EFFECT OF LENGTH OF POLYPROPYLENE FIBER REINFORCED SAND ON LOAD SETTLEMENT CHARACTERISTIC OF MODEL FOOTINGS

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Abstract

Reinforced earth uses frictional soil reinforced with various forms of reinforcement in the form of bars mats, fibers etc. 'Ply soil' which is formed introducing randomly distributed fibers which results in comparatively more homogeneous soil mixture is one of the popular method of soil stabilization. In situations such as foundations on soft compressible stratum, deep foundation is generally recommended which increases cost of the structure. In the present study, direct shear test was conducted with various polypropylene fiber percentages in dry sand to determine the optimum percentage of fiber that gives large value of shear parameters. Loose soil deposit was simulated by compacting saw dust in prefabricated steel tank. Sand reinforced with optimum percentage of polypropylene fibers has been compacted at a relative density of 70%, over loose sawdust and bearing capacity of reinforced sand has determined at various H/B ratios and for different sized model footings, by conducting load settlement tests. A comparative study on the effect of length of the polypropylene fiber on the behavior of model footing has been studied.. The trend in results indicated that the BCR values obtained for H/B = 0.5 is maximum which decreases with increase in H/B ratio. Provision of reinforced sand layer of higher H/B ratio reduces in settlement significantly.

Keywords: *Ply Soil, Model Footing, Polypropylene Fiber.*

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1. INTRODUCTION

According to its original usage, the term "Reinforced soil" referes to a soil that is strengthened by a material able to resist tensile stress with in the soil through friction and/ or adhesion. Subsequently, the meaning of soil reinforcement was broadned, and this term is now also used for other mechanical and structural methods of soil improvement, such as compressive reinforcement and reinforcement by confinement and encapsulation.

The principle of reinforced earth may also be used to improve the bearing capacity of soils overlying weaker cohesive soils. The reinforced earth technique has also been used in increasing the stability of earth slopes, bridges, abutments etc. **(**Binquet and Lee ,1975). A laboratory investigation on the application of reinforced earth for foundation problem was first reported by Yang (1972) and thereafter most comprehensive work on this problem was reported by Binquet and Lee (1975).

Munster (1925) in US. Munster's system considered of timber lattice embedded in the backfill and attached to a relatively thin rigid facing via a vertical sliding connection. Coyne proposed a sloping arrangement of pre-cast face panels (1.5 by 0.8 m) each tied back into stone fill with an anchor. Henry Vidal (1963, 1966), a French engineer, is credited with developing a soil- reinforcing technique to a stage where it could be economically applied to large Civil Engineering structures. His concept was for a composite material formed from flat reinforcing strips laid horizontally in frictional soils. Subsequently metal and polypropylene rods, ropes and strips made of natural fibres [Akinmusuru & Akinbolade (1981), Mandal & Dixit (1986), Ramanatha Iyer (1988), Shankaraiah & Narahari (1988)] Geosynthetics [Guido (1985, 1989) were also used in investigations. The interaction between soil and reinforcing members was being solely due to friction generated by gravity. Randomly distributed fibers in soil-termed as RDFS is among the latest technique in which fibers of desired type and quantity are added in the soil, mixed and laid in position. The composite material is also called 'ply soil'. Thus the method of preparation of RDFS is similar to conventional stabilization techniques.

Fibres can be classified in two categories: synthetic fibre and natural fibre. Both types are being used for civil engineering purposes. Some commonly used fibers are: coconut Fibre, sisal fibre, jute fibre, cotton fibre, wool fibre, asbestos fibre, polyester fibre, polyamide fibre, polypropylene fibre, rubber fibre, metallic fibre and glass fibre The various types of synthetic fibers are polypropylene, nylon, plastic, glass, asbestos etc. They are generally preferred than the natural fibers because of their higher strength and resistance. The important properties of polypropylene are: its versatility, excellent chemical resistance, low density, high melting point and moderate cost. All these make it an important fibre in construction. Polypropylene fibers were tested in eight different media (distilled water, iron , bacteria culture , sea water and soil) for the seventeen months and found no degradation . Results showed that there was no change in tensile strength. Randomly distributed fiber reinforced soils have wide application in many geotechnical engineering field, since it maintains strength isotropy with the absence of potential planes of weakness that may develop parallel to the oriented reinforcement. The polypropylene fiber is a type of thermo plastic polymer fiber used in wide variety of application including packaging, labeling, reinforcing, textiles, stationery, plastic parts and reusable containers of various types of laboratory equipments.

The present investigation studies the feasibility of using polypropylene fiber reinforced sand layer over loose stratum, to reduce particularly the effect of settlement of the footings. Thus the load settlement characteristics of model footing resting both on reinforced and unreinforced soil stratum underline loose soil stratum have been studied to understand the effect of different parameters.

2. MATERIALS

2.1 Sand

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. Sand is formed by disintegration of sedimentary rocks by weathering action. Locally available sand was used for the present experimental investigation. The properties of sand used are shown in Table 1.

Table-1: Properties of Sand

Coefficient of uniformity, Cu	4.54
Coefficient of curvature, Cc	1.02
Specific gravity, G	2.58
Maximum density of sand, ϒd(max.)	1.67gm/cc

2.2 Polypropylene Fiber

The polypropylene fiber is a type of thermo plastic polymer fiber used in wide variety of application including packaging, labeling, reinforcing, textiles, stationery, plastic parts and reusable containers of various types of laboratory equipments. The polypropylene fiber taken from reliance industries.

Table- 2: Properties of Polypropylene Fiber

Material	100% Virgin synthetic
Fiber length	3,4,8,6,12,18,24 mm available (Other lengths on request)
Dispersion	Excellent
Specific Gravity	0.91
Colour	Brilliant White
Melt Point	160°C
Alkali Resistance	Very Good
U V Stability	Very Good

2.3 Saw Dust

Sawdust or wood dust is a by-product of cutting, grinding, drilling or otherwise pulverizing wood with a saw or other tool. It is composed of fine particles of wood. It is also the by-product of certain animals, birds and insects which live in wood, such as the woodpecker and carpenter ant. Saw dust was taken from saw mill, Bangalore. Since the design is done by considering the worst condition of the lower layer of soil therefore for practicality saw dust was chosen and whose density is 0.28 gm/cc.

3. METHODOLOGY

3.1 To Determine the Shear Strength Parameters for a Sand and Polypropylene Reinforced Sand

To determine the shear strength parameters for a Sand and Polypropylene reinforced sand using the direct shear test. In order to determine optimum polypropylene fiber content direct shear test was done using sand mixed with different percentage of polypropylene fibers. The angle of internal friction thus obtained was compared with that obtained for unreinforced, sand, to determine optimum polypropylene fiber content

3.2 Model Footing Test

The saw dust bed was hand compacted to have a density 0.28 gm/cc and over that sand bed was prepared in the steel test tank of diameter 25 cm and height 30 cm. The side walls of the tank were made smooth by properly grinding and then by coating with a lubricating gel to reduce the boundary effects. In case of tests with reinforced sand beds, coir fibres were mixed randomly while preparing the sand bed. After preparing the sand bed, the surface was leveled, and the footing of dia 30mm was placed exactly at the centre of the loading jack to avoid eccentric loading. An indentation was made in the footing plate at its centre to accommodate ball bearing, through which vertical load were applied to the footing.

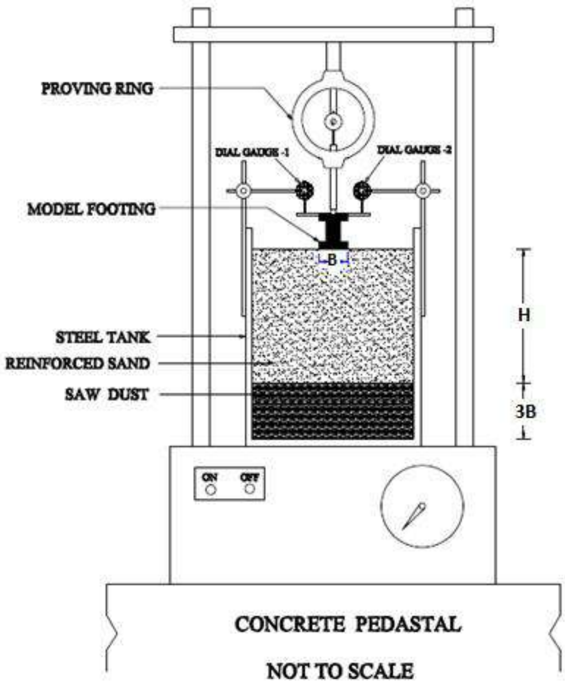

Fig- 1: Typical loading arrangement

A pre-calibrated proving ring was used to measure the load transferred to the footing. The load was applied in small increments. Each load increment was maintained constant until the footing settlement stabilized (loading is made monotonic). The footing settlement and surface deformations were measured through dial gauges (Dg1, Dg2, and Dg3), whose location are shown in figure.

4. RESULT AND DISCUSSION

In order to determine optimum polypropylene fiber content, direct shear test was conducted using sand mixed with different percentage of polypropylene fibers. The angle of internal friction thus obtained was compared with that obtained for unreinforced sand, to determine optimum polypropylene fiber content.

4.1 Optimum Fiber Content for Constant Length of Polypropylene Fiber

Fig. 2 shows effect of length of the fiber on Φ at optimum fiber content. The Φ- value significantly increases up to 6mm length and decreases marginally beyond 6mm length Polypropylene fiber. Hence the minimum length of Polypropylene fiber that gives maximum shear strength shall be 6mm and above.

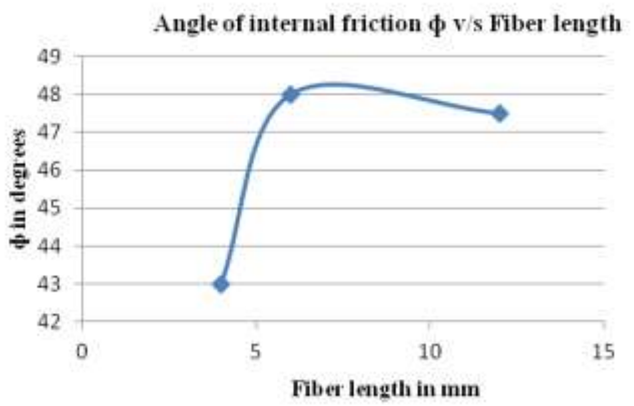

Fig-2: Optimum fiber length of Polypropylene Fiber

4.2 Load Settlement Characteristics

In the present study saw dust has been used to simulate a loose soil stratum having approximately a depth equal to 3 times width of the footing. Model footings of diameter 30mm has been used to study load settlement characteristics of reinforced earth compacted over loose saw dust using polypropylene fiber mixed at optimum percentage obtained from the results of direct shear test.

In order to study the effect of thickness of the reinforced earth over loose stratum, the height of the reinforced sand has been varied to have H/B ratio equal to 0.5,1,2 & 3 where H is height of the reinforced sand and B is width or diameter of model footing used in the test. Fig 3 shows load settlement Characteristics obtained for a model footings of size 30mm resting on unreinforced and sand compacted over saw dust at H/B ratio 0.5,1,2 and 3.

To understand effect of H/B ratio on bearing capacity, tests were done using fiber reinforced sand compacted over saw dust at same H/B ratio of 0.5,1,2 and 3 and bearing capacity ratio was obtained for different length of polypropylene fiber 4mm,6mm & 12mm.The Fig.4 shows the settlement of fiber reinforced sand for different length of 4mm,6mm &12mm at different H/B ratios. At lower H/B ratio of 0.5 there is no reduction in settlement of fiber reinforced sand when compared with unreinforced sand layer. This is because; the failure surface passes through the bottom loose saw dust stratum, there by influencing the settlement of top reinforced sand layer

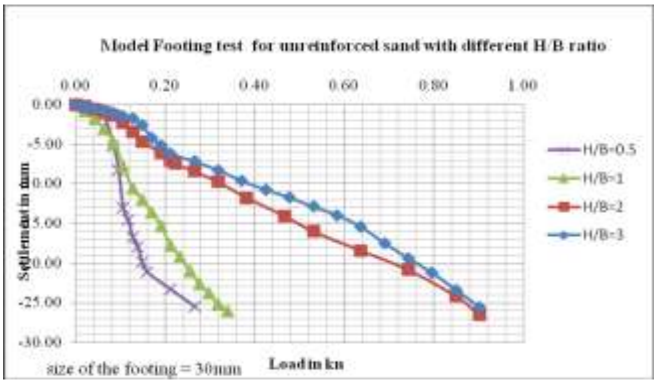

Fig-3: load settlement Characteristics for model footing of size 30mm

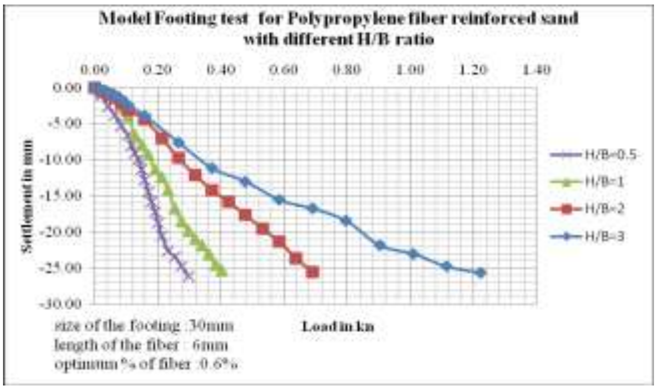

Fig-4: load settlement Characteristics for model footing resting on sand reinforced with 6mm length of polypropylene fiber

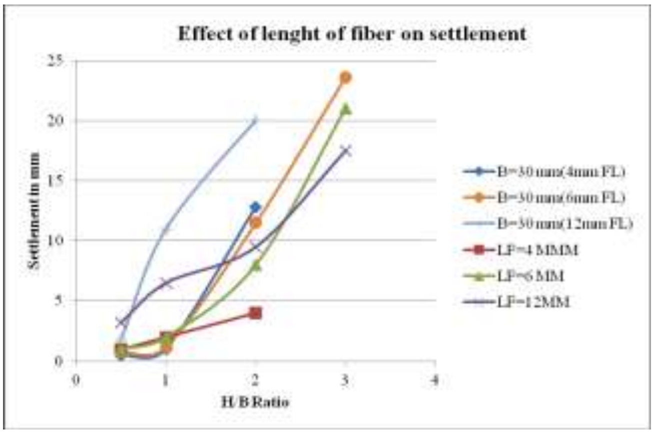

Fig-5: Effect of length of fiber on settlement for footing size 30mm

The Bearing capacity ratio was thus calculated by dividing the bearing capacity of reinforced sand to unreinforced sand at a specified settlement. The bearing capacity ratio obtained from model footing test corresponding to a specified settlement of 25mm. Fig.6 shows the variation of bearing capacity ratio values with H/B ratio for a constant length of fiber equal to 6mm.

The effect of H/B ratio of PP fiber reinforced sand compacted over loose sawdust stratum are studied by obtaining settlement corresponding to 1/5th of the load obtained at specified settlement of 25mm and was compared with corresponding settlement of unreinforced sand at the same H/B ratio.

Using load settlement curves, the settlement unreinforced sand as well as reinforced sand was obtained for constant length of the fibre, viz., 4mm,6mm and 12mm. Majority of the trend in results shows that provision of PP fiber reinforced sand layer reduces a settlement significantly when compared with introduction of unreinforced sand layer over loose soil stratum. Further at lower H/B ratio of 0.5 there is no reduction in settlement of fiber reinforced sand when compared with unreinforced sand layer. This is because; the failure surface passes through the bottom loose saw dust stratum, there by influencing the settlement of top reinforced sand layer. However at higher H/B ratios increases in width of the footing it is found to reduces settlement for both the cases of unreinforced sand and reinforced sand layer. Thus the trend in results indicates provision of reinforced sand layer of higher H/B ratio reduces in settlement significantly.

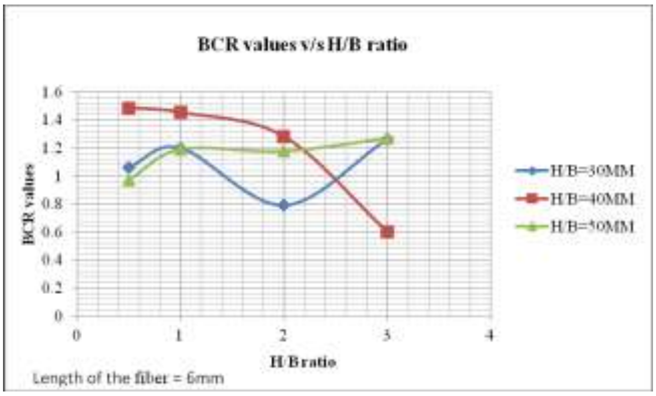

Fig-6: Effect of H/B v/s BCR values for 6mm length & 25 mm settlement

5. CONCLUSION

On the basis of present experimental investigations, the following conclusions have been drawn:

The optimum percentage corresponds to 0.6% polypropylene fiber content for a specified constant length fiber as max value of ϕ has been obtained at this percentage for 4mm, 6mm and 12mm length of the fibres.

The trend in results indicated that the BCR values obtained for H/B = 0.5 is maximum which decreases with increase in H/B ratio

At lower H/B ratio of 0.5 there is no reduction in settlement of fiber reinforced sand when compared with unreinforced sand layer. This is because; the failure surface passes through the bottom loose saw dust stratum, there by influencing the settlement of top reinforced sand layer

With increase in H/B ratio the settlement obtained corresponding to 4mm fiber is significantly smaller than those obtained for 6mm and 12mm length fiber. Thus shorter the length, fibre mixes uniformly with sand producing a homogenous mixture, thus providing a better confining stress that reduces settlement significantly at higher H/B ratio.

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