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Analysis Of Retrofitting Of Simply Supported Beam By BFRP And AFRP Wrapping

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ABSTRACT:

Retrofitting of existing concrete structures has become an important issue nowadays in the construction industry. Such necessity had been caused by several factors, especially when concrete is subjected to severe environmental and loading conditions. In such situations, the remedy is either to demolish the existing structure and construct a new one or to retrofit the existing structure by an appropriate strengthening methodology. The analysis of simply supported concrete beam externally wrapped with aramid fiber reinforcement polymer (AFRP) and basalt fiber reinforcement polymer (BFRP) unidirectional sheet is carried out. The wrapped and unwrapped specimens were loaded. Mechanical Performance is evaluated to find effectiveness of wrapping in retrofitting of beams. Result shows that externally wrapping of simply supported concrete beam by AFRP and BFRP sheets can significantly enhance flexural strength. This paper presents the review of analytical and numerical study of flexural and shear performance of retrofitted or strengthening of beam by fibre reinforced polymer (FRP). Now a day investigator prefers numerical and analytical study to minimize error which can't reduce in experimental study, hence numerical study is more reliable than experimental study and analytical study less time consuming then experimental still having good agreement with experimental study

Keywords – Retrofitting, Compressive strength, Flexural strength, Basalt Fiber Reinforced Polymer (BFRP), Aramid Fiber Reinforced Polymer (AFRP), Compression Testing Machine (CTM), Universal testing machine (UTM)

INTRODUCTION:

In the last decade, the development of strong epoxy glue has led to a technique which has great potential in the field of upgrading structures. Basically, the technique involves gluing steel plates or fiber reinforced polymer (FRP) plates to the surface of the concrete. The plates then act compositely with the concrete and help to carry the loads. FRP can be convenient compared to steel for a number of reasons. These materials have higher ultimate strength and lower density than steel. The installation is easier and temporary support is not required due to low weight and high rate of strength gain. They can be formed on site into complicated shapes and can also be easily cut to length on site.

NEED OF RESEARCH

Considering through the inquire about, it is watched that, there is not any procedural information or standard code accessible in India for application of FRP. That's why the investigate and application is taken after by the writing accessible on the FRP. By considering the significance of past writing practical and explanatory consider is done on the FRP

EXPERIMENTAL ANALYSIS

1) Ingredients of Concrete

Conventional Ingredients 1) cement 2) Sand 3) Water 4) Corse Aggregate along with additional ingredients which is use for strengthen like **Basalt unidirectional fabric, Kevlar unidirectional fabric (AFRP) Adhesive (Sikadur-330) (2-part epoxy impregnation resin)**

2) Procedure and testing

Analysis of reinforced beam

For this experimental work. We have considered the reinforced beam specimen with size of 150 mm × 150 mm × 700 mm. Section details and reinforcement details given in figure below.

Analysis of beam:

Cross-section of beam = 150mm × 150mm

Length: - 700mm

Top reinforcement: - 2#10mm (A_{sc} =157 mm^2)

Bottom reinforcement: - 3#10mm (A_{st} =235.5 mm^2)

Cover on all side: - 25mm

3) Casting of beam specimen

Concrete beams of standard size 750 mm x 150 mm x 150 mm confirming to IS: 516-1959 was used for this study. A total number of 15 beam specimens and 9 concrete cubes were cast

Before placing of concrete in mould internal face of mould is properly weted with oil, to get smooth finish on all the side and easy removal of the concrete beam specimen.

•Concrete is to be placed is grade of M35.Concrete mix for the M35 grade is given below in table.

4) Application of BFRP and AFRP by "Dry application method"

1. Tools




Brush **Mixing container** **Roller** **Mixing spindle**

Material used for application of fiber sheet

2. Cleaning

Clean all tools and application equipment with immediately after use. Any uncured epoxy should be wiped up with a clean cloth wetted with turpentine. Hardened material can only be removed mechanically.

3. Preparation

• Review the project specifications and requirement in detail.

• Obtain all of the necessary equipment and tools plus materials required.

• Repairs to concrete surface irregularities such as blowholes or voids must be made with a suitable repair mortar.

• The concrete surface must be brushed and air blasted to achieve a dust free condition and no loose particles should be present on surface.

4. Dry application process

• The name of the 'dry' application method comes from the state of the fabric at the time it is applied in its final position. For this process, Sikadur-330 is normally used both as the substrate primer and as the fabric impregnating resin.

• The dry application method is suitable for woven fabrics with an area weight of up to 430 g/m^2, dependent on the fibre type.

• For the dry application of the BFRP and AFRP sheets Sikadur-330 is normally used for the resin priming coat and as the impregnating resin.

• It is shorter at high temperatures and longer at low temperatures.

• The greater the quantity that is mixed, the shorter the pot life becomes. To obtain longer workability at high temperatures, the mixed adhesive may be divided into portions. Another method is to chill components A and B before mixing them.

• The actual consumption, especially of the priming layer, is primarily dependent on the roughness of the substrate and the type and amount of FRP sheets to be impregnated.

A. Primer / Resin Application

• Apply Sikadur-330 to the prepared substrate using a trowel, roller or brush. Only one application step is necessary here, because the same product is used as primer and as impregnating resin

B. Fabric Positioning / Lamination

• Place the pre-cut dry BFRP and AFRP fabric in the required direction onto the Sikadur-330 priming layer.

• Carefully work the resin into the fabric with the plastic impregnation roller, working parallel to the fibre direction and until the resin is squeezed out between and through the fibre strands should distribute evenly over the whole of the fabric surface.

• The fabric has to be completely 'wetted' with the Sikadur resin.

• There must be no dry spots and the fabric must be pressed firmly onto the substrate. Squeeze out any entrapped air in the fibre direction to ensure there are no bubbles or blisters between the fabric and the substrate.

C. Results and Discussions

1 Cube test result

Results: -

- Following Graph and result represents variation in the Compressive strength of Concrete cube.
- 3 cubes are cast for each date of casting, Total nine numbers of cubes are cast and tested after 28 days curing period.

Title	**Casting Date**	**Size of cube(mm)**	**Maximum load (KN)**	**Result (N/mm^2)**	**Average (N/mm^2)**
Concrete cube test	08-Jan-19	150 × 150 × 150	890	39.56	36.50
			753	33.47	
			821	36.49	
	10-Jan-19		908	40.36	36.86
			798	35.47	
			782	34.76	
	12-Jan-19		801	35.60	38.36

Table: - 4.1 Compression strength of concrete cube

Discussion: -

- Compressive strength of concrete for M35 is 36.50 N/mm^2 ,36.86 N/mm^2, 38.36 N/mm^2
- Average compressive strength of concrete 37.24 N/mm^2 which is more than 35 $N/mm^{2.}$
- Result is satisfactory and validate the concrete mix proportion

Test result and graph for control beam

Results: -

- Following Graph and result represents variation in the load carrying capacity and flexural strength of Concrete beam specimen after 28 days of curing.
- Among 15 numbers of beam 3 beam are tested for the ultimate load carrying capacity till complete failure of beam.
- Single point load is applied at centre of beam span

Control beam test results

Title	Results (kN)	Average (kN)	Moment ($N.mm^2$)	Bending stress(N/mm^2)
Control beam	1. 92.15 2. 91.78 3. 86.00	89.98	13047100	23.20

- The average load carrying capacity of control beam specimen 90KN and maximum bending moment is 13.04 kNm
- 13.04 N.mm bending moment is more than estimated theoretical ultimate moment resistant capacity that is 11kNm.
- It is obvious and right that beam will fail at 13.04 kNm by testing, as compare to manual calculation.
- Load carrying capacity after distressing depends upon future loading types and values.
- After 60% de-stressing of beam, remaining load carrying capacity is about 40% only i.e. about 36 kN so corresponding Bending stress or flexural strength of beam 9.28 N/mm^2

Test result for beam wrapped with BFRP sheet

Results :-

- Following Graph and result represents variation in the load carrying capacity and bending stress of Concrete beam specimen after they wrapped with basalt fiber reinforcement polymer sheets.
- The beam are distressed by apply 60% load of the ultimate load before wrapping.
- Among 15 numbers of beam 6 beam are tested for the ultimate load carrying capacity till complete failure of beam.
- Single point load is applied at centre of beam span

<table>
<tr><th>Title</th><th>Load (kN)</th><th>Average (kN)</th><th>Moment (N.mm)</th><th>Bending stress (N/mm^2)</th></tr>
<tr><td rowspan="6">Wrap with basalt fiber</td><td>1. 111.50</td><td rowspan="3">124</td><td rowspan="3">17980000</td><td rowspan="3">31.97</td></tr>
<tr><td>2. 131.60</td></tr>
<tr><td>3. 128.90</td></tr>
<tr><td>4. 118.80</td><td rowspan="3">119.83</td><td rowspan="3">17375350</td><td rowspan="3">30.89</td></tr>
<tr><td>5. 124.30</td></tr>
<tr><td>6. 116.40</td></tr>
</table>

Discussion: -

- Increment in load carrying capacity after wrapping with BFRP sheets is for first 3 beam sample 37.78% and for last three beam sample 33.14% of original load carrying capacity of beam specimen.

Ultimate load capacity for beam wrapped with BFRP sheets

- Increment in flexural strength of beam after retrofit with BFRP sheets is 8.77 N/mm^2 i.e. by 37.8% of original flexural strength of beam.
- After wrapping load carrying capacity and flexural strength is increased even more than the original load carrying capacity.

- Increment in capacity is in range of 35% - 40%
- Increment in load carrying capacity after wrapped with BFRP sheets for first 3 beam sample 344.44% and for last three beam sample 332.86% that of 60% distressed beam specimen. Increment in flexural strength of beam after retrofit with BFRP sheets is 22.69 N/mm^2 i.e. by about 2.5 times of flexural strength of 60% de-stressed beam.

Test result for beam wrapped with AFRP sheet

Results:-

- Following Graph and result represents variation in the load carrying capacity and bending stress of Concrete beam specimen after they wrapped with basalt fiber reinforcement polymer sheets.
- The beams are distressed by apply 60% load of the ultimate load before wrapping.
- Among 15 numbers of beam 6 beam were tested for the ultimate load carrying capacity till complete failure of beam.
- Single point load is applied at centre of beam span.

Discussion:-

- Increment in load carrying capacity after wrapping with AFRP sheets for first three sample 29.68% and for last three sample 27.17% of original load carrying capacity of beam specimen.
- Increment in flexural strength of beam after retrofit with AFRP sheets is 6.88 N/mm^2 i.e. by 29.7% of original flexural strength of beam.
- After wrapping load carrying capacity and flexural strength is increased even more than the original capacity.
- Increment in capacity is in range of 25% - 30%
- Increment in load carrying capacity after wrapped with AFRP sheets for first 3 beam sample 324.22% and for last three beam sample 317.94% of load carrying capacity of 60% distressed beam specimen.
- Increment in flexural strength of beam after retrofit with AFRP sheets is 20.80 N/mm^2 i.e. by about 2.25 times of flexural strength of 60% de-stressed beam.

Title	Load (kN)	Average (kN)	Moment (N.mm^2)	Bending stress(N/mm^2)
Wrap with aramid fiber	1113.94	116.72	16924400	30.08
	2.114.74			
	3.121.50			
	4.107.20	114.46	16596700	29.50
	5.115.50			
	6.120.70			

Table: - 4.4 Ultimate load capacity for beam wrapped with AFRP sheets

Comparison of BFRP and AFRP from strength and cost point of views

- Beam wrapped with BFRP sheet shows grater load carrying capacity with difference of 7.24 kN as compare to beam wrapped with AFRP sheets.
- Beam wrapped with BFRP sheet shows grater flexural strength capacity with difference of 1.89 kN/mm^2 as compare to beam wrapped with AFRP sheets.
- BFRP sheets are 20-25% economical as compare to AFRP sheets.

CONCLUSION:

1. Load carrying capacity and flexural strength increased by 37.80% as compared to original load carrying capacity and flexural strength after U-shaped wrapping of Basalt fiber reinforcement polymer (BFRP) sheets.

2. It is observed that for beam wrapped with Aramid fiber reinforcement polymer (AFRP) sheets load carrying capacity and flexural strength increased by 29.71% as compared to original load carrying capacity.

3. In case of retrofitted simple supported beam by U-shaped wrapping of BFRP and AFRP sheets major failure of beam specimen is by crushing of concrete.

4. Beam wrapped with BFRP sheet shows 6.29% higher load carrying capacity and flexural strength as compare to beam wrapped with AFRP sheets.

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