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STUDY THE BEHAVIOR OF REINFORCED CONCRETE BEAM STRENGTHEN BY ANCHORED FRPUNDER BENDING MOMENT

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Abstract:

Although the steel reinforcement in concrete structure is protected by concrete, aggressive environmental condition can stimulate the carbonation of concrete and the formation of hydrated ferrous oxide in steel, resulting in spilling of concrete cover. However, the use of fiber reinforced polymers (FRP) has become a subject of great interest in structural community. The aging of the nation’s infrastructure in a tight economic environment has necessitated the search for innovative and cost effective solutions, several studies have focused on the use of externally bonded FRP to strengthen existing structure although FRP are more expensive than traditional structure materials, the savings in labor and equipment costs associated with the use of FRP make them an attractive alternative for strengthening because of its corrosion resistance to environmental agents as well as the advantages of high stiffness - to -weight and strength – to –weight ratios when compared to conventional construction materials. Other advantages of FRP include low thermal expansion, good fatigue performance and damage tolerance, non –magnetic properties and easy to transport. This study was conducted to study and compare the behavior of reinforced concrete beams using different fibers (carbon fiber, fiberglass and basalt fiber) and exposed to static vertical load until the collapse. 2 - Fully supported beams using carbon fiber, basalt and glass fiber 3 - Beams supported and fixed with basalt fiber, these samples have been tested under the influence of concentrated loads to collapse and compare the different variables. The results in this study are aimed at the behavior of these beams is known under the influence of several factors and using different methods of consolidation. In this study we have compared the results of the tests carried out on the samples.

Keywords: Basalt Fiber, Carbon Fiber, Circular column, Confinement reinforcement concrete.

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I. INTRODUCTION

The urgent need to strengthen concrete structure is on the rise. Various motivations lead to the increased demand for strengthening. Deterioration and aging of concrete structure are not the only reasons for strengthening beams, other reasons include upgrading design standards, committing mistakes in design or construction, exposure to unpredicted loads such as truck hits or powerful earthquakes, and changing the usage of the structure. Recently, the use of advanced composite materials has gained the interest of many researchers within last two decades.

II. EXPERIMENTAL WORK

In order to investigate the above points, all tested beams have the same total length 2.20m and overall cross section of 15x30 cm, they were simply support at span of 2m apart. The steel reinforcement of all beams was: two bars 12 mm diameter as tension reinforcement, two bars 12 mm diameter as compression reinforcement, and stirrups 8mm diameter with 20cm spacing. The number of beams that have been prepared for the test is seven beams as a control specimen solid beam Figure (4.1). These beams were divided according to the type of synthetic fibers and form of strengthening together with the control beams into three main groups:

1- Group (1) control beams.

2- Group (2) strengthened using deferent fibres covering whole beam span.

3- Group (3) strengthened using basalt fibre anchored on beams.

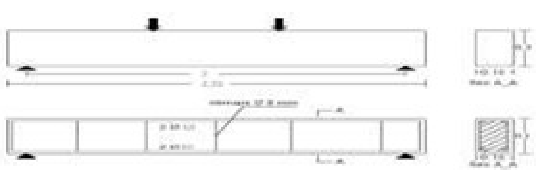
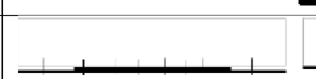
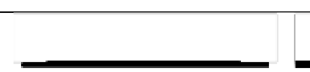


Fig. 1: Details of The Solid Beam (control beam).

Two parameters were considered in this study; strengthening shape and Strengthening Material. Details of tested specimens with different parameters are shown in table I.

TABLE I
EXPERIMENTAL PROGRAM.

Group	Type strengthening	Beam no	Shape of strengthening
A	Control beam	B1	
B	strengthened with (BFRP) covering the whole span of the beam	B2	
	strengthened with (GFRP) covering the whole span of the beam	B3	
	strengthened with (CFRP) covering the whole span of the beam	B4	
C	Basalt Fiber	B5	
		B6	
		B7	

The experimental work has been planned to investigate the difference in global behaviour between beams strengthened with different types of fibers such as:

1- Basalt fiber strengthening.

2- Carbon fiber strengthening.

3-glass fiber strengthening.

The test measurements include the first crack loads, failure loads, crack patterns, and concrete strains. Therefore, a total of seven beams classified into three groups as shown in Table (1).

The first group consists of one beam designated by B1 Where B1 represents the behavior of control Beam reference specimens without any strengthening.

The second group represents the U-shape Strengthening Basalt Fiber. Carbon Fiber and Glass fiber group which consists of three beams designated by B2 ,B3 & B4.

Where:

B2: strengthened with (BFRP) covering the whole span of the beam.

B3: strengthened with (GFRP) covering the whole span of the beam.

B4: strengthened with (CFRP) covering the whole span of the beam.

The third group represents the Partial & total Strengthening Basalt Fiber group which consists of three beams designated by B5 , B6 & B7.

Where:

B5: Is strengthened with a two layer of basalt Fiber .

B6: Is strengthened Using mechanically anchored Basalt Fibers sheet strips stopped at section of maximum moment.

B7: Beam Using Basalt Fibers Strips had a double sheet strips one of them stopped at section of maximum moment .

- The concrete mix was designed to achieve a target compressive strength of 25N/mm² after 28 days. The mix properties are shown in table II.

TABLE II
PROPERTIES OF CONCRETE MIX CONSTITUENTS USED IN THE EXPERIMENTAL WORK

Constituents	units	Contents (m³)
Cement	Kg	350
Sand	Kg	720
Water	Liter	175
Water-cement ratio	%	0.5
Coarse aggregate	Kg	1400

Each beam is strengthened with 2ø10 mm longitudinal fortifying plain bars giving support proportion of 0.022 longitudinal way. For all sections, tied stirrups were given of 5Ø8 mm plain bars. Though the stirrups are accumulated at the segment finishes maintaining a strategic distance from neighborhood disappointment at the segment finishes because of stress focus.

The electrical strain gauges are used to measure different strains of the beams. One strain gauge is used for each specimen to measure strain of reinforcement, the location of strain gauges at the middle of the beam at max momment. All columns were tested up to failure in axial compression using universal testing machine having 1200000Newton capacity. The upper head was fitted with seat. Both end surfaces of the beams are capped using gypsum layer to ensure horizontal and smooth surfaces. Care is taken to load the beams axially and reduce any possible eccentricity of the beams as showen in figure 2.

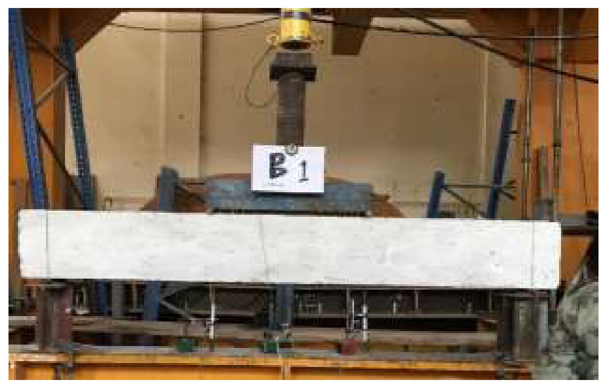


Fig. 2: Test Setup

III. TEST RESULTS AND ANALYSIS

In this part, the obtained test results are compared together and discussed to evaluate the effects of different types of strengthening on the beams behavior.

A. *Ultimate Loads and Strength*

Crack Patterns and Mode of Failure:

In control beam (B1), the first crack was initiated at the span midpoint of the beam bottom at a load of 32 KN. When the load increased, other cracked initiated and extended towards the point of load application. Diagonal cracks were observed in the shear zones at later stages of loading. The maximum load of the beam is 75.9 KN, after that the beam failure. The mode of failure, is a typical flexural failure .Flexural failure usually accompanied by crushing of concrete in the compression zone. It has been observed that the cracks were almost identical in a symmetrical pattern.

TABLE III

	Beam No	Type of Fibers	Cracking load(KN)	Failure load (KN)
Control beams	B1	Without strengthening	32	75.9
Group A	B2	Basalt fiber	83.1	85.2
	B3	Glass Fibers	48	79.5
	B4	Carbon fiber	27.4	84.4
Group B	B5	Basalt Fibers	32.86	94.15
	B6		30.1	85
	B7		22.76	84.85

MEASURED LOADS AND STRENGTH CAPACITIES FOR TESTED BEAMS

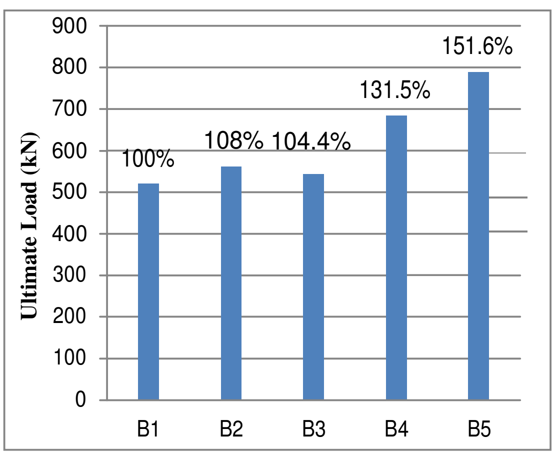


Fig. 3: Comparison of ultimate stress capacity for tested columns

IV. CONCLUSIONS

Test results in this research revealed following conclusions:

Regarding Crack pattern and Mode of Failure:

1. he cracks for control beam without stregthening were distributed in most areas of beam in a typical flexural failure.
2. The elongation characteristic of GFRP sheets led to increased beam flexibility as in the beam using (U – Shape) strengthening scheme, resulting in increased cracking area and distribution along the beam. Rapid de bonding of the fibers at the end of the strips which led to the ease of separation of the fiber's strips from the beam surface and increase the depth of cracks until failure.
3. The high value of the tensile strength and modulus of elasticity of BFRP strips resulted in delaying the initiation of cracks. For beam strengthened with (U- shape) scheme.
4. Strengthening the beams with BFRP strips gave more strength. BFRP strips characterized by good elongation, which gives the beams flexibility of load distribution, and this is shown at increase of cracks along the beams. Also, BFRP strips is characterized by high modulus of elasticity, which gave the beams an extra ability to strength the load. It was also good in its coherence with the surface of the beams.

Regarding Cracking and Ultimate Loads:

1. The capacity of Control beam without strengthening was.
2. For beams strengthened with GFRP strips, the cracking load for strengthening using (U – Shape) schemes are higher compared to the control beam (B1) by 50%, and the ultimate loads by 5.2%.
3. For beams strengthened with CFRP strips, the cracking load for strengthening using (U – Shape) schemes are lower compared to the control beam (B1) by 14.375% and the ultimate loads increased by 11.19%.
4. For beams strengthened with BFRP strips, the cracking load for strengthening using (U – Shape) is higher compared to the control beam (B1) by 159.68%, and the ultimate loads by 12.25%.

Regarding Deflections:

1. strengthening with BFRP is more effective in deflection and deformation because it gives the minimum deflection ratio at ultimate loads.

2. Strengthening with CFRP is more effective in controlling the beams deflection at cracking loads.

3. Strengthening with anchored BFRP scheme No 2 is more effective in controlling deflection and deformation at both ultimate and cracking loads

Regarding Steel Tensile Strains:

1. Strengthening beams with GFRP, CFRP and BFRP causes a noticeable reduction in the relative tensile strain ratios at ultimate loads a mid-span.

2. Strengthening with anchored BFRP scheme N.O 2 is the best in reducing tensile strain values than strengthening with (U – Shape) scheme.

Generally, GFRP, CFRP and BFRP sheets can be used, successfully, at strengthening beams with rectangular section. But the ability of strengthening depends on the properties of sheets, strengthening scheme, ease of use and cost because CFRP sheets is very exaggerate and BFRP is least expensive compare other fibers

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