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Improving the Properties of Stabilized Mud Composites Utilizing PET Plastic Binders and Bamboo Fiber Reinforcement

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Abstract: This study investigates the development of stabilized mud composites (SMCs) using melted PET plastic as a binder and bamboo fibers as reinforcement. The research focuses on formulating and optimizing PET-Bamboo SMCs to improve mechanical strength, durability, and thermal properties. The methodology includes soil characterization, bamboo fiber extraction and treatment, and preparation of composite samples with varying proportions. The optimal mix ratio of mud and plastic was determined, with 60% PET plastic (SP60) yielding the highest compressive strength. Further investigation evaluated the impact of bamboo fiber addition, revealing that a 4% fiber content (SP60-4) significantly improves compressive strength and mitigates brittle failure. The SP60-4 composite demonstrates superior compressive strength and water absorption performance compared to conventional stabilized mud composites with alternative stabilizers. This research highlights the potential of PET-Bamboo SMCs as high-performance materials for construction, offering enhanced mechanical properties and water resistance. The findings provide valuable insights for developing scalable applications in the construction industry.
Keywords: PET plastic, bamboo fibers, stabilized mud composites (SMCs), compressive strength, mechanical properties, construction materials, water absorption, material optimization.

I. INTRODUCTION

The construction industry continually seeks innovative materials to meet evolving structural demands while enhancing efficiency and performance. Stabilized Mud Composites (SMCs), made from a combination of mud, stabilizers, and reinforcements, have garnered interest for their affordability, adaptability, and practicality. Despite their promise, SMCs face challenges such as limited mechanical strength, susceptibility to cracking, and durability issues, which restrict their application in modern construction. Addressing these shortcomings is crucial to unlocking their full potential as a viable alternative in structural and non-structural elements. This research investigates the use of melted PET plastic as a binder and bamboo fibers as reinforcement to overcome the limitations of traditional SMCs. PET plastic, widely recognized for its binding strength and durability, provides structural integrity, while bamboo fibers, with their superior tensile properties, enhance the composite’s performance under stress. Together, these materials offer a strategic approach to improving SMCs' compressive and tensile strength, durability, and resistance to water absorption. By optimizing the proportions of mud, PET plastic, and bamboo fibers, this study aims to develop a high-performance composite capable of meeting the demands of modern construction. The findings not only provide insights into material behavior and performance but also present a practical pathway for integrating innovative materials into construction practices, advancing the scope and versatility of SMCs for diverse applications

II. NEED AND SCOPE OF STUDY.

The need for this study arises from the growing interest in advancing construction materials that enhance mechanical properties while maintaining cost-effectiveness and sustainability. By incorporating PET plastic binders and bamboo fiber reinforcements, this research aims to improve the strength, durability, and thermal efficiency of Stabilized Mud Composites (SMCs). The study seeks to explore innovative ways of developing these composites to overcome the current limitations of traditional SMCs, particularly in terms of tensile strength, cracking resistance, and overall structural integrity. The scope of this research includes formulating and optimizing the mix proportions of PET plastic and bamboo fibers in SMCs to enhance their mechanical properties. Extensive performance evaluations, such as compressive strength, water absorption, and tensile strength testing, will be conducted to assess the composite’s structural integrity.

The feasibility of scaling up the production of PET-Bamboo SMCs for real-world applications will be assessed, along with a cost comparison to conventional materials. Finally, the study will provide recommendations for optimizing the use of these enhanced composites in modern construction practices, aiming to offer viable solutions for the sustainable and efficient construction industry.

III. OBJECTIVES OF STUDY

1) To determine optimal mix proportion of melted PET, bamboo fibre and mud to obtain a stabilized mud composite. (SMC)
2) To compare the effect of bamboo fibre on the mechanical properties of the SMC.
3) To compare the stabilized PET-bamboo fibre -mud composite with ordinary Stabilized Mud Composites.

IV. MATERIALS USED

1) *Soil* : Soil samples were collected from four different locations in Askhuto town, Zunheboto district, following the guidelines outlined in the Indian Standards (IS).For optimal mud block construction, the soil should ideally contain 10-15% gravel, 50-75% sand, and 15-30% silt and clay. Seive analysis and Atterberg limit tests were conducted as per IS: 2720 (Part-5): 1985.
2) Mature bamboo, aged between 3 and 5 years, was selected for reinforcement purposes in the composite. To extract the fibers, long steel rods were used to manually puncture holes through the bamboo culms, leaving the bottom culm unpunctured. The bamboo was then immersed in a solution of 10% borax and boric acid for seven days to improve insect resistance and preserve the material. After the treatment period, the bamboo was punctured at the unpunctured end to allow excess solution to drain, and this drained solution was recycled. The treated bamboo poles were left to dry in a cool, dry area, ensuring effective solution settling. Subsequently, the bamboo was exposed to sunlight for a week to further dry and naturally bleach, giving it a golden yellow hue. After this drying process, the bamboo was cut into 1 cm lengths and 0.75 mm thick fibers for use in the composite preparation.
3) PET Plastic Waste: PET plastic waste was gathered from around the campus and crushed into smaller fragments for use in the composite. The PET plastic will be processed and melted to act as a binder in the Stabilized Mud Composites (SMCs).
4) Bitumen and Thinner: Additional quantities of bitumen and thinner were used in the mix to maintain consistency, ensuring proper binding and a uniform texture in the composite.
5) Mold Preparation: Molds with dimensions of 230mm x 190mm x 100mm were prepared using wood. These molds will be used for casting the composite samples, ensuring standardized shape and size for testing and evaluation.

V. METHODOLOGY

1) Soil Preparation and Test:
   - Gather soil samples for the composite preparation.
   - Conduct tests to evaluate soil properties like composition, moisture content, and particle size distribution.
2) Soil Stabilization:
   - Prepare stabilized soil samples using lime/cement and sand to standardize soil conditions for composite production.
3) Bamboo Treatment and Fiber Extraction:
   - Identify and collect bamboo species suitable for fiber extraction.
   - Treat bamboo strips with 5% boric acid solution to enhance properties.
   - Extract fibers from treated bamboo using mechanical or chemical processes, ensuring quality and uniformity.
4) Material Preparation:
   - Gather mud, melted plastic, and bamboo fiber in varying proportions for trialing composite mixes.
   - Conduct preliminary trials to determine stable mix proportions for composite creation.
5) Composite Creation:
   - Prepare composite samples using the finalized mix proportions.Fabricate multiple samples for subsequent testing and analysis.
6) Testing Procedure:
   - Compressive and Tensile Strength:Perform tests according to IS standards for both compressive and tensile strength.
   - Utilize standardized testing equipment and protocols for accuracy.
   - Record and analyze the obtained data comprehensively.
7) Impact of Bamboo Fiber Percentage:
   - Vary the percentage of bamboo fiber in composite samples systematically.
   - Document and analyze the effects on the properties (strength) of the composite.

8) Comparative Analysis:
- Compare the developed composite's properties (strength) with ordinary mud stabilized composites.

V. RESULT AND DISCUSSION

A. Sieve Analysis

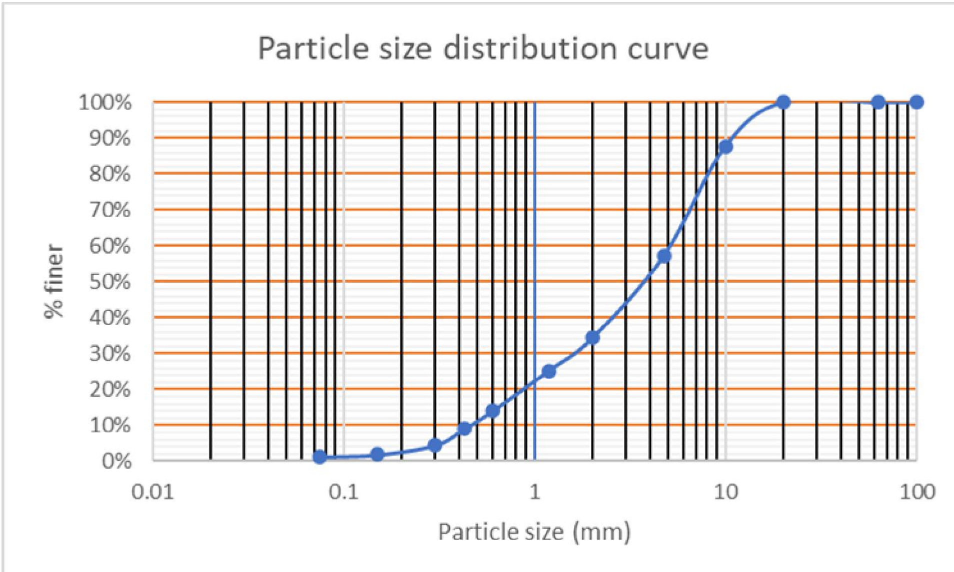

Figure -1: Seive analysis result of sample 1

Gravel(4.75-75mm)	43%
Sand (4.75mm-0.075mm)	56%
Silt and clay (<0.075mm)	1%

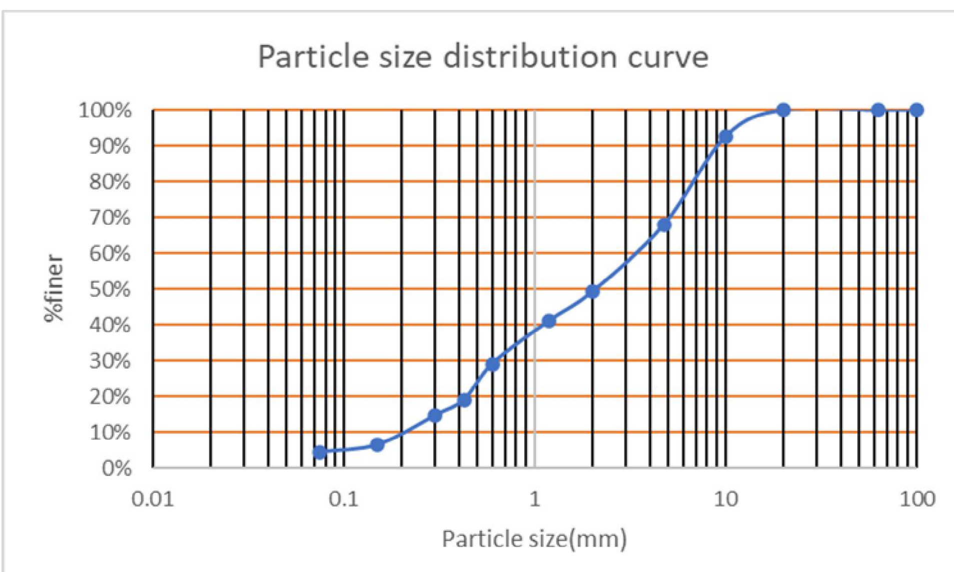

Figure 2: Seive analysis result of sample 2

Gravel(4.75-75mm)	32%
Sand (4.75mm-0.075mm)	63%
Silt and clay (<0.075mm)	4%

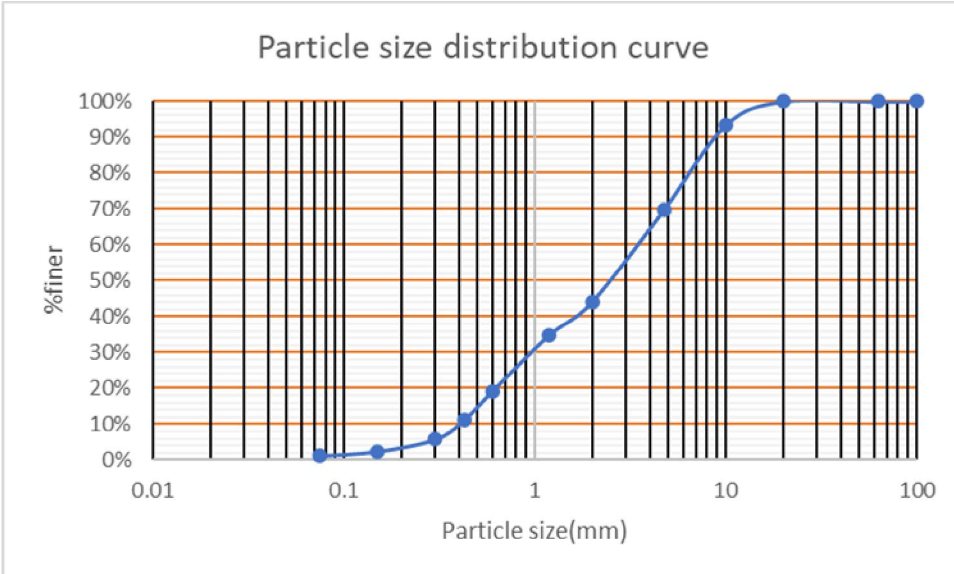

Figure -3: Seive analysis result of sample 3

Gravel(4.75-75mm)	30%
Sand (4.75mm-0.075mm)	69%
Silt and clay (<0.075mm)	1%

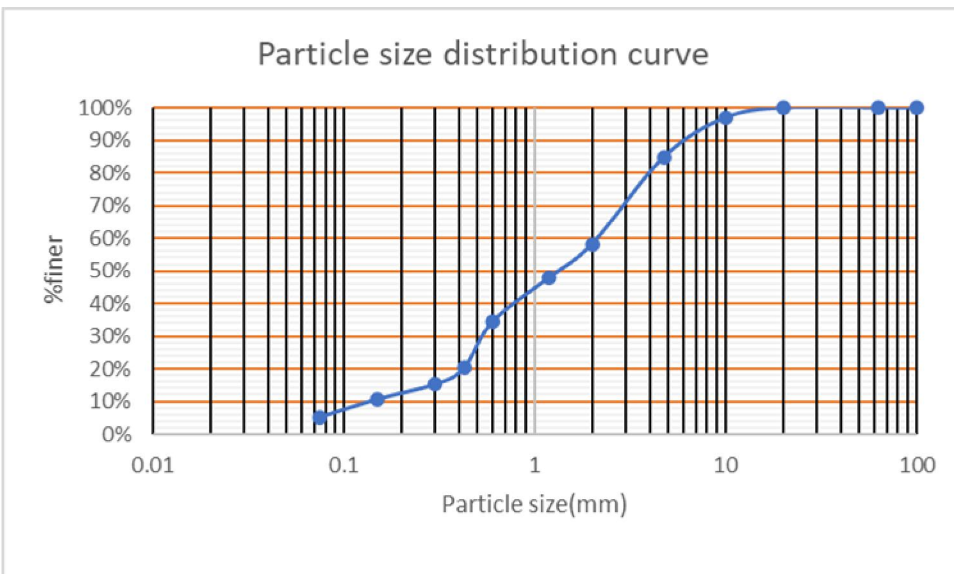

Figure -4: Seive analysis result of sample 4

Gravel(4.75-75mm)	15%
Sand (4.75mm-0.075mm)	80%
Silt and clay (<0.075mm)	5%

From the sieve analysis report, it was found that sample 4 has almost similar proportions for making a good mud block. Sample 4 has 15% gravel, 80% Sand and 5% silt and clay.

Sample	Liquid limit (%)	Plastic Limit(%)	Plasticity index(%)
1	42.8	41.2	1.6
2	35.9	32.4	3.5
3	53	27.2	25.7
4	36.4	24.4	12

Mixing proportions of soil and plastic

PROPORTIONS SELECTED	DESCRIPTION
S	Soil only
SP40	Soil+plastic-40%
SP50	Soil+plastic-50%
SP60	Soil+plastic-60%
SP70	Soil+plastic-70%

Mixing proportions of soil, plastic & bamboo fibre

PROPORTIONS SELECTED	DESCRIPTION
SP60-1	Bamboo fibre-1%
SP60-2	Bamboo fibre-2%
SP60-3	Bamboo fibre-3%
SP60-4	Bamboo fibre-4%
SP60-5	Bamboo fibre-5%

Table 1 Composite mix of varying PET without fibre

MIX PROPORTION FOR STABILISED MIX FOR TESTING COMPRESSSIVE STRENGTH

Plastic 40%

SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	2	0.5	0.5
2	GCD		1	5	5
3	RATIO W.R.T DRY SOIL		5:2	1:0.1	1:0.1
4	PERCENTAGE	100%	40%	10%	10%

Plastic 50%

SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	2.5	0.5	0.5
2	GCD		1	5	5
3	RATIO W.R.T DRY SOIL		5:2.5	1:0.1	1:0.1
4	PERCENTAGE	100%	50%	10%	10%

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Plastic 60%					
SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	3	0.5	0.5
2	GCD		1	5	5
3	RATIO W.R.T DRY SOIL		5:3	1:0.1	1:0.1
4	PERCENTAGE	100%	60%	10%	10%

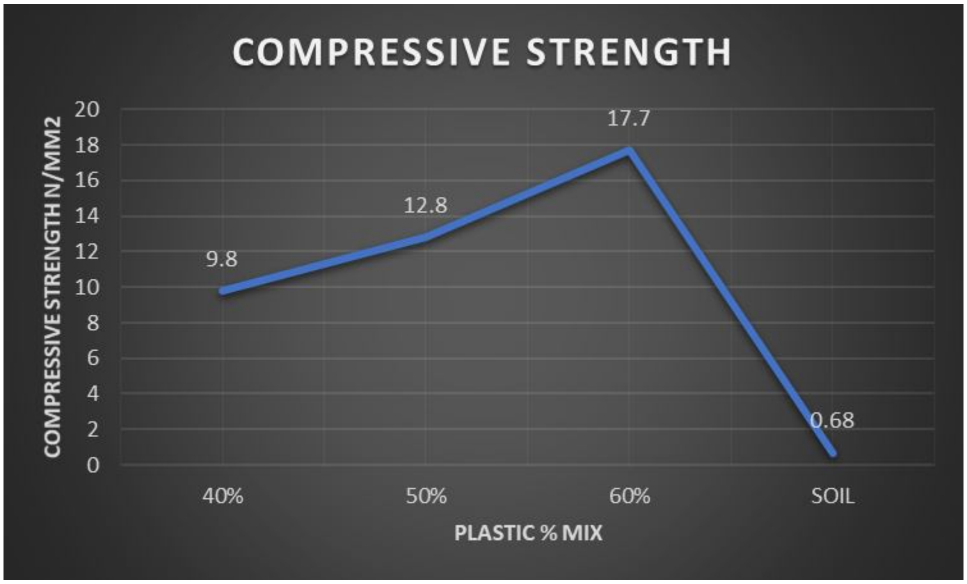

Figure -5: Compressive strength of Composite mix of varying PET without fibre

Table 2 Composite mix of PET with varying percentages of fibre

TABLE:2						
MIX PROPORTION FOR STABILISED MIX FOR TESTING COMPRESSSIVE STRENGTH						
FIBRE 1%						
SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	FIBRE (kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	3	0.05	0.5	0.5
2	GCD		1	5	5	5
3	RATIO W.R.T DRY SOIL		5:3	1:0.01	1:0.1	1:0.1
4	PERCENTAGE	100%	60%	1%	10%	10%
FIBRE 2%						
SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	FIBRE (kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	3	0.1	0.5	0.5
2	GCD		1	5	5	5
3	RATIO W.R.T DRY SOIL		5:3	1:0.02	1:0.1	1:0.1

4	PERCENTAGE		60%	2%	10%	10%
FIBRE 3%						
SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	FIBRE (kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	3	0.15	0.5	0.5
2	GCD		1	5	5	5
3	RATIO W.R.T DRY SOIL		5:3	1:0.03	1:0.1	1:0.1
4	PERCENTAGE		60%	3%	10%	10%
FIBRE 4%						
SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	FIBRE (kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	3	0.2	0.5	0.5
2	GCD		1	5	5	5
3	RATIO W.R.T DRY SOIL		5:3	1:0.04	1:0.1	1:0.1
4	PERCENTAGE		60%	4%	10%	10%
FIBRE 5%						
SL NO	INGREDIENT	MUD (Kg)	PLASTIC (Kg)	FIBRE (kg)	BITUMEN (Litre)	THINNER (Litre)
1	QUANTITY	5	3	0.25	0.5	0.5
2	GCD		1	5	5	5
3	RATIO W.R.T DRY SOIL		5:3	1:0.05	1:0.1	1:0.1
4	PERCENTAGE		60%	5%	10%	10%

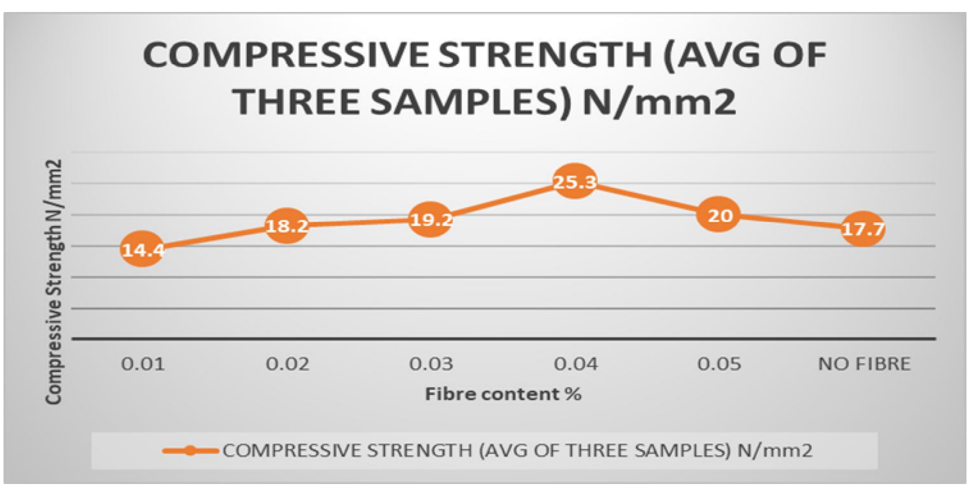

Figure -6: Compressive strength of Composite mix of PET with varying percentages of fibre

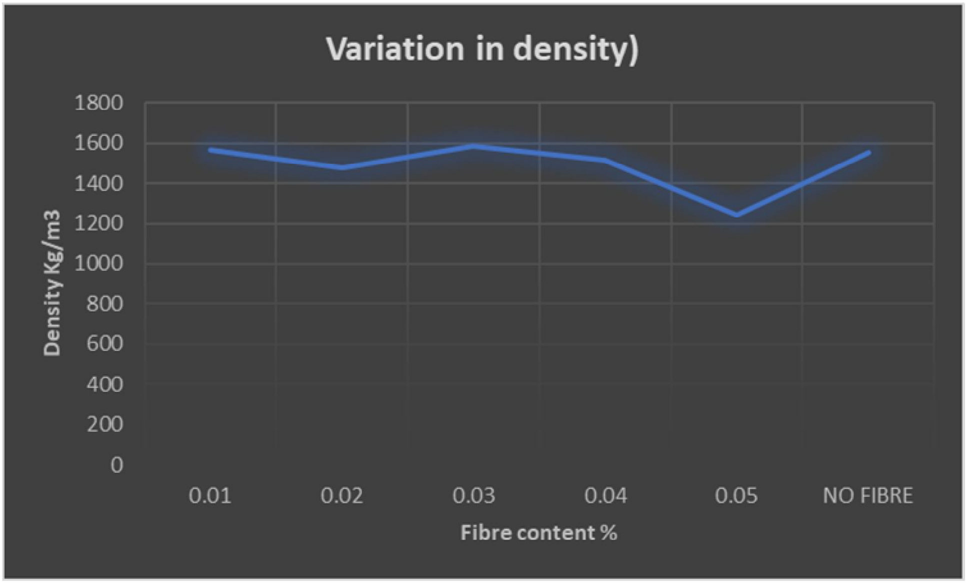

Figure -7: Variation in density of Composite mix of PET with varying percentages of fibre

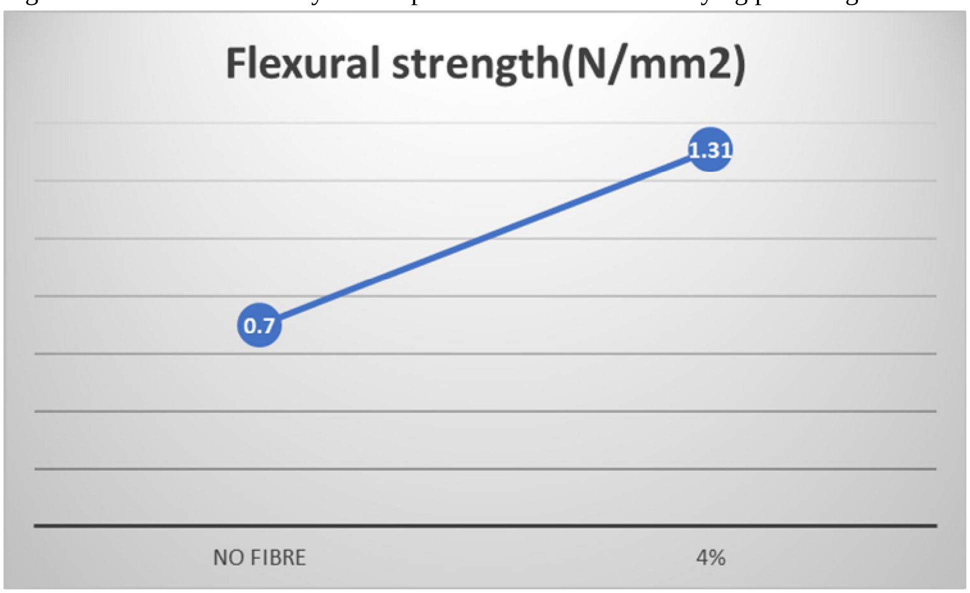

Figure -8: Variation in flexural strength of Composite mix

Table 3: Water absorption on different samples

ITEM	WEIGHT OF SAMPLE(g)	WEIGHT AFTER 24HR SOAKING (g)	%water absorption
SP60	5990	6030	0.67%
SP60-1	5750	5800	0.87%
SP60-2	6030	6097	1.11%
SP60-3	6110	6250	2.29%
SP60-4	5030	5160	2.58%
SP60-5	5090	5220	2.55%

VI. CONCLUSION

1) The stabilized mix with 60% PET and 4% bamboo fibers (SP60-4) achieved a compressive strength of 25.3 N/mm², demonstrating more than a 700% improvement compared to soil stabilized with 15% cement.
2) The addition of 4% bamboo fibers increased tensile strength by 87.14%, highlighting the role of fibers in improving the mix's ductility and tensile performance.
3) The water absorption rate of the mix was 2.6%, meeting the IS standards, ensuring durability and resistance to moisture-related degradation.
4) The optimized mix is affordable and contributes to sustainability by repurposing PET waste and reducing dependence on traditional stabilizers like cement.
5) The results indicate that the SP60-4 mix offers superior strength, reduced brittleness, and moisture resistance, making it suitable for soil stabilization applications.
6) The use of PET binders and bamboo fibers shows significant promise as a sustainable construction material, with potential for broader application as advancements in plastic melting technologies progress.

REFERENCES

[1] N. P. Vignesh, N. Arunachelam, K. Mahendran, and B. Dinesh Kumar, “A Study on Polymeric Fibre Reinforced Stabilized Mud Blocks,” IOP Conf. Ser. Mater. Sci. Eng., vol. 1026, no. 1, p. 012010, Jan. 2021, doi: 10.1088/1757-899X/1026/1/012010.
[2] Y. Xian, D. Ma, C. Wang, G. Wang, L. Smith, and H. Cheng, “Characterization and Research on Mechanical Properties of Bamboo Plastic Composites,” Polymers, vol. 10, no. 8, Art. no. 8, Aug. 2018, doi: 10.3390/polym10080814.
[3] Y. O. Babatunde, R. A. Ibrahim, and D. O. Oguntayo, “Effect of mix proportion on the strength and durability of plastic and sand composite for construction applications,” Innov. Infrastruct. Solut., vol. 7, no. 6, p. 333, Dec. 2022, doi: 10.1007/s41062-022-00930-9.
[4] S. Panda and D. Behera, “Effect of red mud on mechanical and chemical properties of unsaturated polyester-epoxy-bamboo fiber composites,” Mater. Today Proc., vol. 4, no. 2, Part A, pp. 3325–3333, Jan. 2017, doi: 10.1016/j.matpr.2017.02.219.
[5] Y. Xian, H. Li, C. Wang, G. Wang, W. Ren, and H. Cheng, “Effect of White Mud as a Second Filler on the Mechanical and Thermal Properties of Bamboo Residue Fiber/Polyethylene Composites,” BioResources, vol. 10, no. 3, Art. no. 3, May 2015.
[6] M. Thiam and M. Fall, “Engineering properties of a building material with melted plastic waste as the only binder,” J. Build. Eng., vol. 44, p. 102684, Dec. 2021, doi: 10.1016/j.jobe.2021.102684.
[7] Y. O. Babatunde, J. Mwero, R. Mutuku, Y. Jimoh, and D. Oguntayo, “Effects of filler types on the microstructural and engineering properties of waste plastic binder composite for construction purposes,” Cogent Eng., vol. 9, no. 1, p. 2143057, Dec. 2022, doi: 10.1080/23311916.2022.2143057.
[8] C. K. Subramaniaprasad, B. M. Abraham, and E. K. Kunhanandan Nambiar, “Influence of Embedded Waste-Plastic Fibers on the Improvement of the Tensile Strength of Stabilized Mud Masonry Blocks,” J. Mater. Civ. Eng., vol. 27, no. 7, p. 04014203, Jul. 2015, doi: 10.1061/(ASCE)MT.1943-5533.0001165.
[9] Y. Babatunde, J. Mwero, R. Mutuku, Y. Jimoh, and D. Oguntayo, “Influence of material composition on the morphology and engineering properties of waste plastic binder composite for construction purposes,” Heliyon, vol. 8, no. 10, p. e11207, Oct. 2022, doi: 10.1016/j.heliyon.2022.e11207.
[10] M. Thiam, M. Fall, and M. S. Diarra, “Mechanical properties of a mortar with melted plastic waste as the only binder: Influence of material composition and curing regime, and application in Bamako,” Case Stud. Constr. Mater., vol. 15, p. e00634, Dec. 2021, doi: 10.1016/j.cscm.2021.e00634.
[11] M. Thiam and M. Fall, “Mechanical, physical and microstructural properties of a mortar with melted plastic waste binder,” Constr. Build. Mater., vol. 302, p. 124190, Oct. 2021, doi: 10.1016/j.conbuildmat.2021.124190.
[12] C. Prasad, E. K. K. Nambiar, and B. M. Abraham, “Plastic Fibre Reinforced Soil Blocks as a Sustainable Building Material,” 2012. Accessed: Dec. 24, 2023. [Online]. Available: https://www.semanticscholar.org/paper/Plastic-Fibre-Reinforced-Soil-Blocks-as-a-Building-Prasad-Nambiar/dc8f84eccd671f1d7fc914f40a3233af30720c4a
[13] V. Prakash and A. Raj, “STUDIES ON STABILIZED MUD BLOCK AS A CONSTRUCTION MATERIAL,” Nter Natl. Jour Nal Nnovative Resear Ch Adv. Eng. Ing, vol. 3, 2016
[14] N. M. Yusof et al., “Effects of Boric Acid Pretreatment on the Properties of Four Selected Malaysian Bamboo Strips,” Forests, vol. 14, no. 2, Art. no. 2, Feb. 2023, doi: 10.3390/f14020196.
[15] IS: 1725:1982 Specification for Soil based blocks used in general building Construction.