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Footings resting on a trench of waste glass material

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ABSTRACT

One of the best methods used to improve the bearing capacity of a soil is by making a trench filled with granular material. The present study focused on the effect of providing waste glass as a replacement material in the trench. The result shows that glass is a good replacing material at an optimum configuration with the rectangular shaped trench.

Keywords— *Bearing capacity, CBR, Plate load test, Trench, Waste glass*

1. INTRODUCTION

In the fast developing world, the needs of people are increasing and the buildings are the most important necessity of every man. For every construction, the availability of land is a crucial factor. But with the technical and technological developments, the availability of land is decreasing day by day. Hence it is forced to construct the buildings on the available land which may or may not be strong. There are different ground improvement methods which can be done to improve the bearing capacity of weak soil and replacement technique is one among such method. But by considering the economic point of view, the replacement of entire weak soil is not possible. Hence a partial replacement method can be adopted and replacing material may be any soil having better engineering properties. Nowadays the replacement material used is river sand. But simply replacing the weak soil by river sand is not practical due to high costs and environmental restrictions in mining and reclamation.

From the studies conducted by Madhav et al (1978), it has been found that granular trench significantly reinforces the clay deposits. Studies done by Unnikrishnan et al (2010) showed that granular trenches below strip footings on loose sand deposits improved the load carrying capacity. Further studies by Unnikrishnan (2015) showed the additional improvement in bearing capacity by encapsulating the granular trench with a suitable geosynthetic and effect of trenches under repeated loading. Investigations by Mohammed.Y.Fattah (2015) proved that reclaimed asphalt material is a good replacement material in increasing the bearing capacity. Nael.K.Dalaly (2016) studied the effect of providing geogrid micromesh in the granular trenches for improving bearing capacity of soft soil and found the random arrangement of reinforcement provides better strength. Ujjwal Mishra (2017) conducted studies on the enhancement of subgrade strength using glass fibres and the found that an optimum amount of glass lies between 5 to 10%.

The objectives of the present study are to make use of waste glass as a replacement material underneath a footing resting on soft clay with jute as the encapsulation material. For the efficient use of replacement material, an optimum trench configuration and shape have to be determined.

2. MATERIALS USED

2.1 Soft soil

Experiments were carried out on a red coloured soft soil which is collected from English India Clay Limited (EICL), Thonnakkal in Trivandrum district, Kerala. It is a clayey soil having a liquid limit 42.5%.

Table 1: Properties of soft soil

Properties	Values
Specific Gravity	2.52
Liquid limit (%)	42.5
Plastic limit (%)	30
Plasticity Index (%)	12.5
Clay content (%)	56
Silt content (%)	26
Optimum moisture content (%)	17
Maximum dry density (g/cc)	1.76
Unconfined compressive strength (kN/m^2)	30

2.2 Waste glass

Waste glass becomes the most crucial material which changes the landscape of the ecosystem and causes damage to the environment. Efficient utilization of this waste glass as an alternative to sand were analyzed by choosing the particle of glass passing through 2.36mm and retaining on the 600µ sieve. Properties of glass are given in table 2.

Table 2: Properties of glass

Properties	Values
Particle size	Passing 2.36 mm
Specific Gravity	2.53
Maximum dry density (kN/m^3)	17.25
Minimum dry density (kN/m^3)	15.12
Cohesion (c) (kg/cm^2)	0.05
The angle of internal friction (ϕ)	45º

2.3 Geotextile

Jute is a type of geotextile used to encapsulate the granular trench in the present study. The properties of this geotextile are given in table 3.

Table 3: Properties of geotextile

Properties	Values
Material	jute
Mass per unit area (g/m^2)	448
Thickness (mm)	2.67
Aperture size (mm)	0.131
Ultimate tensile strength (kN/m)	10.6

3. METHODOLOGY

Two types of trenches, triangular and rectangular were tested with Plate load test to obtain the effective shape of the trench. CBR tests were conducted in the lab with and without granular trenches and load- settlement graph were plotted. An optimum trench dimension was obtained from the test results and plate load test conducted at optimum trench configuration with and without encapsulation using glass as a replacing material.

4. EXPERIMENTAL SETUP

Laboratory studies were conducted on a tank of dimension 80 x 80 x 80cm and a model strip footing made of mild steel of 80cm length and 8cm width. Loading system consisted of a hand operated hydraulic jack and a proving ring. Two dial gauges of 0.01mm least count were used to record the settlement and in order to record the load applied, proving ring of 50kN capacity is used.CBR test was conducted by making a trench of required dimension in the CBR mould and filling it with granular material. Thus optimum dimension has to be determined.

5. RESULTS and DISCUSSIONS

5.1 Effect of shape of trench

Figure 1 shows that rectangular trenches are more efficient than triangular one for reducing settlements. Bearing Capacity Ratio (BCR) calculated for both shapes are:

- BCR for triangular trench = 1.54
- BCR for rectangular trench = 1.92

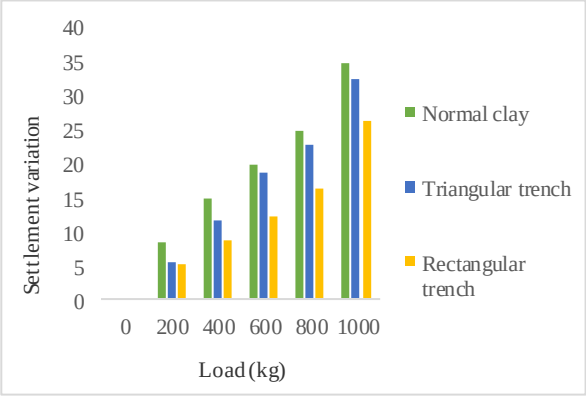

Fig. 1: Settlement variation with load

5.2 Effect of optimum trench configuration

Effect of depth and width obtained from test results shows that optimum trench depth was 1.5 times the footing width and optimum trench width was 1.6 times the footing width. The effect of depth was studied by keeping width constant and vice versa to study the effect of width.

5.3 Rectangular trench at optimum configuration: Optimum trench configuration obtained from the CBR test results were used for finding the effect of the rectangular trench in different conditions by plate load test. The optimum trench configuration obtained as 12.8cm width and 12cm depth. That is optimum width is 1.6 times the footing width, while optimum depth is 1.5 times the footing width. Figure 2 shows the results obtained from the plate load test.

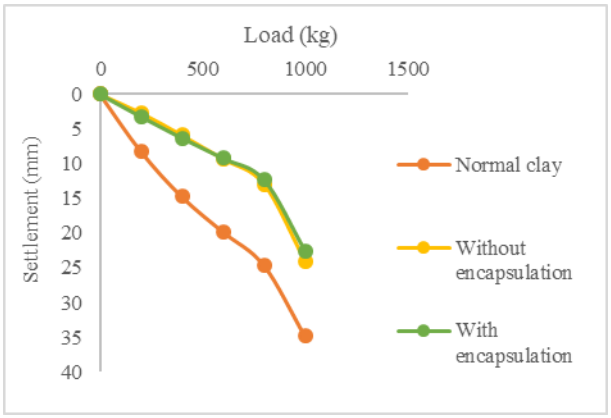

Fig. 2: Rectangular trench with glass

5.4 Effect of encapsulation

Encapsulated granular trenches show an additional improvement in bearing capacity and settlement reduction. Figure 3 shows that, for a given load. Rectangular trench without encapsulation reduces settlement to 31% while that with encapsulation, it is 35%. That is the effect of encapsulation has marginal influence in settlement reduction.

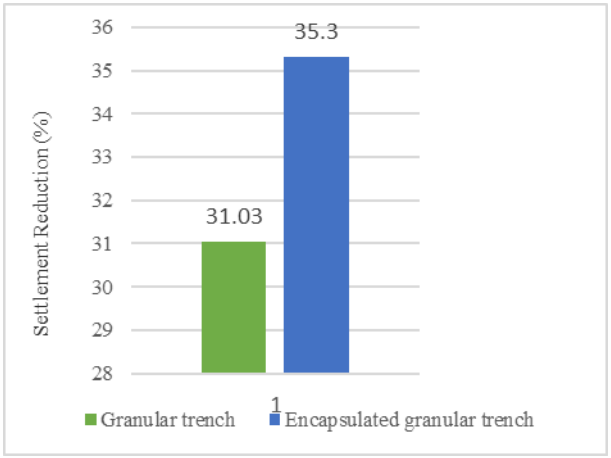

Fig. 3: Effect of encapsulation in settlement reduction

6. CONCLUSION

This project mainly aimed at exploring the effect of footing on granular trenches. The following conclusions were drawn based on the discussions of the results.

- Footing on granular trenches showed an improvement in the load carrying capacity and a reduction in a settlement.
- Considering the settlement reduction, the rectangular shaped trench is more efficient than triangular trenches.
- The result clearly shows that, a the width of the trench increases, load carrying capacity increases up to an optimum of 1.6 times the footing width and then decreases.
- Load carrying capacity increases with an increase in depth up to 1.5 times footing width and then rate of increase gradually reduces.
- Glass has an efficiency of 36% in reducing settlement and a 64% increase in bearing capacity.

- Encapsulation by a suitable geosynthetic material (jute) gives an additional improvement in the settlement reduction. But this reduction was marginal compared with that of trenches without encapsulation.
- Thus, strip footing over encapsulated trenches is an efficient method of improving the bearing capacity ratio and reducing the settlement.

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