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Review paper on Strengthening of Column using BFRP

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Abstract - *This paper provides a detailed overview of column strengthening strategies utilizing Basalt Fiber Reinforced Polymer (BFRP) composites. With the growing demand for retrofitting and increasing load-carrying capacity in existing structures, BFRP is now recognized as a useful material because of its outstanding mechanical qualities, corrosion resistance, and environmental sustainability. The review discusses a wide range of topics, including BFRP properties, different strengthening procedures, experimental research, analytical models, and design guidelines for BFRP strengthened columns.*

Key Words: Column, Basalt Fibre Reinforced Polymer (BFRP), Strengthening, Wrapping, Compression Strength.

1.INTRODUCTION

Old reinforced concrete structures frequently suffer from weakened concrete and insufficient reinforcing, which leads to instability. To address this issue, engineers use approaches such as wrapping columns with steel jackets or fiber-reinforced cementitious matrix (FRCM) composites. These methods improve the structural integrity and seismic resilience of the columns. Steel jackets, FRCM composites, Ferro cement jackets, and fiber-reinforced polymer (FRP) jackets are among the ways utilized to increase the strength and ductility of these columns, particularly in key stress zones. Studies show that technologies such as steel jackets and FRCM composites considerably enhance the performance of reinforced concrete columns.

Fiber Reinforced Polymer (FRP) have been used in the form of external wrapping such that it will strengthen the existing structure. Significant researches are being carried out in this field for the past few decades, as the need for strengthening has been grown rapidly, and many design guidelines have been published for Fiber Reinforced Polymer reinforcements including column confinement. The method of application of these fibers is of great importance. From the application point of view, the FRP products are placed, according to various techniques, such that the in case of discrete fibers they are dispersed in the matrix and fiber sheets they are wrapped around the structures. When the load is applied axially to a concrete column, there will be the lateral expansion, and it can be restrained by the effect of confinement provided by the FRP laminates. A lateral confinement pressure will be provided by FRP which delays the softening of the column under the various loading conditions and has shown to enhance the strength and ductility of the column.

FRP, a composite material that combines a polymer matrix with fibers with typically glass, carbon, or aramid, likewise basalt, paper, wood, or asbestos is widely used in industries such as aerospace, automotive, marine, and construction. The researchers investigated the effect of wrapping concrete cylinders with various FRP materials and bonding sizes on their strength. Their findings showed that critical elements such as the wrapping material's elasticity and Poisson's ratio have a significant influence on the strength of covered concrete.

1.1 Basalt Fiber Reinforced Polymer (BFRP)

Basalt Fiber Reinforced Polymer (BFRP) composites have developed as a possible alternative to traditional construction materials because to its superior mechanical qualities, durability, longevity, and affordability.

Fibers produced from basalt are made from the natural volcanic rock basalt using a complex process that includes melting, extrusion, and spinning. The resultant fibers have great tensile strength, superior corrosion resistance, and thermal stability. Then these fibers are combined with a polymer matrix, such as epoxy or polyester resin, to create Basalt fiber reinforced polymer composites. To acquire the appropriate mechanical qualities, the basalt fibers are conceived with polymer resin before being cured under regulated conditions.

BFRP composites have a unique set quality that make them appropriate structural reinforcement applications. High tensile strength, rigidity, resilience to corrosion and thermal stability. Additionally, BFRP composites are lightweight, making them simple to transport and install. Furthermore, basalt fibers are non-toxic and non-carcinogenic, unlike typical reinforcement materials like fiberglass or carbon fiber.

Due to the usage of basalt fibers produced from abundant basalt rock around the world, BFRP composites provide environmental benefits. Unlike carbon fibers, which have a large environmental footprint due to petroleum-based manufacture, basalt fibers have a small carbon footprint and are renewable. In addition, BFRP composites are recyclable, which reduces their environmental impact.

2. APPLICATION OF BASALT FIBRE REINFORCED POLYMER IN CONSTRUCTION FIELD

BFRP is being used in construction in a number of ways, offering creative ways to improve Strengthening and other characteristics.

1.**Exceptional Strength-to-Weight Ratio**: BFRP composites are stronger than steel while being much lighter, which means they are suitable for situations where weight reduction is a top priority.

2.**Unmatched Corrosion Resistance**: Unlike steel, BFRP composites can withstand corrosion and degradation in extreme situations such as marine or chemical settings.

3. **Versatile Design Possibilities**: BFRP composites are easily molded into complicated shapes, allowing for increased design innovation and adaptability.

4. **Long-Term Cost Savings**: Despite greater initial costs than steel, BFRP composites offer major savings in the future due to its resilience, low maintenance, and increased lifespan.

5. **Sustainability Focus**: Basalt fiber they are made from natural, renewable materials, BFRP composites are environmentally friendly and can be recycled at the end of their useful life, reducing landfill waste and pollution.

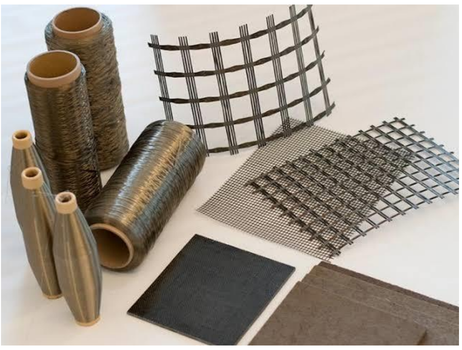

Fig -1: a) Basalt Fiber material

Fig -2 b) BFRP used on column

3. LITREATURE REVIEW

Arathi Krishna et al. [2018] [1]

This research investigates how covering short concrete columns with BFRP jackets can improve their strength. According to the abstract, employing BFRP instead of steel can reduce corrosion and increase column strength. The study employs experiments and models to determine how effectively BFRP jackets function in strengthening columns. They include factors such as whether the column is entirely or partially wrapped, as well as the number of BFRP layers used. The result states that covering columns with BFRP can significantly strengthen them, particularly when fully covered. Adding more layers of BFRP to the columns can increase their strength. The study also compares the results to several models, discovering that one model occasionally provides higher estimations of strength than the real experiments Overall, this research presents how BFRP jackets can additionally increase the strength of short concrete columns. It recommends completely covering the columns in BFRP for the greatest results and provides valuable information for engineers and researchers.

Chiadighikaobi Paschal Chimeremeze et al. [2019] [2]

This study discusses making concrete columns stronger by coating them in BFRP. It shows that while columns in structures are crucial for supporting the structure's weight, they can weaken over time. The study assessed how well BFRP can strengthen concrete blocks by making them more difficult to break. The results showed that adding BFRP increased the strength and flexibility of the blocks. The paper also indicates that the fibers in BFRP may not always line up correctly, affecting how efficiently it supports structures. It shows that when concrete columns with BFRP age, their strength increases. Overall, this study helps us understand how to make concrete columns stronger using BFRP, but more research is needed to know exactly how well it works in different situations.

Zhiqiang Dong et al. [2023] [3]

The research describes a unique composite technique for enhance the performance of concrete columns by combining high-density polyethylene (HDPE) and fiber-reinforced polymer (FRP) confinement with rubber concrete filling. The work uses extensive experimental testing and theoretical modeling to evaluate the effects of critical variables such as HDPE tube diameter, FRP sheet layers, and rubber particle addition on the compressive strength and deformation capacity of the specimens. The results show that the hybrid confinement system improves the load capacity and ductility of concrete columns, especially in earthquake-prone areas. While the work presents the results and practical consequences clearly, From the recommendation for development are enhancing figure and table clarity, diving deeper into model assumptions, and expanding on future research possibilities. Overall, the work provides excellent insights and makes major contributions to the field of structural engineering. The study describes a novel composite technique for increasing the performance of concrete columns that incorporates high-density polyethylene (HDPE) and fiber-reinforced polymer (FRP) confinement with rubber concrete infill. The study employs difficult experimental testing and theoretical modeling to evaluate the effects of crucial variables such as HDPE tube diameter, FRP sheet layers, and rubber particle addition on the compressive strength and deformation capacity of the specimens. The findings indicate that the hybrid confinement system increases the load capacity and ductility of concrete columns, particularly in earthquake-prone areas. While the work effectively conveys the results and practical repercussions, ideas for improvement include enhancing figure and table clarity, digging deeper into the model.

L.M. Abd el-Hafez et al. [2023] [4]

The experimental study on basalt fiber-reinforced polymers (BFRP) for strengthening reinforced concrete (RC) columns presents comprehensive findings that underscore the effectiveness of BFRP in enhancing structural performance. Through systematic investigation of various parameters such as strengthening materials, techniques, and loading conditions, the study demonstrates significant improvements in energy absorption, crack propagation resistance, and load-bearing capacity. Notably, BFRP wraps and bars, as well as hybrid FRP systems, show promise in increasing the ultimate load capacity of RC columns, with substantial enhancements observed under both eccentric and concentric loading conditions. Moreover, the study highlights the importance of optimizing wrapping techniques and considering column geometry in strengthening design. The incorporation of BFRP reinforcement, particularly through near-surface mounted (NSM) techniques, is shown to greatly improve column behavior, further emphasizing the potential of BFRP in enhancing structural resilience. Overall, the research provides valuable insights into the application of BFRP in RC column strengthening, with implications for advancing structural performance and durability in practice.

Tejash Pate et al. [2018] [5]

The research conducts a thorough examination of 13 different column types, evaluating their work in different strengthening approaches, including FRP wrapping. It indicates that FRP wrapping greatly improves axial load and displacement capacity, with fully wrapped columns failing primarily due to ruptures in the FRP material. The study further stresses the effectiveness of partial top and top-bottom strengthening methods, demonstrating significant increases in load-carrying capacity and displacement control over non-strengthened or partially strengthened columns. Furthermore, the axial stress-strain behavior is investigated, revealing discrete phases and trends that match to various strengthening configurations. Importantly, the work validates the accuracy of prediction models, demonstrating their utility in building FRP-confined RC columns. Notably, the results indicate that BFRP materials have comparable performance to GFRP at a potentially lower cost, making it a compelling choice for practical applications. Overall, the paper provides valuable knowledge into the behavior and strengthening of RC columns, offering practical implications for structural engineering practice.

Sayed Abd El-Baky [2021] [6]

This experimental study investigates the axial behavior of RC columns reinforced with either steel or Basalt Fiber Reinforced Polymer (BFRP) bars. The research design is strong, with three RC columns evaluated under compression loading to failure, each having a square cross-section of 200 mm width and 2000 mm height. Key aspects such as reinforcement type and load eccentricity (both centric and non-centric, with a tiny eccentricity of 5 cm) are thoroughly considered, resulting in a comprehensive analysis of the columns performance under various scenarios. The study's findings show a number of key discoveries. To begin, it is found that utilizing BFRP bars results in a minor loss in column load capacity when compared to typical steel reinforcement. However, BFRP bars reduce axial shortening in the studied columns, indicating possible benefits for long-term structural stability and longevity. Also, the study shows that BFRP bars cause higher strain levels in the main reinforcement than typical columns, which could have ramifications for design and structural behavior. Furthermore, the study highlights the influence of eccentric loading, demonstrating a significant drop in load capacity for BFRP bar specimens under such conditions, showing limitations in specific loading scenarios. Overall, this study sheds light on the utilization of BFRP bars in RC columns, highlighting both advantages and limits over typical steel reinforcement. The findings add to the body of knowledge about alternative reinforcement materials in structural engineering and offer engineers and designers practical advice when deciding whether BFRP bars are suitable for specific structural applications. More study might look at additional characteristics and loading circumstances to better understand the behavior of BFRP-reinforced columns and maximize their performance in practical engineering applications.

3. CONCLUSIONS

Based on evaluations of numerous studies on enhancing the strength of concrete columns with fiber-reinforced polymers (FRP), it is clear that these techniques have immense potential to improve structural performance. Arathi Krishna et al. (2018) and Chiadighikaobi Paschal Chimeremeze et al. (2019) both emphasize the efficiency of Basalt Fiber Reinforced Polymer (BFRP) in reinforcing columns, although further study is needed to fully comprehend its possibilities. Zhiqiang Dong et al. (2023) present a unique composite approach that incorporates high-density polyethylene

(HDPE) with FRP, with promising results, particularly in earthquake-prone areas. L.M. Abd el-Hafez et al. (2023) underline the full advantages of BFRP in terms of structural resilience and load-bearing capacity Tejash Pate et al. (2018) investigate the performance of various strengthening methods, verifying the efficacy of FRP wrapping and emphasizing the potential economic benefits of BFRP materials. Collectively, these studies highlight the significance of FRP technologies in developing structural engineering practice, with BFRP emerging as a particularly promising approach for increasing the strength and durability of concrete columns.

REFERENCES

[1] Arathi Krishna, Milu Mary Jacob, K.Saravana Raja Mohan "Experimental Study on Strengthening of RC Short Columns with BFRP Sheets", International Journal of Engineering &Technology- 2018.

[2] Chiadighikaobi Paschal Chimeremeze "Assessment of Compression strength of Concrete Columns Confined with Basalt Fibre Reinforced Polymer", MATEC Web of Conferences · 2019.

[3] Tianhao Han, Jianghao Ji, Zhiqiang Dong, Hong Zhu, Gang Wu "Compression behavior of concrete columns strengthened by a hybrid BFRP/HDPE tube coupled with a crumb rubber concrete cladding layer", ScienceDirect-2019.

[4] Sayed Abd El-Baky, Sameh Yehia, Arafa M. A. Ibrahim and Abdullah Moubarak "Behavior of Columns Reinforced with BFRP Bars in case of Centric and Eccentric Conditions", International Journal of Scientific & Engineering Research- 2021.

[5] Tejash Patel, Sanjay Salla, Sandip Vasanwala and Chetankumar Modhera "Strengthened of a Square RC Columns using BFRP and GFRP: The Experimental Investigations" TRENDS IN SCIENCES -2022.

[6] Asaad M. H. Kadhim , Hesham A. Numan, and Mustafa O¨ zakça "Flexural Strengthening and Rehabilitation of Reinforced Concrete Beam Using BFRP Composites: Finite Element Approach"-2019.

[7] Ling Zhou, Qing Liu, Shengqiang Ma and Xia Han "Eccentric compression behavior of long Poplar columns externally reinforced by BFRP" Journal of Wood Science- 2021.

[8] Sara Kadhim and Mustafa Ozakça "Flexural performance of RC beams externally strengthened with a single-layer of basalt fiber reinforced polymer sheets" Green Composites for Structural Applications-Original Article- 2022.

[9] Adnan AL-Sabahi. "Behavior of Reinforced concrete columns strengthened with ferrocement under compression load ", world journal of engineering and technology", (2016).

[10] Cem Yalcin and Osman kaya "experimental study on the behavior of reinforced concrete columns using FRP materials", (2004).

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