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A Review on FRP Strengthening In Reinforced Concrete Slabs

C. Gawari[1], Dr. M. Murugan[2]
[1]Post Graduate Student, Department of Civil Engineering,Government College of Engineering, Tirunelveli, Tamilnadu, India.
[2]Assistant Professor, Department of Civil Engineering,Government College of Engineering, Tirunelveli, Tamilnadu, India.

ABSTRACT:
In the recent years the destruction and deterioration of RC structures due to various natural disaster, improper use of material, poor workmanship, higher stress concentration, corrosion there became an urgent need to develop a new material which can overcome the above problem. Hence there emerged a polymer called fibre reinforced polymer which due to its high strength to weight ratio, light in weight, higher stiffness, and electromagnetic neutral property is becoming a solution for the above problem. Henceforth this paper provides the literature review of FRP strengthened RC slabs analysed experimentally. It focuses on the strengthening technique, different loading condition and made a comparative study between strengthened FRP slabs and non strengthened RC slabs.

KEYWORDS: *FRP strengthening techniques, reinforced slabs, Flexural behaviour, Fire insulation.*

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I. INTRODUCTION

The use of a fibre reinforced polymer has had a dramatic impact on civil engineering techniques over the past three decades. Due to its excellent unique properties such as high strength to weight ratio, non corrosive, convenient electrical, magnetic and thermal properties, the demand has been increasing. The use of FRP in engineering applications enables engineers to obtain significant achievements in the functionality, safety and economy of construction because of their mechanical properties.

II. LITERATURE REVIEW

Brea Williams et.al (2006) presented the paper showing the experimental results of an insulated FRP strengthened RC slabs under fire exposure. They concluded that FRP losses its strength at elevated temperature but providing insulation minimised cracks and prevented delamination of the slab bottom.

A. Ghani Razaqpur et.al (2007) experimentally investigated the blast loading response of reinforced concrete panels which is bonded externally by GFRP laminate. Overall GFRP retrofitted panel performed better without losing its structural intergrity, had small residual camber and retained residual compressive strength but when the blast load is increased one of retrofitted panel disintegrated completely but the unretroffited panel doesn't suffered such damage .Hence, they also concluded that GFRP retrofit cannot be applied in every situation. It needs further more investigation and testing is needed rather than theoretical modelling or pseudo dynamic testing.

R. Sivagamasundari et.al (2008) made an attempt to make a comparative study on the flexural behaviour of one way concrete slab reinforced with GFRP and conventional reinforcement subjected to monotonic and repeated loading. They concluded that by varying the thickness ,grade of concrete and reinforcement ratio GFRP slab showed better performance and longer fatigue life. On increasing all the above three factors ultimate load carrying capacity of both the slabs increased ,deflection and crack width is reduced. All the slabs experienced flexural type of failure.

C. Dulude et.al (2010) addressed the structural behaviour of GFRP reinforced concrete two way slab and compared the result with plain RC slab. They concluded that there was no significant difference in terms of general behaviour, mode of failure and strain profile but shear strength of GFRP slab was lower than RC slab.

Emido Nigro et.al (2011) experimented the fire behaviour of FRP-RC slab. They concluded that for a FRP-RC specimen, at room temperature concrete failure is observed first but when the temperature is increased FRP loses its strength and fails first. To prevent this anchorage bars are necessary.

Nur Yazdani et.al (2013) examined the various field assessment of concrete structure rehabilated with FRP. Non destructive evolution (NDE) proved to be a promising technology for the assessment of structural condition and service life of the structural elements.

Hazem A. El-Enein et.al (2014) examined the effectiveness of application of CFRP sheet in RC slab – column connection as a strengthening technique. CFRP sheets were installed on the tension side of the slab to increase the flexural capacity at the negative moment region. Column was placed under three condition eccentric, centric and edge. By using the CFRP sheet in RC slab increased the flexural ultimate load caring capacity of the central, eccentric and edge column by 33%, 37% and 67%.

Masoud Adelzadeh et.al (2014) made a detailed study on fire behaviour of one way glass fiber reinforced polymer concrete slabs. From their analysis, it is concluded that increasing the thickness of cover and providing two layer of fiber reinforcement drastically can increase the fire performance of the slab.

Nur yazdami et.al (2014) this paper critically reviewed the effect of structural element when wrapped with FRP subjected to chloride penetration and also their possible effect associated with concrete clear cover requirement . Results indicated that there was a significant reduction in the chloride penetration in concrete which was about 22% reduction near the surface. Cover reduction ranged from 16% to 26 % for beams and 44% to 50% for slabs, based on the FRP type.

Vivek Dhand et.al (2014) this paper is to access the use of basalt fiber as reinforcement material due to its eco friendly, non toxic, chemically inert, corrosion resistant and low thermal conductivity characteristics they can be used as best alternative solution to glass and carbon fibers.

Husain Abbas et.al (2015) this paper is to access the punching shear strength of RC slab strengthened with externally bonded carbon fiber reinforced polymer (CFRP) and Textile reinforced mortar (TRM) sheets. They showed that for the strengthened slab punching shear strength has been increased and two peak loads are observed. The second peak load is due to the combined action of aggregate interlock and strengthening layer (CFRP, TRM). During the first peak load increase in ultimate punching was about 9-18% and during the second peak load it was about 190-276% for CFRP strengthened and 55-136% for TRM strengthened slab. The energy absorption was ~66% for CFRP and 22-56% for TRM.

Joao P. Firmo et al (2015) intended in the study to experimentally investigate the fire behaviour of FRP strengthened RC beam, slab and column by the application of two FRP system externally bonded reinforcement and nearly mounted reinforcement. It is founded that both the system at elevated temperature showed a decreased mechanical and bond strength but when comparing NSM and EBR, NSM proved to best.

Saad. M. Raoof et.al (2017) made a comparison study on the bond strength of FRP Strengthened and TRM (Textile Reinforced Mortar) strengthened concrete specimen at ambient and high temperature. It is concluded that increasing the temperature increased the bond strength for TRM strengthened specimen at the same time it was decreased for FRP strengthened specimen

S. Dhipanaravind et.al (2018) examined the flexural behaviour of concrete one way slab reinforced with hybrid FRP bars. The results indicated that modulus of elasticity of hybrid FRP bars was lesser than steel . Hybrid reinforced slabs undergone larger deflection than the conventional slab but the surface strain in hybrid FRP slab was two to three times greater than the conventional slab.

Luis Corria et.al (2018) made a detailed study on the flexural behaviour of RC slabs strengthened with prestressed CFRP strips. It was observed that, the strengthening technique itself showed lower deflection, lower crack spacing and crack width delay. The strengthened prestressed CFRP strips also showed higher tensile strength.

Sugyu lee et.al (2018) investigated the flexural behaviour of RC slabs strengthened with basalt fabric reinforced cementitous matrix (FRCM). They concluded that, by the the strengthening process the load carrying capacity of strengthened FRCM slabs increased from 11.2% to 98.2 % when compared to non strengthened RC slabs.

Wenjie Wang et.al (2018) aimed to study the impact behaviour of flax fibre reinforced polymer strengthened with coconut fibre reinforced concrete slab (FFRP-CFRP slab) ,Coconut fibre reinforced concrete slab (CFRP slab) ,Plain concrete slab (PC slab) through experimental studies. FFRP-CFRP slab showed higher energy absorption ,low deflection and kept the integrity of the concrete compared to CFRP and PC slab specimen.

Wensu Chen et.al (2019) the author made attempt to investigate the impact behaviour of RC slab strengthened by BFRP sheet. The test parameters are (1) Direction in which BFRP sheets are placed (diagonal and orthogonal) (2) with or without anchorage system. By using the BRFP sheets impact resistance capacity of the slabs were increased. Placing the BFRP sheets along the diagonal direction prove to be best in suppressing the crack development. Using anchor holes reduced the strength of the slabs.

Meelis Vapper et.al (2020) experimentally investigated the blast loading response of concrete column reinforced with standard rebar reinforcement and short steel fibre which is bonded externally by GFRP strips. In both the cases of reinforcement GFRP retrofitted column has high and retained residual strength ,reduced surface fragmentation / spalling, increased axial load carrying capacity than the unretrofitted panels In some cases opposite too occcured but they concluded it may be due to deficient specimen production. But on average retrofitted panel performed better.

Niloufar Moshri et.al (2020) focused on a fully non metallic system for strengthening RC one way slab with prestressed CFRP composites. Two methods were applied, Externally bonded reinforcement on grooves (EBROG) and Externally bonded reinforcement (EBR). For both prestressed and non prestressed specimens, EBROG method increased the bending capacity by 34% and 77 %.EBROG method proved to be the best in delaying CFRP debonding and increased the strain in reinforcement by 50% when compared to EBR method.

III. CONCLUSION

- The GFRP retrofitted FRP performance was better, at the same time economic too.
- Retrofitting with FRP improved the strength and stiffness of the RC element .
- CFRP strengthening leads to significant improvements in the structural behaviour than GFRP strengthening.
- Basalt fibers are almost as favourable as carbon fibers, but have an edge as they are eco friendly, non-toxic, and green .In the future the use of basalt may reduce costs in industrial applications, stimulating research in the field of basalt materials and composite science.
- Results also showed FFRP-CFRC specimens had better performance in aspects of energy absorption and keeping the integrity.
- Strengthened elements showed reductions in mechanical and bond properties at elevated temperatures, Hence providing ideal insulation would be the better solution for this .

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