VOL. 17, NO. 21, NOVEMBER 2022 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

FLEXURAL BEHAVIOUR OF SFRC RETROFITTED BEAM WITH GFRPIN ADDITION TO ALCCOFINE

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ABSTRACT

Concrete is still the most popular building material because it is cheap and doesn't catch on fire. Hardened cement, fine aggregate and coarse sand are combined with admixtures to create the final product. To meet the necessity of advanced infrastructure, new innovative materials and technologies have evolved; one such technique is adding fibre reinforced polymer composites as both internal and external reinforcement. Glass fibre polymer is becoming more popular for strengthening and fixing things because it is strong for its weight, doesn't wear out quickly, doesn't cost much to maintain, and doesn't rust. Fiber-reinforced polymer laminates are used to improve the flexibility and bending strength. Both small and large cracks can be stopped by fibres. The main focus of the investigation was to look at the efficiency of discrete GFRP wraps in improving the flexural strength of beams. Alcofine and steel fibres were added to the beams before it is wrapped with GFRP to replace the cement and also to take care of the serviceability of the beam. An experimental investigation was done on the conventional beam and GFRP wrapped alcofine beams to determine their load carrying capacity. These tests were administered on a standard beam of 120*180*2000 mm for 28 days to see the behavior of the concrete element. Materials were tested and compared with conventional concrete beams in terms of strength and deflection. It is found from the experimental results that with wrapping up of the yielded concrete beam with GFRP had a significant increase in the flexural strength when compared to the conventional concrete element.

Keywords: alcofine, glass fiber reinforced polymer, flexural strength, concrete beams.

1. INTRODUCTION

Concrete is the most important large-scale individual material ingredient in the built environment. Significant environmental advantages might be realised if the embodied energy of concrete is lowered on a regular basis. Although hydraulic cement provides for just around 12% of total cementitious material energy and 6% to 7% of worldwide dioxin emissions, as a result, concrete embodies 93% of total emissions of CO2 and about 7% of total global CO2 emissions. In spite of the fact that cement manufacturing emits greenhouse gases as a by-product, its demand for infrastructure construction continues to grow worldwide. If this trend continues, this will result in far greater environmental damage and the loss of natural resources as the raw materials available for cement manufacturing will be depleted [1, 2]. Supplementary cementitious materials are employed in this situation since they can be used to completely or partially replace cement. These materials are known as alternative cementing materials. Ambuja Cements has begun producing a microfinecementitious material called Alcofine, which is made in a regulated manner from the industrial by product GGBS. This is a special slag product obtained by the controlled granulation process with high glass content and high reactivity. The basic raw materials are low calcium silicates. Because of its outstanding chemistry and ultra-fine particle size, Control Surfaces produces a particle size distribution (PSD) that is controlled. It is considered ultra-fine because its blain value is around 12000 cm2/gm, reducing water consumption, reducing permeability, and increasing durability. There are two main series of alcofine: the 1200 series and the 1100 series. Alcofine 1201 is used for fine particles, 1202 for microfine particles, and 1203 for ultrafine particles [7]. The maintenance, repair, and enhancement of structural components is one of the most significant concerns in civil engineering applications. Because restoring such faulty structural components costs the government a significant amount of money and time, strengthening has emerged as a feasible method of boosting load bearing capacity and extending service life. The degradation of infrastructure caused by early deterioration of buildings and structures has prompted an examination into numerous causes for restoring and strengthening. Choosing a strengthening method that would improve the structure's strength and workability while addressing restrictions such as constructability, building operation, and budget is one of the issues in concrete structure reinforcing. Structural reinforcement may be required in a variety of scenarios. Polymer reinforced with fibers (FRP) is widely utilized in the construction industry for exterior reinforcement of structural members. These technologies significantly strengthen structural members compared to ordinary concrete members. In recent years, a number of research based on FRP have been conducted. Beams were reinforced with GFRP sheets by wrapping them [3]. The findings demonstrate that RC beams with GFRP have increased strength, deformation capacity, and ductility. By externally bonding GFRP with resin, the structure can have a greater flexural strength and load bearing capacity. By wrapping GFRP sheets around RC beams, the flexural behaviours of the beams were investigated. When flexural testing is completed, As compared with RC beams that are conventionally wrapped with GFRP sheets, a beam with full GFRP sheet wrapping has higher flexural capacity [4, 5]. Internal steel fibres and exterior GFRP can be used to

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strengthen RC beams. The RC beam's flexural strength and ductility are improved thanks to the inclusion of both internal and external fibres. FRP was also the subject of other investigations. This is a non-corrosive, high-strength, light-weight substance that promotes lifespan. It also comprises FRP plates, sheets, etc. that are bonded externally which are used extensively in civil engineering construction. FRP usage strengthens RC members, according to all of these investigations.

2. EXPERIMENTAL PROGRAM

2.1 Materials

Test specimen is batched onsite and are made from concrete having 28day cube strength. Totally four beams were casted, One conventional beam and three beams with percentages of 3%, 6%, and 9% of alcoffine with 1% steel fiber added to the concrete. The ready mix concrete consisting of ordinary Portland cement, manufactured sand (M-sand), and crushed gravel of 10mm maximum size is used in the concrete for all the specimens. Two reinforcement bars in the tensile zone and two in the compressive zone of 12mm diameter are provided and the stirrups with 8mm diameter at a spacing of 150 mm c/c. The mechanical properties of alcoffine, steel fiber, glass fiber used for the specimen are listed in Tables 1, 2, 3, 4, 5.

Table-1. Properties of hooked steel fiber.

Fiber ID	Length L, [mm]	L/D	Diameter, D	Tensile strength (Mpa)
HF-65/35	35	65	0.55	1.345

Table-2. Chemical properties of alcoffine.

Chemical composition	Concentration%
Ca O	30 – 34%
SiO2	30 – 36%
$AL2O_3$	18 – 25%
$Fe20_3$	1.8 – 3%
MgO	6 – 10%
SO3	0.1 – 0.4%

Table-3. Mechanical, Physical, Chemical properties of glass fiber.

Mechanical properties	Values
Tensile strength MPa	3450
Young's modulus GPa	724
Ultimate tensile strain	24
Thermal Expansion Co-efficient	5
Poisson's co-efficient	022
Compressive strength MPa	5000 Max
Hardness MPa	6000 Max
Shear modulus GPa	36

Table-4. Physical properties of glass fiber.

Physical properties	Values
Diameter mm	10–30
Density Kg/m3	2600 Max
Volume Fraction %	33.33
Bulk modulus GPa	50 Max

Table-5. Chemical properties of glass fiber.

Chemical composition	Concentration%
SiO2	54
Al2O3	15
CaO	12

2.2 Specimen Design and Preparation

In this study, four RC beams were cast and put through two point loading tests. One regular beam and three beams with 3%, 6%, and 9% alcoffine and 1% steel fibre added to the concrete. All of the pieces were 120 mm wide, 180 mm tall, and 2000 mm long. All of the beams were double-reinforced with four 12 mm diameter bars, two in the tensile zone and two in the compressive zone. The stirrups had an 8 mm diameter and were spaced 150 mm apart.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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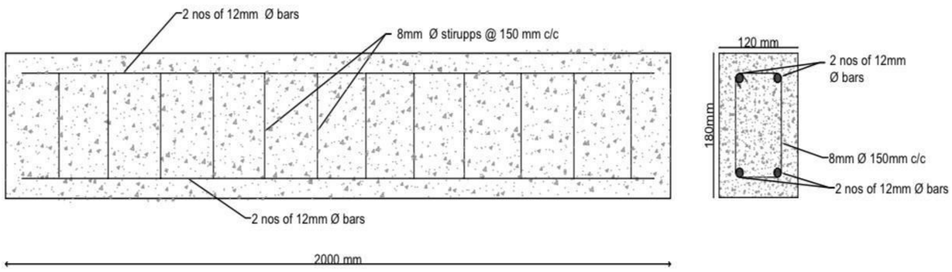

Figure-1. Detailing of RC rectangular beam.

2.3 Testing Procedure

In order to determine flexural behaviour on a loading frame after 28 days of curing, we used the RC beam. A 400kN-capacity loading frame was used to test all the RC beams. End bearings at the two ends reduced the effective span to 1800 mm from the total 2000 mm span of the beam. Deflections were measured using an LVDT dial gauge set immediately below the centre of the beams to provide a more accurate reading of the LVDT's output. The beam was then subjected to gradual loading of 5kN until it failed. The ultimate load and the load at first fracture were recorded together with the deflections measured in the middle. After that, the technique was repeated using GFRP-enhanced RC beams.

Figure-2. Experimental setup for flexural strength of conventional beam.

Table-6. Testing of beams before wrapping of GFRP by applying minimum load.

LOAD	CONVENTIONAL BEAM	1% OF STEEL FIBER		
		3% OF ALCOFINE	6% OF ALCOFINE	9% OF ALCOFINE
	DEFLECTION	DEFLECTION	DEFLECTION	DEFLECTION
5	0.29	0.31	0.18	0.39
10	1.06	0.43	0.90	0.81
15	2.38	1.42	1.97	1.74
20	3.48	2.48	3.12	2.84
25	4.33	3.62	4.08	4.01
30	5.47	4.87	5.02	5.05
35	6.46	5.67	5.85	6.01
40	7.47	6.61	6.92	6.90

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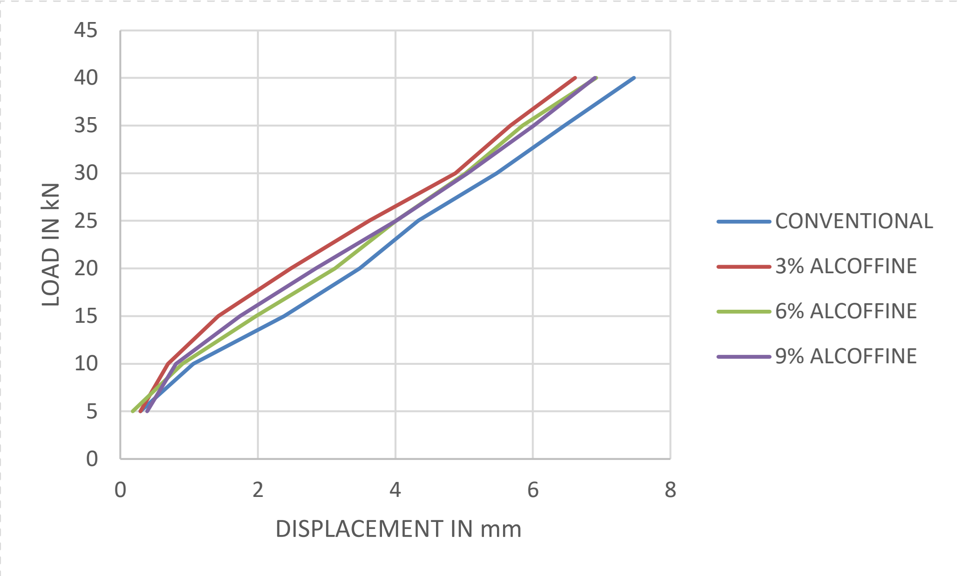

Figure-3. Load - deflection graph.

2.4 Preparation of Strengthened RC Beam with GFRP

Following the flexural test of the RC beam, the damaged RC beam was reinforced with GFRP by wrapping it around the beam. Before attaching the composite fabric to the concrete surface; the appropriate area was roughened with a coarse sand paper texture and cleaned with an air blower to eliminate any dirt and debris. After preparing the surface to the requisite quality, the epoxy resin was mixed according to the manufacturer's instructions. After cutting the textiles to size, the epoxy glue was applied to the concrete surface. The epoxy resin coating was then applied to the composite fabric, and the resin was pressed through the fabric's roving using a roller. Air bubbles trapped at the epoxy/concrete or epoxy/fabric interfaces have to be removed. GFRP sheet was placed over the epoxy resin coating, and the roller pressed resin through the fabric's roving, and the process was done for a second time. Epoxy was hardened with a constant, consistent pressure applied on top of a composite fabric to extrude the surplus epoxy resin and provide great contact between Epoxy, Concrete and the Fabric. At room temperature, this technique was carried out. During the 24 hours before testing, glass fiber-reinforced concrete beams cured at ambient temperature.

Figure-4. Experimental setup for GFRP wrapped beam.

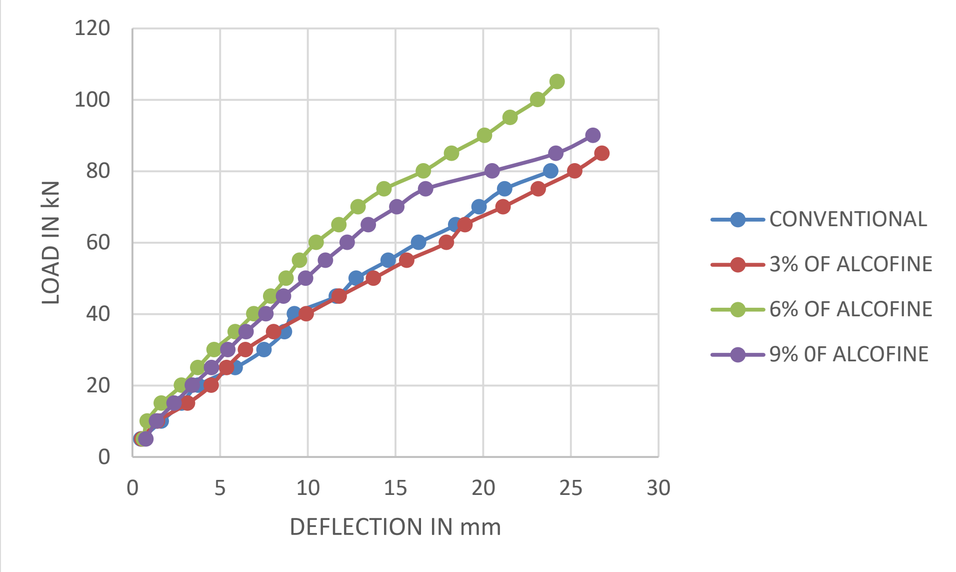

Figure-5. Load - Deflection graph wrapping with GFRP.

3. RESULTS AND DISCUSSION

Figures 3 and 5 presented the results of a flexural test conducted before and after GFRP wrapping. From experimental data, load deflection curves were constructed for all beams and compared with a strengthened RC beam to RC beam. The deflection rate of 3 percent, 6 percent, and 9 percent strengthened beams is enhanced by 5.88 percent, 23.89 percent, and 11.11 percent, respectively. Consequently, 6% of these three enhanced beams exhibit more strength than the other two strengthened beams. The load-deflection curves of strengthened and reinforced RC beams are depicted in Figures 2 and 3.

3.1 Load Deflection History

All of the beams' load deflection histories were documented. Each beam's deflection was compared to the deflection of their corresponding control beams. The load deflection behaviour of wrapped beams with the same reinforcement was also compared. It was discovered that when flexure deficient beams were bonded with GFRP Laminates, their behaviour was superior to that of their comparable control beams. When bonded externally using GFRP Laminates, the deflections were significantly reduced. The usage of GFRP sheet has the effect of slowing the formation of cracks.

3.2 Comparisons of Results

The findings of two sets of beams are presented: beams without strengthening and beams strengthened with a complete GFRP sheet. When reinforced with GFRP sheet in complete layer, for beams yielded with 40percent of the ultimate load enhance load bearing capacity by 5.88 percent, 23.8 percent, and 11.11 percent for 3percent,6percent and 9percent of alcofine respectively when compared to the control beam.

4. CONCLUSIONS

In this experimental investigation the flexural behavior of steel fiber reinforced concrete beams retrofitted by GFRP in addition to alcofine are studied. Totally four nos of RC beams were casted. Test results for One conventional and 3 beams with different proportions (3%, 6%.9%) of alcoffinewere calculated and the following conclusions are drawn:

- Alcofine acted as an excellent replacement to cement by providing equal or more strength when compred to cement concrete in terms of load and deflection.
- It is found that the gfrp wrapped beams were able to take a large amount of deflection when compared to the conventional beams.
- Beams with replacement of 6 percent alcofine which were wrapped with gfrpwas able to take more load when compared to the mixes of 3 percent and 9 percent.
- GFRP wrapped beams were able to take significant amount when compared to the conventioanal beams ie23.8% even though the beams were previously yielded.

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