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LABORATORY STUDY ON PERMEABILITY OF THE GROUTED SAND

Balendra Mouli Marrapu[*1], Prasad Bollini[2] & R. Uma Mahendra Yadav[3]

[*1,2]Associate Professor, Department of Civil Engineering, CMR College of Engineering & Technology

[3]Assisstant Professor, Department of Civil Engineering, CMR College of Engineering & Technology

ABSTRACT

In the construction of dams, foundations of these dams often posing serious threat to the dam in the form of excessive seepage and leaching of upstream water. Seepage not only causes loss of valuable water stored in the reservoir, but also poses problems by its existence through piping in the foundation. Control of these seepage through the dam foundation and minimizing exit gradient on the downstream, plays a critical roles in the design of dams. This seepage problem can be minimized by grouting, which is one of the famous ground improvement technique in the field of civil engineering. Even though grouting has several other applications in the field of civil engineering, studies on grouts and grouting have been very limited. In this study permeability tests was conducted on ungrouted and grouted sand samples collected locally and identified the effect of cement as grouting materials on reduction in the permeability of medium sand. It was observed from the results that permeability of sand is reduced with higher percentages of cement as grout material as well as with curing period.

Keywords: *Soil Stabilization, Grouting, Sand.*

I. INTRODUCTION

Grouting is an ancient technique in the field of geotechnical engineering, this technique is applied in almost all the fields of geotechnical engineering such as advancing in tunnels, cut off walls and seepage control through rocks and soil under dams, etc. Grouting improves the strength characteristics of soils (Axelsson and Gustsfson, 2006). There are many researches worked on grouting technique in this field of geotechnical engineering, Ping et al., (2008) studied the effective compressive strength of grouted soils treated with cement, whereas Yoon and Farsakh (2009) carried out laboratory investigation on effect of grouting on voids in the sands using cement-based injection grouts. Akbulut and Saglamer (2002) studied that the groutability dependency of soil on the effective size of soil. Pandian et al. (1995) studied the permeability and compressibility behaviour of soils with bentonite as a grouting material. Other researchers who worked on cement as a grouting material for seepage control are Glory, et al. (2001); Ibragimov (2005); Akbulut and Saglamer (2002). Even though these many researcher worked on reduction of permeability using grouting technique there was no serious attempts are reported about the effective use of this technique to reduce the permeability of soil.

In this present study the permeability of locally available sand samples was determined using cement+ water as a grouting material. For the effective use of this grouting material different proportions of cement was prepare and mixed with sand and studied its influences by conducting laboratory tests. Finally optimum grouting material was determined. Following sections provides about grouting, the procedure for preparation of samples, results and discussions etc.

II. GROUTING

Grouting is a process of injection of pumpable materials into a soil formation to change its geotechnical characteristics. Where pump-able material is a mixture of water with cement or clay with high pressure. Grouting is a quite familiar technique in the field of geotechnical engineering, especially in the field of foundation engineering. The basic principal involved in grouting was, to fill the voids of the formation material by replacing it with the grout and thereby improving the geotechnical properties of the medium especially reducing the permeability. Grouting can be used for both sand and silt deposits.

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Grouts is a liquid suspensions or solutions that are injected into the soil mass to improve its behaviour. Such liquids can permeate into the void space of the soil and bind the soil particles together. For medium sands or coarser materials the grout used most often is a slurry of water and cement. However this slurry cannot enter into the void space of fine sand and silts for which chemical grouts are used. Grouts can be broadly classified as suspension grouts and solution grouts. Suspension grouts consist of small-size solid particles dispersed in a liquid medium. These include cement grouts, that is, slurry of cement in water; soil-cement grouts consisting of a slurry of soil and cement in water; and bentonite grouts comprising a slurry of bentonite in water.

2.1 Cement as grouting material

Cement is a commonly used grout material for soil stabilization, with this cement as a grout injected under high pressure has come into widespread use in construction. At present, the method of grouting is most commonly applied in a many number of branches like structural engineering, hydraulic engineering for construction of anti-seepage curtains, in mining for the opening of shafts, side drifts, and other workings and in foundation engineering for the reinforcement of existing foundations beneath buildings and structures as well for strengthening the soils in their beds. The primary merits of the method of grouting lie in its technical simplicity, convenience of use, and high reliability of the results achieved. Moreover, the method is sufficiently economic, and does not require complex equipment, and is also ecologically.

III. PROCEDURE

In order to determine the effect of cement in reducing the permeability of the sand medium, permeability tests were conducted on specimens prepared in the permeability mould. For preparing the samples, sand of unit weight 14 kN/m^3 was mixed with different percentages of cement in the dry condition. Then 10 % of water is added to the mixture, mixed thoroughly and filled in the mould for conducting the permeability test. In Figure 1 permeability mould was shown, which was used for the determination of permeability of soil.

Figure 1. Mould Used in the Permeability Test

After successfully conducting the permeability test, Figure 2 shows the effect of cement content on permeability of sandy soil treated with cement contentment with different curing periods of 7 days, 14 days and 28days. As one would expect, the permeability decreases with increase in the percentage of cement. The reduction in permeability is only marginal in case of specimens cured for 7 & 14 days, whereas the reduction is substantial as the curing period is increased to 28 days, this is due to cement attains full strength after 28 days. Similarly increased use of cement (beyond 10%) can influence the permeability at higher curing periods only. When cement alone was added to the medium sand, the cement hydrates and occupied the voids of sand thereby decreasing the inter-connectivity of soil voids by blocking the potential flow paths.

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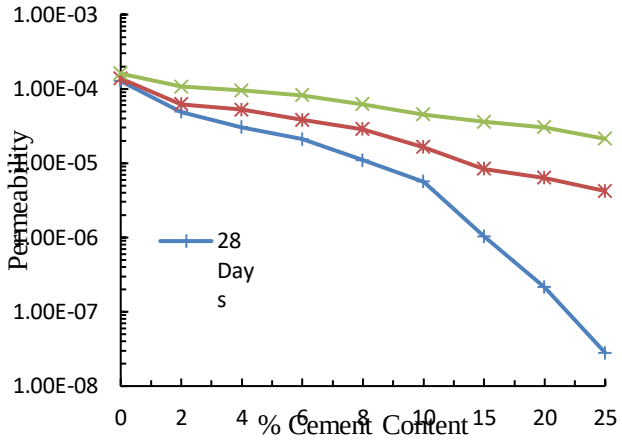

Figure 2. Effect of Cement Content on Permeability of Cement Treated With Sand

The permeability and strength of grouted sand is strongly influenced by the method of grouting because different mechanisms govern the deposition and packing of cement particles within the pores structure. During the injection process, preferential flow paths allow the migration of cement particles into the soil and micro structural packing undoubtedly varies within the pore spaces of the grouted sand (Schwarz and Krizek, 1994).

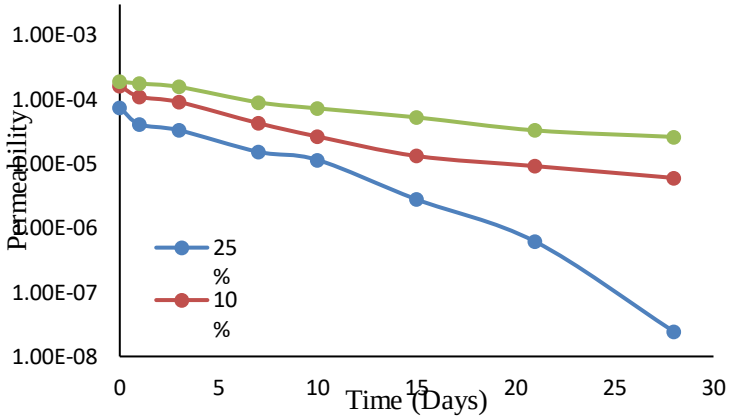

Figure 3. Effect of Curing Period on Permeability of Cement Treated Sand

Figure 3 shows the effect of curing period on permeability of cement treated sand having different cement contents 4%, 10% and 25 %. It can be also be seen that even though the permeability decreases with elapsed time, it becomes almost constant beyond 15 days of curing period for lower cement contents (i.e. 4 % and 10 %), but at higher contents (e.g. 25 %), the permeability goes on reducing drastically even after 15 days. Hence one can presume that reduction in permeability is directly related to the hydration of cement. The reduction in the permeability with reduction in the size of particles of the mixture (sand + cement) is quite clear from Figure 4 which is a plot between the effective size D_{10} of the sand - cement mixture and the corresponding permeability. Similarly, the addition of cement (process taking place in cement grouting) will cause a reduction in the void ratio and consequently the permeability. The plot between the void ratios 'e' and the coefficient of permeability 'k' (Figure 5) illustrates the reduction in permeability accompanied by the reduction in void ratio.

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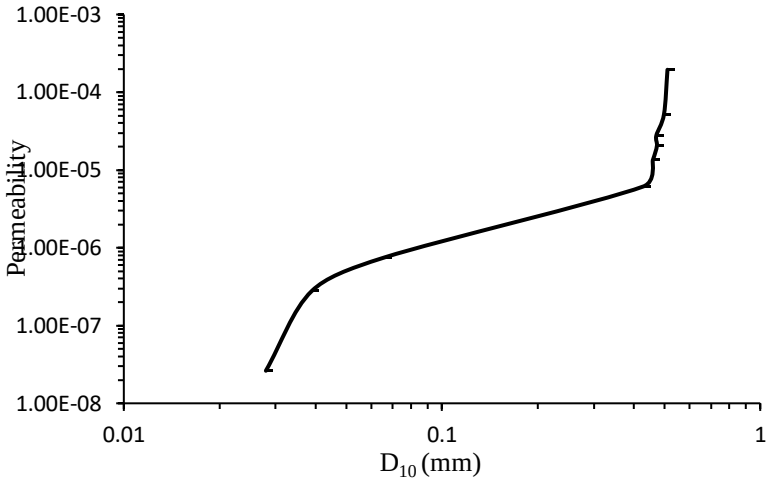

Figure 4. Effect of Permeability With Effective Size of Sand Particles

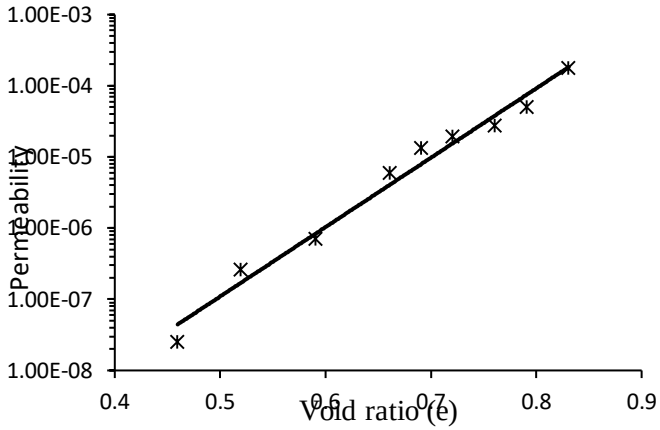

Figure 5. Effect of Permeability With Respect To Void Ratio

For grout injected specimens, decreasing the water to cement ratio of the grout and increasing the curing time significantly lowered the permeability and increased the strength, whereas increasing the distance from the injection point had little effect on the permeability but produced meaningful reductions in strength. These trends are consistent with the sand acting as a filter for the grout suspension (Schwarz and Krizek, 1994).

IV. CONCLUSION

The primary purpose of grouting in this study was to fill the voids of the soil formation material by replacing the existing voids with the grout and thereby improving the engineering properties of the medium especially reducing the permeability. In this study cement grouting was used, it was the most important and the most widely used method in the construction industries for reducing the mass permeability and increasing the strength of formations.Tests conducted on sand samples prepared with different grouting materials.

From this study following conclusions were observed. The permeability goes on reducing with increase in cement content. The effect of the curing period is to decrease the permeability of cement grouted sand. But at lower cement contents, the permeability remains more or less constant beyond a curing period of 14 days. The permeability got reduced in the case of sand grouted with 25% cement and cured for 28 days. Addition of small percentages of

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cement grout drastically reduces the permeability. Thus the present study undoubtedly proves the effectiveness of using grouting as an efficient technique in improving the foundation beds of loose sandy soils.

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