for storage of water such as dam or weir. This seeping water exerts an uplift pressure on the structure depending on the head of water available at upstream and permeability of soil on which the hydraulic structure is founded. It has also been known by almost all the civil engineers that this seepage pressure can be reduced reasonably up to a certain safe amount by providing cut-off in the form of sheet pile beneath the hydraulic structure, especially at upstream side and downstream side of the floor.

The present work is based on an attempt to prepare a physical model, resembling the seepage pressure heads that would occur while water is stored on the upstream side of a weir constructed on permeable soil, seeps beneath the floor and imparts an uplift pressure.

OBJECTIVE

- To prepare a working model of weir resembling actual structure
- To test Khosla's equations for such a small values of head, floor length and pile depth

PROCEDURE

1. Deciding shape, width and dimensions:

In the beginning, without any exercise, the sketch of a weir founded on permeable soil as can be seen in curriculum of the subject, "Design of Hydraulic Structures" was taken into consideration. This sketch was prepared into Auto-Cad with proportionate scale as under.

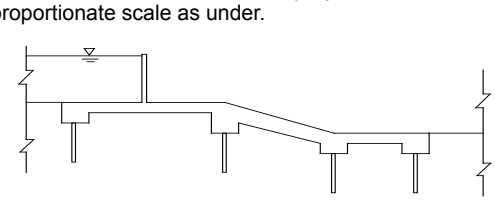


Figure 1

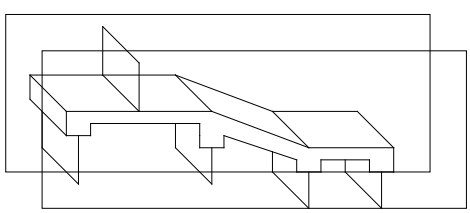


Figure 2

Later on, it was realized that non-linear alignment and varying thickness of floor, joints Finally acrylic was chosen as main material for model construction and fevikwik, feviflex and araldite were decided to be used as adhesives. For obtaining pressure heads, flexible transparent plastic pipes with appropriate diameter were to be used as piezo meters.of sheet piles with floor at various positions, length of floor and more number of joints in the floor; these all simultaneously may not work perfectly and failure of a single functionary may fail the model to work.

Hence, it was decided to prepare a simple model with straight floor and three sheet piles. Now, to direct flow of water in a particular direction, the weir is supposed to be covered from both the sides in a plane parallel to the paper. To obtain such conditions, two water proof sheets were decided to mount on both the sides of weir as shown in figure-3.

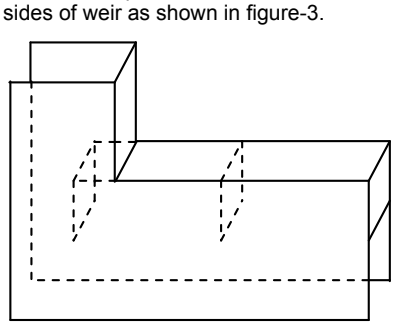


Figure 3

3. Deciding Materials to be used for main parts and adhesives for joints:
As the weir is to be filled by soil as well as by water, visualization around the weir is necessary so as to ensure proper filling and compaction of soil below weir especially around sheet piles and key points; at-least one face must remain transparent. Glass would be the desired material but being brittle and poor against vibrations it was avoided. Hence, acrylic was found the perfect material for the same. Later on, the whole model was decided to be made up of acrylic.

Regarding adhesives to be used, as per the directions of the merchant of acrylic and furniture makers, the best adhesive for acrylic would be either Chloroform or Fevikwik. I found both these adhesives dangerous as Chloroform may cause health hazard and fevikwik is having setting time of a few seconds only. As many adhesives as could be found in the market for joining acrylic were tried to see the effect over joints.

Finally acrylic was chosen as main material for model construction and fevikwik, feviflex and araldite were decided to be used as adhesives. For obtaining pressure heads, flexible transparent plastic pipes with appropriate diameter were to be used as piezo meters.

3. Preparation of Drawings:
For the preliminary model size as decided a rectangular sheet (45cm x 37cm) of 3mm thick acrylic was found from the market.

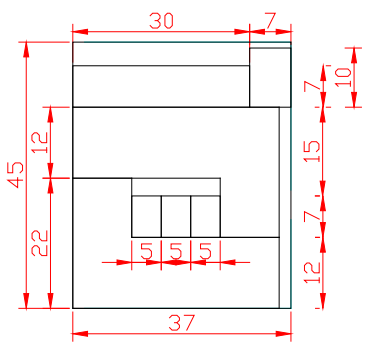


Figure 4
To set all important faces of model, the drawings of the individual faces were drawn in Auto-Cad. A rectangle of the available sheet size was also drawn. Thereafter each of the components of model was moved into the rectangle one by one and so oriented that none of the component remain outside the rectangle. The same drawing was transferred on actual acrylic sheet available.

4. Construction of preliminary model
After lines drawn as per figure-4 on acrylic sheet, it was cut exactly as per the drawings. After cutting all component parts, the floor of the weir was marked for sheet pile positions and holes were drilled at key point positions so as to accommodate plastic tubes at positions. Firstly One L shaped vertical face and weir floor were joined with the help of Fevikwik at right angle. Then all the three sheet piles were joined with the floor at marked positions. After that weir was joined and finally other L shaped vertical face was mounted. To fill small gapes of joints, Bond-tite as well as M-seal was applied at all the joints and the model was allowed to set. The photographic view can be seen in Photo-1.

Photo 1

5. Testing the model for expected results:
As the upstream vertical wall was kept open in the model, it was difficult to maintain water level on the upstream side. One by one experiment failure and solution to overcome led to the successfully operative model as shown in Photo- 2

Photo 2

Photo 3
This model gave appropriate rise of water as a result of uplift pressure because of head at upstream as can be seen in photo-3

6. Deciding shape, width and dimensions for fair model:
It was observed from the testing of preliminary model that even for small heads of 2cm, uplift pressure head can be obtained at various key points. Moreover, the difficulties which came during construction and operation of the preliminary model gave some preventive modifications and design of the fair model. The following changes / modifications were made in the shape, width and dimensions of fair model as compared to preliminary model.

- Model Length: 60cm
- Model Height: 50cm
- Model Width: 10cm
- Weir Length: 40cm
- U/s Head: upto 25cm
- Sheet pile depth: 10cm
- Using 3 sheet piles but not at equidistance
- Provision of openings in floor to ensure proper compaction of soil between floor and sheet piles

7. Deciding Materials to be used for main parts and adhesives for joints:
The material kept unchanged, i.e. acrylic but thickness increased to 5mm for all parts instead of 3mm except floor and sheet piles. As adhesives, Feviflex and aral dite were decided.

8. Preparation of Drawings:
Same procedure was adopted in fair model drawing. A 5mm acrylic sheet of 99cm x 62cm was obtained from market. Individual component parts of the model were drawn on Auto-Cad and all the drawings were transferred to a rectangle of size equal to size of acrylic sheet. The same drawing was transferred on the acrylic sheet as shown in the figure 5.

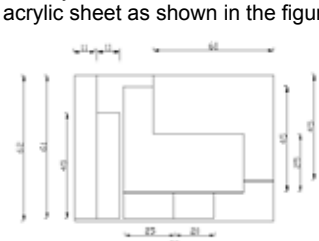


Figure 5(All dimensions in cm)

9. Construction of Fair model:

Joining of faces was started from bottom of the model, which was joined to one of the L shaped vertical face. To keep the surfaces in position, Feviflex was used by applying few drops at end and middle points of the joints. Then araldite was applied thoroughly on the joint to ensure sealing of all minute pore spaces All other faces were mounted one by one in the same manner. Lastly floor and weir in the form of 3mm thick acrylic sheet were mounted in position. Then plastic tubes were inserted from the holes drilled in the floor at key points and the joint was sealed by araldite (Photo-4). The openings made in the floor for compaction were provided with PVC nut-bolts for easy opening during filling of sand and sealing during practical execution. The sheet piles were kept detachable and to prevent water leaks from the faces between sheet pile and floor as well as vertical faces, the sheet pile border was provided with rubber strip as used in refrigerator doors (Photo-5).

Photo 4

Photo 5

10. Experimental Set-up:

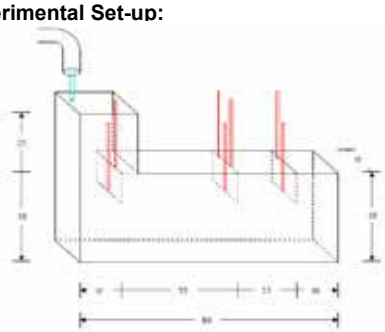


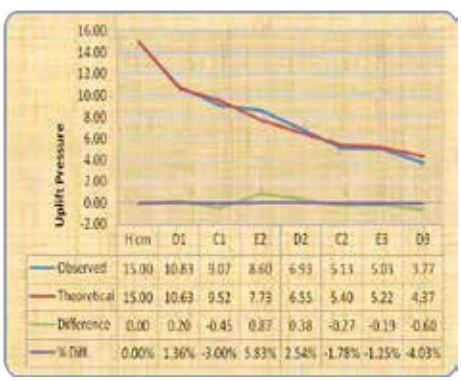
Figure 6

11. Testing the model for expected results:

To test model, sandy soil having less silt content was filled from all openings kept on top equally in the model. After 5-10 cm layer, the sand was compacted and the model was shacked manually. After having model filled by sand, water was filled in the tank. The water flows through soil and comes out from the downstream floor. At each key-point, piezometric tube gave uplift pressure head which are compared to Khosla's theory.

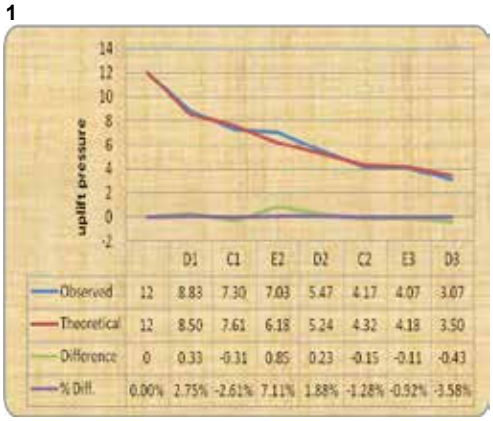
Photo 6

12. Observations and comparison with theoretical values (Khosla):



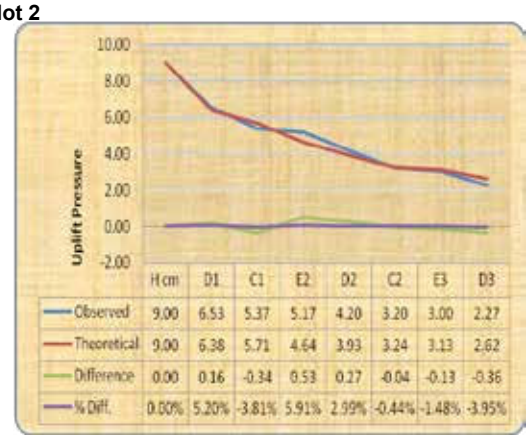
H cm	D1	C1	E2	D2	C2	E3	D3
Observed	15.00	10.83	9.07	8.60	6.93	5.13	5.03	3.77
Theoretical	15.00	10.63	9.52	7.73	6.55	5.40	5.22	4.37
Difference	0.00	0.20	-0.45	0.87	0.38	-0.27	-0.19	-0.60
% Diff.	0.00%	1.36%	-3.00%	5.83%	2.54%	-1.78%	-1.25%	-4.03%

Plot 1



	D1	C1	E2	D2	C2	E3	D3
Observed	12	8.83	7.30	7.03	5.47	4.17	4.07	3.07
Theoretical	12	8.50	7.61	6.18	5.24	4.32	4.18	3.50
Difference	0	0.33	-0.31	0.85	0.23	-0.15	-0.11	-0.43
% Diff.	0.00%	2.75%	-2.61%	7.11%	1.88%	-1.28%	-0.92%	-3.58%

Plot 2



H cm	D1	C1	E2	D2	C2	E3	D3
Observed	9.00	6.53	5.37	5.17	4.20	3.20	3.00	2.27
Theoretical	9.00	6.38	5.71	4.64	3.93	3.24	3.13	2.62
Difference	0.00	0.16	-0.34	0.53	0.27	-0.04	-0.13	-0.36
% Diff.	0.00%	5.20%	-3.81%	5.91%	2.99%	-0.44%	-1.48%	-3.95%

Plot 3

Conclusions:

1. The model gives uplift pressures at key points more or less according to that computed by Khosla's method of independent variable
2. Maximum difference between theoretical and observed results is found at D3. The reason can be restricted boundary which comes at 10 cm from the end of floor.

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