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Design of Electrical Analogy Apparatus for Drawing Flownet and Studying Uplift Pressure

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ABSTRACT

Flow of electrical current through a conducting medium is analogous to groundwater flow through a porous medium because both are governed by Laplace equation. This analogy was used in an alternate representational approach in flownet concepts. The report employed the easily demonstrable electrical counterpart to represent the groundwater flow problem in a laboratory setting. This report discusses the flownet principles better by using the electrical analogy for selected groundwater flow situations. However, it was also demonstrated that the electrical analogy concept can be applied for a wide range of groundwater flow situations with a few simple modifications. Our aim is to design a simplest model for determining flow net concept precisely.

***Keywords**: Flownet, Eqipotential lines, Flow lines, Uplift pressure, Discharge, Electrical analogy*

INTRODUCTION

A **flownet** is graphical representation of two-dimensional steady state groundwater flow through aquifers. Construction of a flownet is often used for solving groundwater flow problems where the geometry makes analytical solutions impractical.

The method is often used in civil engineering, hydrogeology or soil mechanics as a first check for problems of flow under hydraulic structures like dams or sheet pile walls. As such, a grid obtained by drawing a series of equipotential lines and streamlines is called a flownet. The flownet is an important tool in analyzing two-dimensional irrotational flow problems.

Hydraulic structures are a specific type of engineering structures designed and executed in such a way in order to control natural water or save industrial sources to guarantee optimum use of water. These structures are frequently build on soil materials and the foundation thickness must be thick so as to be safe against uplift pressure. The differential head in water levels between the upstream and downstream acts on the foundation and causes seepage flow The Groundwater flow depends on the type of flow, the soil media, and the boundary conditions. Seepage of water is one of the major problems which effect on hydraulic structures**.** To do seepage analysis flownets are used. Hence flownet study is very important.Flow of electrical current through a conducting medium is analogous to groundwater flow through a porous medium because both are governed by Laplace equation. This analogy was used in an alternate representational approach in flownet concepts which is known as electrical analogy method of drawing flownets

Literature Review Paper

Integrating electrical analogy and computer modeling of groundwater flow for teaching flownet concepts.

Teaching complex engineering problems can often be enhanced by utilizing students' prior knowledge in analogously similar problems. Flow of electrical current through a conducting medium is analogous to groundwater flow through a porous medium because both are governed by Laplace equation. This analogy was used in an alternate representational approach by the authors in teaching flownet concepts. The authors employed the easily demonstrable electrical counterpart to represent the groundwater flow problem in a laboratory setting. This paper discusses the efforts of authors to teach the flownet principles better by using the electrical analogy for selected groundwater flow situations. However, it was also demonstrated that the electrical analogy concept can be applied for a wide range of groundwater flow situations with a few simple modifications.

Students also used a groundwater flow computer model to obtain flownets for the same flow ituations as the ones that were obtained using an electrical analogy. The student feedback indicated that this approach could improve student learning of flownet concepts.

Limitations of previous research

1 It lacks expansion and contraction of fluid flow apparatus
2 Flownet analysis pipes as well as spillways cannot be studied effectively.
3 3.Earlier studies only focus on just one condition of fluid flow

Objective

To design electrical analogy apparatus.

To obtain flownet for the flow of water through homogeneous permeable foundation below weir by electrical analogy

- Flow under dam.
- Flow under dam with weir
- Converging flow in open channel
- Diverging flow in open channel.

I. To determine the discharge passing below the weir.
II. To obtain the actual hydrostatic pressure distribution on its base.

5. Methodology

Flownets :-

Flownets are convenient graphical representations of steady patterns of groundwater flow consisting of equipotential lines and stream or flow lines.

Equipotential lines (Φ) :-

Equipotential lines are lines along which a constant potential exists.

Flowlines (Ψ):–

Flowlines are lines along which the velocity vectors are tangents.

Methods of drawing flownets :-

1.Analytical method.

2.Graphical method.

3.Experimental Analogy method.

a) Electrical Analogy.
b) Membrane Analogy.
c) Viscous Flow Analogy.

4.Relaxation method.

Graphical Method :-

The graphical method of flow net construction, first given by Forchheimer (1930), is based on trial sketching. The hydraulic boundary conditions have a great effect on the general shape of the flow net, and hence must be examined before sketching is started. The flow net can be plotted by trial and error by observing the properties of flow net.

Electrical analogy:-

The Darcy's law governing the flow of water through soil is analogous to Ohm's law by governing the flow of electric current through conductors. The corresponding analogous quantities are shown in the table below:-

DAERCY'S LAW OF WATER SEEPAGE	OHM'S LAW OF ELECTRIC FLOW
q=k h/L x A q= Quantity of seepage k= coefficient of permeability A= cross-sectional area h= hydraulic head L= length of seepage	I=C E/l x a I= rate of flow of electricity C= electric conductivity coefficient a= cross-sectional area E= electric potential l= length of path of electric current

Procedure :-

1. connect the system as shown in the diagram by adjusting 90% potential on potentiometer obtain as many points in the flow field of the same 90% potential with the help of null indicator so that they can be joined by smooth curve.

2. Repeat the procedure for 80%,70%.... 10% potential. plotting simultaneously on graph ,we will obtain streamlines orthogonal to theses potential lines

Cases- In this project we are studying four cases -

CASE - 1. First case concerned to the study of flow properties under the dam, two copper plates are attached to one side of the tank with space between them. The gap which is electrically resistant is analogous to the dam.

CASE - 2. In second case one acrylic sheet is inserted near first copper plate. This arrangement is analogous with the sheet pile inserted under the dam to avoid direct low of water below the hydraulic structure.

CASE - 3. The third case is studied with second type of tank cu plates were attached to opposite sides of tank showing converging and diverging faces. In this case flow is diverging that is from narrow to wide side of tank. The direction of flow is maintained by providing voltage difference between cu plates.

CASE - 4 .Similarly in fourth case, flow direction is from widened side to narrow side of the tank that is converging condition of flow of water.

Conclusion

Thus we concluded that by applying analogical method of electricity we can plot flow nets which help us to understand the flow under dam with sheet pile and without sheet pile ; Also by studying expansion and contraction of flow we can understand the eddy's formed at contracted section.

Results and discussion

		SUDDEN EXPANSION		
X AXIS	**Y AXIS**		**X AXIS**	**Y AXIS**
18	68	9 volts	117	135
14	130		117	82
15	84		150	80
12	110		151	96
10	69		150	127
12	62		151	140
35	82	8 Volts	151	58
35	106		181	42
34	130		197	90
31	140		165	172
34	84		187	148
34	70		192	75
60	70	7 Volts	165	25
60	96		191	125
60	111		270	22
58	135		270	60
58	115		270	95
87	112	6 Volts	262	178
86	125		261	196
86	140		275	20
86	80		270	130
86	65		268	160
85	60		280	10

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