Investigation on the Enhancement of Flexural Behaviour of Retrofitted Reinforced Concrete Beams

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Abstract- An experimental investigation has been carried out to study the enhancement in the flexural behaviour of retrofitted reinforced concrete beams. M25 grade of concrete has been adopted. This paper explains the behaviour of retrofitted RC beams under two point loading. Six numbers of beams were cast. All the beams were subjected to two point loading and the deflection was measured using LVDT. The beams were subjected to ultimate load till they failed. Two retrofitting techniques were adopted to study their significance. The load deflection behaviour for all the beams before and after retrofit was studied and parameters like stiffness, ductility factor and energy absorption capacity were determined. The results of the retrofitted RC beams are compared with the initial values obtained.

Keywords – retrofitted reinforced concrete beams, deflection, stiffness, ductility ratio, energy absorption capacity.

I. INTRODUCTION

The old existing buildings are affected by their original structural inadequacies, material degradation due to time, and alterations carried out during use over the years such as making new openings, addition of new parts inducing dissymmetry in plan and elevation, etc. The possibility of substituting them with new buildings is generally neglected due to historical, artistic, social and economical reasons. The complete replacement of the buildings in a given area will also lead to destroying a number of social and human links. Structure repair and rehabilitating is a process whereby an existing structure is enhanced to increase the probability that the structure will survive for a long period of time and also against earthquake forces. The main objective of retrofitting is to carry out structural repairs to load bearing elements to restore its original strength or enhance the strength of the member. It may involve cutting portions of the elements and rebuilding them or simply adding more structural material so that the original strength is more or less restored.

In general, every structural element should be designed for its strength and durability. However structural elements like reinforced concrete beams are often required to be repaired to restore the structural integrity and durability. Recently repairing is gradually increasing with the increase of age of concrete structures. In some instances it may be more economical to accept the need for maintenance or repair at suitable intervals than to attempt to build a structure that will be maintenance-free under severe conditions for a long period. Several types of materials and techniques are available for repairing the exiting deteriorated reinforced concrete beams.

II. PROPOSED ALGORITHM

A. Methodology –

Six numbers of reinforced concrete beams were cast and subjected to ultimate load. Then the beams were retrofitted using two different techniques. Again the beams were loaded to ultimate.

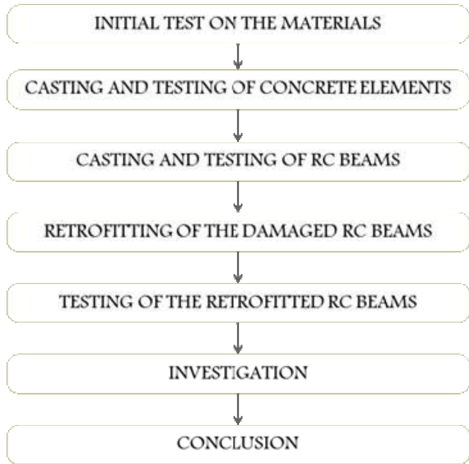

Figure1 Methodology of the project

III. EXPERIMENT AND RESULT

The experimental investigation consists of casting and testing of RC beams, adopting two different retrofit strategies, testing of the retrofitted RC beams again. Six reinforced concrete beams were cast and tested. The beams were designated as F1, F2, F3, F4, F5 and F6.

Material properties:

Cement:

Portland Pozzolana cement is being used for the experimental work. The physical properties of cement are as in table 1.

Table 1 Physical properties of cement

S.NO	Property	Value
1	Normal Consistency	32%
2	Initial Setting Time (min)	35
3	Final Setting Time (min)	330
4	Specific Gravity	3.16

Aggregates:

Fine aggregate: - The natural river sand was used. The fine aggregate conforming to IS 383-1987 was used

Coarse aggregate: - Crushed stone coarse aggregate conforming to IS 383 – 1987 was used.

Table 2 Physical properties of aggregates

S.No	Property	Fine aggregate	Coarse aggregate
1.	Specific Gravity	2.6	2.73
2.	Fineness Modulus	2.4	7.23
3.	Bulk Density	1498	1770
4.	Water absorption	0.7%	0.25%

Microconcrete: - Microconcrete mixture has higher compressive strength, higher tensile strength and a lower modulus of elasticity than Portland cement concrete.

Table 3 Physical properties of microconcrete

S. No	Property	Value
1.	Initial setting time	2 hours
2.	Final setting time	5 hours
3.	Compressive strength	20 N/mm²
4.	Tensile strength	1.7 N/mm²
5.	Flexural strength	4.5 N/mm²

Nitowrap: - Nitowrap typically has a large impact on strength, but only a moderate increase in stiffness. Nitowrap can also be applied to enhance strength of reinforced concrete by wrapping fabrics or fibres around the section to be strengthened.

Table 4 Physical properties of nito wrap

S. No	Property	Value
1.	Weight	200 g/m²
2.	Density	1.14 g/cc
3.	Fibre thickness	0.11mm
4.	Tensile strength	4900 N/mm²
5.	Tensile modulus	285000 N/mm²

Casting of test specimens:

The materials used in casting the test specimens (beams) are Portland Pozzolana cement, fine sand, coarse aggregate and water. The cross section of the beam is 130 mm x 250 mm and length of the beam is 2000 mm.
The dimensions and reinforcement details are as shown in figure 2.

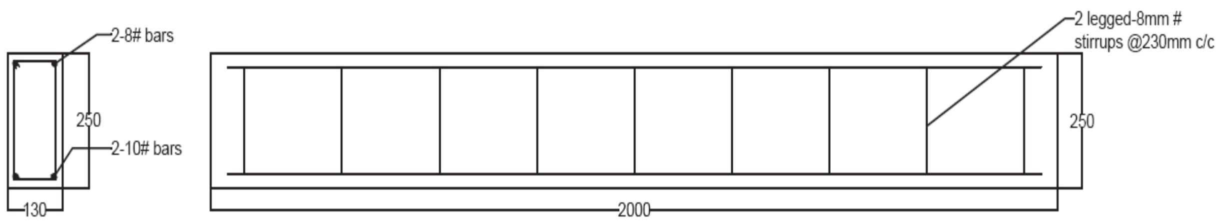

Figure 2 Reinforcement details

Test procedure:

The beams were cast and cured for 28 days. Before testing, they were painted white and grids were drawn to investigate the crack propagation during testing. The beams were simply supported and subjected to two point loading as shown in figure 3. The load was applied to the beams by means of hydraulic jack. For all the tested beams, first crack load, ultimate load and the cracking patterns were recorded. After retrofitting the cracks using microconcrete and nito wrap, the same procedure of testing is carried out again on all specimens and the first crack load, ultimate load and the cracking patterns were again recorded.

Figure 3 Load setup

Retrofit procedure

Prior to the retrofit strategy adopted for the beams, the cracks developed in the beams were injected with polymer to fill the cracks in the beam. The microconcrete was placed on the bottom and sides of the beam. The top surface of the beam is left without any repair and cured for 7 days. Similarly, the primer for the wrap was coated and dried for 24 hours. Then the saturant was coated and the nitowrap sheet was bonded to the surface of the beam. After 7 days the beams were tested again.

Figure 4. Testing of retrofitted beams

The six beams were loaded to ultimate and their average deflection was taken as the control beam. Out of six beams, three beams (F1,F2 and F3) were retrofitted using microconcrete and the other three beams (F4,F5 and F6) were retrofitted using nito wrap.

Results

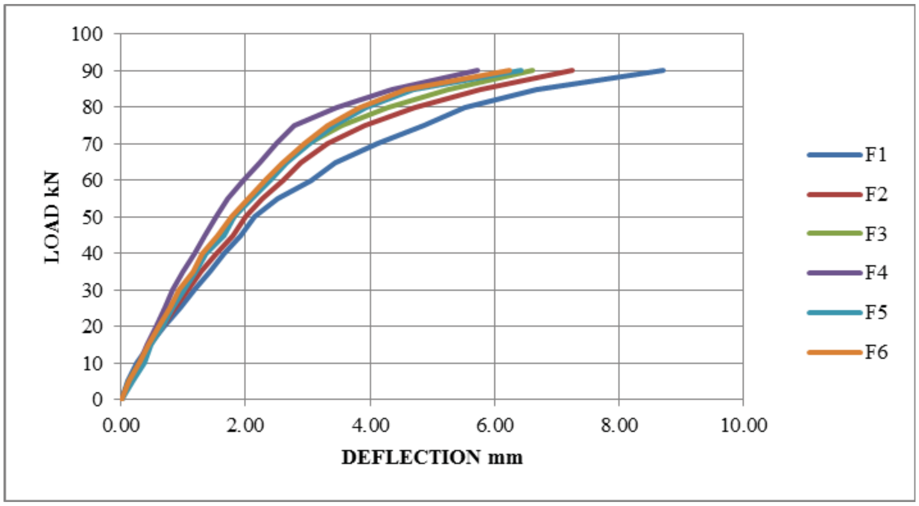

Figure 5 Load Vs deflection of control beams

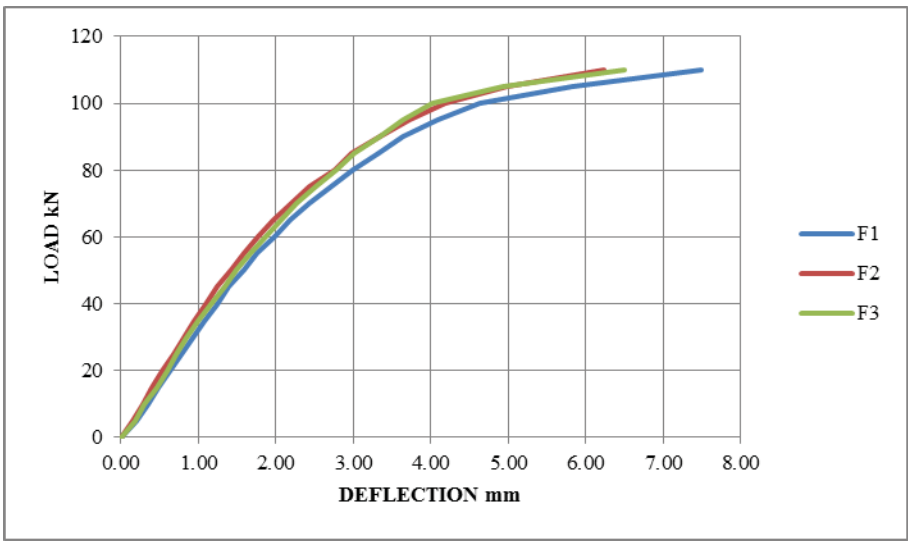

Figure 6 Load Vs deflection of beams retrofitted using microconcrete

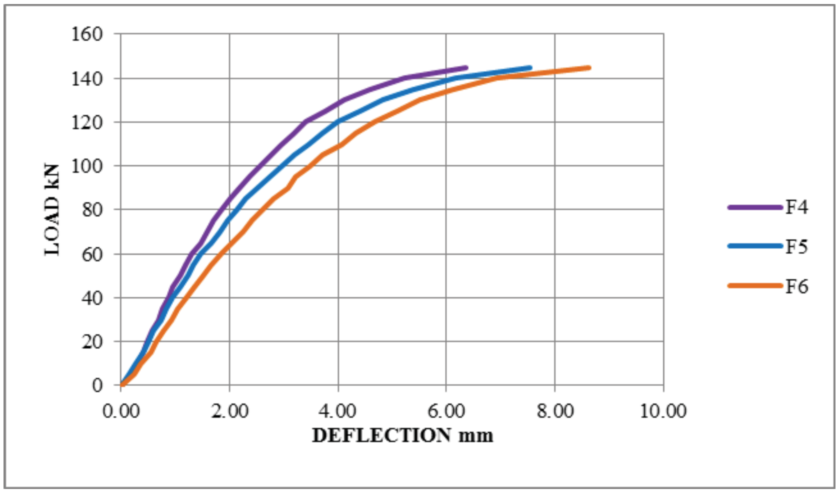

Figure 7 Load Vs deflection of beams retrofitted using nitowrap

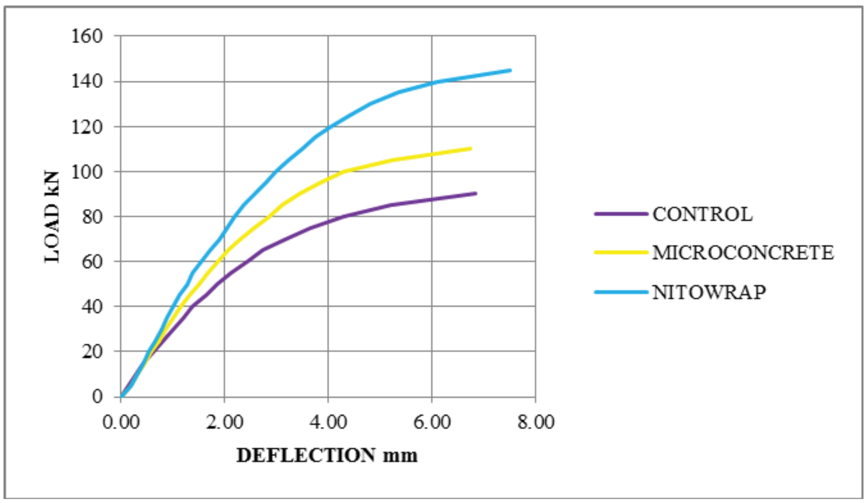

Figure 8 Load Vs deflection (Avg) of control, microconcrete and nitowrapped beams

Table 5 Results comparison

PARAMETERS	CONTROL	MICROCONCRETE	NITOWRAP
Cracking load(kN)	47.5	62.5	73
Ultimate load (kN)	90.83	112	148.33
Stiffness (kN/mm)	29.565	33.939	39.491
Ductility factor	3.679	3.785	4.359
Energy absorption capacity (kNmm)	195.203	239.393	353.030

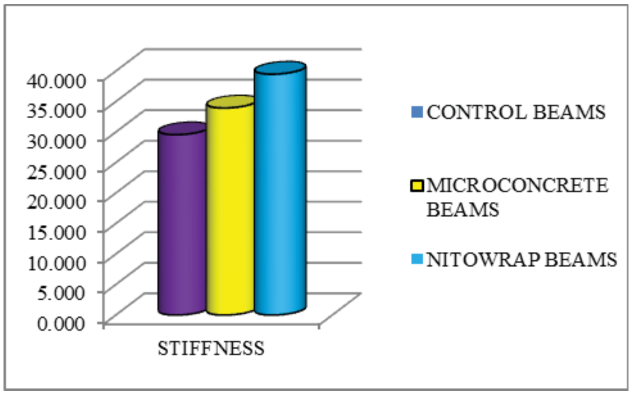

Figure 9 Stiffness of control, microconcrete and nitowrapped beams

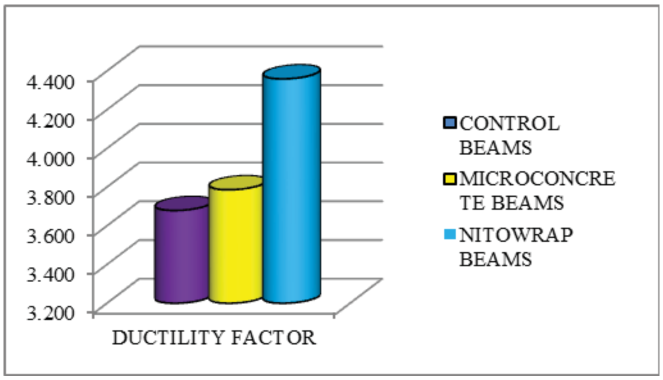

Figure 10 Ductility factor of control, microconcrete and wrapped beams

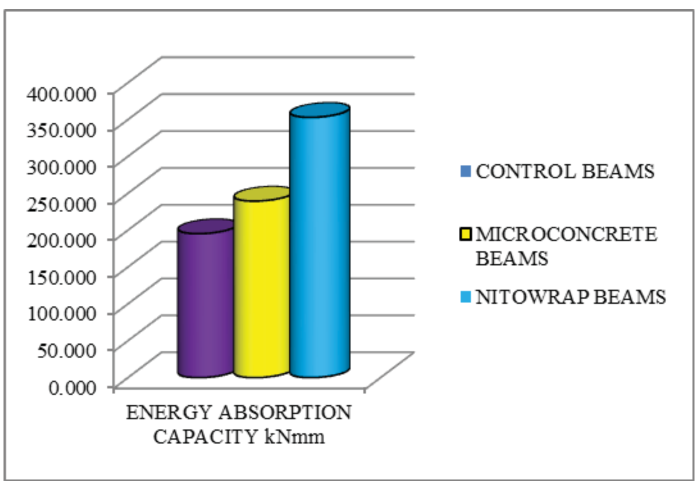

Figure 11 Energy Absorption capacity of control, microconcrete and wrapped beams

IV.CONCLUSION

- Beams retrofitted with microconcrete shows improvement in load carrying capacity by 23.31%, stiffness by 14.79%, ductility ratio by 2.88% and energy absorption capacity by 24.64%
- Beams retrofitted with nitowrap shows improvement in load carrying capacity by 63.3%, stiffness by 33.51%, ductility ratio by 18.48% and energy absorption capacity by 80.85%

- As an alternate for demolition and reconstruction, retrofitting by nitowrap is an economical solution as the beams retrofitted using nitowrap shows significant enhancement in terms of load carrying capacity, stiffness, ductility ratio and energy absorption capacity.

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