Experimental Study of Ugat Canal Soil for Slope Stability

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Abstract: Slope stability is one of the major aspects of geotechnical engineering and plays significance on large scale infrastructure projects such as highways, railways or canals. Slope failure is the major problem in earthen canal due to seepage problem. Due to excess imposed loads, discharge forces, erosion, and gravity forces, drainage and irrigation canals may suffer from a full or restricted slope failure. Side slope failures of irrigation at Ugat canal located near Jahangir Pura, Surat will possibly suffer from heavy catastrophes with destructive damages to public lives and belongings. The reason of canal slope failure is due to piping in salt influenced or distributive soil, discharge forces in soft clayey or sandy soil, deficient standard of the soil mass mound same as in black cotton soil i.e. soft clay or loose sand, and accordingly dissolution due to immoderate use of irrigation water or utilizing surface irrigation method at places near to the bank. There is no generalized method of restoration for slope failures because of the distinctiveness of the attributes and situations of each site. Hence, based on characteristics of sites, each site needs to be studied individually. To prevent the failure the side slope of the embankment is strengthened by coconut husk which reduces slope failure in earthen canal. There is significant increment in load carrying capacity of soil by adding coconut husk at various contents such as, 0.5 %, 1.0 % and 1.5% replacement by soil. At 0.5 %, 1.0 % and 1.50 % replacement the strength increment is 1.52, 1.70 and 2.11 times of normal soil.

Keywords: Canal failure; Stability; Coconut husk; Shear strength; Bearing capacity.

1 Introduction

1.1 Context

Slope failure is the major problem in earthen canal due to seepage. Many slope failures are observed in different canals. This slope failure is due to the Liquefaction of very shallow subsurface sediments. The liquefied layer disassociated the overlying hard deposits from the fundamental sediments that permitted the upper non-liquefied matter to temporary move back and forth in the form of ground failure called lateral spreading. Ancient earthen irrigation channels in pervious soils deposits may release a plenty amount of water due to seepage. Massive amount of losses from the sides and bed of channel may results in low transport productivity; i.e. the proportion of water coming to cultivation lands turnouts to that emancipated at the water supply source i.e. river or any stream line.

Therefore, Ugat canal is a minor canal i.e. not lined. But, due to development of Surat city this canal is the part of city require special attention. As, polymer fibers have capacity to reduce seepage, even at the same loss rate per unit area there will be a saving in water and increase in bearing capacity and shear strength of canal slope. Many scientists and geotechnical engineers related to such background stated that the hydraulic conductivity of fiber reinforced soil can be improved by increase in fiber content.

To prevent canal slope failure, the side slope of the embankment is strengthened by coconut husk i.e. polymer fibers as a partial replacement of soil which reduces slope failure in earthen canal. This study focuses on the reinforced earth slope stability of canal using coconut husk. The experimental study of canal slope strengthening is selected to study the different characteristics of soil mass. The canal is situated on the Ugat Road, near Jahangir Pura, Surat.

Fig. 1. Canal Slope Failure

1.2 Types of Slope Failure:

A slope failure is an incident in which a slope collapses quickly due to disabled self-holding ability of the earth under the effect of a rainfall or an earthquake. There are generally 4 types of slope failures described here;.

Rotational Failure:

A gliding type landslip is a down-slope motion of material that happens along a unique surface. The slide said to be rotational, if the slip surface is curved. The slip surface of a rotational landslide leads to be deep. Blocks of failed material may rotate as they fail and can at times be seen to move in reverse towards the slope.

Translational Failure:

A slide-type landslip is a down-slope movement of material that occurs along a particular surface of fragility such as a fault, joint or bedding plane. It is termed translational or planar failure, if the slip surface is straight.

Compound Failure:

A failure composing the aspects of both rotational and translational failure is known as compound failure.

Wedge Failure:

A failure along an inclined plane is known as wedge failure. It is also called plane failure or block failure. It occurs when particular blocks and wedges of the soil mass become isolated.

1.3 What is Polymer Fiber Reinforcement in Soil?

An idea of soil mass reinforcement by adding a kind of fiber was performed by our ancient culture which used soil combined with accessible fiber. It was helpful to increase strength and durability and of the dried brick used as construction materials. It was originated that fiber reinforced soil proves better than natural soil.

1.4 Objective of Study:

- To increase stability of slope that occurs in failure zone of canal system.
- To provide a cost effective work and increase bearing capacity and shear strength of soil by adding coconut husk i.e. polymer fiber as a partial replacement of soil at 0.5%, 1.0% and 1.5% replacement to increase the stability of the adjoining road.
- To reduce soil volume change due to temperature or moisture effect by soil stabilization.

2 Research Material and Methodology Adopted:

In the experimental study, two materials were used; polymer fiber i.e. coconut husk and soil sample i.e. available at site. A description of coconut husk is provided as follows.

Coconut fibers are the natural fibers taken out from the coconut husk. It is widely utilized in products like doormats, floor mats, sweeping brushes and mattresses. Coir is the stiff coarse fiber from the outer husk of a coconut. It is the knotty kind of material seen between the interior shell and the outer coat of a coconut. Brown coir is made up from ripe coconut. They are further used in covering, crafting and cultivation. White coir is gathered from unripe coconuts, utilized for preparing sweepers, strings, strands and fishing mesh.

Fig. 2. Coconut husk

Fibers are light in weight, strong and elastic. Based on experimental work performed in M-Test Laboratory, Udhana, Surat, various parameters were studied of coconut husk. The properties of coconut husk are derived from tests performed by the authors and the results are mentioned here.

Table 1. Physical Characteristics of Coconut Husk

Characteristics	Description
Tensile strength	13.8 kN/m
Absorption	None
Elongation	30 %
Diameter	10 to 20 μm (0.0004 to 0.0008 in)
Length	10 to 30 centimeters (4 to 12 in)
Density	0.67-10.0 g/cm^3
Thermal Conductivity	Low

3 Experimental Study:

Fig. 3. Proctor Compaction test set up

In present experimental study, diverse soil samples have been studied i.e. normal soil sample i.e. 0% replacement, 0.5 % replacement, 1.0 % replacement and 1.5 % replacement of Coconut Husk by weight of soil. The testing of mechanical property i.e. shear strength was conducted by Triaxial shear test.

3.1 Parameter Studied:

During the research work, three parameters were studied i.e. optimum moisture content, maximum dry density and shear strength by Proctor compaction test and Triaxial shear test.

3.2 Proctor Compaction Test:

Proctor Compaction Test is the most common test to evaluate the optimum moisture content at which a tested soil sample become most dense and attain the relevant maximum dry density.

Fig. 4. Proctor Compaction Equipment

3.3 Triaxial Shear Test:

Fig. 5. Triaxial shear test set up

Triaxial shear strength test is the most common test i.e. widely recommended and suitable for all kinds of soils. It used to assess the mechanical properties of the soil sample. In this test, soil sample is subjected to stress, in such a manner that the stress generated in one direction will be different in orthogonal direction. The material properties of the soil i.e. shear resistance (angle of internal friction), cohesion and the dilatancy stress is evaluated from triaxial shear strength test. And from that, shear strength is evaluated.

4 Results and Discussions

A research work on canal slope stability was performed to assess the shear strength of treated and untreated soil sample to enhance stability at Ugat Canal Soil. The results of MDD and OMC of untreated soil sample are 1.67 gm/cc and 19.30% respectively as indicated in figure 6. Now, from figure 7, 8 and 9, MDD and OMC of treated soil samples are 1.774 gm/cc and 15.50% (for 0.5% Coconut Husk), 1.80 gm/cc and 17.75% (for 1.0% Coconut Husk) and 1.648 gm/cc and 13.00% (for 1.5% Coconut Husk) respectively.

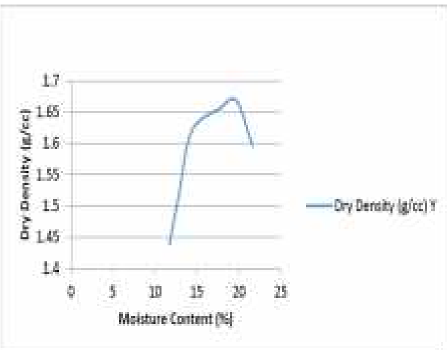

Fig. 6. Proctor Test Results of untreated Soil Sample

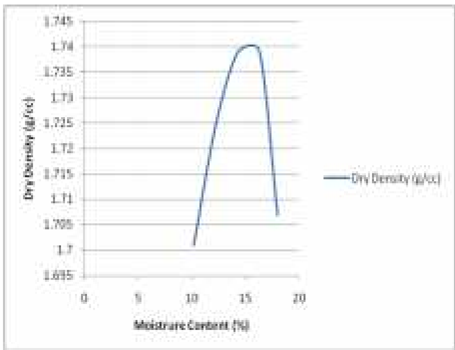

Fig. 7. Proctor Test Results of Soil Sample with 0.5 % Coconut Husk

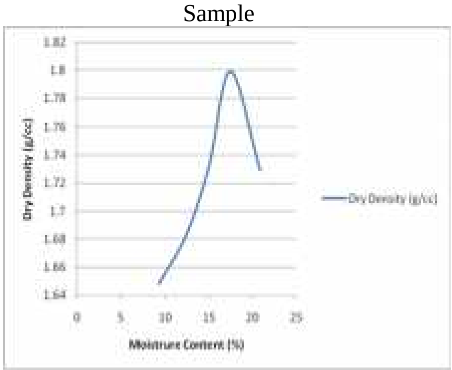

Fig. 8. Proctor Test Results of Soil Sample with 1.0 % Coconut Husk

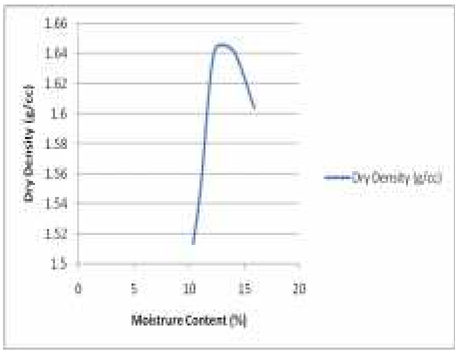

Fig. 9. Proctor Test Results of Soil Sample with 1.5 % Coconut Husk

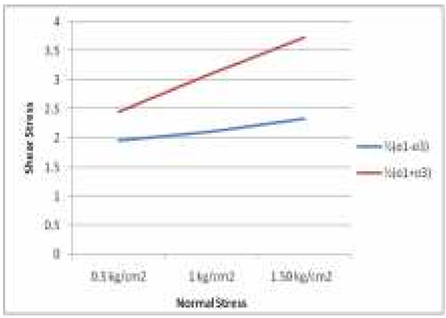

Fig. 10. Untreated soil C-Ø (Simple soil) C = 1.9 kg/cm^2 Ø = 15 degree

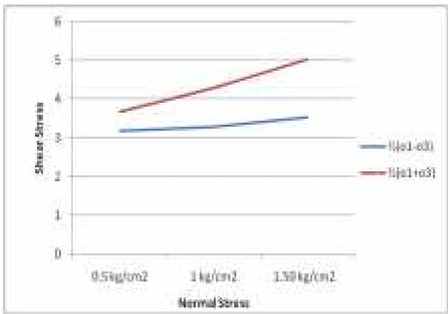

Fig. 11. Treated soil C-Ø (0.5 % Coconut husk) C = 3.1 kg/cm^2 Ø = 10 degree

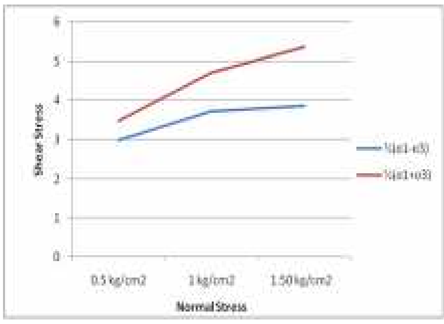

Fig. 12. Treated soil C-Ø (1.0 % Coconut husk) C = 3.0 kg/cm^2 Ø = 20 degree

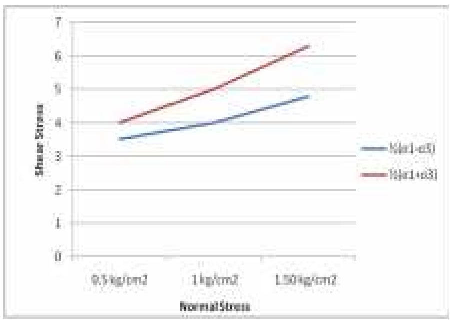

Fig. 13. Treated soil C-Ø (1.5 % Coconut husk) C = 3.5 kg/cm^2 Ø = 16 degree

The results of Triaxial shear test shows that there is significant increment in strength or bearing capacity of soil by adding coconut husk at various contents i.e. 0.5%, 1.0% and 1.5% replacement by soil. At 0.5% replacement the strength increment is 1.52 times of the normal soil, at 1.0% replacement the strength increment is 1.70 times of normal soil and at 1.5% replacement the strength increment is 2.11 times of normal soil.

5 Concluding Remarks

Detailed conclusions as results of the study have been discussed. The variations of the results are shown in terms of percentage. Also, these variations are related to only studied cases. Hence, these percentage changes could be varying from case to case.

- From the various literature studies, it has been seen that, the canal slope failure and bearing capacity can be prevented using alternative mineral admixtures by replacement of soil at various percentage.
- Coconut husk as a partial replacement of soil proves to be most economical, suitable solution to increase mechanical properties of soil.
- There is significant increment in shear strength or bearing capacity of soil by adding coconut husk at various contents i.e. 0.5%, 1.0% and 1.5% replacement by weight of soil. At 0.5% replacement the strength increment is 1.52 times of the normal soil, at 1.0% replacement the strength increment is 1.70 times of normal soil and at 1.5% replacement the strength increment is 2.11 times of normal soil. Also, as the fiber content i.e. coconut husk increased, cohesion value is also increased.
- The relative cheapness of material and potential for producing and laying the matting with local labour recommends the use of coconut waste not only as soil reinforcement but also as concrete reinforcement a very suitable option for sustainable development scenario.
- The experimental results are restricted to Ugat Canal Soil Embankment, for other site the results may vary.

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