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A Study on the Effect of Permeation Grouting With Cement and Lime in Sandy Soil

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Abstract

Permeation grouting is an effective way to improve the engineering properties of the sandy soil. In this technique the grout is injected into the ground without disturbing the soil structure. In this investigation an attempt is made to study the comparison of permeation grouting with cement and lime grout. The cement grout and lime grout are injected into the soil specimen by changing weight of cement and lime which will be at 2%, 4%, 6%, 8%, & 10% by the soil weight. Grouting is conducted in a tank of size 30 x 30 x 30cm. The grouted samples are tested in triaxial test after 1, 7, & 14 days of curing period. The permeability test also conducted on the grouted samples. The test results revealed that the shear strength properties are improved for grouted soil, where as the permeability is reduced.

Keywords*: - Permeation grouting*, soil specimen, triaxial test

INTRODUCTION

Soil improvement is an important project in construction works, especially in those for buildings, bridges, and roads, etc. In practice, many methods are used to improve in-situ properties of deep soil layers, such as dynamic compaction, stone columns, jet grouting, compaction grouting, vibroflotation and wick-drains. However, these methods are generally expensive as they involve accumulation of huge machinery and equipment. The permeation grouting has wider application in small scale projects because of its low

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investment and ease of application. The presence of voids, soft ground, settlement and water inflow are just a few barrier encountered where grouting can be employed to check their effects during construction.

Permeation grouting method is by and large used to decrease ground deformation and control ground water flow, however it can be used to fortify and harden the ground (CIRIA, 2000). Suat Akbulut et al. (2002) observed that the particle size of soil and the maximum particle size of binder have fruitful effect on grouting. Pretreatment of soil with lime before use of cement or use of cement only is advisable while grouting with a mixture of lime and cement according to Purbi Sen. et al. (2011). Cost as. A. Anagnostopoulos, (2005) has found that the mixture of calcareous material with cement contributes significantly to the improvement of grouting in accordance with water cement ratio.

In order to decrease the permeability and to increase the stiffening quality of soil containing course to medium size particles, Dano et al., (2004) concluded that the low pressure permeation grouting is an effective technique.

The objective of this study is to determine the shear strength and permeability properties of lime and cement grouted sandy soil after 1, 7, and 14 days of curing period with different percentages of lime and cement.

MATERIALS AND METHODOLOGY

Materials

In this study the materials used are locally available soil sample, cement and lime. The soil was collected from Satilitecity, Rudhrabharathi Peta, Kadapa. The index and engineering properties of the collected soil were determined. The cement used for the study is 53 Grade Ordinary Portland cement. The basic properties of the cement used were determined as per Indian Standards.

METHODOLOGY

Permeation grouting of silty sand soil is done with cement grout and lime grout each separately in different tanks. The container is an acrylic tank of size 30 cm x 30 cm x 30 cm. The tank is made completely dry before filling the soil. One-third of the tank is filled with soil. Then the grout pipe is placed in the tank in such a manner to spread the grout uniformly over the entire tank. Four PVC Pipes of 20 mm diameter with perforations are used for the grouting process. The bottom of the

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PVC pipe is plugged so as to disperse the grout circumferentially and make the grouting more effective. The grout which is prepared with water: cement ratio of 2:1, is stirred well to get uniform grout solution.

The soil is filled in the tank without disturbing the four grout pipes as shown in Fig. 1. The cement grout is prepared in the mixing tank with continuous stirring. By controlling the valves, grout solution is poured into the four PVC pipes uniformly. The grout solution will flow through the soil particles by permeation. After permeating the grout solution into the silty sand soil, the grout pipes are removed from the tank slowly without disturbing the soil after 24 hours. The gap is replaced with soil. The same procedure is followed for the lime grout separately in different tanks. The study is carried out with different percentage of cement and lime with respect to weight of soil. The different percentages studied are 2, 4, 6, 8 and 10.

After one day of permeation the samples are collected from the tank using samplers (Fig. 2). The soil samples are removed from samplers and are placed in desiccators. After 1 day, 7 days and 14 days of curing the soil specimens are tested in triaxial shear test to determine the shear parameters. The permeability of lime and cement grouted silty sand soil is determined using constant head permeability test after 14 days of curing.



Fig 1 Tank setup for grouting

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Fig 2 Collection of samples from the tank

RESULTS AND DISCUSSIONS

The physical properties of silty sand soil collected from the study area are determined by means of laboratory tests conforming to I S code and are tabulated in Table 1.

Table No. 1: Physical Properties of soil

PROPERTIES	VALUES
Specific Gravity	2.37
Sand, %	64.7
Silt + Clay %	12.2 + 23.1
Liquid Limit, %	34
Plastic Limit, %	16
Plasticity Index, %	18
IS Classification of Soil	SC
Free Swell Index, %	10
Degree of expansion	LOW
Optimum Moisture Content, %	14.8
Maximum Dry Density (gm/cc)	1.77
Coefficient of Permeability (cm/sec)	$3.4X10^{-3}$
Shear parameters	Cohesion = 0.47 kg/cm^2 Angle of internal friction = 18˚ shear strength = 1.036 kg/cm^2

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After 1day, 7 days and 14 days of curing in desiccators, the soil samples are subjected to triaxial shear test to determine shear parameters. The results of lime grouted soil are shown in Table 2, 3 and 4.

Table 2 Shear parameters of lime grouted soil after 1 day curing

Shear parameters	**2% of lime**	**4% of lime**	**6% of lime**	**8% of lime**	**10% of lime**
Cohesion (kg/cm^2)	0.63	0.78	0.91	1.03	1.15
Angle of internal friction	16˚10’	13˚56’	12˚21’	10˚72’	9˚86’
Shear strength (kg/cm^2)	1.212	1.317	1.428	1.537	1.666

Table 3 Shear parameters of lime grouted soil after 7 days of curing

Shear parameters	**2% of lime**	**4% of lime**	**6% of lime**	**8% of lime**	**10% of lime**
Cohesion (kg/cm^2)	0.71	0.86	0.98	1.1	1.21
Angle of internal friction	15˚82’	13˚34’	11˚90’	10˚56’	9˚72’
Shear strength (kg/cm^2)	1.654	1.679	1.774	1.831	1.93

Table 4 Shear parameters of lime grouted soil after14 days of curing

Shear parameters	**2% of lime**	**4% of lime**	**6% of lime**	**8% of lime**	**10% of lime**
Cohesion (kg/cm^2)	0.79	0.94	1.05	1.18	1.27
Angle of internal friction	15˚56’	13˚12’	11˚69’	10˚23’	9˚58’
Shear strength (kg/cm^2)	1.98	1.968	2.03	2.045	2.126

It is observed that with increasing the percentage of lime, the shear strength of grouted soil is found to increase considerably.

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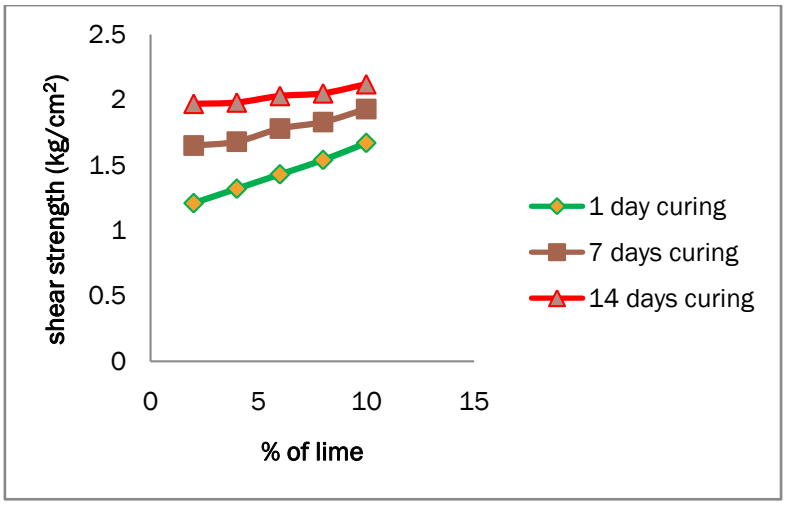


Fig 3: Variation of shear strength with % of lime for different curing period

The results of cement grouted soil after 1day, 7 days and 14 days of curing are shown in Table 5, 6 and 7.

Table 5 Shear parameters of cement grouted soil after 1 day curing

Shear parameters	**2% of cement**	**4% of cement**	**6% of cement**	**8% of cement**	**10% of cement**
Cohesion (kg/cm^2)	0.66	0.84	1.02	1.19	1.35
Angle of internal friction	15˚20’	12˚23’	11˚15’	9˚86’	8˚93’
Shear strength (kg/cm^2)	1.453	1.538	1.678	1.834	1.96

Table 6 Shear parameters of cement grouted soil after 7 days of curing

Shear parameters	**2% of cement**	**4% of cement**	**6% of cement**	**8% of cement**	**10% of cement**
Cohesion (kg/cm^2)	0.76	0.94	1.11	1.27	1.43
Angle of internal friction	14˚95’	11˚96’	10˚86’	9˚55’	8˚68’
Shear strength (kg/cm^2)	1.89	1.895	2.016	2.09	2.218

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Table 7 Shear parameters of cement grouted soil after 14 days of curing

Shear parameters	2% of cement	4% of cement	6% of cement	8% of cement	10% of cement
Cohesion (kg/cm^2)	0.8	1.04	1.16	1.35	1.5
Angle of internal friction	14˚62’	11˚58’	10˚45’	9˚23’	8˚35’
Shear strength (kg/cm^2)	2.15	2.17	2.205	2.294	2.393

The shear strength of cement grouted soil is found to increase considerably with increase in percentage of cement.

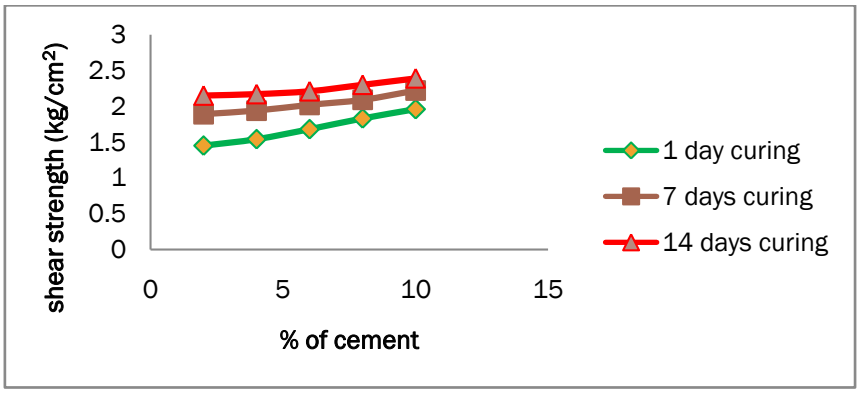


Fig 4: Variation of shear strength with % of cement for different curing period

After 1 day of curing in desiccators, the grouted soil samples are subjected constant head permeability test to determine the coefficient of permeability. The permeability values of lime and cement grouted soils are shown in Table 8 and 9.

Table 8 Coefficient of permeability of the Lime grouted soil samples

Sl. No.	% of Lime	Permeability (cm/sec)
1	2	2.5×10^{-3}
2	4	2.05×10^{-3}
3	6	1.64×10^{-3}
4	8	1.25×10^{-3}
5	10	0.93×10^{-3}

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Table 9 Coefficient of permeability of the Cement grouted soil samples

Sl. No.	% of Cement	Permeability (cm/sec)
1	2	2.4×10^{-3}
2	4	1.88×10^{-3}
3	6	1.45×10^{-3}
4	8	1.07×10^{-3}
5	10	0.76×10^{-3}

Considerable decrease in permeability values of lime and cement grouted soil samples are observed with increase in percentage of lime and cement in the grout. Fig. 3 and 4 shows the variation of coefficient of permeability of grouted soil at various percentages of lime and cement respectively.

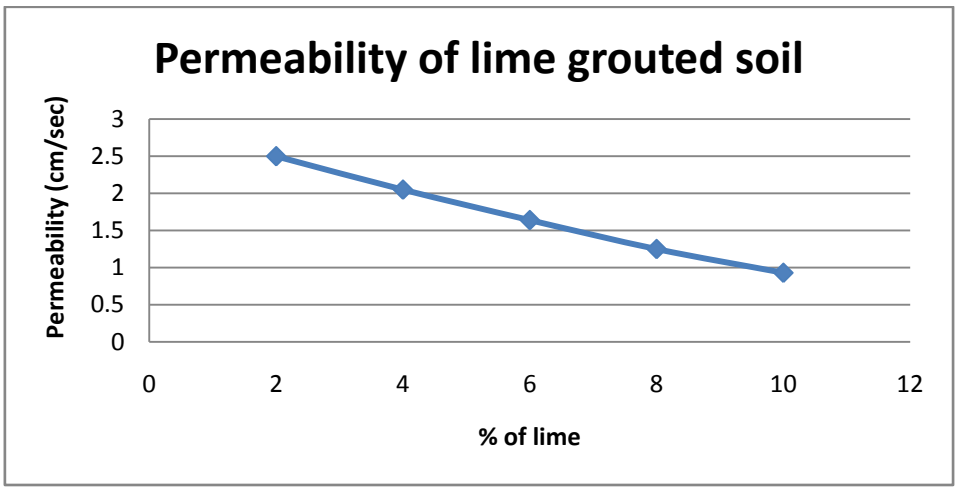


Figure: - 5 Variation of permeability with % of lime

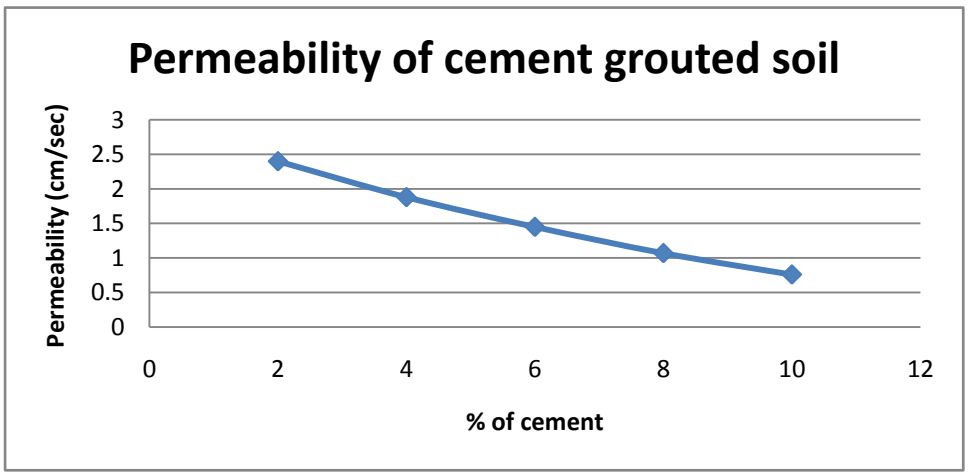


Figure: - 6 Variation of permeability with % of cement

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CONCLUSIONS

The present study examines the effect of lime and cement grout in the silty sand soil. Following conclusions are drawn from the experimental investigations.

- The shear strength of lime grouted soil sample is found to increase by 105%, where as that of cement grouted soil sample by 131% when compared to ungrouted soil sample.

- An increase of about 170% and 219% in cohesion of lime and cement grouted soils respectively was witnessed in comparison with soil not treated with grout.

- The angle of internal friction decreases for treated soil with lime and cement grout.

- The permeability of lime and cement grouted soil samples reduce by about 73% and 78% in comparison to untreated soil.

- At the outset, cement grout is more efficient than the lime grout.

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