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Remedial Measures to Seepage Using Grout Curtain

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Abstract: **- Grout curtains are vertically drilled tangent shafts that are filled with cementatious material that create a barrier to help prevent excessive seepage under a dam. Grout curtains are intended to be impervious walls that typically exist below infrastructure to minimize water seepage. Along with seepage minimalization under dams, grout curtains are also minimize groundwater infiltration and subsequent erosion of the geologic formation. Grout curtains are typical used impermeable soil or rock masses to decrease seepage. Grout curtains are important to dam and other earthen impoundment restoration projects. Electrical resistivity methods are used to find out the effectiveness of grout curtain. Experiments are conducts using three types of grouts. Electrical resistivity of soil with different grout curtains are analysed and compared. Also the effect spacing on performance grout curtain were studied.**

Keywords: Electrical resistivity methods, Grout curtain

1. INTRODUCTION

Grout curtains are vertically drilled tangent shafts that are filled with cementatious material that create a barrier to help prevent excessive seepage under a dam. Grout curtains are intended to be impervious walls that typically exist below infrastructure to minimize water seepage. Along with seepage minimalization under dams, grout curtains are also minimize groundwater infiltration and subsequent erosion of the geologic formation. Curtain grouting is a construction technique by which a continuous grout wall is formed from a series of cylindrical columns placed adjacent to one another. Grout curtains are typical used impermeable soil or rock masses to decrease seepage. Case studies have shown the efficacy of curtain grouting in minimizing seepage.

Mainly there are three types of grouts ; suspension grout, chemical grout, colloidal silica grout. Colloidal silica grout (CSG) comprises a mixture of sodium silicate and reagent solution, which change in viscosity overtime to produce a gel. Reagent solution is organic or inorganic materials . CSG has a low viscosity. Perself made tests to determine the hydraulic conductivity of sand grouted by silica gel, it was found the hydraulic conductivity is decreased by increasing concentration of colloidal silica in the grout. The soil improvement techniques are effective for each of the allowed or required disturbance of existing structure. Permeation grouting includes the injection of a low-viscosity fluid in the soil pores without changes in the soil physical structure. The main goal of permeation grouting is both to strengthen soil and to waterproof ground by filling its pores with injected fluid. This method improves the soil physical and mechanical characteristics, stabilizes the excavation walls in soft soils and controls the groundwater migration

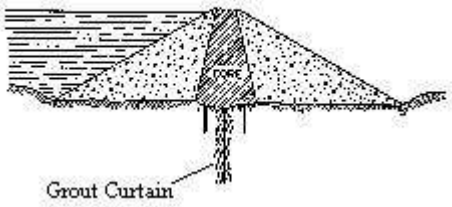

Fig. 1 Grout curtain under dam

II. MATERIALS USED

Locally collected clean sand was used in all the experiments as a soil medium. A glass tank of 40x40x21 is used in test. Two steel rods are used as electrodes, having length 31.5cm.Distance between electrodes are 15 cm. A DC power supply is used for power supply. Ammeter and volt meter are also connected to the setup.

A. Properties of Sand

Table. I Index properties of sands

Parameters	Value
Specific Gravity	2.51
Effective size, D10 (mm)	0.20
D30 (mm)	0. 33
D60 (mm)	0.58
Uniformity coefficient, Cu	2.9
Coefficient of curvature, Cc	0.938
Gradation of sand	SP

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Maximum density (g/cc)	1.7
Minimum density (g/cc)	1.45
Angle of internal friction ,Φ	39
Coefficient of permeability(cm/s)	$1.494x10^{-3}$

III. EXPERIMENTAL PROGRAMME

The hydraulic conductivity of sand can be determine by electrical resistivity methods. Electrical resistance of soil can be find out using electrodes. A glass tank is prepared for finding out the electrical resistivity .Tank is filled with clean sand .Grout columns are made using PVC pipes. Grout is injected to the pipes by pressure grouting. Mainly three types of grouts are used; they are colloidal silica grout, cement bentonite grout, and a chemical grout. Colloidal silica grout were prepared in three different concentrations by varying the percentage of brine solution. After preparing grout columns water poured in upstream of soil and it will come out in down stream side. Three different voltages are applied to the electrode and corresponding current is note down. Resistance is find out using equation. Same procedure is repeated for cement bentonite grout. Cement bentonite grout was prepared in three different water cement ratio. And the values are note down. Third type of grout is chemical grout. Using chemical grout test repeated and values are noted. Then the grout curtains are arranged in different pattern. They placed at an interval of 6.6cm.Same procedure repeated and readings are noted down.

Fig. 2 Test set up for the experiment

IV. RESULTS AND DISCUSSIONS

A. Results when grout curtains are closely spaced in sand

Three types of grouts are used in test. Grouts are prepared and injected to PVC pipes which are placed close to each other. After some time the pipes are taken out and providing required time for curing. Switched on the power supply and note down the value of current from the ammeter.

resistance of soil can be find out using ohm's law.

$R = V / I$ Eq.1

Graphs show the results obtained when voltage applied. Figure 3 shows the values of resistance when the colloidal silica grout curtains are arranged closely. Maximum value of resistance is 76.87,which is obtained when 10% of brine solution added to colloidal silica. Minimum value of

resistance is 55.53,which is obtained when 6% of brine solution is added to colloidal silica. Graph shows that as percentage of brine solution increasing the resistance value will increase also the conductance of the soil decrease. It helps to reduce the seepage of water. Brine solution used for reducing the gel time of colloidal silica.

Figure 4 shows the resistance versus current graph obtained when the cement bentonite grout columns are spaced closely. Three water cement ratios are used here. Maximum value of resistance obtained in 2.5:1:0.3 ratio. Minimum resistance obtained in 4.5:1:0.3 ratio.

Figure 5 represent the relation between current and resistance in chemical grout columns. Maximum value of resistance obtained at 20% of chemical grout. Minimum resistance obtained at 10% of chemical grout. Its shows the increase of resistance with the increase of percentage of chemical grout.

B. Results when grout curtains are 6.6cm spaced in sand

Figure 6 plot the relationship between resistance and current while using the colloidal silica grout. Here the grout columns are spaced at a distance of 6.6cm.It allow more water to pass through it. So the resistance values will be low because of high conductivity .Maximum value of resistance is 47.9 ,obtained at 10% of brine solution in colloidal silica. As the concentration of brine solution increase the resistance will also increase.

Figure 7 shows the relation between resistance and current while using the cement bentonite grout. Maximum value of resistance obtained at 2.5:1:0.3 .Minimum value of resistance

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obtained in 4.5:1:0.3m.

Figure 8 plots the relation between resistance and current in the chemical grout. Maximum value of resistance obtained at 20% and its 62.7.Minimum value obtained at 10% and its 60.As the percentage of chemical grout increase the resistance will also increase.

Figure 9 shows the variation in resistance of soil by varying the percentage of brine solution.it shows that the resistance increased with increase in percentage of brine solution.by adding more brine solution the gel time will decrease and colloidal silica will get hard in less time.

Figure 10 plot the graph between resistance and water cement ratio. Among the three water cement ratio the grout with lesser water content provided more resistance compared to other grouts. Grout with lesser water content become harder in fast rate.

Figure 11 shows the variation of resistance with respect to percentage of chemical grout. As the percentage increase the value of resistance also increase.

Figure 12 shows the resistance of soil offered by different grouts. Maximum value of resistance obtained while using the cement bentonite grout. Chemical grout offered minimum value of resistance. Also it shows that close spacing arrangement is more effective for curtain grouting.

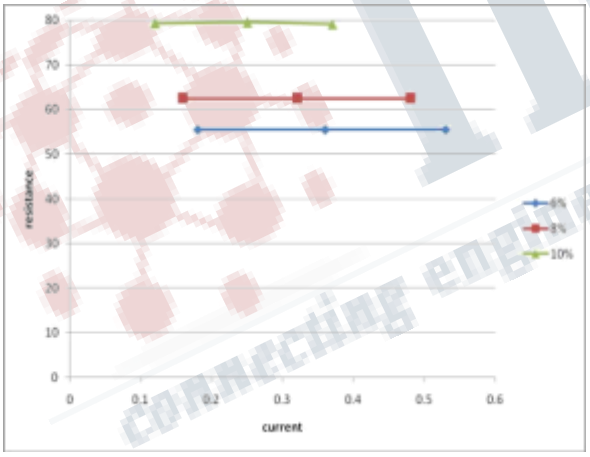

Fig.3 Current resistance graph of colloidal silica grout arranged in close spacing

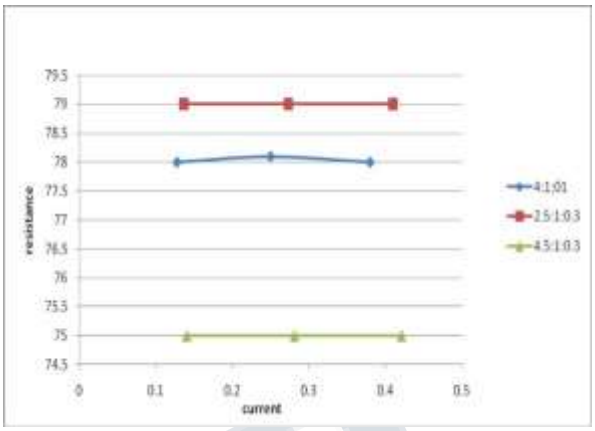

Fig.4 Current resistance graph of cement bentonite grout arranged in close spacing

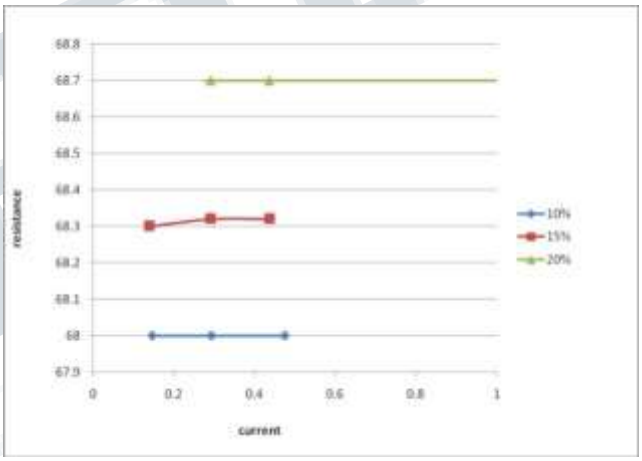

Fig.5 Current resistance graph of chemical grout arranged in close spacing

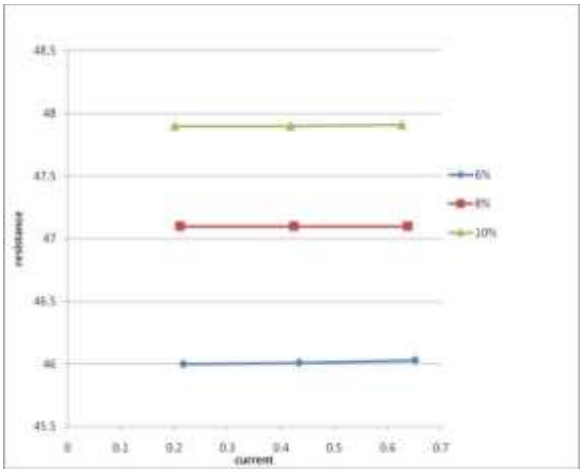

Fig.6 Current resistance graph of colloidal silica grout arranged in 6.6cm spacing

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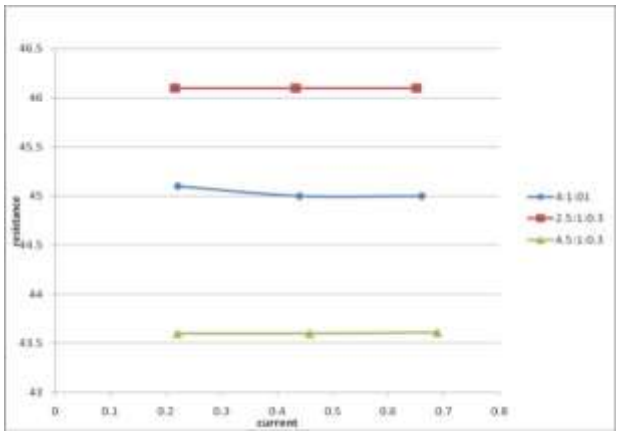

Fig.7 Current resistance graph of cement bentonite grout arranged in 6.6cm spacing

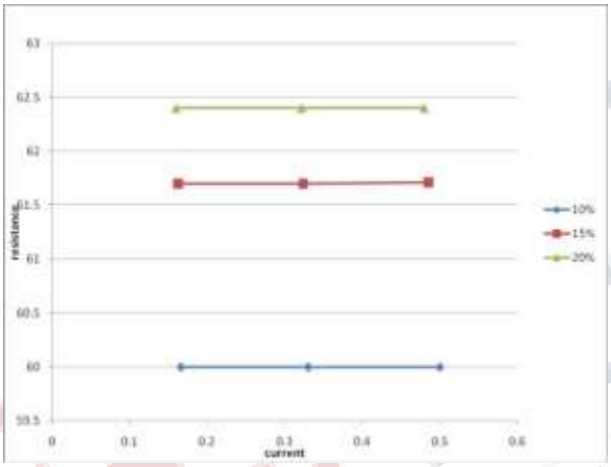

Fig.8 Current resistance graph of chemical grout arranged in 6.6cm spacing

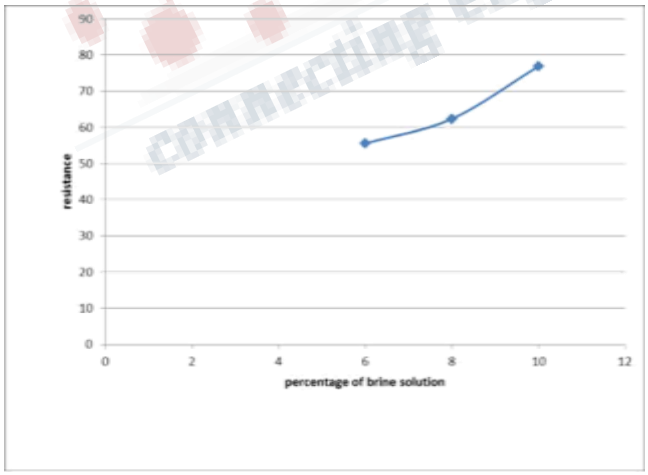

Fig 9. Variation of resistance with percentage of brine solution

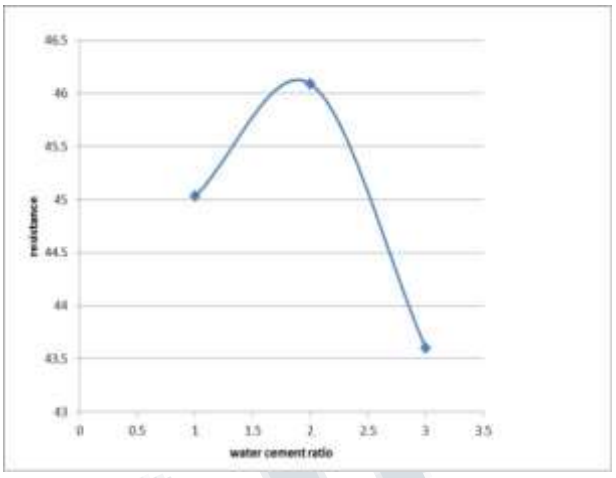

Fig 10. Variation of resistance with different water cement ratio

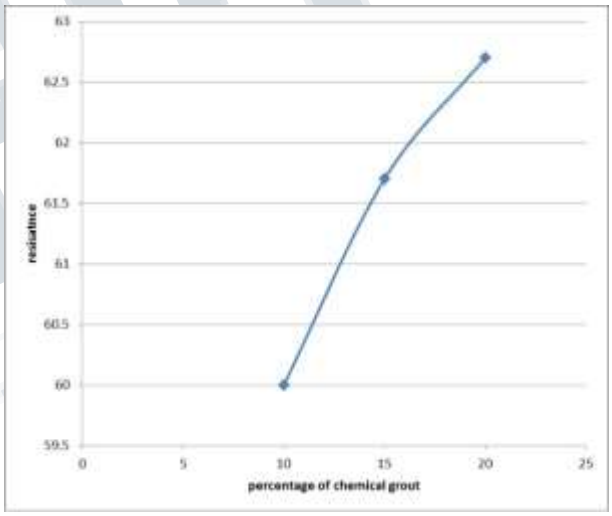

Fig 11. Variation of resistance with different percentage of chemical grout

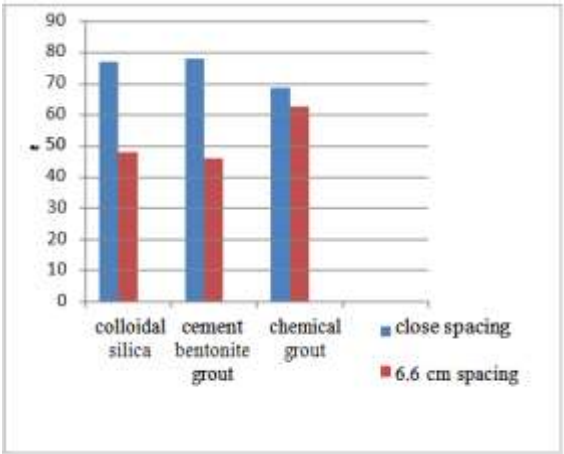

Fig 12. Comparison of grouts based on the resistance

V. CONCLUSION

- Maximum resistance offered while using the colloidal silica grout. Maximum resistance of soil is 76.87 ohm.
- Close spacing of grout curtain provide more resistance compared to 6.6cm spacing.
- Cement bentonite grout curtains provide less resistance compared to colloidal silica grout. Value of resistance is 73ohm.
- Chemical grout provide very less resistance to soil compared to both colloidal silica and cement bentonite grout.
- Grout curtains are more effective when they arranged in close spacing.

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