COMPARATIVE SHEAR PERFORMANCE OF HAIR AND COCONUT FIBRE REINFORCED SAND

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Abstract

The main aim of this research is to analyse the effect of sand reinforcement using hair and coconut fibres, and determine the relative performance of the two fibres. The direct shear test is carried out at different percentages of reinforcement, and the optimum fibre content and the maximum value of shear strength parameter, viz. the angle of internal friction is determined with both the fibres. The results depict an increase in the angle of internal friction of almost 21% by the use of both coconut and fibre.

Keywords: *Shear Strength, Sandy Soil, Hair Fibres, Coconut Fibres.*

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1. INTRODUCTION

Soil reinforcement is not a new phenomenon in geotechnical engineering. It has been observed that reinforcement is naturally carried out by plants and trees, making it one of the major reasons for the current emphasis on prevention of deforestation. Along with this, a lot of work has been carried out to study the effect of reinforcement by materials such as geonets and geosynthetics. Soil reinforcement has proved to be very useful in case of retaining walls, tunnels, and underground air bases for defence purposes. To go with these, soil reinforcement is also useful for massive structures and in cases when soil is of inferior quality even at great depths and removal and replacement of soil is not very economical. Although the concept of reinforcement of soil with natural fibres has been proved by various research workers, the idea of randomly reinforcing soil is considered to be relatively new. Natural fibres such as coconut fibres and hair fibres are easily available and involve low cost of procurement. Hair fibres are readily available in various salons and parlours, and can be obtained at almost zero cost. Coconut fibres are of two types- brown fibres are generally more suitable as they are obtained from mature coconuts and have better strength, durability and resistance to abrasion as compared to white fibres, which are obtained from immature coconuts. Thus, the focus of this paper is on the effect of reinforcement by brown coconut fibres and the naturally obtained hair fibres.

India is rich in coconut cultivation. As per more current records of the year 2013, India's coconut cultivation alone is 11.9 million tonnes, behind only Indonesia and Phillipines.

Coconut fibres involve three steps in its manufacture- husking, retting and the final extraction. Husking is the separation of the husk from the harvested fruits. Fruits are harvested when they are still green, to obtain good quality coir. This is then followed by retting, in which the husk is kept in an environment that allows microbial action, so as to allow the decomposition of the pulp and its separation into coir fibres and coir pith. For fresh water retting, the husks are soaked in fresh water for six to eight months, while in salt water retting, soaking is done is salinated water for a period of ten to twelve months. After retting, the husks are taken out of water and washed. The outer skin is peeled off, placed on wooden blocks and beaten for separating the fibres from the pith. After this, fibres are cleaned and dried, with occasional beating and tossing to remove any impurities remaining.

Table 1: Chemical composition of coconut fibres

Component	Percentage
Lignin	45.84
Cellulose	43.44
Hemi-cellulose	0.25
Pection	3.00

Table 2: General properties of coconut fibres

Property	Specifications
Length	6-8 inches
Density	1.4 g/cc
Tenacity	10.0
Breaking elongation	30%
Diameter	.1mm-.5mm
Modulus of Rigidity	1.8924 dyne/cm²
Swelling in water	30%

2. THE MATERIALS

2.1 Soil Sample

The sample used for this research work is sand. Sieve analysis, as per the provisions of IS 383-1970 provided that the sample belongs to Zone III, having a Fineness Modulus of 3.19

2.2 Coconut Fibres

For the purpose of this work, the coconut fibres used were taken at finite length of 15 mm. The fibres were extracted from the outer shell of the coconut, soaked in water and then dried under the sun.

2.3 Hair Fibres

Hair fibres were obtained from salons and parlours. The fibres were dried to remove moisture. For ease of work, the length of the fibres was taken in a fixed range of 10 mm to 25 mm.

3. METHODOLOGY

Direct shear test was carried out on the sample at normal stresses of 0.5, 1.0 and 1,5 kg/cm². The test was performed for unreinforced soil, and reinforced soil. Soil reinforcement was individually tested at 1%, 2% and 3% by weight of sand for both hair and coconut fibres. From the data of the tests carried out, the optimum fibre content of both the fibres was determined to study the relative performance of both fibres.

4. RESULTS OBTAINED

From the stress-strain relationship in each case, the maximum shear stress was determined in case of soil without reinforcement and with reinforcement at 1%, 2% and 3% by weight of soil for both fibres. Then, the angle of internal friction was determined in each case for both materials. A final relationship showing the variation of angle of internal friction with fibre content was deduced, from which the maximum value of angle of internal friction and the corresponding optimum fibre content was obtained, and the relative performance of the two fibres was studied.

4.1 Unreinforced Soil

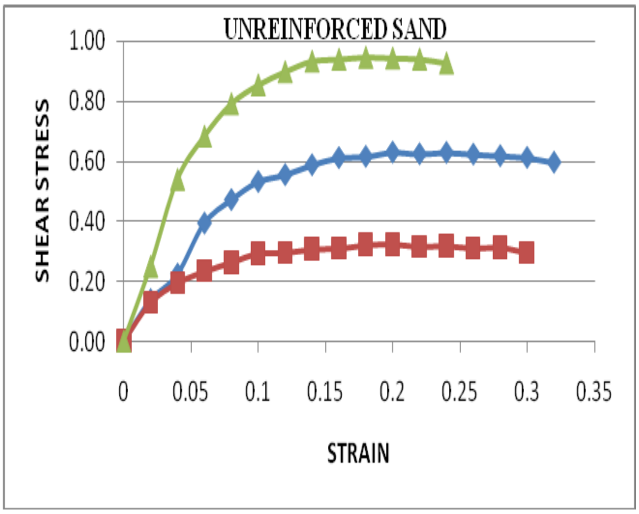

Fig 1. Stress-Strain relationship for unreinforced sand.

Figure 1 shows the stress-strain relationship for unreinforced soil. The maximum value of shear stress are 0.32 kg/cm², 0.63 kg/cm² and 0.95 kg/cm² at normal stresses of 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² respectively.

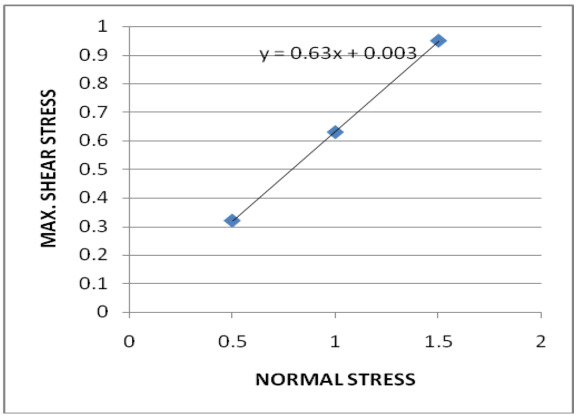

Fig 2. Relation between maximum shear stress and normal stress for unreinforced sand.

Figure 2 shows the relationship between the maximum shear stress and normal stress for unreinforced soil. The angle of internal friction obtained is 32.21°.

4.2 Reinforcement at 1% by Weight

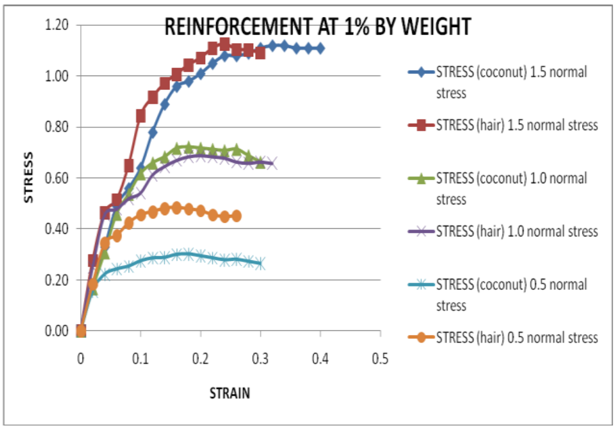

Fig 3. Stress-Strain relationship for sand reinforced at 1% by weight.

Figure 3 shows the stress-strain relationship for sand reinforced at 1% by weight. The maximum values of shear stress in case of coconut fibre are 0.30 kg/cm², 0.72 kg/cm² and 1.12 kg/cm² and 0.48 kg/cm², 0.69 kg/cm² and 1.13 kg/cm² for hair fibres at 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² normal stress.

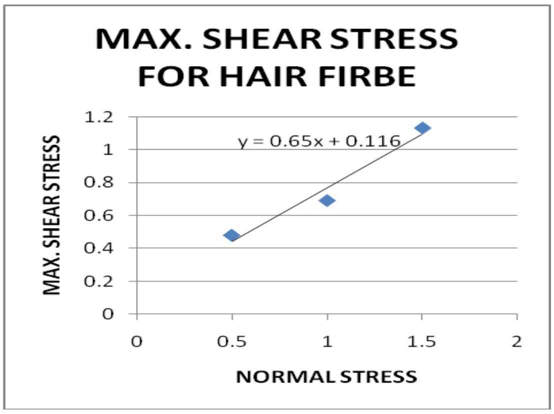

Fig. 4 Relation between maximum shear stress and normal stress at 1% by weight for hair fibre.

Figure 4 shows the relationship between maximum shear stress and normal stress for sand reinforced with hair fibre at 1% by weight. The angle of internal friction obtained is 33.02°.

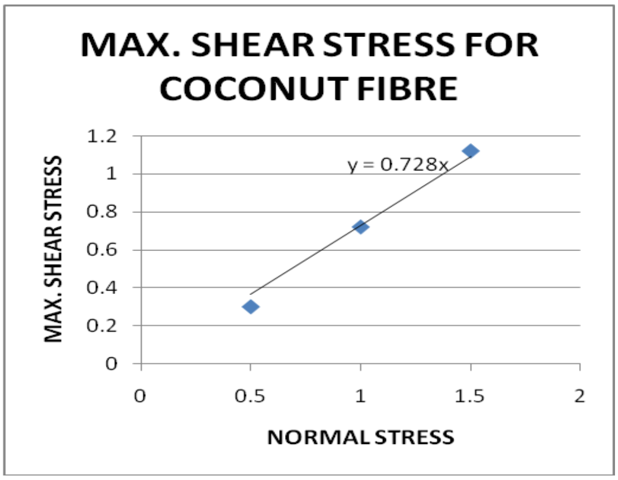

Fig 5. Relation between maximum shear stress and normal stress at 1% by weight for coconut fibre.

Figure 5 shows the relationship between maximum shear stress and normal stress for sand reinforced with coconut fibre at 1% by weight. The angle of internal friction is 36.05°

4.3 Reinforcement at 2% by Weight

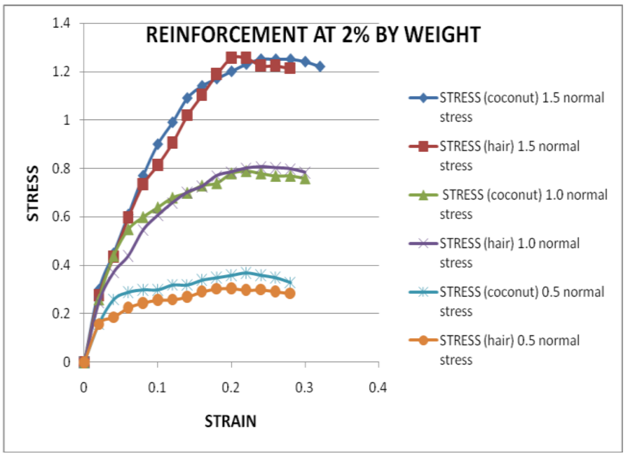

Fig 6. Stress-Strain relationship for sand reinforced at 2% by weight.

Figure 6 shows the stress-strain relationship for sand reinforced at 1% by weight. The maximum values of shear stress in case of coconut fibre are 0.37 kg/cm², 0.79 kg/cm² and 1.25 kg/cm² and 0.30 kg/cm², 0.81 kg/cm² and 1.26 kg/cm² for hair fibres at 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² normal stress.

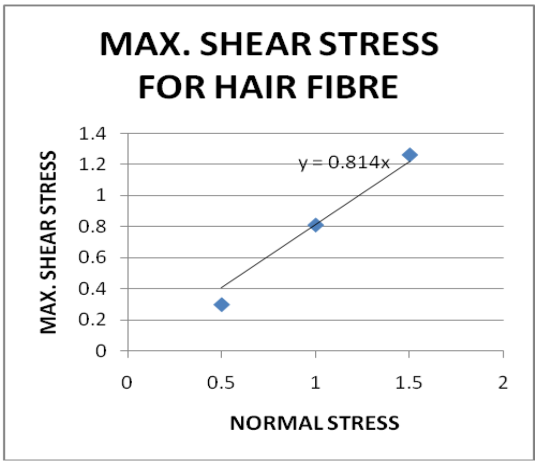

Fig 7. Relation between maximum shear stress and normal stress at 2% by weight for hair fibre.

Figure 7 shows the relationship between maximum shear stress and normal stress for sand reinforced with hair fibre at 2% by weight. The angle of internal friction is 39.14°.

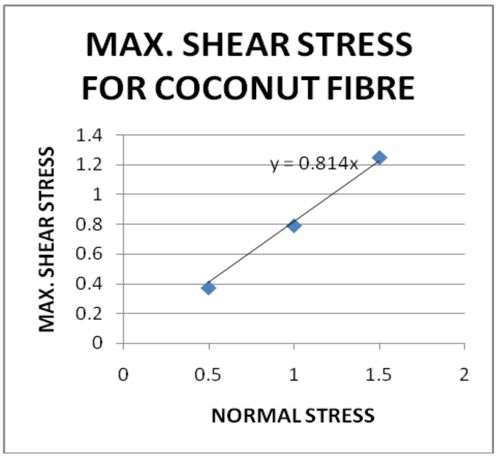

Fig 8. Relation between maximum shear stress and normal stress at 2% by weight for coconut fibre.

Figure 8 shows the relationship between maximum shear stress and normal stress for sand reinforced with coconut fibre at 2% by weight. The angle of internal friction is 39.14°.

4.4 Reinforcement at 3% by Weight

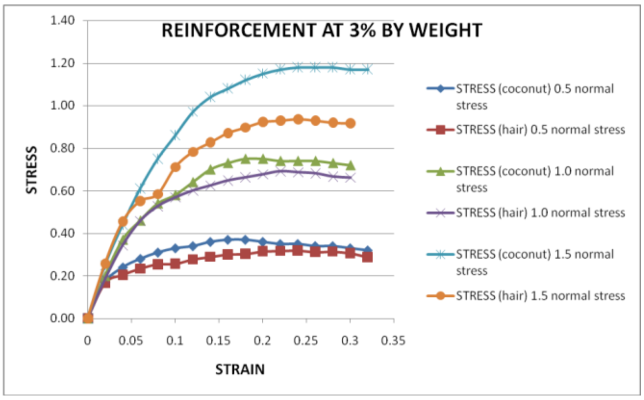

Fig 9. Stress-Strain relationship for sand reinforced at 3% by weight.

Figure 9 shows the stress-strain relationship for sand reinforced at 1% by weight. The maximum values of shear stress in case of coconut fibre are 0.37 kg/cm², 0.75 kg/cm² and 1.18 kg/cm² and 0.32 kg/cm², 0.69 kg/cm² and 0.94 kg/cm² for hair fibres at 0.5 kg/cm², 1.0 kg/cm² and 1.5 kg/cm² normal stress.

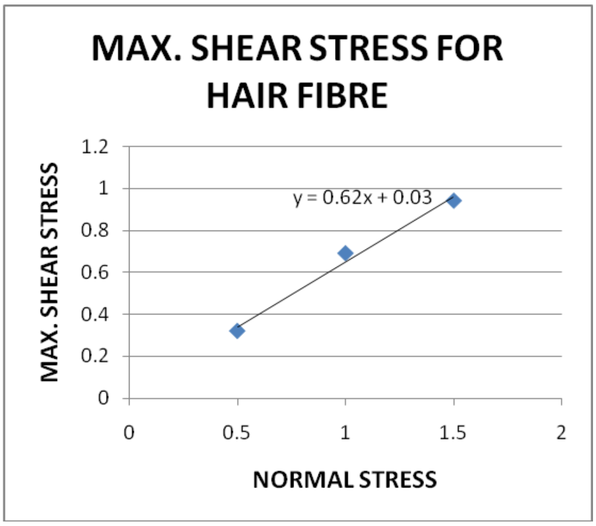

Fig 10. Relation between maximum shear stress and normal stress at 3% by weight for hair fibre.

Figure 10 shows the relationship between maximum shear stress and normal stress for sand reinforced with hair fibre at 3% by weight. The angle of internal friction is 31.79°.

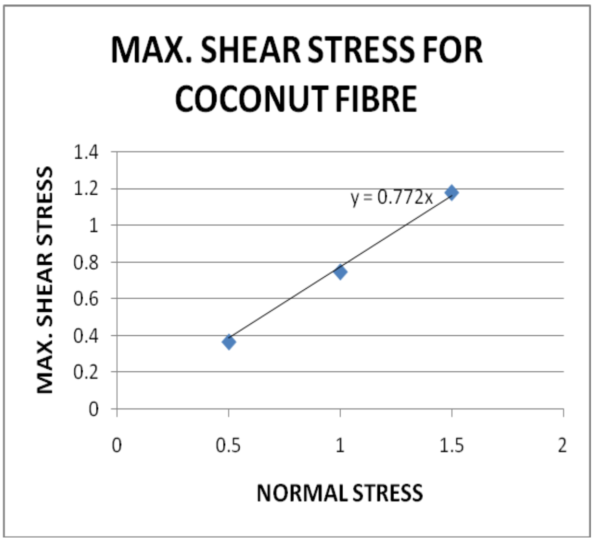

Fig. 11 Relation between maximum shear stress and normal stress at 3% by weight for coconut fibre.

Figure 11 shows the relationship between maximum shear stress and normal stress for sand reinforced with coconut fibre at 3% by weight. The angle of internal friction is 37.66°.

4.5 Optimum Fibre Content

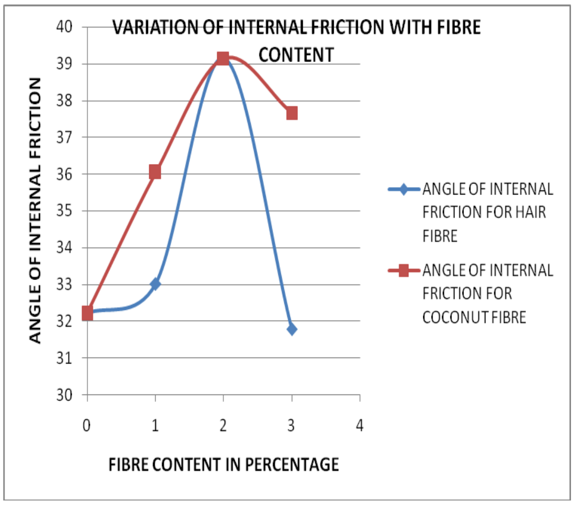

Fig 12. Variation of angle of internal friction with percentage of fibre content

From the relationship between the angle of internal friction and percentage by weight of reinforcemnt utilised, it has been observed that the maximum value of internal friction was obtained as 39.14° in case of hair fibre and 39.40° in case of coconut fibre. This maximum value was obtained corresponding to an optimum reinforcement content of 2% in by weight of soil in case of hair fibres and 2.1% by weight of soil in case of coconut fibres.

5. INTERPRETATION OF RESULTS

It is observed that on application of coconut fibres and hair fibres on sand, the angle of internal friction is increased by 21.70% on the given sand of zone III and fineness modulus of 3.19. The main cause of this increase is reasoned out to the fact that in absence of reinforcement, soil shows brittle failure but upon reinforcement, ductility is provided to the soil. The main concept involved is the development of friction between the soil and the reinforcement which leads to the transfer of the loads of the soil to the reinforcing materials. Moreover, we observe that on application of fibres, the soil gradually shifts to the condition of general shear failure. But at a certain content of hair fibres, the soil shifts back to the transition between general and local shear failure and eventually the angle of internal friction falls below that of unreinforced soil. The reason for this drop is attributed to the fact that when the fibres are more densely provided, there may be a situation where the fibres undergo shear failure before the soil can reach its shear capacity. In such cases, the shear strength of soil gets reduced. The optimum value of fibre content, for obtaining maximum value of angle of internal friction is at 2% for hair fibres and 2.1% for coconut fibres. Coconut fibre shows a more uniform variation in the angle of internal friction with fibre content, while the variation is observed to be more abrupt in case of hair fibres. The main advantage of these fibres is that at the point of optimum fibre content, both cases of reinforcement show the mode of general shear failure. Both fibres show similar performance in terms of optimum fibre content and maximum value of angle of internal friction.

6. CONCLUSION

The effect of reinforcement of sandy soil by the use of coconut fibre and hair fibre has been analysed in this paper. The results show an increase in the value of angle of internal friction, on utilisation of reinforcement. The maximum increase in angle of internal friction is 21.70% for hair fibres and 22.30% in case of coconut fibres, corresponding to optimum fibre content of 2.0% and 2.1% respectively. Beyond the optimum content, a reduction in the angle of internal friction is obtained. Thus, there is not much appreciable difference in the performance of coconut fibre and hair fibre in terms of maximum value of internal friction and optimum fibre content, but there is considerable difference in the performance of the fibres beyond the optimum content, as hair fibre shows a more abrupt fall in capacity, and in case of reinforcement at 3% by weight of soil using hair fibres, the angle of internal friction falls below that of unreinforced soil. Both materials can be well utilised for reinforcement and to obtain maximum increase in angle of internal friction. The easy availability of both fibres, and the widespread cultivation of coconut fibres can prove to be an economic and highly efficient means of soil reinforcement. Further research can be carreid out to compare the relative performance of both the fibres in other aspects such as that of settlement and bearing capacity. Research can also be carried out on more efficient methods of random placing of fibres in soil, and on the enhancement of cultivation of coconut and manufacture of coconut fibres.

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