



STUDY OF MECHANICAL PROPERTIES OF BASALT FIBER CONCRETE

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Abstract: Basalt fiber-reinforced concrete (BFRC) is relatively a new type of fiber-reinforced concrete, which has demonstrated good mechanical performance. This project aimed to investigate the mechanical properties of basalt fiber-reinforced concrete (BFRC) and analyze its potential for use in various construction applications. Basalt fibers are a promising material due to their excellent mechanical properties, including high strength, stiffness, and excellent resistance to heat and chemicals. In this study, different proportions of basalt fibers were added to the concrete mix to produce BFRC. The mechanical properties of the BFRC were evaluated by conducting compression, flexural, and split tensile strength tests. The results showed that the addition of basalt fibers to the concrete mix improved its mechanical properties, especially the flexural strength.

Keywords: Basalt fiber, Mechanical properties, Concrete, Compressive strength, Tensile strength, Flexural strength, Reinforced concrete, Fiber-reinforced concrete

I INTRODUCTION

Basalt fiber is a material created from extremely fine basalt fibers, which are melted and spun into fibers. Basalt fibers have the same strength as fiberglass but are substantially lighter and have a greater melting point. Basalt fiber is a non-toxic, non-flammable, and non-carcinogenic material used in construction, automotive, aerospace, marine, and sports equipment. Basalt fiber can be woven into fabrics or manufactured into mats, tapes, and rovings for a variety of purposes, as well as utilized as a reinforcement material for concrete, composites, and plastics.

Because of its high tensile strength, excellent corrosion resistance, and durability, basalt fiber is increasingly being used as a reinforcement material in the construction industry. It is frequently used to replace traditional reinforcement materials like steel, fiberglass, and carbon fiber. Basalt fiber can be used as an additive in concrete to increase the strength and durability of the concrete. It can also be used in concrete structures such as bridges, tunnels, and buildings to replace steel rebar. Basalt rebar is lighter and easier to handle than steel rebar, and it resists corrosion and high temperatures well.

Basalt fiber can also be used to make composite materials like laminates and panels. Basalt fiber composites are impacted, vibration, and thermal shock resistant, making them perfect for usage in high-performance constructions such as wind turbine blades, maritime boats, and aviation parts. Basalt fiber is an environmentally beneficial material in addition to its mechanical capabilities. It is made from a renewable and abundant natural resource, is recyclable, and is non-toxic. As a result of this, it becomes a more common choice in green building projects.

II LITERATURE REVIEW

Numerous papers state that the concrete has moderate compressive capabilities but no tensile properties. To compensate for the lack of tensile strength, Meyyappan et. Al. [16] added to regular cement concrete. Basalt fibers, among other types of fibers, have piqued the interest of academics in recent studies. Basalt fiber has numerous advantages, including high elastic modulus, increased thermal stability, superior chemical stability, good sound insulation, and electrical qualities. Basalt fiber is mixed with M 30 grade concrete at volume fractions of 0.5%, 1%, 1.5%, 2%, 2.5%, and 3% for this study. According to the test results, adding 1% of basalt fibers into concrete is best for strengthening strength qualities, and increasing the volume fraction of basalt fibers has a severe diminishing tendency. The 7-day compressive strength of this basalt fiber reinforced concrete is around 55% to 64% of the 28-day compressive strength, and the greatest split tensile strength is 5.48 N/mm² for 1% basalt fiber content. The split tensile strength is 18.24% greater than that of ordinary concrete.

Adeyemi Adesina [10] provide an overview of the usage of basalt fibers in cementitious composites and the resulting performance impacts. The qualities of basalt fibers were discussed, as well as the performance of cementitious composites reinforced with basalt fibers in terms of mechanical and durability aspects. This review demonstrated that the introduction of basalt fibers improved the mechanical parameters of cementitious composites such as flexural strength and split tensile strength. More research is needed, however, to fully understand the overall effect of basalt fibers on the compressive strength and durability performance of cementitious composites. The slump of cementitious composite mixtures containing BF is smaller than that of non-BF mixtures.

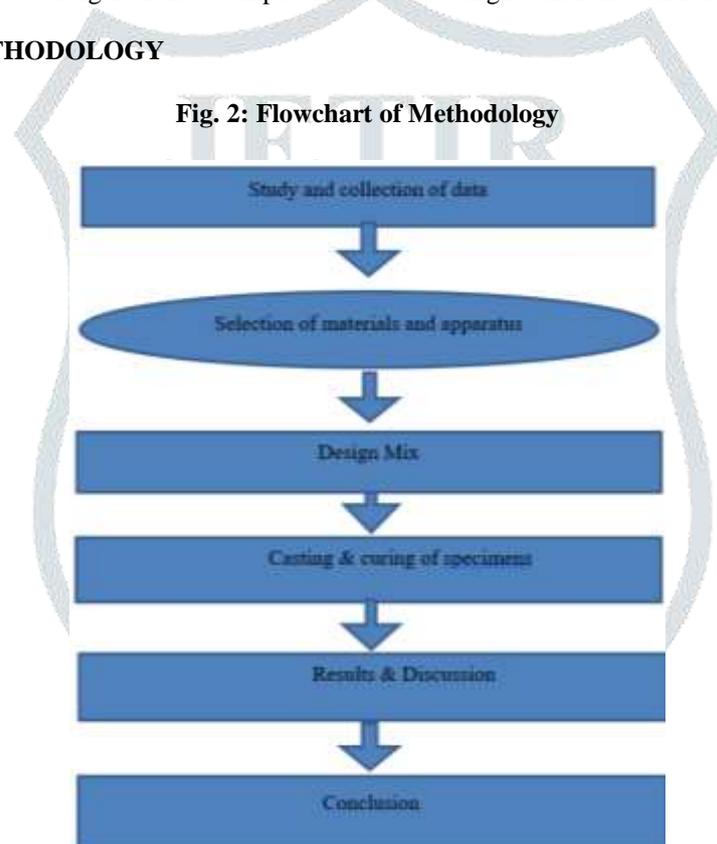
The effect of employing basalt fibers in the matrix of an ultra-high-performance concrete (UHPC) T-beam on diagonal fracture load and ultimate shear capacity was experimentally studied. The results, ref. [2], were compared to a similar T-beam with

an equal percentage of steel fibers. In this investigation, two parameters were used. These were the fiber volume fraction and shear span to effective depth ratio. The results demonstrated that employing steel fibers in the matrix resulted in a more ductile failure behavior than adding basalt fibers. Adding basalt fibers to UHPC improves compressive strength more than adding steel fibers by the same percentage. The enhancement showed up in the shear capacity of the compression zone of the T-beam. The presence of the flange also increased the compression zone in the T-beam. As a result, the flange contributed to an increase in compression shear capacity. The use of basalt fibers in the ultra-high-performance matrix delayed the beginning of diagonal cracking more than steel fibers. Adding 0.5%, 1.0%, and 1.5% basalt fibers increased the cracking shear load by 160% over the non-fibrous one. The 0.5% and 1.0% basalt fiber content, on the other hand, increased their final shear capacity more than the 1.5% content. The 1.5% steel fiber concentration increased shear capacity by 133% compared to the nonfibrous one.

The use of basalt fiber in the creation of self-compacting concrete (SCC) has been researched to see how the addition of fiber affects the SCC's fresh and hardened qualities, ref [8]. The SCC combinations contain 0%, 0.1%, 0.3%, and 0.5% of the volume of concrete from basalt fibers that are 3, 6, 12, and 24 mm in length, respectively. To determine the hardened characteristics of SCC made with basalt fiber, tests for compressive strength, flexural strength, splitting tensile strength, rapid chloride permeability, and water penetration were conducted after the progression of flow diameter, T500 flow time, and V-funnel time tests on the fresh SCC. The findings show that adding basalt fiber to SCC reduces its workability while enhancing its mechanical characteristics. The concrete mixtures containing 0.5% fiber with a length of 24 mm produce the best results in terms of flexural and splitting tensile strength. The mixes with a 0.1% fiber content for the used fiber lengths of 12 mm and 24 mm produce the highest compressive strength results. Based on the optimized strength and permeability-based durability qualities of SCC, 0.49% and 21.12 mm are found to be the optimal volume percentage and length of basalt fiber, respectively. The highest compressive strength (91.15 MPa) is obtained from the samples containing the fiber content of 0.1% for the utilized fiber lengths of 12 mm and 24 mm. The resulted compressive strength of these samples is about 9.5% higher than the control sample.

III MIX DESIGN AND METHODOLOGY

Fig. 2: Flowchart of Methodology



3.1 Chopped Basalt fiber

- Length: 12 mm
- Sustained operating temperature: +680 °C
- Minimum operating temperature: (-)260 °C
- Melting Temperature: 1450 °C
- Density: 2.6g/cm³
- Tensile Strength: 3200 – 3850 MPa
- Filament Diameter: 13 – 20 microns
- Elastic Modulus: 93Gpa
- Elongation at break: 3.15%
- Sizing Content: 0.4%
- Moisture Content: 0.1 – 12%

3.2 MIX DESIGN

- **Specimens**
 - 6 cubes (15 cm * 15 cm * 15 cm)
 - 1 cylinder (15 cm * 30 cm)
 - 1 beam (15 cm * 15 cm * 75 cm)
- **M35 Proportion Mix:**
 - Cement = 350 kg/m³
 - Crush sand = 955 kg/m³
 - Aggregate = 1190 kg/m³
 - Water-to-Cement ratio = 0,38
 - Admixture = 4.6 kg/m³
- Basalt fiber (%) = (0, 0.5, 1.0, 1.5) % of Weight of cement

Table 1: Mix with Basalt Fiber Content

Mix =>	0.0%	0.5%	1.0%	1.5%
Cement (kg)	16.90	16.90	16.90	16.90
Crush Sand (kg)	46.10	46.10	46.10	46.10
Aggregate (kg)	57.50	57.50	57.50	57.50
Water (kg)	6.50	6.50	6.50	6.50
Admixture (kg)	222.00	222.00	222.00	222.00
Basalt Fiber (gm)	0.00	84.50	169.00	253.50

3.3 MATERIALS

Cement: Cement used in this study is ordinary Portland cement obtained from local supplier and of 53 grades as per IS 11269 it has a specific gravity of 3.15 with fineness (IS:4031-PART 1-1996) is less than 5% and have good specific surface area of more than 600 m² / kg. The cement obtained is stored in airtight environment without moisture entry and formation of lumps is avoided.

Fine aggregate: Fine aggregate used in this study is obtained from nearby source and its clean river sand adhering to the norms prescribed in IS:383 and it confirms to Zone-II with a specific gravity of 2.68 and free from any foreign particles. Sand obtained is stored in large containers without moisture entry and it is managed as clean and dry to manage the water content in the mix design.

Coarse aggregate: Coarse aggregate adopted in this work is obtained from nearby crusher unit which is derived from basalt rock, and it is non-flaky with clear edges. The aggregates are sieved on crusher end with nominal size of 20 mm as per IS 383 it adheres strictly to the protocols. The coarse aggregate has a specific gravity of 2.65 and abrasion value of less than 6% with good impact crushing strength of less than 3% which shows that it can be even used for highway purpose. The obtained material is stored in a concrete tank with shelter to avoid water entry and clean, dried aggregate only is used throughout the study.

Water: The water used in the entire process is tap water and the density is taken as 1000 kg/m³ and a pH of 6.2 with TDS of less than 500 ppm with clear and no color.

Admixture: Master Rheobuild 8051 is used for this project. Good for concrete of grade up to M40, it is good to make strong bonds between fine particles.

Basalt fiber: basalt fiber is a type of fiber made from basalt rock, which is a volcanic rock commonly found in many parts of the world. Basalt fibers are produced by melting the rock at high temperatures and then extruding it through fine nozzles. The resulting fibers have high strength, stiffness, and excellent resistance to heat and chemicals. Basalt fiber is becoming increasing popular in the construction industry due to its potential to improve the mechanical properties and durability of concrete. When added to the concrete mix, basalt fibers can enhance the strength, toughness of the resulting composite. Additionally, basalt fibers have low thermal conductivity, making them ideal for applications requiring insulation properties. Overall, basalt fiber is a promising material with significant potential for use in various applications, including construction, aerospace, automotive and sports equipment. The study of the mechanical properties of basalt fiber is essential to understand its potential applications and to optimize its use in different industries.

Fig. 1 Basalt Fiber, length 12 mm



IV TESTING

The compressive strength of the concrete cube test provides an idea about all the characteristics of concrete. By this single test one judges whether Concreting has been done properly or not. A concrete cube test or concrete cylinder test is generally carried out to assess the strength of concrete after 7 days, 14 days, or 28 days of curing.

Split tensile strength and Flexural Strength of Cylinder and Beam were also obtained for 28th Day after curing.

V RESULT

Table 2: Compressive Strength of Cubes

Days of Testing	Name	Curing (Days)	Weight (kg)	Load (kN)	Compression Load on Cured Cube (N/mm ²)
7	P1-1-7	6	8.395	254.300	11.302
	P1-2-7	6	8.500	357.000	15.867
	P2-1-7	6	8.420	257.900	11.462
	P2-2-7	6	8.420	358.100	15.916
	P3-1-7	6	8.780	383.300	17.036
	P3-2-7	6	8.795	360.900	16.040
14	P1-1-14	13	8.190	305.800	13.591
	P1-2-14	13	8.715	327.000	14.533
	P2-1-14	13	8.425	463.300	20.591
	P2-2-14	13	8.615	453.700	20.164
	P3-1-14	13	8.755	663.700	29.498
	P3-2-14	13	8.790	590.800	26.258
28	P1-1-28	27	8.725	492.400	21.884
	P1-2-28	27	8.720	449.100	19.960
	P2-1-28	27	8.665	545.400	24.240
	P2-2-28	27	8.815	404.500	17.978
	P3-1-28	27	8.635	779.300	34.636
	P3-2-28	27	8.445	664.300	29.524

Fig. 3: Compressive Strength of Cubes on 7th day

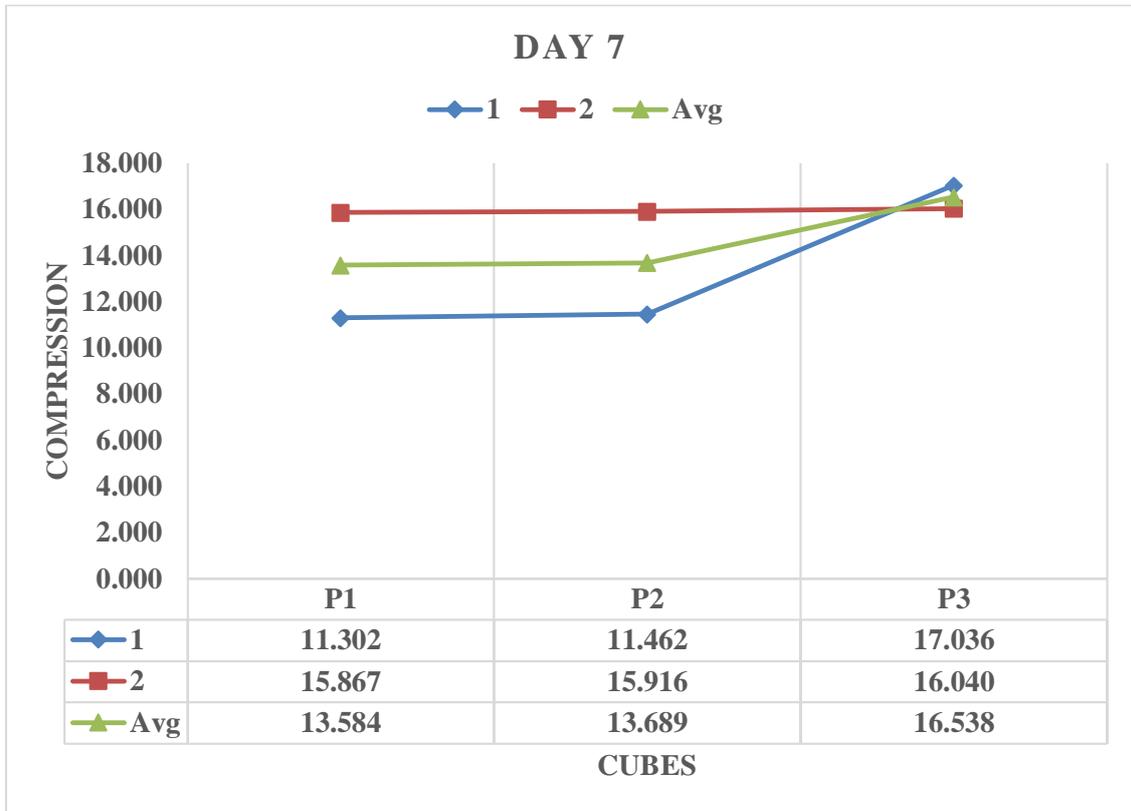


Fig. 4: Compressive Strength of Cubes on 14th day

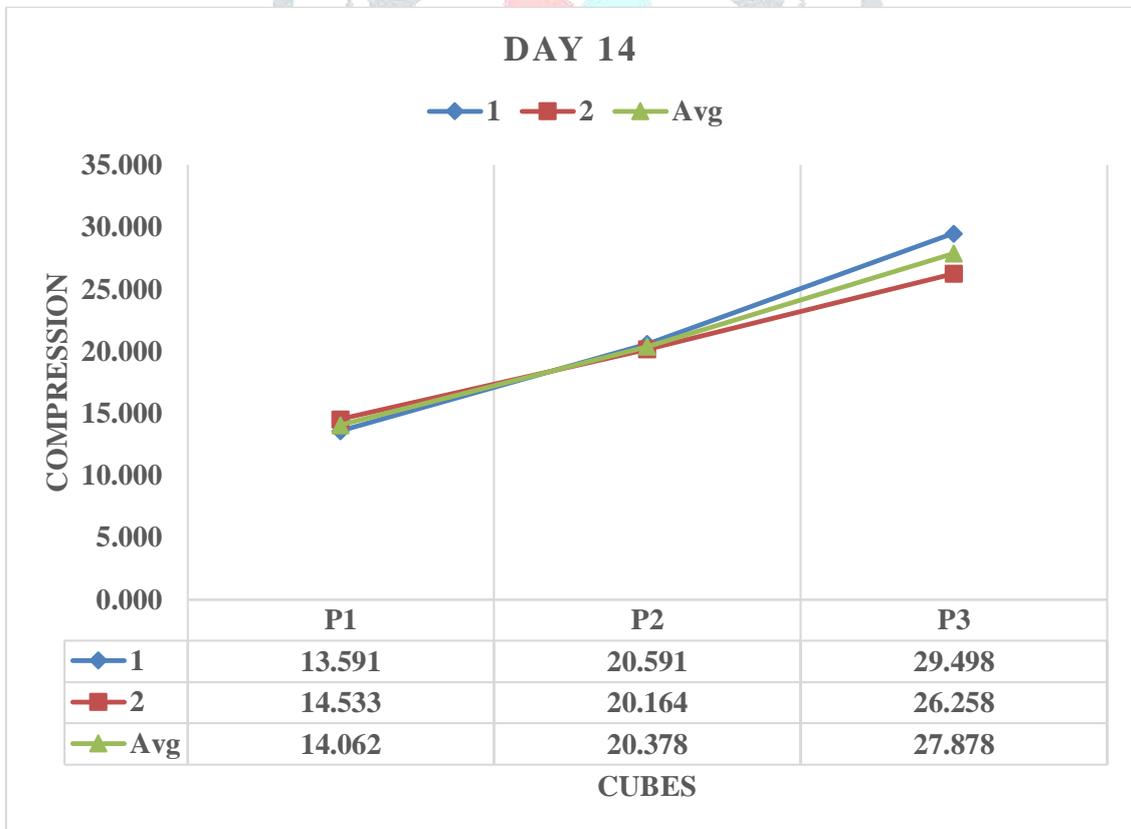


Fig. 5: Compressive Strength of Cubes on 28th day

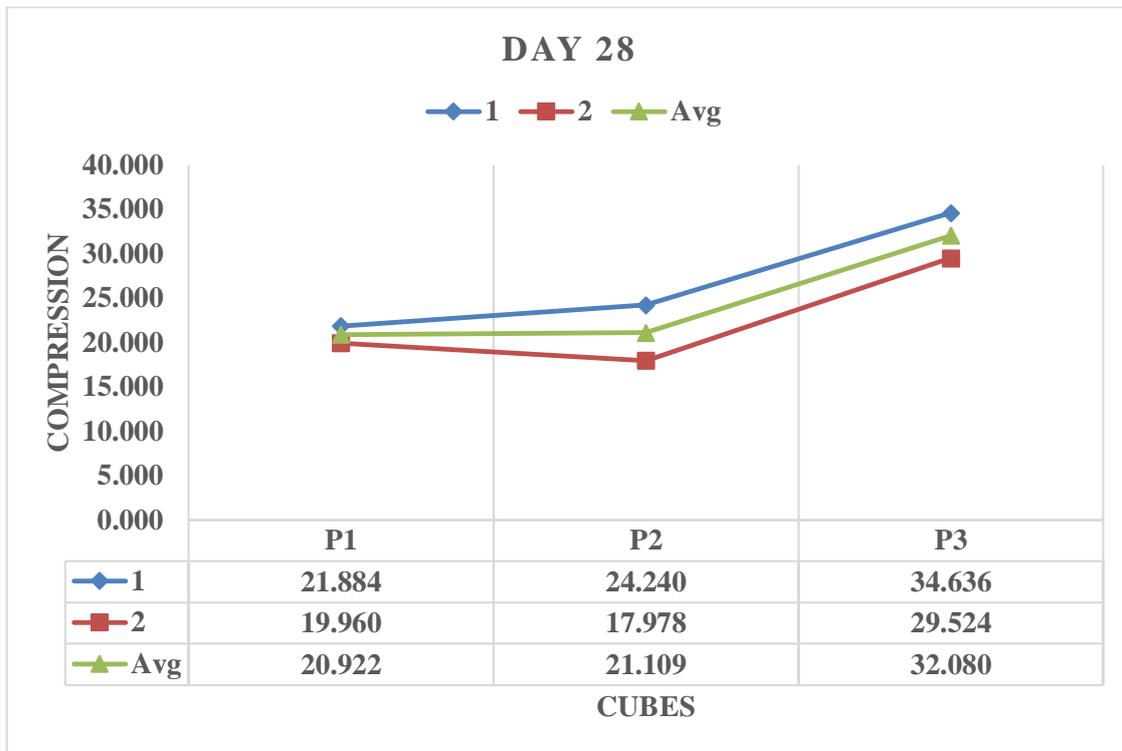


Table 3: Split Tensile Strength of Cylinder

Specimen	Name	Results on 28 th Day		Split Tensile Strength (N/mm ²)
		Weight (kg)	Load (kN)	
Cylinder	P1	13.485	140.8	1.9929
	P2	13.46	143.6	2.0326
	P3	13.825	215.5	3.0502

Fig. 6: Split Tensile Strength of Cylinder

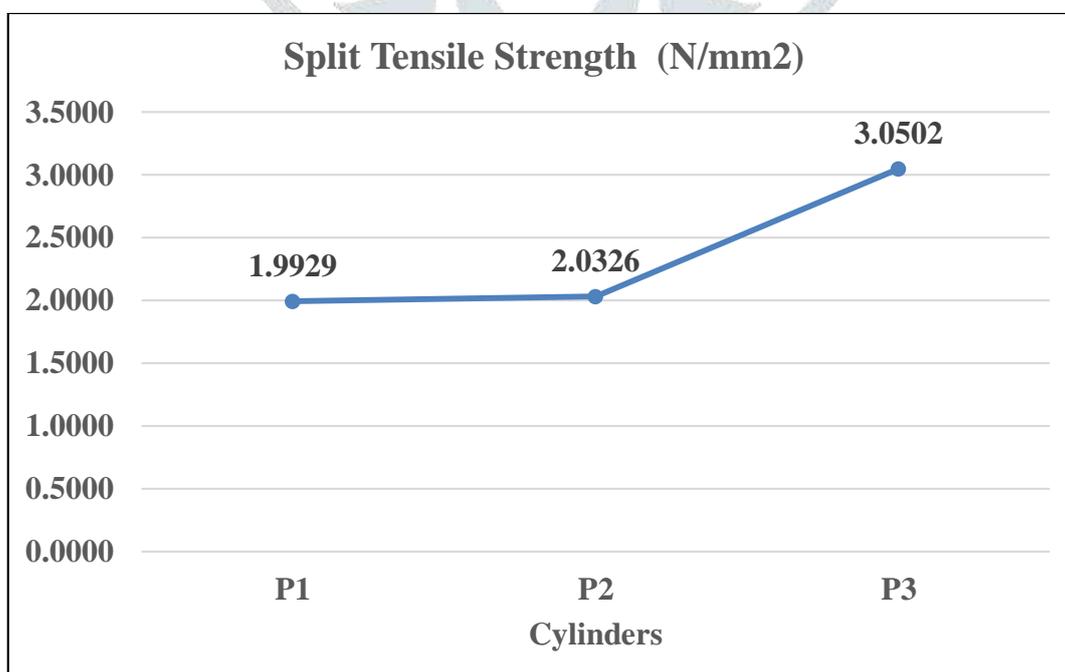
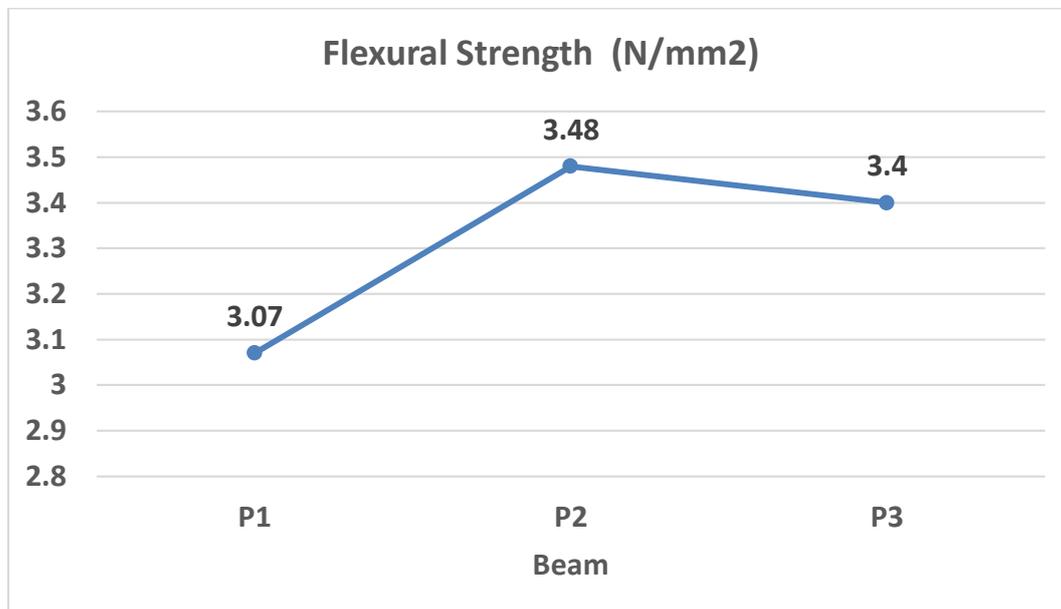


Table 4: Split Tensile Strength of Cylinder

Specimen	Name	Results on 28 th Day		Flexural Strength (N/mm ²)
		Weight(kg)	Load (kN)	
Beam	P1	40.410	11.50	3.07
	P2	39.820	13.05	3.48
	P3	40.350	12.75	3.40

Fig. 7: Flexural Strength of Beam



VI CONCLUSION

Conclusion of above tests were drawn in the following manner:

1. Compression Strength of cubes increased percentage of basalt fiber increased, respectively.
2. Similarly for Split Tensile Strength, it increased with increase in percentage of basalt fiber.
3. For flexural strength, mix P2 with 1% basalt fiber showed higher value.
4. As per Meyyappan et. Al. [16], the optimum value is 1% of volume fraction, but the 1% of cement weight was added to the mix P2 and henceforth it showed higher flexural strength.

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