IMPROVEMENT OF WEAK SOIL BY HORIZONTALLY REINFORCED CUPOLA SLAG GRANULAR PILE

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Abstract : Steel/Iron Industries produces about 11 million tons of slag yearly. This huge amount of waste production puts lot of burden on industrialists as dumping of this waste requires landfills, which are decreasing day by day, also with rapid industrialization and increasing population around the globe causing reduction in good quality land. For the soils with low shear strength, geotechnical engineers facing great problem for construction on weak soils. Few foundation systems are available to support structures on weak soils. For the structures with flexible foundation who can afford good settlement, granular pile is one of effective way of ground improvement. The present study involves use of waste cupola slag as granular pile material. It has been seen in current study involves testing program on 40 mm granular pile both unreinforced and horizontally reinforced with different reinforcement spacing, in weak soils. It has been founded that load bearing capacity of weak soil is increased up to 1.7 to 1.95 times by using unreinforced granular pile and can be increase up to 3.36 times by using horizontally reinforced granular pile.

IndexTerms **- Granular Columns, Slag Aggregates, Horizontal Reinforcement.**

I. INTRODUCTION

In current world, prime focus is on effective utilization of waste materials in effective way. Use of slag in various purposes has been started day by day. About 11 million ton slag is produced in India annually. Dumping problem of such huge waste creates lot of problem. One possible use of slag is as aggregates in various applications. Use of slag as aggregates in various engineering applications has been reported by Indian mineral book 2017.the present study will involves use of cupola slag. Cupola slag is produced from cupola furnaceoperations. The cupola furnace is used to melt waste steel, iron metal and molten metal is used for casting other metal equipment's according to need. During this operation impurities are collected in the form of slag and is collected in separate bins. This produced slag creates problem for manufacturer as dumping will cost will also include in his expenditure and also pollution in nearbyarea. The current study will involve utilization of slag aggregates as granular fill in granular pile. Granular pile are used to increase bearing capacity of weak soils.as stiffness of granular pile is more than surrounding soil larger amount of stresses is taken by granular pile and makes treated soil capable to load of structures with flexible foundations.

II. LITERATURE REVIEW

Large amount of text is available on encased granular pile however only few texts are available for horizontally reinforced granular column.Parsaad S.S.G. and Satyanaryana P.V.V. 2016 uses geogrid discs to reinforced granular pile in soft soil. They founded by placing discs at "D" spacing, increase 16% increment in load carrying capacity of granular pile and 41% increment at "D/2" spacing. Ghazavi.M. et al. 2018 uses different modulus of elasticity of geotextiles and geogrids to reinforce granular pile laterally. They have founded that with increase in modulus of elasticity, effectiveness of reinforcement increases significantly .also best spacing founded that 0.25D for lateral reinforcement. Lateral reinforcement at 0.25 D spacing shows 30% increment then encased granular column. Hasan M and Samadhiya N.K.2016 uses combined vertical and horizontal reinforcement form in granular pile. They founded that combined reinforcement 440% increment in load carrying capacity of treated soil. Ali.K.et. al. 2014 show that geogrid is better geotextile for reinforcement in granular pile. An increase of 2 times in bearing capacity has been noted by treating soft soil with ordinary granular column and 2.5-3 times by improving with laterally reinforced granular pile.it has also been founded that reinforcing column up to bulging zone are more effective then fully reinforce granular pile. Floating column has little increase in bearing capacity of granular column. Ambily A.P. et. al. 2007 shows in their work that load carrying capacity of granular column not only depends upon diameter of granular pile as well as in angle of internal friction of granular fill. With increase in angle of internal friction of granular fill, the mobilization in stresses also increases. Tandel Y.K. et al 2012 shows in their work reinforced granular pile of smaller diameter pile are more capable then larger diameter ordinary granular column.it has also be founded that spacing of granular column also puts effect on load carrying capacity of soil. With decrease in spacing over stressing of soil can be takes place but with increase in spacing group action of granular pile will be eliminated. So optimum spacing based on trial method must be taken.

III. EXPERIMENTAL INVESTIGATION

3 series of testing program was done. First test involves on virgin clay bed. Second test done on clay bed treated with ordinary granular column, third test involves clay bed treated with laterally reinforced granular pile with horizontal reinforcement at "D" spacing, fourth test involves clay bed treated with laterally reinforced granular pile with horizontal reinforcement at "D/2" spacing.

3.1 MATERAILS

Clayey soil was collected from pamal village, dist Ludhiana. The properties of clay are:-

Table 1properties of clayey soil

Specific gravity	2.53
Max dry density	17.56kN/m^3
Optimum moisture content	16 %
Liquid limit	42 %
Plastic limit	25 %
Plastic index	17 %
Classification as per IS	CI

Cupola slag was collected from Shree Krishna works, Industrial area, Ludhiana. The particle size used in current was 2-10mm.

Table 2 Properties of slag aggregates

Specific gravity	2.81
Max dry unit weight	16.5 kN/m^3
Mini dry unit weight	15.2 kN/m^3

The test tank in current study used was cylindrical, with inside clear diameter of 320mm and depth of 390 m. all granular column constructed were end bearing, area ratio of 25% and L/D ratio of 4.5.

Fig. 1: Model test arrangement

3.2 Preparation of Clayey Bed

Dried and pulverised soil was used in current study. The soil was initially passed through is sieve no.4 to remove any lumps present. A relation between undrained shear strength and water content was determined by unconfined compressive strength tests. It was founded that 25% of water content produces a shear strength of 12 kPa.

A required amount of water is mixed in soil and soil is compacted in layers in test tank with accordance IS 2720 light compaction. Before compacting soil lubrication is applied to tank inside boundaries to remove friction between soil and boundaries. The compacted soil tank was covered with plastic sheet was placed aside and left fir 24 hours for moisture equalization.

3.3 Preparation of Granular Pile

After preparing clayey bed, a PVC pipe of outer diameter equal to inner diameter of granular pipe was pushed in clayey bed with surface lubricated. The soil inside pipe was excavated out and granular material was filled and compacted with steel rod of 800mm and 12 mm diameter. Required no. of blows are done to compact aggregates at max dry unit weight. During aggregates compaction pipe was slowly lifted up and clearance of 10mm is maintained with soil and aggregates. After granular pile was completed the treated soil was left for 24 hours.

3.4 Preparation of Horizontal Reinforced Granular Pile

During granular pile construction, reinforcement discs were placed at intervals of required spacing i.e. D spacing and D/2 spacing. To do so required volume of aggregates with accordance D or D/2 spacing as depth and diameter of pile. After that reinforcement was placed and 2^{nd} layer of aggregates was placed and compacted. Similar all layers were placed and treated soil was left for 24 hours for water content equalization and tank was covered with plastic cover.

Fig. 2: horizontally reinforced granular column

3.5 Testing

After 24 hours model testing was done by using footing double the diameter of granular pile i.e. in current case diameter of footing was 80mm and thickness was 12 mm. The model footing was made of mild steel.

IV. RESULTS AND DISCUSSIONS

4 tests were done on model arrangement. First on untreated soil. Second on soil treated with ordinary granular column.third test was done on soil treated with laterally reinforced granular pile at "D" spacing of reinforcement and fourth test was done laterally reinforced granular pile at "D/2" spacing.

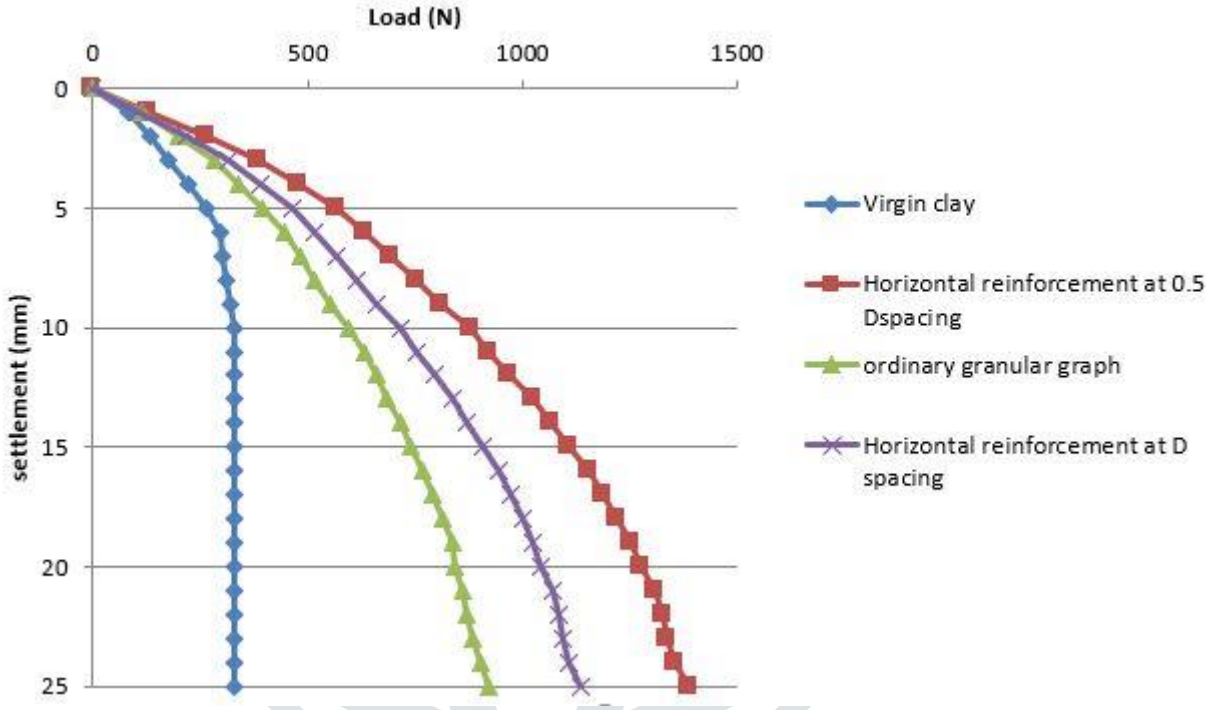

Fig. 3: load versus settlement variation of 40 mm granular pile

Table 3 Tabular result

Ultimate bearing capacity of virgin soil	Ultimate bearing capacity of soil treated with ordinary granular pile	Ultimate bearing capacity of soil treated with granular pile with lateral reinforcement with'D' spacing	Ultimate bearing capacity of soil treated with granular pile with lateral reinforcement at 'D/2' spacing
65.55 kN/m^2	183.02 kN/m^2	225.60 kN/m^2	275.73 kN/m^2

The bearing capacity is calculated at 25 mm settlement of each case and was represented in tabular form above.

It has been founded by observing the graph that virgin soil fails in punching failure. Whereas soil treated with granular pile either ordinary and laterally reinforced, fails by local shear failure. The increment in bearing capacity of soil treated with granular column may be due to high stiffness of granular pile then surrounding soil. Thus, large amount of load is taken by granular pile.

In case of laterally reinforced granular column, due mobilization of frictional stress on surface of reinforcement sheet and granular fill, the load carrying capacity of granular column increased, also with increase of no. layers of reinforcement in granular column, more frictional stresses will increase and capability of granular column has been increased.

V. CONCLUSIONS

The bearing capacity of granular pile has been increased with introduction of lateral reinforcement.

The following conclusions are made: -

a) The bearing capacity of treated ground with ordinary granular column increased up to 2.79 times then virginclayey bed.

b) The bearing capacity of treatedground with horizontally reinforced granular pile with reinforcement at 'D' spacing has been increased up to3.44 times then virgin clayey bed and 1.23 times ordinary granular column.
c) The bearing capacity of treated soil with horizontally reinforced granular column with reinforcement at D/2 spacing has been increased up to 4.2 times then virgin clayey bed,1.50 times ordinary granular pile and 1.22 times then granular pile with lateral reinforcement at' D' spacing.
d) Increases in bearing capacity due to horizontal reinforcement is may be due to mobilization of frictional stresses between reinforcement material and granular fill. More no. of layers will increase more frictional stress thus preventing bulging failure of granular column.

VI. REFERENCES

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