Retraction

Retraction: Experimental Study on PCC Beams Strengthened With External Wrapping of Basalt Fibre Reinforced Polymer (BFRP) (IOP Conf. Ser.: Mater. Sci. Eng. 1145 012085)

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This article (and all articles in the proceedings volume relating to the same conference) has been retracted by IOP Publishing following an extensive investigation in line with the COPE guidelines. This investigation has uncovered evidence of systematic manipulation of the publication process and considerable citation manipulation.

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IOP Publishing regrets that our usual quality checks did not identify these issues before publication, and have since put additional measures in place to try to prevent these issues from reoccurring. IOP Publishing wishes to credit anonymous whistleblowers and the Problematic Paper Screener [1] for bringing some of the above issues to our attention, prompting us to investigate further.

[1] Cabanac G, Labbé C and Magazinov A 2021 arXiv:2107.06751v1

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Experimental Study on PCC Beams Strengthened With External Wrapping of Basalt Fibre Reinforced Polymer (BFRP)

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Abstract. Infrastructure plays a vital role in development for recent times and humiliation of structural materials that is caused by some environmental effects has to be protected by strengthening of structures. One of the finest challenges in Civil Engineering is strengthening and rehabilitation of existing structures. There are various rehabilitation technique such as external wrapping of fiber reinforced polymers (FRP) have been developed. At initial period, strengthening has been done externally using steel plates bonded to the tension side and it has numerous difficulties including durability, manipulation, and heavy weight. The main aim of the study is to investigate the flexural behavior of the PCC beam with respect to orientation of the wrapped basalt fiber reinforced polymer (BFRP). A sequence of 12 PCC beams with 500mm as its length, 100mm as its width and 100mm as its depth are cast with M25 grade concrete. All the 12 specimens are cured for a period of 28 days. Of the 12 PCC beams two beams are control specimens and a comparative study on the orientation of the fiber such as wrapped tension zone, shear zone, U shaped -1, U shaped -2, and fully wrapped are used on the specimen. The fiber is to be wrapped according to the orientation of the beam with epoxy resin. The experimental results shows that PCC beam that is wrapped as U shaped – 2 Shows higher Flexural strength compared to all other fabric orientations. BFRP Fully wrapped beam gives minimum Load carrying capacity when compare with other fabrics. U shaped – 2 orientation has higher load carrying capacity and economical as compared to fully wrapped and all other modes of orientations.

Keywords: fiber reinforced polymers (FRP), basalt fiber reinforced polymer (BFRP), Strengthening and rehabilitation, Epoxy resin, PCC beams, Wrapped beams.

1. Introduction

A most important feature in the design of building structures is durability and it is recovered by the retrofitting of existing RC (reinforced concrete) structures using fiber reinforced polymer. The local cracks are formed during the design life of reinforced concrete (RC) structures due to overloading or from the flaws of construction technology unavoidably occurs [1]. Load-carrying capacity of structures is reduced by these cracks, which changes the dynamic characteristics of structures and even adversely affect the durability and safety of structure. Since the pioneering attempts at the middle of the 80’s, the consumption of fiber-reinforced polymer (FRP) composites for the restoration/strengthening of beams...
and slabs exhibited promising and fascinating results, allowing to obtain a significant improvement in both strength (ultimate limit state) and rigidity (serviceability limit state) of the structure. FRP-based strengthening is mainly performed by applying unidirectional FRP sheets on the beam traction side. Moreover, many experimental and analytical models have been recently proposed for evaluating both the mechanical behaviour of strengthened RC structural elements and the FRP debonding/failure features. Nevertheless, performance assessment of strengthened RC beams is usually restricted to the case of traditional carbon-based and glass-based [2]. The objectives of the study are to investigate the flexural behaviour of the controlled specimen and externally wrapped basalt fibre reinforced polymer. To determine the enhanced strength of the BFRP wrapped beams with variation of parameters with respective orientation [3]. To study the effect of orientation in fibre with stress strain behaviour, strength, ductility and failure mode. To study the effect of BFRP sheets in varying wrapping patterns with different orientation. To find the performance of the specimen under two point static loading.

2. Materials Used and Its Properties

2.1 Cement:
Cement is manufactured by scorching and humiliating of natural cement stones which contain 15% to 45% of Clay so called as argillaceous matter and remaining percent is covered by either calcium carbonate or magnesium carbonate so called as calcareous matter [4]. The Ordinary Portland Cement (OPC) of grade 43 was used. The specific gravity of cement is 3.12. Standard consistency of cement was 31.25%, Initial and final setting time of cement is 36 minutes and 360 minutes.

2.2 Fine Aggregate
The fine aggregate is the one of the essential ingredient in concrete which is used to fill the pores over it. Fine aggregate consists of fine sand that can be obtained naturally or by crushing of stone to required size. The quality and density of fines toughly influence the hardened properties of the concrete. While considering fine aggregate the particles should passes through 4.75 mm sieve and retain on 75 micron sieve [5]. Specific gravity of cement is found out to be 2.6. Fineness modulus is obtained as 4.68 and Zone division by sieve analysis is conforming to zone II of IS 383-1970, Water absorption of fine aggregate is 2.24%.

2.3 Coarse Aggregate:
The aggregate of particles whose size is bigger than 4.75 mm is considered to be coarse aggregate. Conferring to sources of coarse aggregates, it can be further classified as uncrushed gravel or stone which are obtained from natural fragmentation of rock and other one is crushed gravel or stone which are obtained from crushing of gravel or hard stones [6-7]. Specific gravity of coarse aggregate is found out to be 2.7, Fineness modulus is found out to be 4.08 %, Zone division by sieve analysis is conforming to zone II of IS 383-1970, Water absorption of coarse aggregate is 1.5%.

2.4 Basalt Fibre Reinforced Polymer (BFRP):
Basalt rock is a volcanic rock that can be segregated into small fragmented particles which are shaped into continues or chopped fibers. Compared with all other sorts of fibre, Basalt fiber is said to have a greater working temperature as it can withstand larger thermal load compared to other fibres and also possess a very good results while considering any sorts of chemical attack, impact load, and fire with less poisonous fumes [8-10]. Certain prospective applications of basalt composites are bridges, highways, industrial floors and ceilings, heat and sound insulation panels for residential and industrial buildings. This fibre is widely used in retrofitting and rehabilitation of concrete structures. Basalt is composed of plagioclase, feldspar, magnetite and pyroxene with or without olivine containing not more than 55 wt. % SiO2 and less than 5 wt. % total alkalis. Basalt Fibre reinforced polymer sheet of 2m X 2m is used for wrapping the beam with respective orientation. BFRP of bi-directional with 200GSM of thickness 2mm is used.
2.5 Epoxy Resin:
Epoxy resin LY556 with hardener HY951 is used in this study. Araldite LY556 is an epoxy resin based on Bisphenol-A which is commonly known for its high performance. The composite epoxy FRP applications which includes filament Winding, Pultrusion, and Pressure Moulding. It has good fiber impregnation properties excellent mechanical, dynamic and thermal. Figure 1 shows the BFRP with epoxy resin.

![BFRP with epoxy resin](image)

**Figure 1.** BFRP with epoxy resin

2.6 Concrete mix proportion ratio:
The calculated mix proportional ratio for M25 grade concrete is 1:2.90:2.84 was designed to attain the compressive strength of 25N/mm2 with the water cement ratio of 0.45. The compressive strength is tested for this mix proposition and average compressive strength was found to be 29N/mm2 at the end of 28 days curing. The mix design of M25 grade concrete is calculated using IS 456-2000 and IS 10262-2009. Table 1 shows the Mix propositions.

| Materials | W/C Ratio | Cement | Fine aggregate | Coarse aggregate |
|-----------|-----------|--------|----------------|------------------|
| Ratio     | 0.45      | 1      | 1.90           | 2.84             |

3. Experimental Methods
In this study the flexural behavior of the PCC beam with respect to orientation of the wrapped basalt fiber. A sequence of 12 PCC beams with 500mm as its length, 100mm as its width and 100mm as its depth are cast with M25 grade concrete. All the 12 specimens are cured for a period of 28 days. Of the 12 PCC beams two beams are control specimens [11-15]. A comparative study on the orientation of the fiber as wrapped on Tension zone, shear zone, U shaped -1, U shaped -2 and Fully wrapped. The fiber is to be wrapped according to the orientation of the beam with epoxy resin.

3.1 Experimental setup:
The beam casing of cross section with 500mm length, 100mm width and 100mm depth was used for casting of specimen. Screws are used to make the casing stiff so that there is no change in the dimension of the beam. Corroded and wobbly debris prevailing in the casing were evicted fully with a help of wire brush which is made up of steel. Concrete that are prepared using the mix proposition was placed inside the mould casing of respective size and it is tightened using screws to prevent the leakage of slurry and concrete is thoroughly compacted using tamping rod and it is made well finished without any honeycomb formation, to keep it free from air gaps. Total of 12 specimens were cast and the specimens were kept under the course of wet curing for a period of 28 days. Figure 2 shows the Casting of specimen.
3.2 Casting of BFRP specimens
After 28 days specimens were taken out from the curing chamber and kept for dry. The external surface is wiped using the salt paper. BFRP sheets are cut into required size to wrap according to the required orientations [16-17]. The epoxy is mixed with hardener to required proportion and coated over the beam and BFRP sheet are made to be wrapped to the beam with no air gaps present over it. The wrapped beams are kept for 24hours to dry. Figure 3 shows Casting of specimen with BFRP layers

3.3 Instrumentation and test procedure
All the 12 specimens were tested under two point loading in a flexural testing machine of 100kN capacity. The beams that are wrapped along with a conventional beam is placed one by one in the flexural testing machine they are centered and levelled using spirit level. Data Acquisition System of A 16- channel was used to store the data acquired from the point of loading. In order to initiate the test, load was applied to make the beam to rest on their base and removed. The experimental set up is shown in Figure 4 and Figure 5. Then incremental loads at regular intervals are begun to act on the beam which is placed on the setup and the experiment is carried out till beam attain its maximum load carrying capacity and fails. The results are tabulated in Table 2. The comparison of flexural load carrying capacity of conventional specimen with that of externally wrapped BFRP beams.
4. Results and Discussions
This investigation was carried out by varying the orientation of the BFRP sheets that are externally wrapped with varying orientation of fibers. The flexural behaviour of PCC beam with that of BFRP layer were observed and analysed with the codal provisions. Finally, the flexural strength of PCC BFRP beams and conventional beams are observed and compared by experimental analysis. Figure 6 shows the Deflection of beams and Figure 7 shows the Comparison of results.

| S.No | PATTERN      | Load (kN) | Deflection (mm) |
|------|--------------|-----------|-----------------|
| 1    | Controlled specimen | 4         | 0.005           |
| 2    | Tension zone  | 13        | 1.6             |
| 3    | Shear zone   | 14        | 1.75            |
| 4    | u shaped -1  | 15        | 1.88            |
| 5    | u shaped -2  | 21        | 2.63            |
| 6    | Fully wrapped| 19        | 2.3             |

Figure 4. Experimental setup

Figure 5. Failure mode specimen

Table 2. Experimental results

Figure 6. Deflection of beams
5. Conclusion

The flexural behaviour of 12 PCC beams which are externally wrapped by BFRP layers with varying orientations were tested with two-point loading conditions by varying parameters. The 12 beams were loaded with two point and its ultimate flexural load along with deflection is recorded. The test results were compared and analysed with the codal provisions and the following conclusions were observed:

- BFRP can be applied in strengthened RC beam, whose overall performance lies between those of control beam.
- Cracking of concrete can be effectively inhibited by external bonding of BFRP.
- The experimental results shows that PCC beam that is wrapped as U shaped – 2 Shows higher flexural strength compared to all other fabric orientations.
- The upgrading strength and ductility of strengthened beams with BFRP u shaped wrapped beam transverse direction are more remarkable. Whereas its Ultimate load is 21 kN.
- BFRP Fully wrapped beam gives minimum Load carrying capacity when compare with other fabrics.
- U shaped – 2 orientation has higher load carrying capacity and economical as compared to fully wrapped and all other modes of orientations.
- Since the BFRP owns a higher ratio of performance to cost, eco-friendly quality and unique high temperature resistance, it can be a superior option as a strengthening material the graph load vs deflection (d) shows the major difference between all six specimens.
- U shaped - 2 oriented BFRP can be used in retrofitting and strengthening of bridges, high rise buildings and in an existing structure to increase its load carrying capacity.

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