# Stabilization of Soil Using Sugarcane Straw Ash and Polypropylene Fibres

**T. Suresh Reddy, Dr. D S V Prasad**

*Abstract*—**Soils pose problems to civil engineers in general and to geotechnical engineers in particular. They cause damage to structure founded in them because of their potential to react to changes in moisture regime. Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improvement soil material which has all the desired engineering properties. In this paper, sugarcane straw ash and polypropylene fibres were used at varying percentages are blending to stabilize the soil. Various geotechnical laboratory tests like compaction, Unconfined Compression Test and California Bearing Test were carried by varying the percentage of sugarcane straw ash (10% ,15%,20% and 25%) and polypropylene fibres (0.5%, 1.0% and 1.5%) respectively. It is found that 20 % increase in the percentage of sugarcane straw ash and 1% polypropylene fibres increases the UCS and CBR values.**

*Index Terms*— **Soil, Sugarcane Straw Ash, Compaction and CBR.**

## I. INTRODUCTION

The introduction of randomly oriented fibres to a soil mass may also be considered similar to admixture stabilization. Reinforcement of soils with natural and synthetic fibres is potentially an effective technique for increasing soil strength. In recent years, this technique has been suggested for a variety of geotechnical applications ranging from retaining structures, earth embankments and footings to subgrade/subbase stabilization of pavements [2]. The improvement of the engineering properties due to the inclusion of discrete fibres was determined to be a function of a variety of parameters including fibre type, fibre length, fibre content, orientation and soil properties. [1], felt that the placing of reinforcement can effectively reduce the crack propagation into the top layers, improve load spreading in the unbound base layer and prolong the overall life of pavement, the use of geosynthetic materials involves high costs especially for moderate projects, that prompted to try for other materials including those from natural fibers like coir and bamboo. One of the primary advantages of randomly distributed fibers is the absence of potential planes of weakness that can develop parallel to oriented reinforcement [3]. Material used to make fibers for reinforcement may be derived from paper, metal, nylon, synthetic plastics and other materials having widely varied physical properties. The majority of currently published literature about randomly oriented fiber reinforcement deals with the reinforcement of cohesion less or granular soils. This makes the factor of slippage more apparent at areas where the shear stress is greatest. [6] also examined distinct relationships between the grain size of given soils and the fiber-bond strength. He found that the finer sand size particles had significantly greater fiber-bond strengths, thus they were less likely to fail by conditions of slippage than the coarser grained soils. Silts, being even smaller than fine-grained sands, might then be expected to achieve a stronger bond with fibers. [8], has study the fiber reinforcement effect on CBR values in admixture stabilized soil. By addition of the fly ash and fiber to the expansive soils the CBR value is increased. For 1.5% of fiber and 15 % of fly ash the thickness of the pavement is decreased by 60% and the 8610 $m^3$ of soil can be saved for one km length of the road. In soaked condition the maximum 23 thickness reduction achieved was 45% by addition of fly ash only the reduction is 40% and 9870 mt3 of earth for one km length of the road. [4] used solid waste materials such as rice husk ash and waste tyres are used for this intended purpose with or without lime or cement. Rice husk ash an agricultural waste can be effectively used for stabilization of soils using cement or lime as additive. Rice husk ash is source of silica has numerous applications in silicon based industries. Addition of RHA to the soil in general increases optimum moisture content and reduces the maximum dry density. RHA and lime/cement improves plasticity index and swelling potential of expansive soils. Using waste tyres in geotechnical engineering applications may be feasible to consume the scrap tyres. Waste tyre can use for improvement of bearing capacity soil up to optimum rubber content and. Tyre waste can effectively use as soil reinforcement beneath footing, embankment and retaining wall. [5] study to investigate feasibility of Sugarcane Bagasse Ash to stabilize the soil with partial replacement of 4%, 8%, 12%, 16%, 20%, 24% and 28% which affects the MDD and OMC up to an optimum percentage. The use of Sugarcane Bagasse Ash improves some properties of the clayey soil and can be used as replacement in clayey soil up to certain limits. It may be used in construction of rural roads etc. In the meantime, the problem of disposal and handling may be solved. [7], studied consolidation and rebound characteristics of expansive soil by using lime and Bagasse ash, based on the test results, increases in Bagasse ash content with Lime, reduction in liquid limit whereas plastic limit is increases. This change of Atterberg limit is due to the cation exchange reaction and flocculation-aggregation for presence of more amount of Bagasse ash -Lime, which reduces plasticity index of soil. A reduction in plasticity index causes a significant decrease in swell potential and removal of some water that can be absorbed by clay minerals. The maximum dry density of soil decreased with the addition of Bagasse ash - Lime and value of optimum moisture content mixes treated soil increased because of the Puzzolanic action of Bagasse ash - Lime and

**T. Suresh Reddy**, PG Student, (Soil Mechanics &Foundation Engineering), Department of Civil Engineering, BVC Engineering College, Odalarevu, E.G.Dt. Andhra Pradesh, India Affiliated to JNT University, Kakinada, Mobile No: 09963128666

**Dr. D S V Prasad,** Professor and Principal, BVC Engineering College, Odalarevu, E.G.Dt. Andhra Pradesh, India Affiliated to JNT University, Kakinada, Mobile No: 09490183366

soil, which needs more water. A review of the literature reviews that various laboratory investigations have been conducted on various forms of ash and poly propylene. The improvement in the strength and durability of soil in the recent time become imperative, this has geared up researches towards using stabilizing materials that can be source locally at a very low cost. In this project, to improve the strength of local soil blended with sugarcane straw ash and polypropylene fibres 10%, 15%, 20%, 25%, and 0.5%, 1.0% and 1.5%, of polypropylene fibres are used as reinforcement respectively and conducted compaction and CBR tests in the laboratory with a view to determine the optimum percentages. The optimum percentage by weight of soil of the sugar cane straw ash for the improvement of the geotechnical properties of the black cotton soil is 20%. And the optimum percentage by weight of soil of the polypropylene fiber is 1.%.

## II. MATERIALS USED

Details of various materials used during the laboratory experimentation are reported in the following section.

### *A. Soil Sample*

The soil used for this study has collected from Muramalla, E.G.Dt., AP. The properties of the soil presented in the table 1.

Table. 1 Geotechnical Properties Soil Sample

| Property | Soil |
|---|---|
| Water Content (%) | 30.9 |
| DFS (%) | 62.5 |
| Specific Gravity | 2.62 |
| Liquid Limit | 81.25 |
| Plastic Limit | 50 |
| OMC (%) | 28.07 |
| MDD (g/cc) | 1.419 |
| UCS (kg/cm$^2$) | 0.352 |
| CBR | 1.47 |

### *B. Sugarcane Straw Ash*

Sugarcane straw is the one of the organic wastes obtained from sugar industry during the process of sugar manufacturing as shown in the Figs 1&2. It's use in agriculture as organic fertilizer for crop production. Sugarcane straw ash as a good source of micronutrients like, Fe, Mn, Zn and Cu. It can also be used as soil additive in agriculture due to its capacity to supply the plants with small amounts of nutrients. In many situations, soils in natural state do not present adequate geotechnical properties to be used as road service layers, foundation layers and as filter material. In order to make deficient soils useful and meet geotechnical engineering design requirements researchers have focused more on the use of potentially cost-effective materials that are locally available from industrial and agricultural waste in order to improve the properties of deficient soils and also to minimize the cost of construction.

Table 2 Chemical Properties of Sugarcane Straw Ash

| Chemical Element | % by weight |
|---|---|
| Silica(Sio2) | 62.43 |
| $Fe_2O_3$ | 6.98 |
| $Al_2O_3$ | 4.38 |
| LOI | 4.73 |
| $K_2O$ | 3.33 |
| CaO | 2.51 |
| $SO_3$ | 1.48 |
| Mn | 0.5 |
| Zinc(Zn) | 0.3 |
| Cu | 0.1 |

Fig.1. Cut Sugarcane

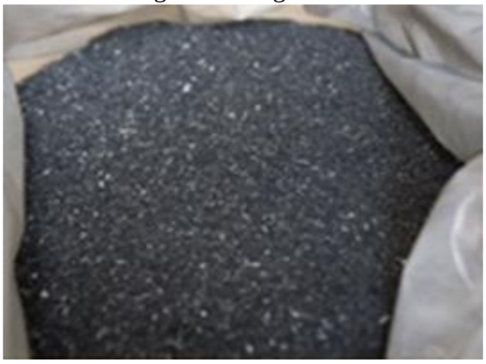

Fig. 2. Sugarcane Straw Ash

### *C. Polypropylene Fibres*

Polypropylenes are hydrophobic, on corrosive and resistant to alkalis, chemicals and chlorides as shown in the Fig.3. The improvement of the engineering properties due to the inclusion of polypropylene fibers was determined to be a function of a variety of parameters including fiber type, fiber length, aspects ratios (length/diameter), fiber content, orientation and soil properties.

Fig 3. Polypropylene Fibers

Table 3 Properties of Polypropylene Fibers

| Behavior Parameters | Values |
|---|---|
| Fiber Type | Single fiber |
| Unit Weight | 0.91g/cc |
| Average Diameter | 0.034mm |
| Average Length | 4-5cm |
| Breaking Tensile Strength | 350MPa |
| Modulus of Elasticity | 3500MPa |
| Fusion Point | 165°C |
| Burning Point | 590°C |
| Acid and Alkali Resistance | Very good |
| Dispensability | Excellent |

## III. Experimental Programme

The overall testing program is conducted in two-phase. In the first phase soil sample blended with 10%, 15%, 20% and 25% of sugar cane straw ash by weight with a view to determine the optimum percentage of sugarcane straw ash by conducting compaction studies were followed by CBR and UCS and soaked CBR .In second phase soil, bended with optimum % of sugarcane straw ash (20%) as a base mix reinforced with o.5%,1% and 1.5% fibres with a view to determine the optimum percentage of fibres by conducting soaked California Bearing Ratio (CBR) and Unconfined Compressive Strength tests in the laboratory and finally calculated the soaked CBR and UCS for all the optimum percentages for a comparative study.

## IV. Laboratory Testing

Various tests are carried out in the laboratory for finding the index and other important properties of the soils used during the study. Modified Proctor Compaction, soaked CBR and Unconfined Strength tests were conducted by using different percentages of Sugarcane straw ash and fibres as per IS Code procedures with a view to determine the optimum percentages of additives. The details of these tests are given in the following sections.

*Modified Proctor's Compaction Test:* The compaction test was performed in Proctor's mould. This was used to find the optimum moisture content and its corresponding dry unit weight. The test was carried out according to IS: 2720 (Part 8) 1983.

*California Bearing Ratio (CBR) Tests:* The California Bearing Ratio (CBR) tests were conducted in the laboratory by using a standard California Bearing Ratio (CBR) testing machine. According toIS:2720 (part – XVI), 1979.

*Unconfined Compressive Strength Test:* Unconfined compressive strength is one of the most widely referenced properties of stabilized soils. Unconfined compressive test at OMC is conducted as per IS:2720 (part - X)-1991.

## V. Laboratory Test Results

### *A. Effect of Sugarcane Ash on Geotechnical Properties of Soil*

For finding the optimum percentage of Sugarcane Straw Ash different percentages ie.10%, 15%, 20% and 25% is blended in the selected soil sample by weight. From the compaction test results the MDD values are increasing from 1.419g/cc to 1.69g/cc and Optimum Moisture Content decreases from 28.07% to 15.65% up to the addition of 20% sugarcane straw ash and beyond the addition decreases the MDD and increases the OMC as shown in the Fig.4.Similarly unconfined compressive strength increases from 0.352 kg/cm$^2$ to 0.441 kg/cm$^2$ and beyond it starts decreasing as shown in the Fig.5. Soaked CBR values are increasing from 1.39 to 2.15 beyond the addition it decreases as shown in the Fig.6. From the above test results 20% of sugarcane straw ash is the optimum percentage.

### *B. Effect of Optimum % Sugarcane Ash with Polypropylene fibre on Geotechnical Properties of Soil*

From the above experimental results the optimum percentage of Sugarcane Straw Ash is 20%. With a view to effective utilization of Sugarcane Straw Ash different percentages of Polypropylene fibre is mixed in the optimum mix for finding the optimum %. From the Fig.7 the unconfined compressive strength increases from 0.352 kg/cm$^2$ to 1.34 kg/cm$^2$ and Soaked CBR values are increasing from 1.39 to 3.94 up to the addition of 1% fibre and beyond the addition it decreases as shown in the Fig.8. From the above test results 1% of Polypropylene Fibre is the optimum percentage.

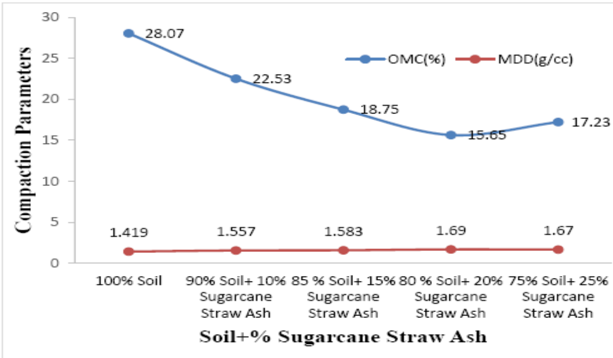


Fig. 4. Variation of Compaction Values for Different % Sugarcane Straw Ash Blended in Soil

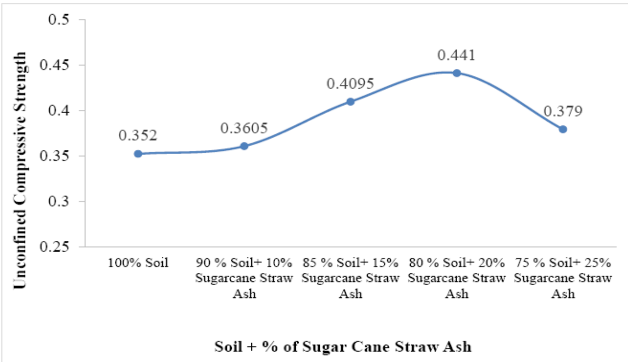


Fig.5.Variation of Unconfined Compressive Strength of Soil with Different % of Sugarcane Straw Ash

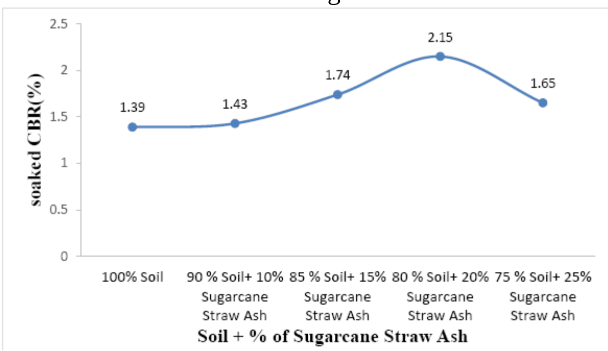


Fig. 6. Variation of Soaked CBR Values for Soil with Different % of Sugarcane Straw Ash

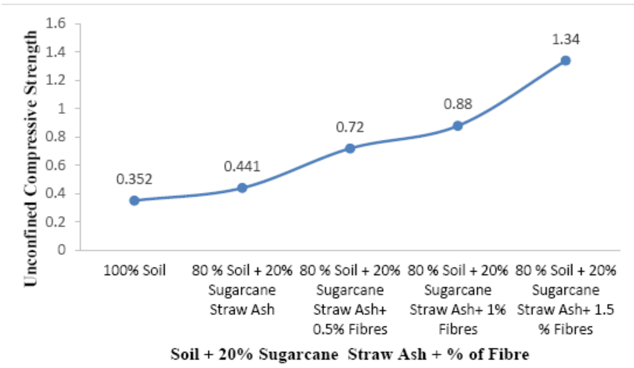


Fig. 7. Variation of Unconfined Compressive Strength for Soil + 20 % of Sugarcane Straw Ash + % of Polypropylene Fibres

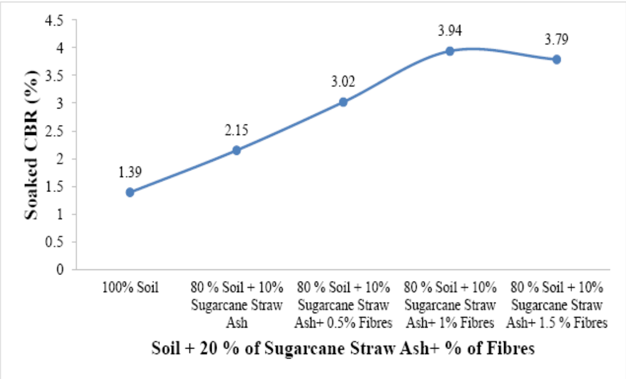


Fig.8. Variation of Soaked CBR Values for Soil + 20 % of Sugarcane Straw Ash + % of Polypropylene Fibres

Finally, it can be summarized, that the replacement of local soil with sugar cane straw showed an improvement in compaction, strength and penetration characteristics of the local soil to some extent and on further blending it with waste fibres, the strength mobilization more pronounced. The durability was also studied with good amount of success as there is considerable improvement in strength mobilization fibres.

## VI. Conclusion

The use of agricultural waste slightly improves the properties of local soils; sugar cane straw ash can be used as replacement in local soil up to certain limits. The following conclusions are made based on the laboratory experiments carried out in this investigation.

It was observed that the treatment local soil as individually with 20% sugarcane straw ash has moderately improved the strength properties.

There is a gradual increase in maximum dry density with an increment in the % replacement of sugarcane straw ash up to 20% with an improvement further addition decreases the dry density characteristics and also corresponding strength characteristics with an increase in the fibre content from 0% to 1.5 % with an improvement of 45%, 3 times for soaked CBR respectively.

There is an improvement in unconfined compressive strength near two times at 20% addition of sugar cane straw ash and three times strength increases in the fibre content at 1% respectively.

It is evident that the addition of sugarcane straw ash to the virgin soil showed an improvement in compaction, strength and penetration characteristics to some extent and on further blending it with fibres, the strength mobilization was more pronounced.

Finally, it can be summarized that the materials 20% of sugarcane straw ash, and 1% of fibres had shown promising influence on the strength characteristics of soil, thereby giving a two-fold advantage in improving poor soil and also solving a problem of waste disposal.

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**T. Suresh Reddy** completed B. Tech (civil) in Aditya Engineering College, Surampalam, E.G.Dt., AP and presently perusing M. Tech in Soil Mechanics and Foundation Engineering in the same institution.

**Dr. D. S. V. Prasad** working as Professor and Principal BVC Engineering College, Odalarevu, AP, has more than 20 years of experience in teaching. Published more than 80 technical papers in National & International Journals & Conferences in the research area of Soil Mechanics & Foundation, Structural Engineering. He got a prestigious Crop's of Engineers Award constituted by IEI Journal and Meritorious Teachers Award in 2009 by JNT University, Kakinada. Life memberships in ISTE, IEI and Indian Geotechnical Society.