Analytical Investigation on Shear Behaviour of Glass Fibre Reinforced Concrete Beams Strengthened With Externally Bonded GFRP Laminates

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ABSTRACT-Nowadays the usages of concrete structures are increased for utilization. The reinforced concrete is used for framed structures. Shear is the major failure pattern and corrosion is the major failure manner in RC members. In present days the usage of FRP material for strengthening and retrofitting purpose was raised. FRP materials are lightweight, noncorrosive, and exhibits high tensile strength. In this study GFPR materials are used for strengthening purpose. As comparing of other FRP materials GFRP gives optimum strength and economic. The reason of GFRP bars usage to avoid corrosion in reinforcement. The study will be done in analytical process for check the shear behaviour of RC beams. The behaviour will check in various configurations of wrapping GFRP laminates in the sides of beams ANSYS package is used in this study for modeling and analyzing. The ultimate load, load vs. deflection and crack patterns are investigated.

Keywords: *Glass fibre reinforced polymer (GFRP), Shear, and Retrofitting.*

1. INTRODUCTION

One of the successful and most commonly used methods is providing steel reinforcement. Steel bars, however, reinforce concrete against local tension only. Cracks in reinforced concrete members extend freely until encountering are bar. Thus need for multidirectional and closely spaced steel reinforcement arises. That cannot be practically possible.

Fiber-reinforced polymer / plastic (FRP) is a composite material made of a polymer matrix reinforced with fibers. Examination of fractured specimens of fiber-reinforced polymer shows that failure takes place primarily due to fibrepull-out or deboning. Thus unlike plain concrete, a fiber-reinforced polymer concrete specimen does not break immediately after initiation of the first crack. The external bonding of high-strength Fibre Reinforced Plastics (FRP) to structural concrete members has widely gained popularity in recent years, particularly in rehabilitation works and newly builds structure. Comprehensive experimental investigations conducted in the past have shown that this strengthening method has several advantages over the traditional ones, especially due to its corrosion resistance, high stiffness-to-weight ratio, improved durability and flexibility in its use over steel plates. . Although, the materials used in FRP for example, fibre and resins are relatively expensive when compared with traditional materials, noting that the crises of equipment for the installation of FRP systems are lower in cost .Amier.M .Ibrahim et al (2009) examined demonstrate that carbon fibre polymer is efficient more than glass fibre polymer in strengthening the reinforced concrete beams for shear. The present finite element model can be used in additional studies to develop design rules for strengthening reinforced concrete members using FRP laminates [1].

The corrosion of the steel reinforcement affects drastically the long-term durability of many reinforced concrete (RC) structures in the world, especially the ones near the sea. Solution to replace the tension steel reinforcement of a RC beam with GFRP bars, which is a material immune to corrosion. Compared to other reinforcements GFRP bars give optimum strength and economic point of view. Tarek H. Almusallam examined the use of steel NSM bars with enough end anchorage can be considered as a successful technique at restoring the flexural load capacity of RC beams with corroded steel reinforcement.FRP NSM bars with low modulus are used, the effective stiffness of the beam will be reduced that may bring about increased deflection at service load level.[2]

2. RESEARCH SIGNIFICANCE

The maintenance, rehabilitation and upgrading of structural members is perhaps one of the most crucial problems in civil engineering applications. Moreover a large number of structures constructed in the past using the older design codes in different parts of the world are structurally unsafe according to the new design codes. Infrastructure decay caused by premature deterioration of building and structures has lead to the investigation of several processes for repairing or strengthening purposes. In order to avoid the problems created by the corrosion of steel reinforcement in concrete structures, research has demonstrated that one could replace the steel reinforcement by fibre reinforced polymer FRP reinforcement.

3. EXPERIMENTAL PROGRAM

The properties of the specimen s are found out by experimental tests such as compressive strength, split tensile strength and young's modulus for analytical input requirements. The Mechanical Properties such as compressive strength, and flexural strength identified The specimens gave 28 days strength for the respective M_{30} grade of concrete respectively, average compressive strength of cube is 32.43N/mm^2 and young's modulus is 0.23 for concrete and 0.3 for reinforcement steel.

4. ANALYTICAL STUDY

4.1 INTRODUCTION OF ANSYS

ANSYS/civil FEM is the most advanced comprehensive and reputable finite element analysis and design software available for structural engineering projects. The system combines the state of art general purpose structural

Analysis features of ANSYS with the high and civil engineering specific structural analysis capabilities of civil engineering research works.

4.2 FINITE ELEMENT MODEL IN ANSYS

The finite element model will be created by using the basic properties of concrete and reinforcement details of the shear beam. The beam having dimensions 150 x 200 x 2100 mm and reinforcements 8mm dia bars for stirrups and 2 nos of 8 mm bars @ top and 3 nos of 12 mm bars @ bottom. This model is for control beam analysis of shear behavior. There after the composite beam will be created and analyzed in phase 2 work with GFRP reinforcements with laminates in various configurations. The configurations of the beams are shown in table 4.1.

The Ansys model will be shown in the following Figures. The beam was strengthened by using various configurations of using GFRP laminates in side wrapping of beams. The configurations are full wrapping, critical zone wrapping, loading points, x-shape wrapping, vertical strip wrapping and inclined strip wrapping. The Ansys modeling was shown in figure 4.1 and 4.2 shows the concrete meshed element and loading setup. From the figure 4.3a to b the various configurations of B1,B2,B3,B4,B5,BA are shown.

Table 4.1 Beam configurations

Control shear beam size of 150 x 200 x 2100 mm with reinforcements of 2nos of 8mm dia @top , 3nos of 12mm dia @ bottom and 8mm dia @ 450mm spacing.		
Beam ID	**Configuration of wrapping of FRP laminates**	**No of specimens**
BA	NIL	1
B1	Full wrapping	1
B2	Clear span	1
B3	Critical zone	1
B4	Vertical strip side bonded	1
B5	Inclined strip side bonding	1
B5	Inclined x-shaped side bonding	1

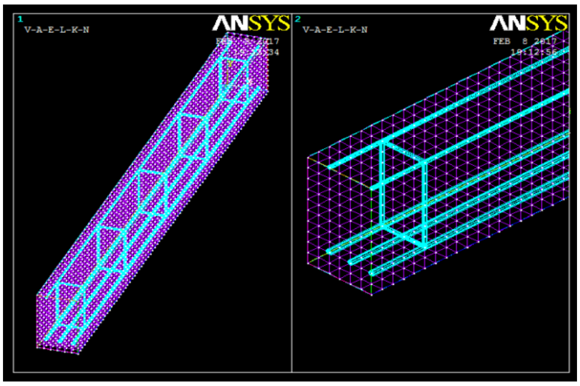

Figure 4.1 conventional beam with reinforcement (BA)

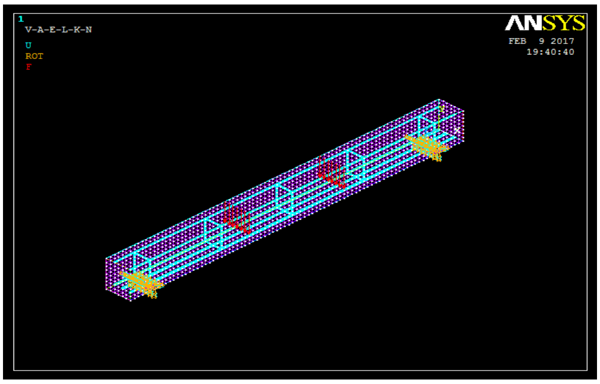

Figure 4.2 loading setup

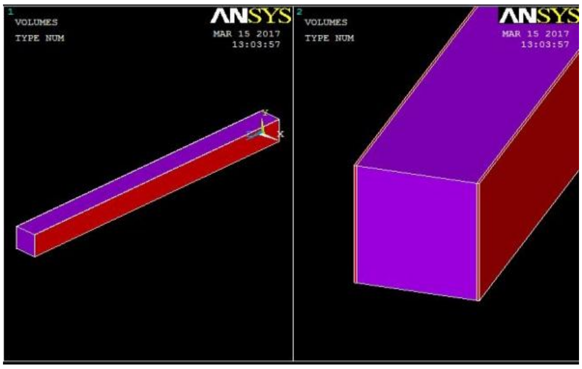

Figure4.3 full wrapping (B1)

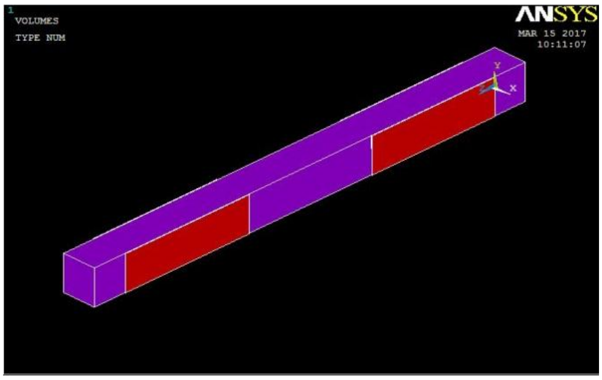

Figure 4.3a Critical zone (B3)

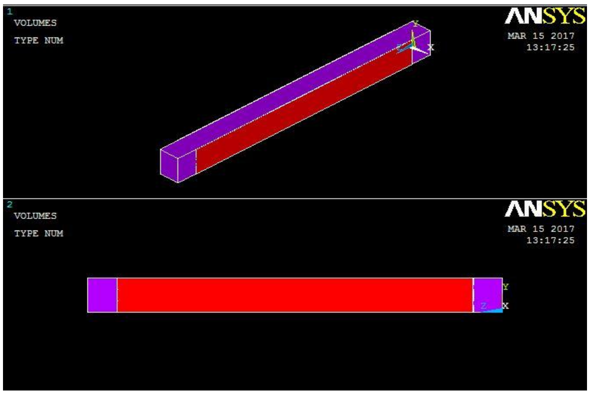

Figure 4.3b Clear span (B2)

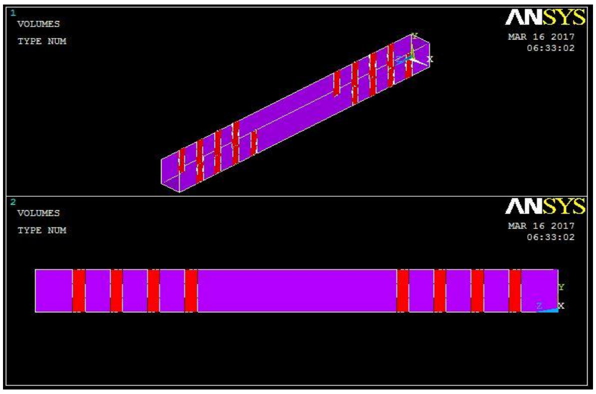

Figure 4.3c vertical strip wrapping (B4)

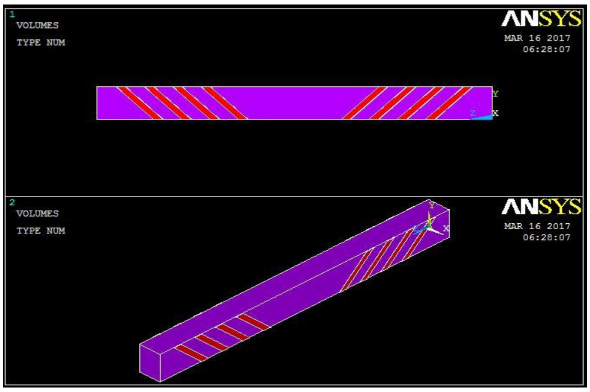

Figure 4.3d Inclined strips wrapping (B5)

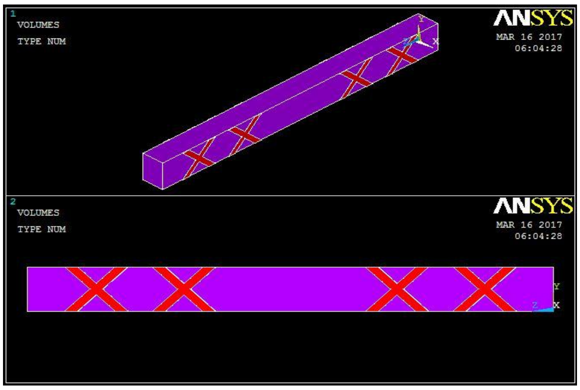

Figure 4.3e X-shaped wrapping (B6)

5. RESULTS AND DISCUSSION

The load deflection curve was plotted by using the analytical results from Ansys and also the crack development will be shown in the following figures6.1 and also the stress distribution diagram for inclined strips wrapping and conventional beam is shown in fig 5.2 and 5.3

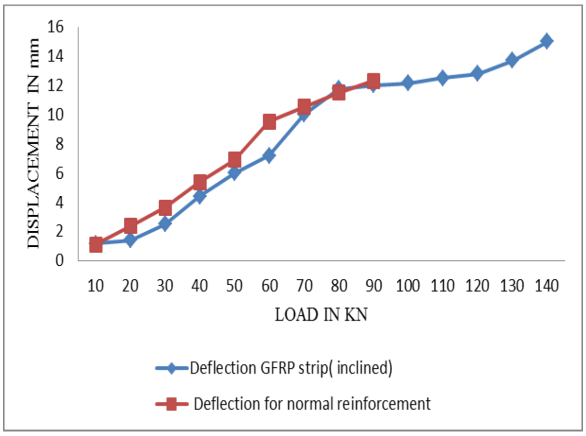

Figure 5.1 load deflection curve for inclined wrapping of GFRP laminates (B5) and conventional beam (BA)

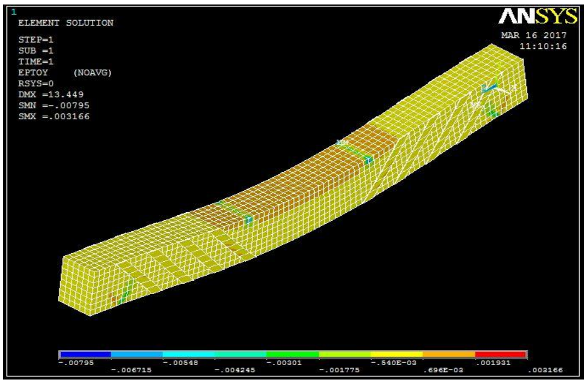

Figure 5.2 stress distribution diagram for inclined laminate wrapped beam

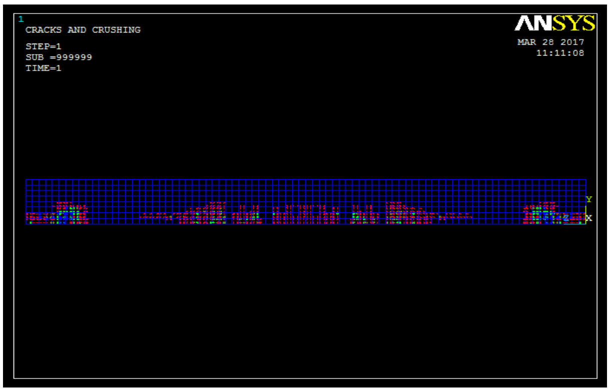

Figure 5.4 Ultimate load crack pattern for BA

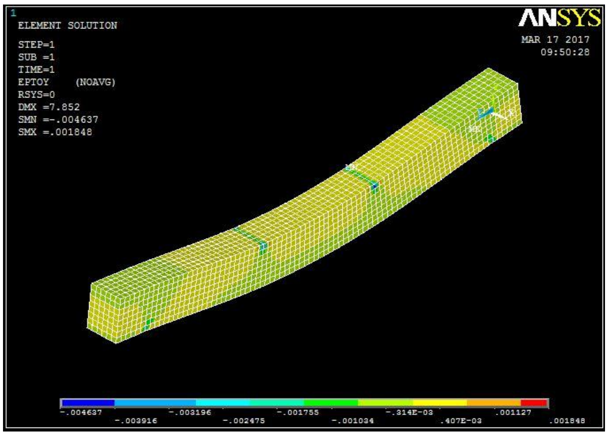

Figure 5.3 stress diagram for conventional beam with normal reinforcement

The load and deflection value for the respective beams are shown in table 5a and the crack pattern will be shown from figure 5.6 with respective loads. The ultimate load and deflection for all beams with configurations are shown in table 6a.

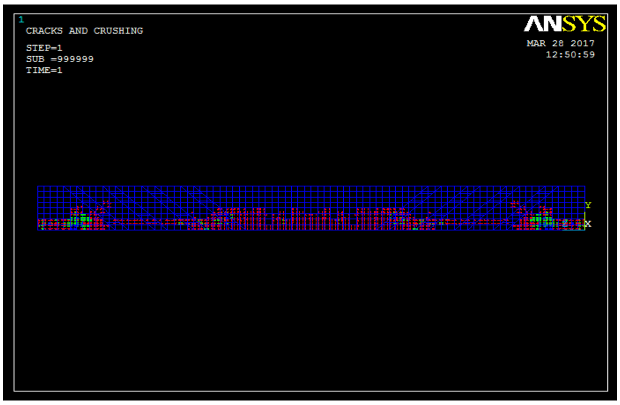

Figure 5.5 ultimate load crack pattern of inclined strips wrapped normal reinforcement beam

BEAM ID	ULTIMATE LOAD IN KN	DEFLECTION IN MM
BA	70	14
B1	100	14
B2	85	13.5
B3	100	14
B4	75	13
B5	**135**	**13.5**
B6	105	14

Table 5a ultimate load and deflection

6. CONCLUSION

In this analytical study the shear strengthening of shear beam was strengthened using GFRP laminates with various configurations with normal reinforcement.by this study the following results are found out and the optimum strengthen configuration will be chosen based on load deflection, stress variation and strain values. The following are the major conclusions.

- Compared to all configurations full wrapping and inclined wrapping gives optimum performance.
- Based on economic point of view the inclined strips give more performance to resist the formation of cracks under ultimate load of 135 KN.
- The load carrying capacity of the strengthened beam with inclined wrapping of GFRP laminates (B5) was increased to 135% than conventional beam BA.

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