EXPERIMENTAL STUDY ON COMPRESSIVE AND SPLIT TENSILE STRENGTH OF LOOFAH FIBER REINFORCED CONCRETE BY PARTIAL REPLACEMENT WITH PERLITE POWDER

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Abstract - *Materials currently viewed as workable substitutes for natural sources include industrial and building wastes. Perlite powder can enhance the strength qualities of concrete, according to earlier research on the subject. Perlite is an amorphous volcanic glass with a high water content that is often created when obsidian is hydrated. It is a commercial commodity and an industrial mineral that is valuable for its low density after processing. Perlite is also used sparingly as a clay addition in ceramics, cryogenic insulation, and foundries. The explosives sector uses it as well. Perlite is frequently utilised in biotechnological applications due to its thermal and mechanical stability, non-toxicity, and strong resistance against microbial assaults and organic solvents. This study looked into the strength characteristics of concrete reinforced using loofah fibres and perlite powder. The sponge gourd, commonly known as loofah fiber, is a cheap natural fibre reinforcement. The loofah fibre is treated for 24 hours with a 4% con. NaOH solution, followed by a distilled water wash. Perlite powder is a superior cementitious material that can be used in place of cement in some applications. The Loofah fibre was added to the concrete at 0, 0.5%, 1%, 1.5%, and 2%, and 10% of the cement was replaced with perlite powder. The mix ratio is M30.Along with the curing times of 7 and 28 days, the compressive strength test and split tensile strength test of cast concrete are noted.*

***Key Words*: Loofah fiber, perlite powder, Compressive strength, Tensile strength, Natural fiber, Chemical treatment**

1. INTRODUCTION

Due to its excellent environmental adaptability and great compressive strength, concrete is one of the most widely used structural materials. Concrete can be used in a variety of specialist and challenging engineering scenarios, but its limitations include brittleness, low tensile strength, and poor fracture growth resistance. Therefore, it is crucial to optimise and improve concrete structures to meet various engineering requirements. Numerous investigations on fibre-reinforced concrete have shown that adding fibres can enhance the mechanical properties of concrete.

Given their advantages for the economy, the environment, and the possibility to be recycled as building materials for new green structures, natural fibres are thought to be worthwhile for use in the creation of composites. The biological, chemical, economic, and environmental benefits of natural fibres can greatly enhance the final properties of fibre composites and their use in a variety of contemporary applications, including those in the building and other industries. Growing in popularity as a natural reinforcement for concrete and transformation material for environmental applications, such as wastewater treatment, is luffa cylindrical fibre. Despite having a low density, cellular material possesses exceptional mechanical and physical qualities. It is made up of a network of connected struts or plates that form the edges and faces of cells.

1.1 Loofah Fiber

The sponge gourd plant, which is widely cultivated in India, Asia, and Africa, yields loofah fiber, a type of natural fibre. Recently, loofah fibre has been used to make reinforced polymers. It is a fast evolving substance with the alluring advantages of low density and affordability in comparison to metals and other fibre-reinforced materials. By replacing artificial fibre reinforcements in composites, natural fibres have a great chance of lowering CO2 emissions while also conserving non-renewable resources. The strength and durability of concrete and loofah fibre can both be improved by treating them with 4% NaOH solution. after being cleaned with distilled water and left to dry for 24 hours at room temperature

1.2 Perlite Powder

Perlite is an amorphous volcanic glass with a high water content that is often created when obsidian is hydrated. It appears spontaneously and possesses the peculiar quality of considerably expanding when heated to an appropriate temperature. It is a commercial commodity and an industrial mineral that is valuable for its low density after processing. When perlite reaches temperatures between 850 and 900 °C, it softens. The material expands to 7–16 times its initial volume as a result of trapped water vaporising and escaping from the substance's structure. Due to the bubbles' reflectivity, the expanded material is a bright white. The bulk density of unexpanded perlite is approximately 1100 kg/m3, whereas the bulk density of normal expanded perlite is approximately 30-150 kg/m3.

2. MATERIALS USED

2.1 cement

For this investigation, Portland Pozzolona Cement from Ultratech is employed. The tests were carried out in accordance with IS: 4031-1988, and the outcomes met IS Standards. Portland Pozzolana Cement (PPC), in contrast to Ordinary Portland Cement, is created by combining pozzolanic ingredients.Table 1 provides characteristics of cement.

Table -1 : Properties of Cement

Properties	Test results	Technical reference
Specific gravity	3.06	IS4031(PART 11): 1988
Consistency (%)	34	IS4031(PART 4): 1988
Fineness of cement (%)	6.33	IS4031(PART 2): 1996
Initial setting time (minutes)	80	IS4031(PART 5): 1988

2.2 Fine Aggregate

M Sand served as the fine aggregate. Fine aggregate was subjected to laboratory tests to ascertain its various physical characteristics in accordance with IS 2386 (Parts I and III) and IS: 383-1970. Table 2 lists the fine aggregate's characteristics.

Table -2: Properties of Fine Aggregate

Sl. No.	Tests Conducted	Result
1	Sieve Analysis (%)	3.84
2	Zone of aggregate	II
3	Specific Gravity	2.60

2.3 Coarse Aggregate

As coarse aggregates, 20 mm-sized crushed rock is employed. On the basis of IS: 383 - 1970 and IS: 2386 (Part I and Part III) - 1963, various experiments on coarse aggregate were carried out. The characteristics of coarse aggregate were identified and are shown in Table 3.

Table- 3.: Properties of Coarse Aggregate

Sl. No.	Tests Conducted	Result
1	Sieve Analysis (%)	5.73
2	Specific Gravity	3.04

2.4 Perlite

Perlite ore consists mainly of SiO2, Al2O3 and lesser amounts of several metal oxides such as sodium, potassium, iron, calcium and magnesium. Perlite has several attractive physical properties. Unexpanded (raw) perlite has a bulk density around 1100 kg/m3 (1.1 g/cm3), while typical expanded perlite has a bulk density of about 30-150 kg/m3. The properties of perlite are given in table 4. Perlite is a type of volcanic rock with pearly lustre. It expands and becomes porous when heated. Colour of crude perlite is light grey to glossy black whereas, the colour of expanded perlite ranges from snowy white to greyish white.

Table- 4: Properties of Perlite

SI.NO	Property	Result
1	Specific gravity	2.2
2	Physical state	Micronized powder
3	Colour	White
4	Water absorption	1.5%

Fig.-1: Perlite Powder

2.5 Loofah Fiber

Similar to a sponge, loofah is a porous, skeletal fibre that has developed a network of fibres that are arranged longitudinally, transversally, and as loops. The loofah's central section has a three-dimensional fibre network. In transverse orientation, the fibre's average diameter ranged from 0.247 to 0.381 mm, while in longitudinal direction, it ranged from 0.295 to 0.418 mm. It has a 0.353 g/cm3 average density. The properties of loofah fiber are given in table 5.

Fig.-2: Loofah Fiber

Table- 5: Properties of Loofah[1]

SI. No	Particulars	Properties
1	Hot water solubility	3.00
2	Cold water solubility	4.00
3	1% NaOH solubility	16.38

2.6 Loofah Fiber Treatment

The seeds were taken out of the loofah fibres before use, and the fibres were trimmed. The cut samples were given a 4% weight-based NaOH treatment. After being completely submerged in the NaOH solution, the loofah fibres were treated for 24 hours at room temperature. Following a thorough rinsing with distilled water, the loofah fibres were dried in the sun to remove any remaining moisture before being packaged in preserved bags and kept in storage. After that period of storage, the fibre was cut in an angle so that it was not straight and was sliced into 1 cm.

Fig-3: Loofah Fiber Soaked in the Solution

3. TESTING OF SPECIMEN

3.1 Compressive Strength

The calculation took into account the specimen's actual dimensions. After the prescribed amount of curing time, specimens kept in water were removed from the water and allowed to air dry. The cubes were put in the compressive testing apparatus with the opposite side of the cube receiving a load. The specimen is subsequently subjected to the maximum load, which is then noted. The highest force that was applied to the specimen during the test is divided by the cross sectional area to get the specimen's compressive strength.

Fig.-4: Testing of Specimen in Compression Testing Machine

3.2 Split Tensile Strength

The calculation took into account the specimen's actual dimensions. Specimens After the allotted curing time, items that had been in water were removed and air dried. Until no more load can be sustained, apply the load without shock and gradually raise it at a rate to produce a split tensile stress of roughly 1.4 to 2.1 N/mm2/min. Note the greatest load that was put on the specimen. The greatest load applied to the specimen during the test must be documented. The load must be increased until the specimen fails.

Fig.-4: Testing of Specimen for Split Tensile Strength

4. RESULTS AND DISCUSSIONS

4.1 Compressive Strength

The best substitute in concrete with various percentages, add 10 % cement with perlite powder and loofah fibre. The maximum strength was tested using the test findings add LF1 + 10% Perlite to a mixture. Comparatively to the addition of 0.5% and 1% of Loofah fiber, compressive strength is decreased after the addition of 1.5% and 2% fibre. Up to 1% is the maximum amount of luffa fibre that can be used before compressive strength starts to significantly decline. This is mostly caused by the tiny particles and voids in the concrete mixture. Because of this, between the ages of 7 and 28 days, the compressive strength will drop.Compressive strength of specimen is shown in table 6

(LF1 – 1% Loofah Fiber)

Table- 6: Compressive Strength Test Results

Mix Design	7 Days Compressive Strength	28 Days Compressive Strength
CS	21.03	38.1
0% LF + 10% PP	20.7	34.6
0.5% LF + 10% PP	18.33	30.6
1% LF + 10% PP	23	35.6
1.5% LF + 10% PP	17.5	21.6
2% LF + 10% PP	16.2	17.7

LF – Loofah Fiber

PP – Perlite Powder

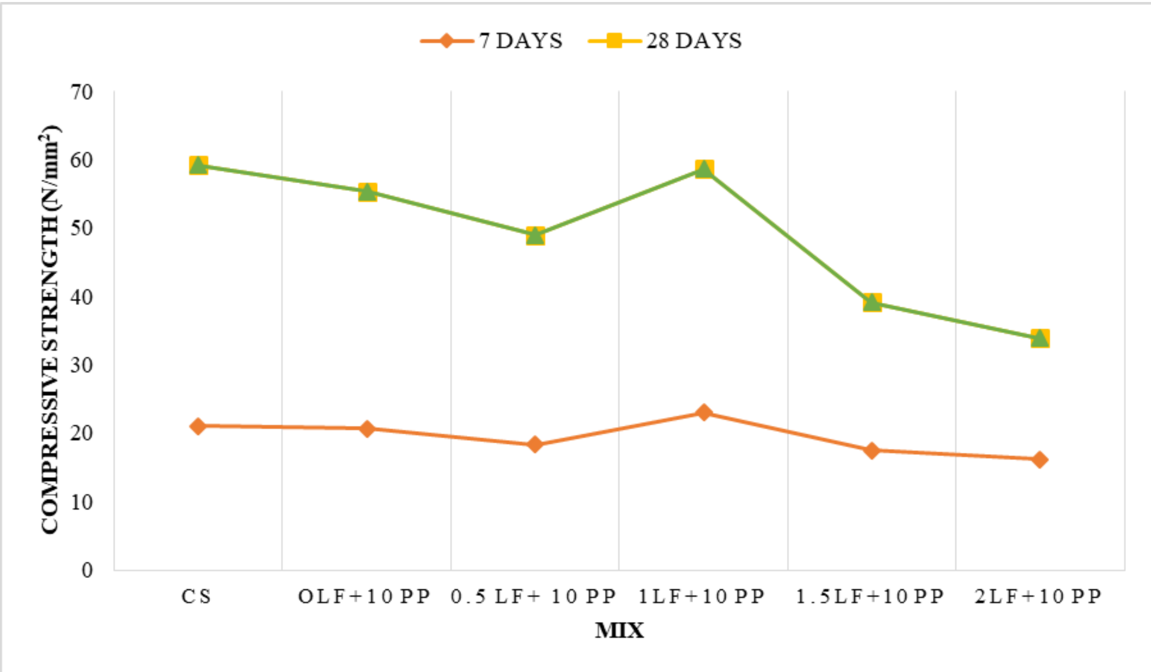

Chart -3: comparison of compressive strength results for various mixes

4.2 Split Tensile Strength

The strength of mixtures after 7 and 28 days is best achieved by replacing 10% of the cement with perlite powder and adding loofah fibre in various amounts. Results of the test: M30 + 10%PP+ 1% LF gives the highest Tensile strength of any composite concrete. Due to the high pozzolanic properties of perlite powder, it produces heat during hydration, reducing concrete strength when used in large quantities. However, when luffa fibre is included, the reduction in strength is smaller as compared to composite materials.

Table- 7: Split Tensile Strength Test Results

Mix Design	28 Days Split Tensile Strength
CS	2.92
0% LF + 10% PP	2.41
0.5% LF + 10% PP	1.8
1% LF + 10% PP	3
1.5% LF + 10% PP	1.7
2% LF + 10% PP	1.4

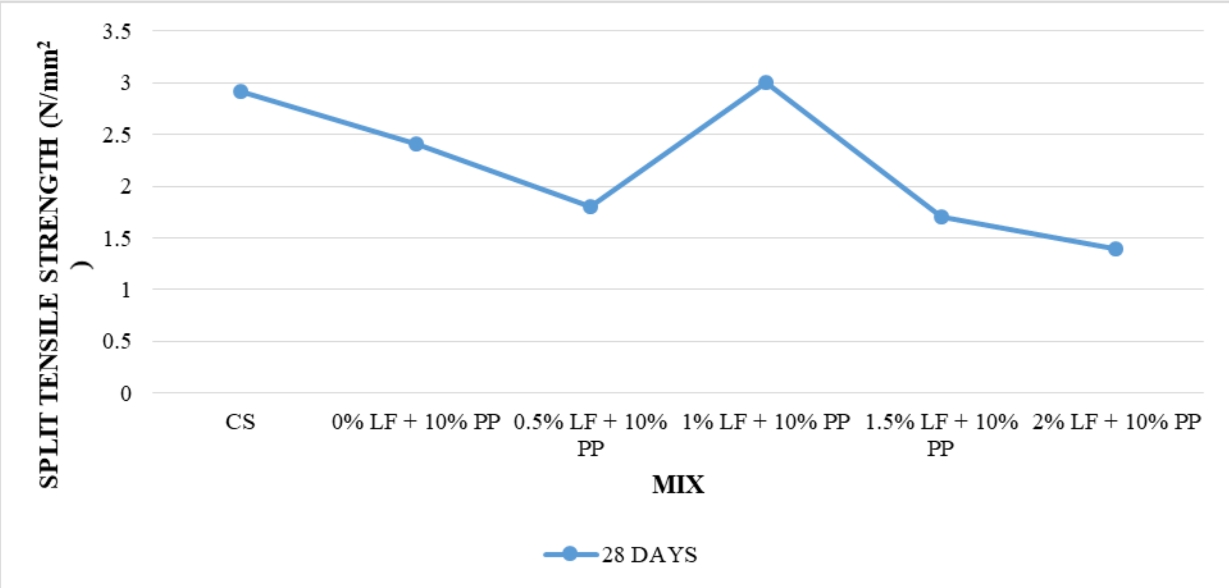

Chart-6 comparison of split tensile strength results for various mixes

5. CONCLUSIONS

- According to test results, adding natural fiber (loofah) to concrete produces superior outcomes. Natural loofah fiber is inexpensive, light weight, and readily available as composite materials. It also has good tensile strength relative to other fibers
- The strength results for 0%, 0.5%, 1%, 1.5%, and 2% of loofah are improving over time with boosts. However , the strength attributes results for 1.5% and 2% of loofah fiber are deteriorating over time
- In comparison to other proportions, 1% loofah fiber and 10% perlite powder provide the best compressive and split tensile strength

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REFERENCES

1. S. Anandaraj et. al (2022) "Strength properties of luffa fibre reinforced concrete containing RHA as cement replacement" Materials Today: Proceedings ,52, 1817-1820

2. Raghda Osama Abd-Al Ftah et.al (2022) "Assessment on structural and mechanical properties of reinforcement concrete beams prepared with luffa cylindrical fibre" case studies in construction material, Vol.11, Issue 08

3. P.O. Awoyera, et al., "Thermal insulation and mechanical characteristics of cement mortar reinforced with mineral wool and rice straw fibers", J. Build. Eng. 53 (2022), 104568.

4. Ruslan, I.; Ruslan, B.; Evgenij, K." The Effect of Metal and Polypropylene Fiber on Technological and Physical Mechanical Properties of Activated Cement Compositions". Case Studies. Construction. Material. (2022), 16, e00882

5. A.R. de Azevedo, et al (2021), "Technological performance of açaí natural fibre reinforced cement-based mortars," J. Build. Eng. 33, 101675

6. Kaplan, G.and Bayraktar, O.Y (2021). "The Effect of Hemp Fiber Usage on the Mechanical and Physical Properties of Cement Based Mortars". Res. Eng. Struct. Mater, 7, 245–258.

7. Iniya, M.P and Nirmalkumar, K.(2021)" A Review on Fiber Reinforced Concrete Using Sisal Fiber". IOP Conf. Ser. Mater. Sci. Eng., 1055, 012027

8. Fokam, C.B et al (20210." Cement Mortar Reinforced with Palm Nuts Naturals Fibers": Study of the Mechanical Properties. Rev. Compos. Matériaux Av, 30, 9–13.

9. Zhang, P et al (2020) "Fracture Models and Effect of Fibers on Fracture Properties of Cementitious Composites—A Review". Materials, 13, 5495

10. Marvila, M. et.al (2020) "Durability of Coating Mortars Containing Açaí Fibers. Case Study". Construction Materials, 13, e00406.

11. Bayapureddy, Y.et al.(2020), "Sugarcane Bagasse Ash as Supplementary Cementitious Material in Cement Composites: Strength, Durability, and Microstructural Analysis. "J. Korean Ceram. Soc57, 513–519

12. Berenguer, R et al (2020), "Durability of Concrete Structures with Sugar Cane Bagasse Ash". Adv. Mater. Sci. Eng., 6907834