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Strength Improvement of Soil by Encased Trench of different Replacement Materials

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Abstract:
One of the main problems that a developing country such as India faces is urban displacement. This leads to insufficient resources to meet the rising demands for accommodation. Soft and very soft clay deposits are considered among the most challenging soil formations to build on, because they possess high compressibility and low shear strength properties. One of the best methods which can be done to improve the bearing capacity of a soil is by making a trench filled with granular material. The present study focuses on the effect of providing different replacement materials in the trench encapsulated with geotextile on settlement reduction. The present study focuses on the effect of providing demolition waste materials (DWM) and mixture of sand and copper slag granules (CSG) as replacement materials in the trench encapsulated with jute and Non-woven geotextile. Footing over the encapsulated trench of demolition waste materials, mixture of sand and copper slag granules showed an improvement in the load carrying capacity and the reduction in the settlement. For trench of demolition waste materials settlement reduced by 45% using encapsulated trench than without using trench. For trench of mixture of sand and copper slag granules Settlement reduced by 38.5% using encapsulated trench than without using trench.

Keywords - ***plate load test, encapsulated trench, demolition waste, copper slag granules***

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I. INTRODUCTION

Rapid growth of urban infrastructure has resulted large scale construction over soft and weak soils. Buildings are the most important necessity of every man. Hence it is forced to construct the buildings on available land which may or may not be strong. The congestion in urban areas has led to increase in all types of developing activities. Due to which availability of good construction sites has started to decline. Soft and very soft clay deposits are considered among the most challenging soil formations to build on, because they possess high compressibility and low shear strength properties. A variety of ground improvement techniques have been developed over the past decades to improve the load-settlement behaviour of soft ground. One of the best methods which can be done to improve the bearing capacity of a soil is replacement technique. Remove and replacing is widely used in construction practices and engineers have proved that it can be an effective method. Several researchers have considered the mechanism of remove and replacement method in the past. The behaviour of foundations on different types of soil remains a challenging task for the geotechnical engineer.

This paper presents a method for estimating the bearing capacity of a square footing on weak soil by encapsulated granular trench of demolition waste materials and mixture of sand and copper slag granules as replacement materials with jute and Non-woven geotextile as the encapsulation material.

II. OBJECTIVE

The objectives of the study are:

- To determine settlement of footing placed on soil with and without trench.
- To determine effect of change in diameter and depth of trench on settlement of footing.
- To determine the effect of optimum trench configuration on settlement of footing.
- To compare & study on settlement and bearing capacity of footing with optimum trench dimensions for both replacement materials

III. MATERIALS AND METHODOLOGY

The materials used for this study are soil, crushed demolition waste material, sand, copper slag granules, geotextile, model square footing and model tank for the test. The locally available soil, sand and demolition waste materials were collected. The geotextile, copper slag granules and square footing were purchased. A model tank is constructed in the laboratory.

A. Materials

The various materials required for the study are listed below:

***1) Clayey Soil*:** The experiments are carried out on soil collected from Punchakkari, Thiruvallom, Thiruvananthapuram, Kerala. The engineering properties of the soil were determined.

Fig. 1 Collected Soil

TABLE I
PROPERTIES OF SOIL

Property	Result
Specific gravity, G	2.05
Liquid limit, W_L	75%
Plastic limit, W_P	38.50%
Plasticity index, I_P	36.5
Percentage of clay	31.2%
Percentage of silt	37.8%
Optimum moisture content (OMC)	25%
Maximum dry density (MDD)	1.35g/cc
Unconfined compressive strength, q_u	0.22kg/cm^2
Soil classification	MH

2) Demolition Waste Materials: Construction and demolition waste is a major environmental concern in most of the Indian municipalities. It is generated during the construction, renovation and demolition of buildings, roads, bridges etc. Demolition waste materials are collected from nearby construction site and it is crushed and used replacement material in the study.

Fig. 2 Crushed demolition waste

TABLE 2
PROPERTIES OF DEMOLITION WASTE MATERIALS

Property	Results
Specific gravity, G	2.19
Particle size distribution	Coarse sand (2.36 - 4.75mm)

3) Sand: Locally available poorly graded sandy soil is used for the study.

Fig. 3 Sand

4) Copper Slag Granules: Copper slag is an abrasive blasting grit made of granulated slag from metal smelting process and refining of copper. It's dumping or disposal in huge quantities is regarded as environmental pollution. Due to the good performance of copper slag in different aspects, its use in production of concrete has significant considerations prevalent earlier. Copper slag can be used as replacement of natural aggregates. Copper slag granules purchased from Blastline India Pvt. Ltd., Eranakulam is used in the study.

Fig.4 Copper slag granules

5) Mixture ***of Sand and CSG:*** A mixture of 70% of sand and 30% of copper slag granules is used as replacement material in the study.

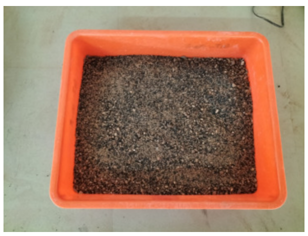

Fig. 5 Mixture of Sand & CSG

TABLE 3
PROPERTIES OF MIXTURE OF SAND & CSG

Property	Results		
	Sand	CSG	Sand+CSG
Specific gravity,G	2.66	3.43	2.82
Percentage of sand	98.8%	100%	98%
Percentage of gravel	0.9%	0%	0.8%
Percentage of silt and clay	0.3%	0%	1.2%
Cu	2.90	1.79	4.63
Cc	0.84	0.95	1.31
Water content	3.58%	—	—
Cohesion, C	0.02Kg/cm^2	0.02Kg/cm^2	0.02Kg/cm^2
Angle of internal friction, φ	26^0	32^0	28^0
Relative density, Dr	12.36%	5.28%	11.53%

6) ***Geotextile:*** Non-woven geotextile and jute geotextile were used as encapsulation materials in the present study.

Fig. 6 Jute geotextile

Fig. 7 Non-woven geotextile

7) ***Model square footing:*** A mild steel square plate of dimension 120 x 120 x 10 mm was used as footing in the study.

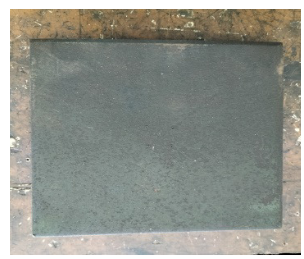

Fig.8 Model square footing

B. Methodology

Laboratory studies were conducted on a steel tank of dimension 600 x 600 x 300mm and a mild steel model square footing of 120 x120 x10mm size were used. The soil is being mixed with water at OMC thoroughly and it is then filled in the steel tank. It is being filled in layers where it is being compacted and levelled. Circular trench were made, then it is encapsulated using geotextile. Replacement materials were filled in the encapsulated trench and footing is placed over it, plate load test were conducted to obtain the bearing capacity and settlement.

C. Experimental Setup

The plate load tests were conducted on 60mm (Set 1), 80mm (Set 2) and 100mm (Set 3) diameter trench with depths 160mm, 180mm and 200mm for each set. For first phase a circular trench were made and encapsulated using jute geotextile. Then it is filled with DWM and footing placed over it, plate load tests were conducted for each set. For second phase non-woven geotextile is used as encapsulation material and mixture of sand and CSG were used as replacement materials. The loads are applied using hand operated – mechanical jack of capacity 50 kN. The applied loads are measured using proving rings of capacities 50 kN. The settlements are measured using two dial gauges each of 0.01mm least count. The load is applied in equal increments to the model footings & settlements are recorded simultaneously from both the dial gauges.

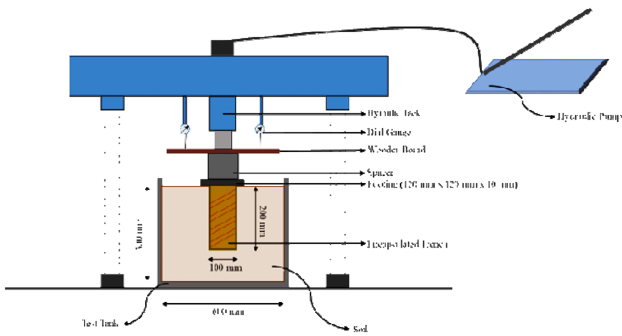

Fig.9 Schematic diagram of loading setup

IV. RESULTS AND DISCUSSION

A. *Test on Square Footing without trench*

After the soil gets filled in the tank square footing were placed over the soil and plate load test were conducted. The settlements were noted and the load-settlement curves were evaluated.

For the determination of bearing capacity by plate load test for clayey soil as per IS 1888: 1982 is given by,

$$S_f = S_p * (B/B_p)$$

Where, S_f – Settlement of foundation

S_p – Settlement of plate

B – Width of tank

B_p – Width of plate

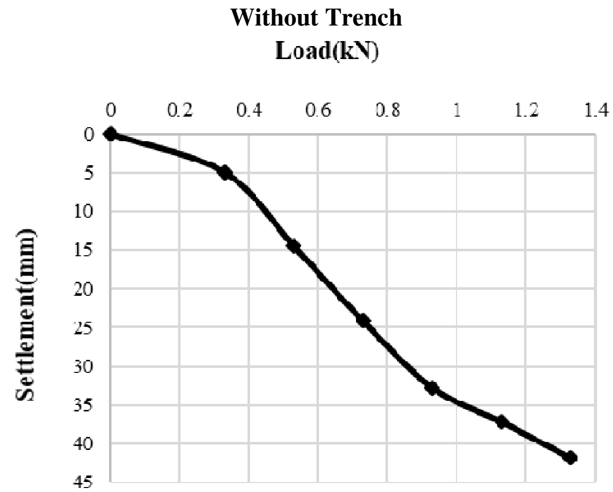

Fig. 10 Load-Settlement graph for footing without trench

B. *Effect of change in depth and diameter of trench*

1) ***Trench of DWM:*** For trench of DWM, the settlement varies with change in depth and diameter of trench. The figure shows that the settlement decreases with increase in diameter and depth of trench. The optimum trench dimension obtained for trench of DWM is of diameter 100mm and depth 200mm.

Effect of change in depth & diameter of trench of DWM

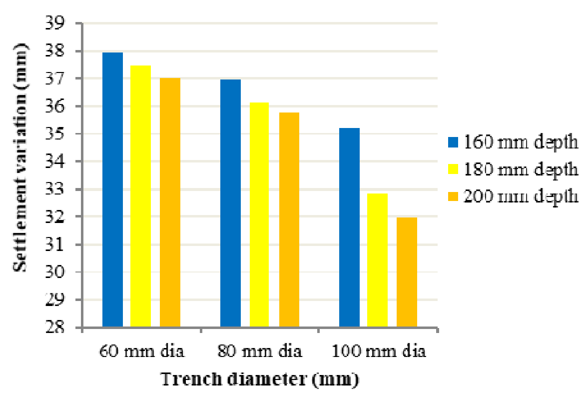

Fig. 11 Settlement variation with change in depth & diameter of trench of DWM.

2) ***Trench of mixture of sand & CSG:*** For trench of mixture of sand & CSG, the settlement varies with change in depth and diameter of trench. The figure shows that the settlement variation with change in diameter and depth of trench. The optimum trench dimension obtained is of diameter 100 mm and depth 180 mm.

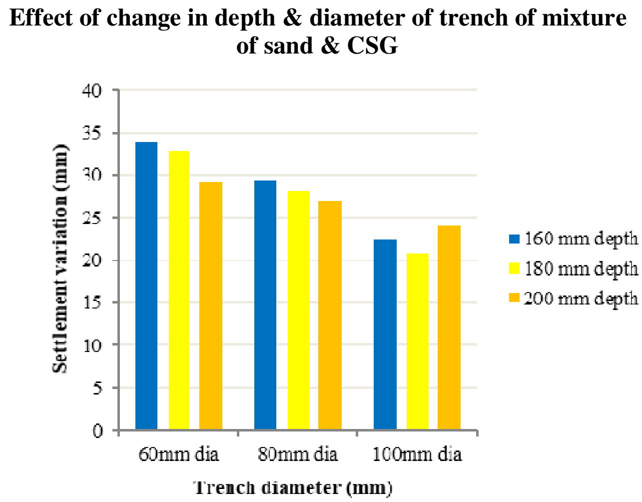

Fig. 12 Settlement variation with change in depth & diameter of trench of mixture of sand & CSG

C. Effect of Optimum trench dimensions

1) ***Trench of DWM:*** The figure shows comparison of settlement in square footing on optimum trench dimension i.e., trench of 100 mm diameter and 200 mm depth with the settlement shown for square footing without trench. It is clearly evident that the footing without trench shows highest settlement and optimum trench dimension has the minimum settlement.

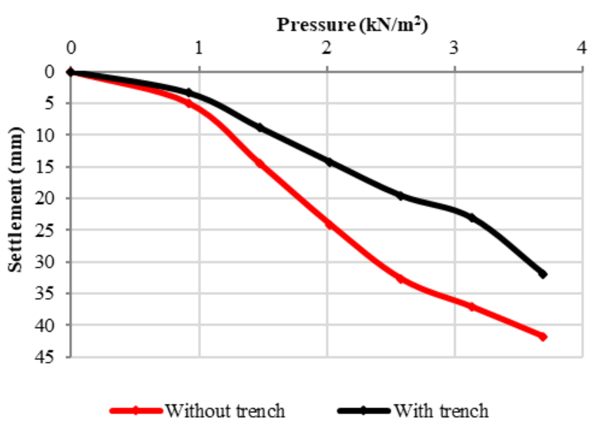

Fig. 13 Variation of Pressure- Settlement on without trench v/s optimum trench dimension (Trench of DWM)

2) ***Trench of mixture of sand & CSG:*** The figure shows comparison of settlement in square footing on optimum trench dimension i.e., trench of 100 mm diameter and 180 mm depth with the settlement shown for square footing without trench. It is clearly evident that the footing without trench shows highest settlement and optimum trench dimension has the minimum settlement.

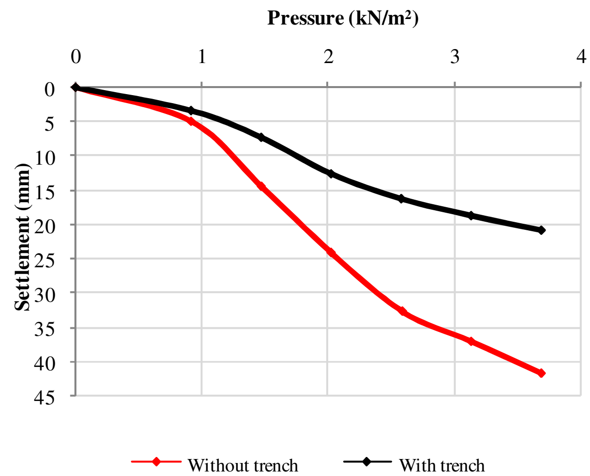

Fig. 14 Variation of Pressure- Settlement on without trench v/s optimum trench dimension (Trench of mixture of sand & CSG)

D. Comparison Study

After conducting tests on both replacement materials, a comparison study was done for both without trench and with optimum trench dimensions obtained. A comparison of final settlement and bearing capacity on both replacement materials were studied.

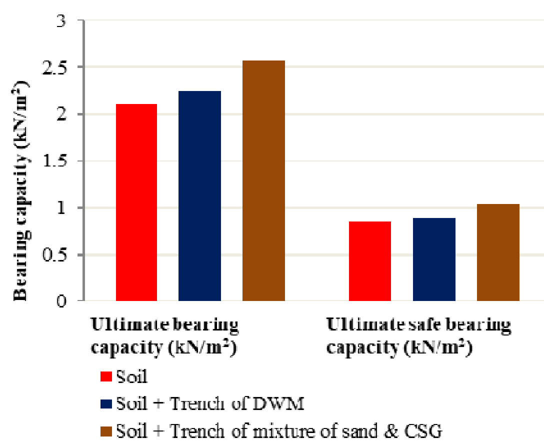

Fig. 15 Comparison of bearing capacity

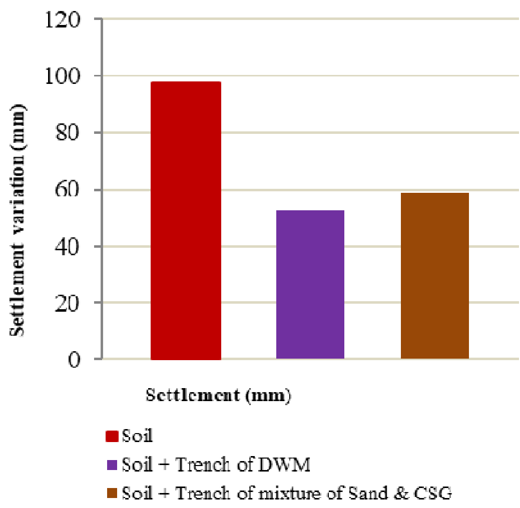

Fig. 16 Comparison of settlement

V. CONCLUSIONS

The following conclusions were drawn based on the discussions of the results:

- Footing over the encapsulated trench of demolition waste materials, mixture of sand and copper slag granules showed an improvement in the load carrying capacity and the reduction in the settlement.
- Optimum trench dimension obtained for demolition waste materials of diameter 100mm and depth 200mm and for mixture of sand and copper slag granules of diameter 100mm and depth 180mm.
- For trench of demolition waste materials Settlement reduced by 45% using encapsulated trench than without using trench.
- For trench of mixture of sand and copper slag granules Settlement reduced by 38.5% using encapsulated trench than without using trench.

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