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An investigation on the flexural strength of retrofitted RC slabs with polypropylene fibre reinforced polymers (PPFRP)

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Abstract
Fibre reinforced polymers (FRPs), commonly used in aerospace and defense industries have emerged as a feasible alternative for structural retrofit from the last few decades. Advantages of FRPs are light weight, high strength, resistant to corrosion and ease of application have made them popular in the up gradation of structural elements. Extensive work has been done on the concrete specimens of slabs, in the experimental and analytical fields since the development of FRP. Polypropylene fibers are micro reinforcement fibers and are 100% virgin homo polymer polypropylene graded monofilament fibers. They contain no reprocessed Olifin materials. This work investigates the effect of flexural strength of the slabs wrapped with and without PPFRP fabric. Four reduced modeled slab specimens were casted and tested under static loading conditions, two specimens were retrofitted with PPFRP in the form of cross wrapping at flexure zone and remaining two were normal reinforced concrete slab specimens. An increase in the flexural strength was observed.

Keywords: FRP, retrofit, monofilament, Olifin, PPFRP

1. Introduction
Fibre reinforced polymers (FRPs), commonly used in aerospace and defense industries have emerged as a feasible alternative for structural retrofit from the last few decades. Advantages of FRPs are light weight, high strength, resistant to corrosion and ease of application have made them popular in the up gradation of structural elements. Reinforced concrete slabs are among the most commonly used structural elements. They have been used in many forms for structural systems such as flat plates, flat slabs, waffled slabs, and two-way slab with beams. There are mainly two motivations for the retrofit of existing reinforced concrete slabs. Firstly, the structural system designed and detailed for prescribed forces using a given code at a given time may be subjected to forces and displacements higher than those considered in the initial design during its lifetime. Secondly, there may be situations where the intended design force and/or displacement capacity of a structural member may be insufficient.

2. Materials
Polypropylene fibers are micro reinforcement fibers and are 100% virgin homo polymer polypropylene graded monofilament fibers. They contain no reprocessed Olifin materials. Polypropylene Fiber Reinforced polymer is an effective construction material which can be described as a polymer having high mechanical strength, Stiffness and durability. By utilization of Polypropylene fibers in concrete not only optimum utilization of materials is achieved but also the cost reduction is achieved. Polypropylene is convincingly cost-effective and when uncoloured appears translucent. It is generally not readily available as acrylic, polystyrene or other plastics. Polypropylene fibers reduces the water permeability, increases the flexural strength. In the post cracking stage, as the fibers are pulled out, energy is absorbed and cracking is reduced. Polypropylene polymerizes to form long polymer chain under high temperature and pressure.

Table 1: Properties of Polypropylene fabric (HT 2513)

Properties	Polypropylene fabric (HT 2513)
Fiber orientation	Uni-directional
Weight of fiber (g/m2)	450
Fiber thickness (mm)	0.3
Ultimate elongation (percentage)	2.6
Primary fiber tensile strength (Mpa)	700
Tensile modulus (Gpa)	15

3. Method
An experimental investigation was conducted to test the reduced modeled reinforced concrete slabs. This includes testing a control slab and retrofitted slabs with PPFRP. The main objective of the investigation was to study the flexural strength of concrete slabs and retrofitted slabs with PPFRP fabric bonded onto the flexural zone of the slab. All the slabs were designed as two way slabs of 1070 mm x 1070 mm with a thickness of 90 mm and tested under uniformly distributed load. The reinforcement of 8 mm diameter was provided along the two directions.

Retrofitting procedure: The FRP application includes the resin system made of two parts namely the resin, the hardener and the fiber sheets. The concrete surface was cleaned and completely dried before the resin is applied. A first coat of thin layer of resin was applied and the FRP fabric precut to the desired dimension was then wrapped directly onto the surface. After the application of the FRP fabric wrap, a second layer of resin was applied to the surface to allow impregnation. The second layer of FRP fabric was then impregnated on top of the first layer. Adequate pressure was applied until the resin was squeezed out. The wrapped specimens were left at room temperature to allow air curing for seven days to allow bonding of the laminates.

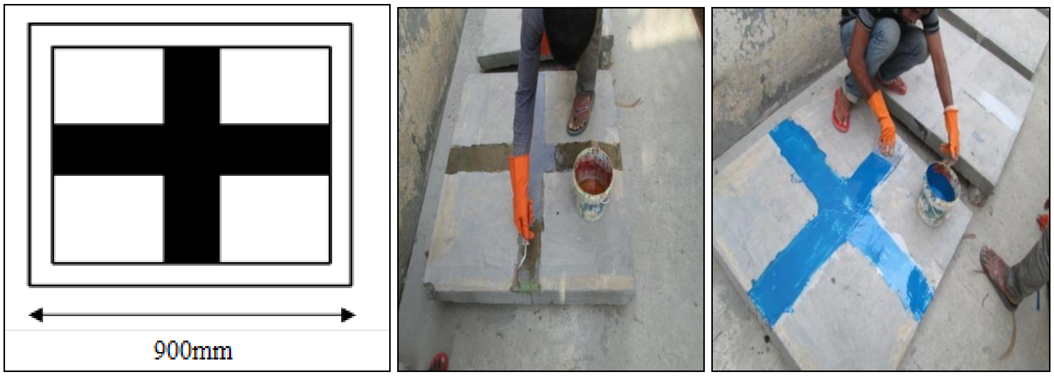

Fig 1: a) Externally bonded BFRP sheet, b) Application of primer coat, c) Application of saturant coat

Fig 2: a) & b) Application of PPFRP, c) Retrofitted slab with PPFRP

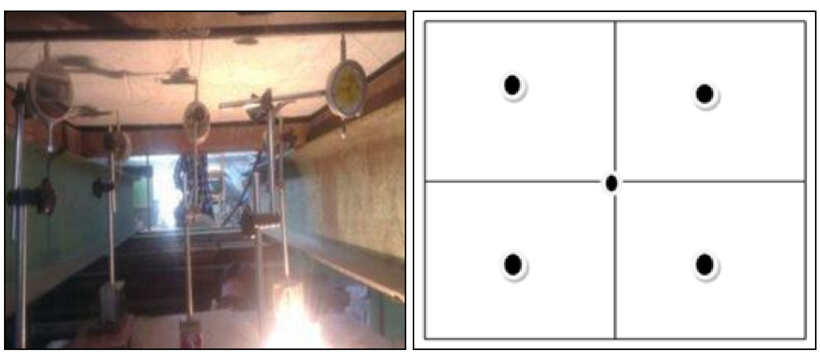

Fig 3: Layout and positioning of dial gauges

4. Results and Discussions

Deflection versus Load curves for mid span deflections are obtained from the investigational work. It is noted that the strengthened specimens are showing a higher deflection value.

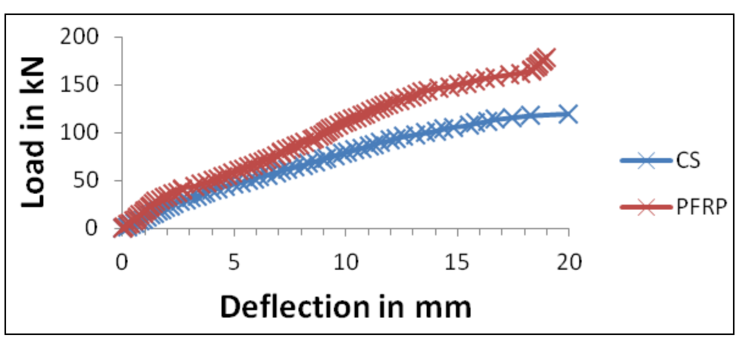

Fig 4: Load v/s Deflection Curves for Control Slab and retrofitted slab

The crack pattern of the retrofitted slab is represented below. The final failure of the retrofitted slab occurred by debonding of the fabric from the slab.

Fig 5: Crack pattern and debonding of the retrofitted slab.

The experimental results of all the specimens were tabulated and a comparative statement of the percentage variation has been drawn.

Table 2: Comparison of Experimental Results

Specimen name	Type of slab	Type of wrapping	Failure load (KN)	% Variation
CS-1	Control slab-1	……...…..	120	……………..
CS-2	Control slab-2	…………	118	……………..
PFRS-1	Polypropylene fabric retrofitted slab	Cross type wrapping	178	49.58%
PFRS-2	Polypropylene fabric retrofitted slab	Cross type wrapping	168	41.18%

5. Conclusions

This experimental study investigates the cross type PPFRP wrapping effect on flexural strength, deflection and stiffness of slabs compared with control slab.

- The two-way RC slabs strengthened with PPFRP in single layer were capable to take more load than the control slab.
- The slabs retrofitted with PPFRP cross wrap technique were found to be effective in increasing the load carrying capacity by 45.38% as compared to control slab.
- The stiffness was found to be high for slabs retrofitted with PPFRP fabric as compared to control slabs.
- Stiffness of slabs retrofitted with PPFRP fabric is increased by 38.4% compared to that of control slabs.
- Load carrying capacity of retrofitted slabs were more compared to control slabs and also observed that the slabs retrofitted using PFRP fabric performed well.
- Overall it shown that PPFRP fabric effectively increases the load carrying capacity and stiffness of slabs.

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7. References

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