Experimental Study on Strengthening of RC Slab using GFRP Sheets

Ben Abey Alex
Department of Civil Engineering
Saintgits College of Engineering
Kottayam, India

Sneha M Varghese
Department of Civil Engineering
Saintgits College of Engineering
Kottayam, India

***Abstract*— Millions of reinforced concrete structures are annually constructed all over the world, there are numbers of concrete structures that are deteriorate due to the change in configuration. Strengthening of RC slab is becoming more important in the field of structural strengthening and retrofitting. GFRP has many advantages like higher strength weight ratios, high stiffness weight ratio, and flexibility in designs, non-corrosive, and lower density. The bonding of fiber reinforced polymer on a tension side is an effective method for strengthening reinforced concrete structures. The purpose of this project is to study the effect of GFRP sheets with various arrangements as strengthening technique for reinforced concrete slabs.**

Keywords*— *Concrete slabs ,Glass Fiber Reinforced Polymer , Strengthening

I. INTRODUCTION

Reinforced concrete is the commonly used material for the construction of structures which are designed in accordance to the specifications given in the standard codes to meet the service life. Based upon these standards, the loads taken for the designes of different elements of the structures like beams., columns and slabs. During the service life if the loading setup change due to purpose of use of the structure, This can result in non-performance of the structural members for which it was designed earlier. The structures are also lead to deterioration due to earthquake, chloride attack, Cyclone and deficiencies of the elements used in adequate design and faulty construction. Retrofitting: Global and Local wrapping. In Global Retrofitting, the whole structure is retrofit to attain the serviceability requirements. It involves the analysis and design of whole structures as per the specifications given in standard codes. Whereas, in Local Retrofitting method, only deficient member of structure is either strengthen or replaced.. Retrofitting should be done by the following methods.

i. Overlaying: It involves extra concrete .sections
ii. Jacketing construction: addition and separate bonding of concrete sections (or confinement)
iii. Vertical girder addition: addition of members is done.

Structural performance, availability and applicability makes FRP laminates most preferred item as a rehabilitating material for RC elements. It has successfully used in repair of beams and columns. Use of FRP in slabs are limited due to the problem of debonding of FRP laminates from the slabs. This is due to the smaller development length at the ends. It improves the effectiveness of FRP laminates if it securely held in its place near supports. Retrofitting of deteriorated buildings done by increasing ductility and strength of elements of the entire buildings. Retrofitting of specific members and elements are referred as local retrofitting.

Fibre Reinforced Polymer (FRP): Fibre reinforced. polymer (FRP) elements are formed by bonding, continuous Fibres using resin epoxy that binds the Fibres, together.
Types : Depending on the use of fibres, composites are three types: Glass Fibre reinforced polymer (GFRP), Carbon fibre reinforced polymer(CFRP) and, Aramid fibre reinforced polymer (AFRP) ,Although FRP laminates are costly and leads to physical damage than steel, they have become suitable substitute for steel in improving strength for structures due to many advantages like strength, resistance to corrosion, fatigue resistance, and reliable surface preparations.

FRP Composite: Fiber Reinforced Polymer composite are defined as the polymer composite, either thermos set or. Thermoplastic, that is recombined with fibre or other material with sufficient aspect ratios to provide an accurate reinforcing functionality in more than one direction.

GFRP Sheets: GFRP is the simplest method for retrofitting the old structures. GFRP .has high strength . high stiffness ,design flexibility, resistance to corrosion, and less density. bonding between the concrete and the reinforcing members

Al-Rousan et al. (2012) (2) tested eight RC slabs strengthen with separate layers and arrangements of Carbon FRP sheets. And FE analysis was conducted to study the behavior of tested specimens. In the nonlinear FE models, full bonding is between steel and concrete and between CFRP layers and concrete. The analysis gives a study of seventeen slabs includes effect of number of layered CFRP, type of fibre on behavior of strengthen slab. The experimental and nonlinear FE results concluded that strengthening of slabs with Carbon FRP improves the flexural strength. Tejendra Tank et al. (2017) (4) conducted a finite element analysis to check the effect of slab thickness and FRP on the effectiveness of strengthen slabs. In this project total of four slabs were analyzed in ANSYS. The first one of size 1500 X

900 X 50mm was non strengthened have 4 mm diameter steel bar spaced at 150mm c/c both ways. The second one was strengthen with GFRP cut near supports. And the third one, strengthened with GFRP at the bottom of the slab with same dimensions and same detailings of first slab.The validation of FE results compared using test results of slabs available in the literature. It shows that the results for fully bonded are stiffened compared to the results that include modeling. It shows that load carry capacity and performance of slab providing bonding of GFRP inside support was higher than Slab having discontinuous Glass FRP sheets. Dr.E.Mohanraj et al. (2016) (6) Hence the behaviour of rectangular concrete beam with GFRP wraps has been studied and the strength and behavior of concrete beam with respect to control concrete beams are discussed. It is noted that there is a significant increase in flexural strength of Glass FRP beam with respect to layer.

II. EXPERIMENTAL INVESTIGATION

A. Experimental Sample

Three specimens are casted for this work using cement(Dalmia), fine aggregates and coarse aggregates for which the mix designs proportion is arrived. . Initial tests are carried out as per IS code standard on the materials for concrete such as consistency ,fineness ,specific gravity, and initial setting time of cement. For fine aggregates and coarse aggregates sieve analysis are conducted, specific gravity are conducted as per standards. GFRP sheets are used for strengthening of slabs (Fig 1). The specimens were casted, as shown in Fig.2.

Fig 1. GFRP sheets

Fig 2. Casted Specimens

To study the load carrying capacity of slab, specimens are casted and designated as follows.

- Control slab (Slab 1) specimen.
- Strengthened Slabs – Slab 2 specimen with bottom full layer of GFRP . Slab 3 specimen strengthened with GFRP in strip shape .

GFRP sheets were attached to the bottom of concrete slabs with different arrangements as shown in Fig.3.

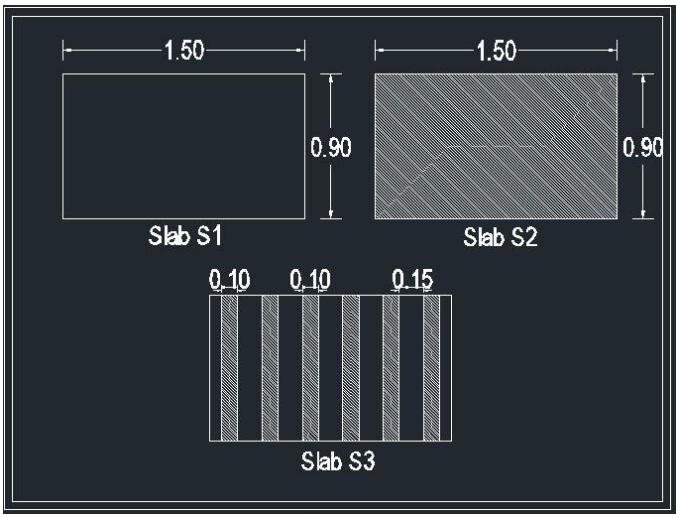

Fig 3. Different arrangements

B. Experimental Setup

Experimental study was done to study the strength of slabs strengthen with glass fiber reinforced polymer laminates with various arrangements. Reinforced Concrete Beam externally bonded with GFRP sheets were tested to failure using a symmetrical eight point loading system as shown in Fig 4.The support conditions were provided as simply supported. Three Reinforced Concrete slabs of size 1500 x 900 x 100 mm have been casted for this experimental test.

Fig 4. Test set up, Loading frame (50Ton capacity), used for testing

For testing the specimens, the specimen is placed in 50Ton capacity loading frame. The load is applied over the top of casted specimen. Strain gauges were used to measure strain value and Dial gauge were used to measure Deflection. The loading is continued and the corresponding readings of the dial gauges are also recorded. This procedure is continued until the following takes place:

a) The yield point of the reinforced slab has been reached,
b) The enclosing concrete has failed

III. RESULTS AND DISCUSSION

Load vs Deflection Characteristics

The load versus Deflection curve was plotted taking the deflection along the X axis and the Load along Y axis. The graphs were compared with different specimens as deflection near support and deflection at Centre. It was observed that the deflection increases as the load increased that is the load and deflection were directly proportional. In the comparison it shows that the deflections is proportional to load applied during the initial load and after which there is a sudden increase in deflection. This shows the deflection increases after the forming of crack. The results are shown in fig 5 below

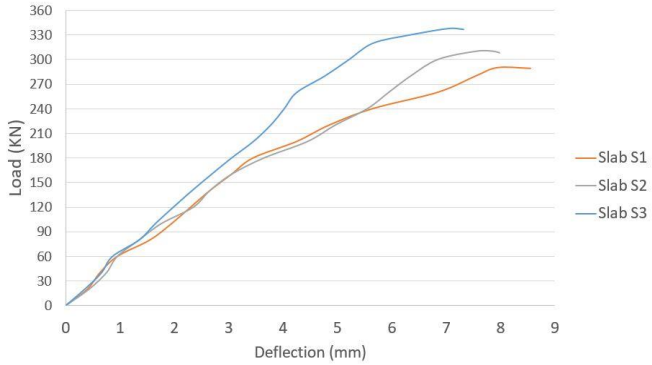

Fig 5. Combination of Load vs Deflection

ULTIMATE LOAD

The ultimate load capacity was studied for various specimens. Load is applied till specimen failed and the load at which the specimen failed was noted as ultimate load. Results are shown in Fig 6 below

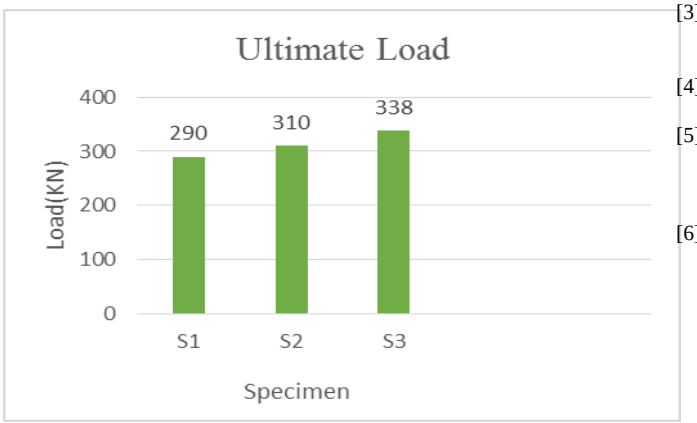

Fig 6. Ultimate load comparison

LOAD STRAIN CHARACTRISTICS

The load versus strain graph was plotted taking strain along the X axis and Load along the Y axis. The curve was plotted for strain along the horizontal line for each slab separately. The combination of Load versus strain graph was plotted as shown in fig 7.

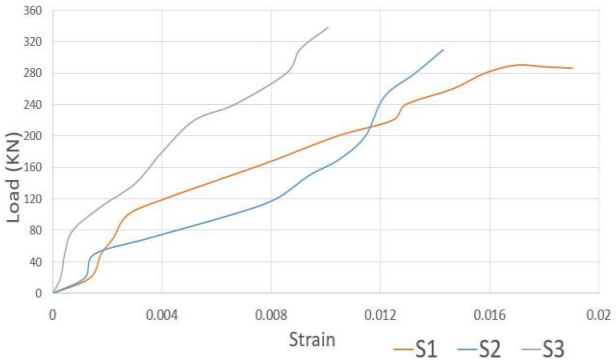

Fig 7. Combination of Load vs Strain

IV. CONCLUSION

Experimental study on strengthening of RC slab with Glass FRP were conducted and the results obtained are as follows

- The load carrying capacity and overall performance of slab with GFRP laminate was significantly higher than the non-strengthened slab
- The strength performance of Reinforced concrete slab strengthened using GFRP (Slab S3) by Strip arrangement was higher than other specimens.
- Least deflection was seen in Slab strengthened with Glass FRP bonded by strip shape in comparison to all other slabs.
- Debonding of GFRP sheet from slab (Slab S1) was occurred during loading in fully strengthened slab.

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