

# Performance Evaluation of Basalt Fiber Reinforced Concrete.

**Mr. Prathamesh S Karche<sup>1</sup>, Prof. Vijay S Shingade<sup>2</sup>, and Dr. Vaibhav V. Shelar<sup>3</sup>**

<sup>1</sup>Student, Trinity College of Engineering & Research, Pune

<sup>2</sup>Assistant Professor, Trinity College of Engineering & Research, Pune

<sup>3</sup>Head of Department (civil Engg.), Trinity College of Engineering & Research, Pune

**Abstract:** The construction industry is continuously striving to develop new, improved, and economical materials for manufacturing products that are highly beneficial to the sector. In recent years, significant growth has been observed in the development of composite materials. Along with this, energy conservation, corrosion resistance, and sustainability have become important considerations when introducing or modifying construction materials. Basalt fiber (BF) is a high-performance, non-metallic fiber made from basalt rock melted at high temperatures. Basalt fiber reinforced concrete (BFRC) offers several advantages, including light weight, good fire resistance, and high strength. In the future, it is expected to be highly beneficial for the construction industry. Basalt fiber has various applications in residential, industrial, highway, and bridge construction.

**Index Terms** – Chopped Basalt Fiber ,Basalt Rebar and Supplementary Material.

## INTRODUCTION

The industry is continuously striving to develop new, improved, and economical materials for manufacturing products that are highly beneficial. In recent years, various fibers have been developed and used in construction, industrial, and highway engineering. Steel is widely used in many applications; however, other fibers such as fiberglass, polyethylene fibers, carbon fibers, and polyamide fibers are also being increasingly utilized in construction and infrastructure development. A newer addition to this list is basalt fiber, derived from basalt rock.

Today, significant growth is observed in the development of composite materials. Along with this, energy conservation, corrosion resistance, sustainability, and environmental impact have become important considerations when introducing or modifying materials. Basalt fiber is a high-performance, non-metallic fiber made from basalt rock melted at high temperatures. It can be manufactured in various forms, such as chopped fibers, fabrics, and continuous filaments.

Basalt fiber originates from volcanic magma, a hot fluid or semi-fluid material beneath the Earth's crust that solidifies upon exposure to air. Basalt is a common term for a variety of volcanic rocks that are typically dark gray in color. The molten rock is extruded through small nozzles to produce continuous basalt filaments. These fibers do not require additional additives during production, making them cost-effective.

Basalt fibers are non-toxic, non-combustible, and explosion-proof. They do not react with air or water and do not produce harmful chemical reactions when exposed to other substances, making them safe for both human health and the environment. Additionally, basalt fiber exhibits good hardness and excellent thermal properties. It has been successfully used in applications such as foundation systems, including slabs-on-ground concrete.

## NEED OF THE STUDY

The aim of the experimental investigation is to analyse the properties of concrete by adding the most suitable combination of basalt fiber percentage and use of basalt rebars into the concrete. This optimum percentage of basalt fiber is used for further investigation.

1. To determine the optimum percentage of basalt fiber quantity into the concrete.
2. To use basalt rebar with optimum percentage of basalt fiber into the concrete.

## LITERATURE REVIEW

In this study, M. Hassani Niaki investigates ways to enhance the mechanical properties of quaternary epoxy-based polymer concrete (PC) by incorporating basalt fiber and clay nanoparticles. The research was carried out in two phases. In the first phase, the effects of chopped basalt fiber on various mechanical properties such as compressive, flexural, splitting tensile, and impact strength—were analyzed. The study also examined how different temperatures, up to 250°C, influenced the strength of fiber-reinforced polymer concrete. The findings showed that adding basalt fiber significantly improved the concrete's mechanical performance and enhanced its thermal stability. In the second phase, the focus shifted to the role of clay nanoparticles in further improving the concrete's mechanical properties and resistance to high temperatures (up to 250°C) in basalt fiber-reinforced polymer concrete (BFRPC). The results demonstrated that nanoparticles increased compressive, flexural, and impact strength while also boosting thermal stability. However, they caused a slight reduction in tensile strength. To better understand these effects, a scanning electron microscope (SEM) analysis was conducted to study the fracture surfaces and microstructure of the concrete specimens. The resulting polymer nanocomposite is expected to be a lightweight yet high-strength material with excellent thermal stability, making it a promising option for advanced construction applications.

Nihat Kabay [5] investigated the splitting tensile strength and flexural strength of basalt fiber-reinforced concrete (BFRC). The study found that flexural strength gradually increased as fiber content increased. However, in glass fiber-reinforced concrete (GFRC), no significant improvement was observed beyond a fiber content of 0.50%. Fracture energy showed a notable increase after a 0.25% fiber dosage in both basalt and glass fiber-reinforced concrete. Additionally, the KIC and CTODC results indicated that incorporating basalt fibers improved concrete performance more effectively than glass fibers, particularly in terms of crack resistance and ductility.

Grija S. [3] conducted a study on the strength of concrete incorporating hypo sludge and Recron 3S fibers. The research involved adding hypo sludge in dosages of 25% and 50%, while Recron 3S fibers were introduced at 0.5% and 1% by weight of cement. The study focused on an M30 concrete mix, evaluating its performance through tests such as compression, split tensile strength, flexural strength, capillary absorption, and porosity analysis. Ultimately, the results of fiber-reinforced concrete were compared with conventional concrete to determine its effectiveness. Nayan Rathod [4] explored the properties and potential applications of basalt fiber, a relatively new material in the construction industry. Basalt fiber is a high-performance, non-metallic fiber made from basalt rock melted at high temperatures. It offers several advantages, including lightweight properties, excellent fire resistance, and high strength. Due to its promising characteristics, basalt fiber is expected to play a significant role in future construction. Its applications extend to residential, industrial, and infrastructure projects such as highways and bridges. This study conducted trial tests on concrete with and without basalt fiber, using cubes and beams to compare compressive and flexural strength. The results, along with a techno-financial comparison with other materials, highlighted the immense potential of basalt fiber-reinforced concrete (BFRC) as a viable alternative construction material.

material.

N. Banthia [2] carried out a comparative analysis of different building materials, particularly metals and polymers. Over the past thirty years, significant advancements have been made in understanding the short- and long-term behavior of fiber-reinforced cementitious materials. This progress has led to the development of innovative applications, expanding the possibilities for advanced construction materials.

## MATERIAL AND METHODS

1. The materials used in this study include the following: **Cement:** Ordinary Portland Cement (OPC) of 53 grade, known for its high strength and durability.

**Aggregates:** Fine and coarse aggregates that meet ASTM standards, ensuring quality and consistency in the concrete mix.

**Basalt Fibers:** Chopped basalt fibers in two lengths, 12 mm and 24 mm, incorporated to enhance the mechanical properties of the concrete.

**Water:** Potable water, conforming to IS specifications, used for mixing and curing.

**Admixtures:** Superplasticizers added to improve the workability of the concrete mix, ensuring ease of handling and proper compaction.

2. Mix Proportions and Sample Preparation:

Concrete mixes were prepared with basalt fiber added at varying dosages of 0%, 0.5%, 1.0%, and 1.5% by volume. To evaluate the performance of these mixes, standard test specimens were cast, including cubes (150mm × 150mm × 150mm), cylinders (150mm × 300mm), and beams (100mm × 100mm × 500mm). After casting, all specimens were cured for 28 days before undergoing testing to assess their mechanical properties.

3. Testing Procedures:

**Compressive Strength:** Compressive strength is a measure of a material's ability to resist forces that attempt to reduce its size. To evaluate this property, three concrete cubes, each with dimensions of 150 × 150 × 150 mm, were cast and tested after 3 days, 7 days, and 28 days of curing. The study focused on assessing the compressive strength of concrete with varying basalt fiber content, ranging from 0% to 0.5%. The test results, presented in the following table, provide valuable insights into how the concrete's strength develops over time.

Mix Notation	% of Basalt fibers	Compressive strength in MPa (3 days)	Compressive strength in MPa (7 days)	Compressive strength in MPa (28 days)
C1	0%	15.26	24.01	40.17
C2	0.1%	16.256	26.87	40.94
C3	0.2%	17.03	27.05	42.17
C4	0.3%	17.41	27.58	42.63
C5	0.4%	16.07	26.93	41.38
C6	0.5%	15.89	26.41	41.15

**Flexural Strength:** To assess the flexural strength of concrete, three beam specimens, each measuring 100mm × 100mm × 500mm, were cast and cured for 28 days. On the 28th day, flexural strength tests were carried out on both the control mix and basalt fiber-reinforced concrete (BFRC) mixes to compare their performance.

The flexural strength (fpe) was calculated using the following formula:

$$fpe = PL/bd^2$$

Where:

**P** = Applied load (N)

**L** = Span length (mm)

**b** = Width of the specimen (mm)

**d** = Depth of the specimen (mm)

The results from these tests provide valuable insights into the impact of basalt fiber on the flexural strength of concrete.

Mix Notation	% of Basalt Fiber	
B1	0%	7.32
B2	0.1%	8.96
B3	0.2%	10.51
B4	0.3%	11.50
B5	0.4%	11.16
B6	0.5%	10.96

## RESULT AND DISCUSSION

The experimental findings demonstrate the beneficial effects of incorporating basalt fiber into concrete:

- **Compressive Strength:** Strength increased with fiber addition up to 1%, after which minor reductions were observed, likely due to fiber agglomeration.
- **Tensile Strength:** A notable improvement was recorded, with the most significant gains achieved at 1% fiber dosage.
- **Flexural Strength:** The highest enhancement was observed at 1% fiber content, indicating improved ductility and crack resistance in the concrete.

## CONCLUSION

The addition of basalt fiber significantly improves the mechanical properties of concrete. The optimal fiber content was found to be 1%, as higher dosages led to dispersion challenges. Basalt fiber-reinforced concrete (BFRC) demonstrates excellent potential for structural applications where high durability and strength are essential.

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## REFERENCES

1. Miryala Vijayakumar, Jagadish Shrisaila Haranatti, Mahantesh Neelappa Paruti, Jajimoggala Sravanthi, Khristina Maksudovna Vafaeva,(2024) Comparative study of basalt fiber and steel fiber as additives to concrete, Conferences 392, 01009
2. Gajanan S. Mundhe, Prakash A. Mahanwar, Jayesh R. Patil, Elamaran S,(2023) A Review on Basalt Fiber and Basalt Fiber Reinforced Polymer Composites: Advancement and Industrial Applications, Volume 11 Issue IV
3. Ehab T. Al-Rousan, Hammad R. Khali, Muhammad Kalimur Rahman,(2023) Fresh, mechanical, and durability properties of basalt fiber-reinforced concrete (BFRC): A review,
4. Ana Carolina Rosa, Ahmed W.A. Hammad, Dieter Boer, Assed Haddad,(2023) Use of operational research techniques for concrete mix design: A systematic review, Construct. Build. Mater. 190 (2018) 479–494
5. Hao Zeng, Jin Zhang, Yang Li, Xin Su, CongZhi Gu and Kai Zhang,(2022) Mechanical Properties and Microstructure of Basalt Fiber Reinforced Concrete Under the Single-Side Salt-Freezing–Drying–Wetting Cycles, ISSN 1976-0485/eISSN 2234-

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6. Yuzhen Guo and J. Phys (2021), Analysis on Concrete Construction Technology in Civil Engineering Construction, Conf. Ser. 2011 012023
7. Ashokkumar R. Tavadi, Yuvaraja Naik, K. Kumaresan, N.I. Jamadar, C. Rajaravi,(2021), Basalt fiber and its composite manufacturing and applications: An overview, Vol. 13, No. 4, 2021, pp. 50-56
8. Sateesh Gaonkar , and Madhu,(2021) Impact of different water-cement ratios on concrete strength: A review, Reviews, 2021, 09(01), 319-328
9. V. S. Parameswaran, T. S. Krishnamoorthy, And K.Balsubramanam,(2016) Current Research and Applications of Fiber Reinforced Concrete Composites in India,
10. Mr. Sachin, Mr. Yudhvir Yadav,(2016) A Research Analysis on Mix Design for High Strength Concrete, ISSN: 2319-7463, Vol. 5 Issue 4
11. Chenchen Li, Danying Gao, Yinglai Wang and Jiyu Tang (2017), Effect of high temperature on the bond performance between basalt fibre reinforced polymer (BFRP) bars and concrete, Journal of Construction and Building Materials, Vol. 141, pp 44-51
12. Marianne Inman, Eythor Rafn Thorhallsson and Kamal Azrague (2017), A mechanical and environmental assessment and comparison of basalt fibre reinforced polymer (BFRP) rebar and steel rebar in concrete beams, Journal of Concrete and Energy Procedia, Vol. 111, pp 31-40.
13. Abhijeet B. Revade (2017), Compressive and split tensile strength of chopped basalt fiber concrete, International Research Journal of Engineering and Technology, Vol. 04, pp 347-351.
14. Sruthi Jalasutram, Dipti Ranjan Sahoo and Vasant Matsagar (2016), Experimental investigation on mechanical properties of basalt fiber-reinforced concrete, Journal of Structural Concrete, Vol. 18, pp 292-302.
15. Eyup Zorla, Cagatay Ipbuker, Volodymyr Gulik, Sergei Kovaljov and Martti Kiisa (2016), Optimization of basalt fiber in concrete composite for industrial application in estonia, Fresenius Environmental Bulletin, Vol. 25, pp 355-364
16. V. Fiore, T. Scalici, G. Di Bella and A. Valenza (2015), A review on basalt fibre and its composites, Journal of Composites and Engineering Part: B, Vol. 74, pp 74-94.
17. Cory High (2015), Use of basalt fibers for concrete structures, Journal of Construction and Building Materials, Vol. 96, pp 37-46.
18. Fareed Elgabbas, Ehab A. Ahmed and Brahim Benmokrane (2015), Physical and mechanical characteristics of new basalt-FRP bars for reinforcing concrete structures, Journal of Construction and Building Materials, Vol. 95, pp 623-635.
19. Nihat Kabay (2014), Abrasion resistance and fracture energy of concretes with basalt fiber, Journal of Construction and Building Materials, Vol. 50, pp 95-101.
20. Chaohua Jiang, Ke Fan, Fei Wu and Da Chen (2014), Experimental study on the mechanical properties and microstructure of chopped basalt fibre reinforced concrete, Journal of Materials and Design, Vol. 58, pp 187-193.
21. R. K.Patil and D. B. Kulkarni. (2014), Comparative study of effect of basalt, glass and steel fiber on compressive and flexural strength of concrete, International Journal of Research in Engineering and Technology, Vol. 3, pp 436-438.
22. Tehmina Ayub, Nasir Shafiq and M. Fadhil Nuruddin (2014), Mechanical properties of high-performance concrete reinforced with basalt fibers, Journal of Concrete and Procedia Engineering, Vol. 77, pp 131-139.
23. Tumadhir M. and Borhan (2013), Thermal and mechanical properties of basalt fibre reinforced concrete, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering, Vol. 7, pp 334-337.
24. Gang Wu, Jia Wei Shi, Wen Jun Jing and Zhi Shen WuShi (2013), Flexural behavior of concrete beams strengthened with new pre-stressed carbon-basalt hybrid fiber sheets, Journal of Composites for Construction, Vol. 18, pp 1-10.
25. Marek Urbanski, Andrzej Lapko and Andrzej Garbacz (2013), Investigation on concrete beams reinforced with basalt rebars as an effective alternative of conventional RC structures, Journal of Concrete and Procedia Engineering, Vol. 57, pp 1183-1191.
26. Jongsung Sim, Cheolwoo Park and Do Young Moon (2005), Characteristics of basalt fiber as a strengthening material for concrete structures, Journal of Concrete Composites and Engineering Part :B, Vol. 36, pp 504-512.
27. IS 10262: 2009, Concrete Mix Proportioning - Guidelines, First revision, Bureau of Indian Standards, New Delhi.
28. IS 456: 2000, Plain and Reinforced Concrete - Code of Practice, Fourth Revision, Bureau of Indian Standards, New Delhi.
29. IS 516: 1959, Methods of tests for strength of concrete, Bureau of Indian Standards, New Delhi.
30. IS 383-1997, Indian Standard Specifications for Course and Fine Aggregates for Natural Sources for Concrete, Bureau of Indian Standards, New Delhi.

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