Influence of Sisal Fibers on the Properties of Rammed Earth

M Eswar Kumar Yadav, P R Kishore, A S Kumar, A S Swetha Sri

Abstract— The use of rammed earth has been increasing widely during recent years in many countries as an alternative material for building houses due to its valuable characteristics such as affordability, environment friendly, comfort, strength and durability. This thesis presents the result of an experimental study to evaluate the compressive strength and bond strength properties of untreated, treated bamboo splints and steel reinforced cement stabilized rammed earth blocks. To overcome the deficiencies of blocks, sisal fibers are added to improve the performance of CSRE blocks. Fibers are secondary reinforced materials and acts as crack arresters which improves the strength of cement stabilized rammed earth blocks.

In this experimental study, red soil is mixed by adding four different percentages (5%, 10%, 15%, and 20%) of OPC and sisal fiber with 0.2%, 0.4%, 0.6%, 0.8%, and 1.0% by weight of soil respectively. The bamboo splints were treated by soaking them in chemical solution of boric acid, Copper -Sulphate and Potassium Di-chromate (1.5:3:4).The resin-based adhesive with coarse sand will be applied to the top of bamboo splints. After 28days of curing period the cubes were tested for compressive strength, pull-out test is done for a series of CSRE blocks in which Bamboo splints and steel bars are embedded to find out its bond strength.

KEYWORDS:— Rammed Earth, Cement Stabilised Rammed Earth (CSRE), Sisal Fiber, Compressive Strength, Bond Strength.

1. INTRODUCTION

a) Rammed Earth: As demand for housing construction increases with affordable materials, it is best for us to choose the rammed earth, and the earth is an ancient form of monolithic earth wall construction. The use of mudguards for the application of load bearing and no-load bearing can be seen all over the world. The properties of the rammed earth can be enhanced by physical, chemical and mechanical stabilization. Physical stabilization is achieved by the proper mix ratio material of gravel, sand and clay. Mechanical stabilization is achieved by dynamic compression using a manual hammer (or) pneumatic hammer. Chemical stabilization can be achieved by mixing chemicals such as cement and lime to improve soil properties.

Rammed district construction can be classified into two groups: stabilized rammed earth and unstable rammed earth. In an unstable buried land, the soil consists of a mixture of sand, gravel, silt and clay. On the other hand, stabilized soil can be obtained by adding cement, lime, etc. to the soil. The mixture is wetted with the optimum moisture content before sanding between the molding operations. China's Great Wall of China, built about 3000 years ago, has a wide area based on Japanese Horyuji temples and rammed earth, just like the wall of the earth built about a year ago.

b) Sisal Fiber: Sisal fiber is one of the most widely used natural fibers and grows very easily. This plant starts with teeth and gradually grows, making roses with sword-shaped leaves. Each leaf contains several long, straight fibers. While peeling, the leaves are suitable to leave behind rough fibers and to remove pulp and plant material. The fibers can be spun for the production of yarns and fabrics or can be pulped to make paper products. The sisal fiber is completely biodegradable and the green complex is made of soy protein resin modified with gelatin. Commercial use of sisal in composites has increased due to strength, low density and environmental friendliness and cost effectiveness**.**

Fig 1. Sisal Plant.

Fig.2 Sisal Fiber.

2. OBJECTIVE

- To identify various materials that can be used in construction as a replacement of concrete materials.
- To make the construction works eco-friendly.
- To enhance the strength of CSRE blocks by adding the Sisal fiber.

Revised Manuscript Received on July 18, 2019.

M Eswar Kumar Yadav, Asst. Prof. Department of Civil Engineering, Aditya Engineering College (A), Surampalem

P R Kishore, Asst. Prof. Department of Civil Engineering, Aditya Engineering College (A), Surampalem

A S Kumar, Asst. Prof. Department of Civil Engineering, Aditya Engineering College (A), Surampalem

A S Swetha Sri, Asst. Prof. Department of Civil Engineering, Aditya Engineering College (A), Surampalem

- To motivate engineers and contractors regarding the usage of natural fibers.

3. MATERIAL CHARACTERISTICS

a) Red Soil: Red soil is the most important part of the Indian land that we can look around like in TamilNadu, Karnataka, Andhra Pradesh and some parts of Madhya Pradesh, Chhattisgarh and Odisha. It is a combination of rock material and ignition part of rock and mountain. Red soils are formed by changes in the atmosphere and the properties of crystalline and metamorphic land. Soil colour is red because iron content is very high. They are found in areas with low precipitation and this colour turns red to reach the heat. There is no nitrogen, phosphorus, or organic material in Indian red soil, but the soil is rich in iron. Some of the major crops grown in our local red soil are peanuts, potatoes, millet, sorghum, palm trees, wheat, and tobacco.
Here, we first collected the soil from our environment (Peddapuram-Andhra Pradesh) and collected the soil at a depth of 0.5-1.5 m. The soil size was determined according to Indian standard 2720-1995 and the soil was exposed. After standing for 24 hours in the atmosphere, the soil was sieved and passed through an IS 4.5 sieve, then the soil was oven dried at 105 ° and subjected to a basic soil test.

Table.1: Properties of Soil Used.

Sl.No.	Property	Quantity
1	OMC (%)	19.3
2	Liquid Limit	35
3	Plastic Limit	18.21
4	Plasticity Index	16.79

b) Cement: Cement is an adhesive material used to make all types of concrete. Of the various types of cement on the market, the 53 grade ordinary Portland cement is identified as ISC 2631-1976 and the final compressive strength of 28 N / mm2 as tested by the DECCAN Company in accordance with ISC 4031-1988. Used for project work. Details of the various tests for cement are as follows.

Table.2: Properties of Cement.

Sl.No.	Test Name	Results
1	Specific Gravity	3.15
2	Normal Consistency	33%
3	Initial Setting Time	55 min.
4	Final Setting Time	210 min.

c) Sisal Fiber: Sisal is a fiber obtained from the leaves of the Agave Sisalana plant. It is from Mexico and is currently being maintained and cultivated in Assam and Indonesia, East Africa, Brazil, Haiti and India**.**

Healthy sisal plants produce about 200-250 leaves consisting of about 1200 fiber bundles per leaf containing about 4% fiber, 0.75% cuticle, 8% dry matter and 87.25% water. Thus, normal leaves will produce about 3% w / w fiber. The sisal leaf is composed of three fibers:-

1. Mechanical, 2. Ribbon and 3. Xylem.

Mechanical fibers are mostly extracted from the edges of the leaves. They have a roughly thick horseshoe shape and almost divide during the extraction process. They are commercially most useful of Sai Fine fibers.

Ribbon fibers occur in the middle of the leaf in relation to conductive tissue. The associated conductive tissue structure of the ribbon fibers provides significant mechanical strength. They are long and can be easily divided longitudinally during machining compared to mechanical fibers.

Xylen fibers are inaccurate in shape and are located on opposite sides of the ribbon fibers through the connections of blood vessels. It is mainly composed of thin-walled cells, which can be easily broken or sometimes lost during the extraction process.

Sisal fiber consists of 65.8% cellulose, 12% hemicellulose, 9.9% lignin, and 0.3% wax and water soluble compound.In many applications, fiber composites require mechanical properties, such as flexibility, good tensile strength, and low wear characteristics. As in previous studies, fibers have been shown to increase the toughness of polymers rather than to increase strength and elastic modulus. Siphon fiber composites have a maximum toughness of about 1250 MNm-2 and a strength of 580 than other fibers. MNm-2.

d) Bamboo: Bamboo is a huge pasture and trees are generally incredible. They belong to Bambu-soideae. Bamboo is very long and mature bamboo is about 30 meters. Bamboo has more benefits and grows fully within a few months. Bamboo is richer in tropical and subtropical regions. Bamboo is found in western Bengal, Sikkim, Manipur, Meghalaya, Nagaland, Tripura, Uttar Pradesh, Arunakul Pradesh and more. There are different types of bamboo depending on the area. They are: 1.Bambusa balcooa. 2. Bambusa pallida. 3. Bambusaburmanica. 4. Melocanna baccifera.In this project we have taken the bambusa balcooa, these bamboos grow in the tropical forest. The bamboo is called as Mullam in this region, we have gathered them from our nearby location (Kakinada-Andhra Pradesh) where they import the bamboo from the tropical forest. The bamboo was harvested at an age greater than 2years, and the bamboo was seasoned for 2months respectively.

The bamboo will then chopped down into the pieces of 1meter length and of equal diameter respectively, with the help of carpenter. Now the bamboo pieces were made into splints of 8mm, 10mm, 12mm diameter and thickness of length 1meter.

Fig 3. Bamboo Splints of 1m Length.

e) Chemicals and Treatment of Bamboo splints: Chemicals are the substances which are pure, in this project we have used boric acid copper sulphate, potassium dichromate as the part of the chemical treatment. Bamboo when exposed to atmosphere it has a chance of attack by insects in-order to prevent the bamboo from insect attacks chemical treatment was done to the bamboo splints. Here the chemicals like Boric acid, copper sulphate and Potassium di-chromate were taken as per IS 1902:2006 with a ratio of 1.5:3:4, now the chemicals per 10 litres of water were taken (150gm: 300gm: 400gm) and mixed separately first and then they were added to the water and mixed thoroughly with a help of a spoon till the colour changes to thick.

Fig 4. Chemical Solution.

Fig 5.Bamboo Splints in Chemical Solution

f) Epoxy Resin Treatment: Epoxy is one of the basic components of the epoxy resin or the cured end product and is the colloquial name of the epoxide functional group. Epoxy resins, also known as polyepoxides, are a family of reactive prepolymers and polymers that contain epoxide groups. A wide range of epoxy resins are produced industrially. Here we have considered the SIKADUR-32 epoxy resin binder, and we have purchased this product from a local retailer.

Fig 6. Sikadur 32 Gel.

Firstly we have taken the SIKADUR 32 gel where the mixture is applied to both the treated and untreated bamboo splints, and with this we have applied the sand which is passed from IS-2.0 and retained on IS-10 MM Sieve, which help as bonding agent for bamboo and soil, now the splints were allowed to dry for 24hours.

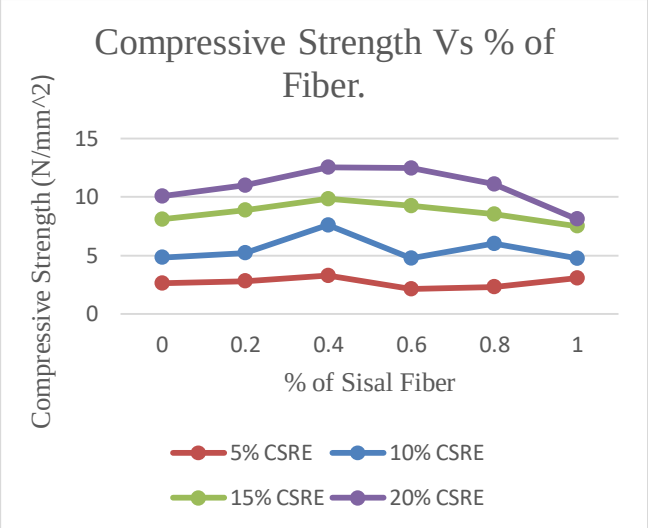
g) Steel: Steel is an alloy of iron, carbon and other elements. High tensile strength and low cost are the main components used in buildings, infrastructure, tools, ships, cars, machinery, electrical products and weapons. Iron is the base metal of steel. Two types of crystals can be taken depending on the temperature. Iron and steel are widely used in road construction, household appliances, railways, and construction.

In our project we are using three different sizes of steel such as 8mm, 10mm, and 12mm diameter respectively of VIZAG TMT.

4. EXPERIMENTAL PROGRAMME

In this experimental study, red soil is mixed by adding four different percentages (5%, 10%, 15%, and 20%) of OPC and sisal fiber with 0.2%, 0.4%, 0.6%, 0.8%, and 1.0% by weight of soil respectively. The bamboo splints were treated by soaking them in chemical solution of boric acid, Copper -Sulphate and Potassium Di-chromate (1.5:3:4).The resin-based adhesive with coarse sand will be applied to the top of bamboo splints. After 28days of curing period the cubes were tested for compressive strength, pull-out test is done for a series of CSRE blocks in which. Bamboo splints and steel bars are embedded to find out its bond strength.

5. TEST RESULT & GRAPH



Graph 1. Compressive strength vs percentage of fiber graph

TABLE 5.1: CUMMULATIVE COMPRESSIVE STRENGTH OF SISAL FIBERED CUBES.

Sl.No.	Percentage of Fiber	Percentage of Cement	Compressive Strength (N/mm^2)
1	0	5%	2.616
		10%	4.831
		15%	8.086
		20%	10.065
2	0.20%	5%	2.808
		10%	5.213
		15%	8.873
		20%	10.99
3	0.40%	5%	3.263
		10%	7.586
		15%	9.83
		20%	12.546
4	0.60%	5%	2.122
		10%	4.754
		15%	9.239
		20%	12.46
5	0.80%	5%	2.308
		10%	6.004
		15%	8.523
		20%	11.094
6	1%	5%	3.054
		10%	4.737
		15%	7.516
		20%	8.113

TABLE 5.2: DETAILS OF MODE OF FAILURE OF TEST SPECIMEN.

Sl.No.	Series	Length (mm)	Average Perimeter (mm)	Average Ultimate Bond Stress (Mpa)	Bond Strength
1	S8	150	28.4	7600	2.02
2	S10	150	35.7	5400	1.152
3	S12	150	42.6	4200	0.74
4	8BTP	150	28.4	11800	3.14
5	10BTP	150	35.7	10600	2.26
6	12BTP	150	42.6	12400	2.20
7	8BTN	150	28.4	6000	1.60
8	10BTN	150	35.7	6400	1.36
9	12BTN	150	42.6	7600	1.35
10	8BUTP	150	28.4	5800	1.54
11	10BUTP	150	35.7	7600	1.62
12	12BUTP	150	42.6	9800	1.74
13	8BUTN	150	28.4	9600	2.56
14	10BUTN	150	35.7	9600	2.04
15	12BUTN	150	42.6	10400	1.84

6. CONCLUSION

In this Project the Compressive Strength of CSRE blocks are obtained from compressive strength test and Bond strength characteristics of untreated, treated bamboo splints and steel rebar's embedded in Cement Stabilized Rammed Earth (CSRE) blocks were obtained from pullout test. After going through all the project work done we have made some of the conclusions. They are:

- The Compressive strength is more for 20% CSRE blocks compared to other percentages (5%, 10% and 15%) of CSRE Blocks.
- In addition of Sisal fiber to CSRE blocks the compressive strength increases from 0% of sisal fiber to 0.4% of sisal fiber and it gradually decreases afterwards.
- The compressive strength is more for 0.4% sisal fibered CSRE blocks.
- Compared to all the compressive strength values we have observed that the compressive strength is more for 0.4% sisal fibered 20% CSRE blocks which is 12.546 N/mm^2..
- So we can conclude that the 0.4% is the required optimum fiber content and 20% is the required optimum cement content for casting the pullout test blocks.
- Finally in the Pullout test we have obtained the greater Strength and deflection of the Reinforced CSRE Blocks.
- The study can add value in areas such as green and sustainable housing and waste utilization.

7. FUTURE SCOPE OF STUDY

In Regard of project "INFLUENCE OF SISAL FIBER ON THE PROPERTIES OF RAMMED EARTH" following things can be taken for future study.

- We can use different natural fibers like banana fiber, Jute fiber etc., in the place of sisal fiber and can test for compression and bond strength.
- A study on the effect of corrosion on the bond strength of Reinforced Rammed earth blocks.
- Study on Bond strength of Bamboo reinforced Rammed earth with different stabilizers.

REFERENCE

1. Abrishami, H. H., and D. Mitchell. 1996. "Analysis of Bond Stress Distributions in Pull-out Specimens." Journal of Structural Engineering 122 (3): 255–261. Berge, B. 2009.
2. Ghavami, K. 2005. "Bamboo As Reinforcement in Structural Concrete Elements." Cement and Concrete Composites 27 (6): 637–649.
3. Ghavami k, Hombeeck RV, Application of bamboo as a construction material: Part 1-Mechanical properties and water repellent treatment of bamboo, Part II-Bamboo reinforced concrete beams. In: Proc of Latin American Symp ON Rational Organization of Building Applied to Low Cost Housing. CIB, Sao Paulo, Brazil, 1981. P. 49-66.
4. Ghavami K. Application of Bamboo as a low-cost construction material. In: Proc of Int Bamboo Workshop, choin, India, 1988. P, 270-9.
5. Janssen JA. Bamboo in building structures, PhD thesis, Endio-ven University of Technology, Holland, 1981.
6. Morel JCmMeshah A, Oggerto M, Walker P. Building Houses with Local Materials: Means to drastically reduce the environmental impact of construction, Building and Environment 2001:36:119-26
7. Janssen JA. The importance of bamboo as a building material. Bamboos current research. In: Proc of the Int Bamboo Workshop, Kerala Forest Research Institute—India & IDRC—Canada, 1988 .p.235-41.
8. Dunkelberg K et al. Bamboo as a building material. Bamboo-IL31, Institute for light weight Structures, University of Stuttgart, 1985. P. 1-431.
9. Walker, P.J.., and S.Dobson. 2001. "Pullout Test on Deformed and Plain Rebars in cement-stabilized Rammed Earth" Journal of Materials in civil engineering 13(4):291-297.
10. Yankelevsky, D.Z.1985 "Bond Action between Concrete and a Deformed Bar- A New Model..." Journal of American Concrete Institute 82(2): 154-161