Journal of Advanced Engineering Research
ISSN: 2393-8447
Volume 10, Issue 2, 2023, pp.208-213

Study on Rammed Earthen Walls Retrofitted using Natural Fibers

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ABSTRACT

According to today's trend buildings are built with architectural elevations and more aesthetic beauty. Modern architectural buildings are expensive, so here comes the scope of rammed earthen houses which can be built with architectural elevations within our budget. In the present study rammed earthen walls retrofitted using coir fibre with bamboo splints and banana petiole strip framed strengthening technique is investigated. Rammed earthen walls are generally thick and bulky, built by compacting sand- soil matrix in successive layers inside a rigid temporary formwork. In previous research, only the strength performance of earth rammed walls were analysed, which was found not satisfactory. But earth rammed walls which are retrofitted and contains coir fibre content as reinforcement and was not studied widely. So, the earth rammed walls when reinforced with coir fibres and retrofitted with bamboo splints will improve the load bearing capacity of the built-up structure. Thus, this investigation is carried out to determine the mechanical properties of fibre reinforced retrofitted earth rammed walls.

Keywords – Rammed Earthen Walls, Retrofitting, Mechanical Properties, Banana Petiole Strip, Strengthening Technique.

1. Introduction

According to today's trend buildings are built with architectural elevations and more aesthetic beauty. Modern architectural buildings are expensive, so here comes the scope of rammed earthen houses which can be built with architectural elevations within our budget. The use of local materials in construction of buildings is one of the potential ways to support sustainable development in both urban and rural areas. In the present study focuses on mechanical characteristics of various types of rammed earths retrofitted with bamboo and banana strip. Bamboo and Banana strip are widely available worldwide and banana strip is an agricultural waste from banana cultivation. Apart from domestic buildings it can also be used in eco-friendly farmhouses, mud bungalows etc. Rammed earthen walls is generally thick and bulky, built by compacting sand-soil matrix in successive layers inside a rigid temporary formwork.

2. Experimental Program

The soil samples are collected and sieved through IS recommendations. Model rammed earth prototype of 15 cm × 15 cm × 15cm were cast.

2.1 Materials

Retrofitting of the rammed earth was done by using bamboo strips and banana petiole strips.

2.2 Mixing Procedure

2.2.1 For Unstabilised Rammed Earth

Soil samples are thoroughly mixed with water at OMC (Optimum Moisture Content) and placed in 3 successive layers of equal thickness inside the framework. Each layer is compacted with 30 blows using a steel rammer. Then, the wallet model including the formwork is cured in open air for 7 days in the lab. The model wallet is allowed to cure in sunlight for the next 3 weeks to attain adequate strength. These sundried earthen walls are retrofitted by bamboo strip and banana strip.

2.2.2 For Stabilised Rammed Earth

Soil samples are thoroughly mixed with Portland cement (5% by weight of soil) and then, placed in 3 successive layers of equal thickness inside the frame work. Each layer is compacted with 30 blows using a steel rammer. A day after casting, the wallet model is unmolded. The model wallet is moist cured under wet burlap wrapped in plastic cover for 7 days and then,

kept in sunlight for the next 3 weeks to obtain attain adequate strength.

2.3 Preliminary Test

2.3.1 Hydrometer Test

Elapsed time, t(min)	**Hydrometer readings, Rh**	**Effective height, He(cm)**	**Particle Size D(mm)**	**N%**
1/2	20	12.4	0.067	66.66
1	19	12.6	0.047	63.338
2	18	13	0.034	60
4	17	12	0.023	56.667
8	16	12.4	0.016	53.33
15	14	13.1	0.0125	46.667
30	13	13.5	0.009	43.334
60	11.5	14	0.0065	38.33
1440	9	14.9	0.00137	30

Fig 1:- Observations – Sedimentation Analysis

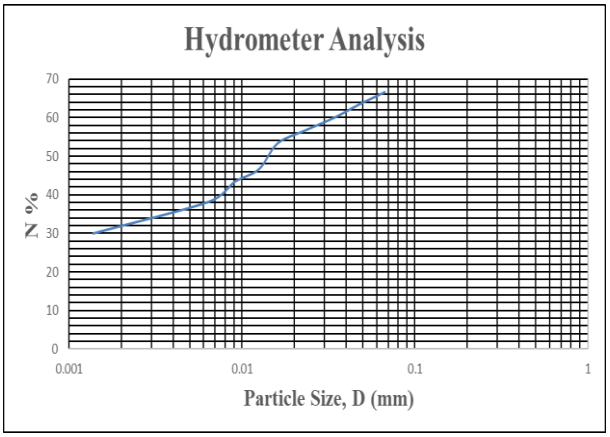

Fig 2 :- Hydrometer analysis graph

From the hydrometer graph the Percentage Clay content of soil sample taken was obtained as 32%. The percentage of clay for Rammed Earthen Walls is 30% - 40%. Therefore, the soil sample taken can be used for further process.

2.3.2 Determination of specific gravity by Pycnometer method

Observations and Calculations :

Weight of Pycnometer (W1)g = 623g

Weight of Pycnometer + Dry soil, (W2)g = 823g

Weight of Pycnometer + Dry soil + Water,

(W3)g = 1634g

Weight of Pycnometer + Water, (W4)g = 1514g

Specific Gravity,

$$G = ((W2-W1))/((W2-W1)-(W3-W4))$$

$$= (823-623)/((823-623)-(1634-1514)) = 2.5$$

2.3.3 Standard Proctor Test

Standard Proctor Test is carried out for finding the optimum moisture content.

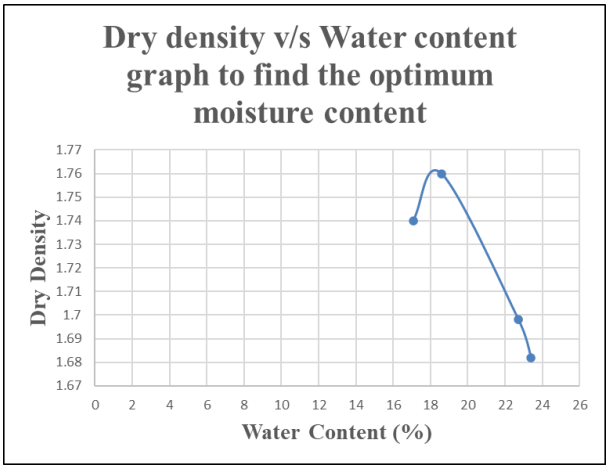

Fig 3 :- Graph to find the optimum moisture content.

From the graph, the optimum moisture content = 18.2%

2.3.4 Sieve Analysis

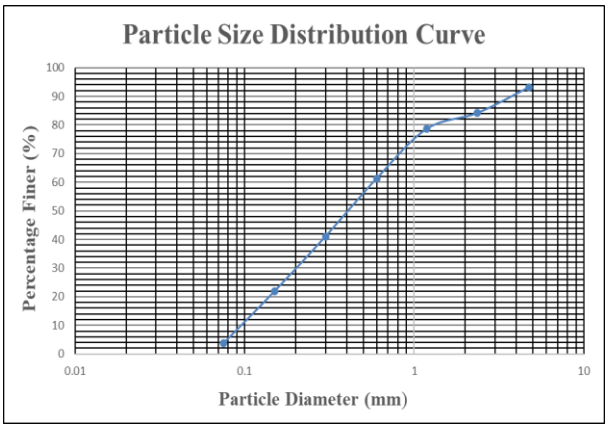

Fig 4 :- Graph showing the particle size distribution curve

D10=0.095mm

D30=0.2mm

D60=0.55mm

Uniformity coefficient, Cu = $D60/D10$ = 5.79

Coefficient of curvature, Cc = $D^2 30/(D60\ X\ D10)$ = 0.76

3. Experimental Setup

Model rammed earth prototype of 15 cm × 15 cm × 15cm were casted for different cases and tested for compressive strength.

3.1 Casting and Testing of Rammed Earth(Unstabilised)

3.1.1 Casting of Rammed Earth specimens

Fig 5 :- Model rammed earthen wallets.

3.1.2 Retrofitted using Bamboo Strip

Fig 6 :- Model rammed earthen wallet retrofitted using bamboo strip in one way

Fig 7 :- Model rammed earthen wallet retrofitted using bamboo strip in both ways

3.1.3 Retrofitted using Banana Petiole Strip

Fig 8 :- Model rammed earthen wallet retrofitted using banana petiole strip in one ways

Fig 9 :- Model rammed earthen wallet retrofitted using banana petiole strip in both ways

3.1.4 Testing of Rammed Earth Retrofitted using Bamboo Strip

Fig 10 :- Testing of rammed earthen wallet retrofitted using bamboo strip in one and both ways.

3.1.5 Testing of Rammed Earth Retrofitted using Banana Petiole Strip

Fig 11 :- Testing of rammed earthen wallet retrofitted using banana petiole strip in one and both ways.

3.2 Results and Discussions

Cases	**Compressive Strength (N/mm^2)**	**Improvement in Strength compared to Earth only (%)**
Earth only	1.42	0
Earth + Bamboo	1.95	37.32

one way		
Earth + Bamboo two way	2.1	47.88
Earth + Coir fiber	1.84	29.57
Earth + Coir fiber + Bamboo one way	2.23	57.04
Earth + Coir fiber + Bamboo two way	3.01	111.97
Earth + Banana strip one way	1.71	20.42
Earth + Banana strip two way	1.86	30.98
Earth +coir fiber + Banana strip one way	1.98	39.43
Earth + coi fiber + banana strip both ways	2.13	50

Fig 11 :- Comparison between compressive strength of different specimens and Improvement in compressive strength compared to earth only

3.3 Casting and Testing of Rammed Earth(Stabilised)

Fig 12 :- Casting and Testing of Stabilised mix

3.3.1 Test Results For Stabilized RE

Case	Compressive Strength (N/Mm^2)	Improvement In Strength Compared To Earth Only (%)
Earth + Coir fiber + Bamboo two way	3.46	143.6

Fig 13:- Test Results For Stabilized RE

- For cement stabilized rammed earth, had improved the compressive strength by 31.63% compared to unstabilized RE specimen.

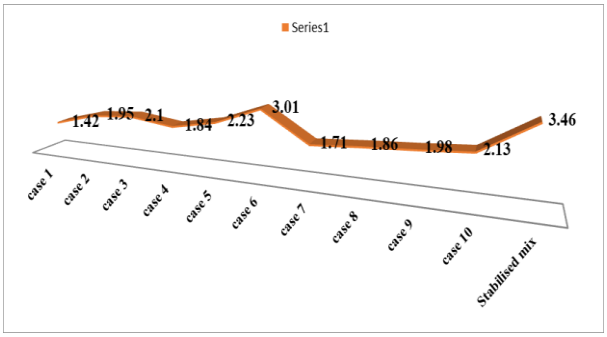

Fig 14 :- Graph showing the comparison of compressive strength of RE specimens

CONCLUSION

All round the world construction materials generate million tons of waste annually. These construction materials require high embodied energy resulting with large CO2 (Carbon Dioxide) emissions. Modern architectural elevations are expensive, So here comes the scope of rammed earth structures which is non-toxic, sustainable and eco-friendly. Since, the sole usage of rammed earth be unsure of providing a strong and durable life for structures, the rammed earth can be reinforced or retrofitted with natural fibers. This present

study, aims at determining the feasible rammed earth mix for durable construction. From the test results it was found that the reinforced or retrofitted rammed earth shows higher compressive strength than earth rammed walls. Also the rammed earth mix which are both retrofitted and reinforced showed high strength than reinforced rammed earth mix. Thus, the rammed earth mix which is reinforced using coir fiber and retrofitted using bamboo splints in both ways showed an improvement of 111.97% in compressive strength as compared to normal rammed earth mix. The unstabilised optimum mix can be stabilized using 5% of OPC and had improved the compressive strength by 31.63% compared to unstabilized RE specimen.

REFERENCE

1. Bipul Sen, Experimental and numerical investigation of mechanical strength characteristics of natural fiber retrofitted rammed earth walls, *Geotextiles and Geomembranes,* 50 (2022).
2. Moein Ramezanpour, Seismic performance of stabilised/unstabilised rammed earth walls, *Engineering Structures,* 245 (2021).
3. J. Canivell, Analysis of the materials and state of conservation of the medieval rammed earth walls of Seville, *Journal of Building Engineering* 44 (2021)
4. Juan P. Villacreses, Seismic and hydromechanical performance of rammed earth walls under changing environmental conditions, *Construction and Building Materials* 300 (2022).
5. Bhattacharya S, A critical review of retrofitting methods for unreinforced masonry structures, *International Journal of Disaster Risk Reduction* 7 (2014).