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Behavior of Non Metallic Reinforcement (FRP) In Beam

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Abstract— FRP material is used due to their excellent features like high strength to weight ratio, resistance to corrosion, convenience of transportation and installation. Using FRP bar instead of steel bar significantly prevent corrosion in concrete members specifically for seashore concrete structures. In this paper investigations are done to prove the benefits of replacing steel rebar with FRP bars partially in concrete beam. Beams are casted by replacing steel rods by Fiber reinforced polymers like polypropylene and acrylic rods. Main reinforcement was replaced with FRP rod and lateral reinforcement is provided using steel rods. For this study beams were casted with steel reinforcement and beams partially replaced with polypropylene rods and acrylic rods were casted and tested for 28days for curing. The results show that comparing both the FRP rods Polypropylene rods when partially replaced perform well than acrylic rods.

Keywords— Reinforcements, FRP, Polypropylene, Acrylic, Peak load, Flexural behavior.

1 INTRODUCTION

Beams are the important component of a building which transfers the load from columns to the substructure and it transfers it to soil. The reinforcement in the beam is the main part which transfers the load and the concrete supports it. The reinforcement material is steel which is used for many decades. Researches based on the replacement of the reinforcing materials have been carried out for many years. FRP rods and FRP based products are used for the research and in construction usage like retrofitting and strengthening of concrete. This research has two types of FRP rods polypropylene and acrylics are partially replaced for main reinforcement and the stirrups are used as steel itself. FRP rods are being used in many countries in Europe due to their climatic conditions and high salt contents near sea which can erode the reinforcements in mean time of exposure. It can also be used in hospitals were MRI scans are being used, the rays affect the steel reinforcement very easily rather it cannot affect the FRP rods. The FRP rods have many other uses as specified above in practical. The research on FRP rods as replacement has been carried for the past decade or so.

Even though FRP rods have many advantages stating that they can be used in construction it lacks in the property of ductility thus a composite can be made to obtain the strength for the beam. Mostly glass fiber rods were been in experimentation for beam reinforcement replacement. Denvid Lau and Hoat Joen Pom [2] gave two methods to increase the structural ductility of the beam like increasing the degree of reinforcement and also by adding extra rebars to the column. He also found out that 135° hook to tie the rebars performed very well than the 90° hook normally used to tie the rebars. Seleh H.Aslay and Abdulrahman [3] gave results that the ductility in the FRP beams is 50% less than the conventional steel beams. Hence by providing more rebars more strength can be achieved and also the required ductility can also be attempted to achieve. MA. Aiello, Ombres L [4] experimented and theoretically analyzed the beam for flexure and concluded that the values from both shows that extra rebars can be used to improve the flexural stability of the beam. Noor Azliman Abdul, Rendy Thorin and Azmi Ibrahim [9] All the parameters chosen in the experimental programmed such as longitudinal reinforcement ratio, shear span length and stirrup ratios significantly affect the failure mode of the beam. In both types of beam, two modes of failure were observed which shows that shear failure occur in beam with low stirrup ratios and shorter shear span length. In contrast, flexural failure was occurred in case of beams with higher stirrups ratio and longer shear span length. Nevertheless, shear capacity of beams reinforced with GFRP bars is lower than that beams reinforced with steel bars which was also reveals from the calculated flexural capacities using codes. Laura De Lorenzis and Antonio Nanni [7] found out that the use of NSM FRP rods is an effective technique to enhance the shear capacity of RC beams. In absence of steel stirrups, an increase in capacity as high as 10.6% with respect to the control beam could be obtained. One of the observed failure modes was deboning of one or more FRP rods due to splitting of the epoxy cover. Test results seem to indicate that this mechanism can be prevented by providing a larger bond length with either anchoring the NSM rods in the beam flange or using 45degree rods at a sufficiently close spacing.

2. EXPERIMENTAL PROGRAM

2.1 Specimens:

In this paper the performance of 5 beams reinforced with steel rods and FRP rods are to be performed and studied. The size of the beam taken is 0.3×0.2m. The length of the beam is 0.5m. In main reinforcement 6 no of 12mm diameter rods are provided and stirrups of 2 legged 8mm rods are provided with a spacing of 125mm. Two varieties of FRP rods are used replacement namely polypropylene rods and acrylic rods combination of rods differs for each beam. In first beam both the main and lateral reinforcement are given with steel rods. For the second beam of six rods the middle 2 rods are replaced by both the type of FRP rods. For 4th and 5th beam the alternative rods are replaced by both the types of FRP respectively.

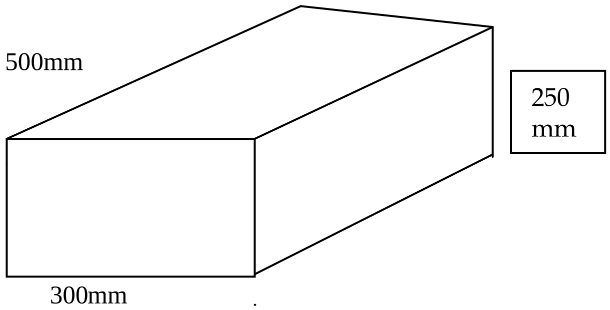

Fig 1 modelling of the beam

2.2 Material Properties:

The materials used for these experiments are conventional iron rod, Polypropylene rods and acrylic rods. The reason for choosing FRP rods is it has been used in the process of retrofitting for a longer period of time and the research for replacing the usage of conventional rod with FRP rods are being done now. All these type of rods differ each other in their properties. Iron rods have high density compared to polypropylene and acrylic rods. Iron rods can be easily eroded or damaged when they are exposed to chemicals and solvents but FRP rods cannot be easily affected by those. Certain types of wavelengths and rays can affect the iron rods but FRP rods protect themselves from wavelength and certain types of rays. FRP rods are brittle in nature compared to iron rods that are conventionally used. The flexural strength of iron rod is also high compared to FRP rods hence the combinations of rods are being tried in this experiment.

Fig.2 Polypropylene Rods

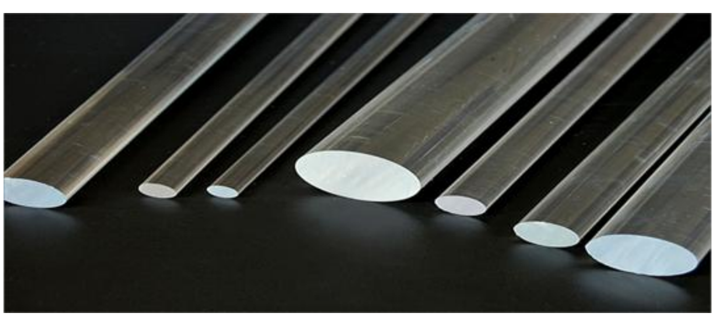

Fig.3 Acrylic Rods

2.3 Mix design:

Concrete mix design for M30 has been done and it is used for the casting of concrete. Mix design for M30 grade concrete as per code IS 10262:2009 was done.

Specific Gravity of Cement =3.15
Specific Gravity of CA =2.74
Specific Gravity of FA =2.68
W/c ratio = 0.43
Water to be used (20mm coarse aggregate) = 186 liters.
Master Matrix, VMA = 2% weight of cement.
Micro air, AEA = 0.5% weight of cement.
Maximum Cement content =186/0.43 = 433 Kg/m3 > 350Kg/m3.
Volume of Coarse Aggregate / Total Volume of aggregate = 0.64.
(Zone-III) Sieve Analysis.
Volume of Concrete = 1 m^3
Volume of cement = 433/ (3.15*1000) = 0.137 m^3
Volume of Water = 186/1000= 0.186 m^3.
Volume of Aggregate= 1-[0.137+0.186] = 0.65 m^3.
Mass of Coarse Aggregate = E*Volume of coarse aggregate*Specific gravity of coarse * 100
= 0.65*0.64*2.74*1000 = 1152.1 Kg/m^3
Mass of Fine Aggregate = E*Volume of fine aggregate * Specific gravity of fine aggregate *100
= 0.657*0.366*2.6*1000 = 615Kg/m^3
Cement: Water: Fine Aggregate: Coarse Aggregate
= 433:186:615:1152 = 1: 0.43: 1.42: 2.66

The coarse aggregate used are of size 12mm. The slump of 75 to 100 mm was achieved for each beam. The cubes of size 150×150 mm were casted and compressive strength tests were done to ensure the quality and grade of the concrete.

TABLE 1 COMPOSITION OF CONCRETE

Components	Batch Kg/m^3
Cement	433
Coarse aggregate	615
Fine aggregate	1152
Water	198

2.4 Placing of reinforcements and Casting of beams:

For casting beams wooden frames which is the conventional method is used. A cover of 30mm is used throughout the beam. Lateral ties are provided at a spacing of 125mm. Regular procedures were carried out to cast the beam. After casting and remoulding of the beams curing is done for 28 days.

Fig.4 Reinforced with 50% Polypropylene rods

Fig.5 Reinforced with 25% polypropylene rods

Fig.6 Reinforced with 100% steel

Fig.7 Reinforced with 25% Acrylic rods

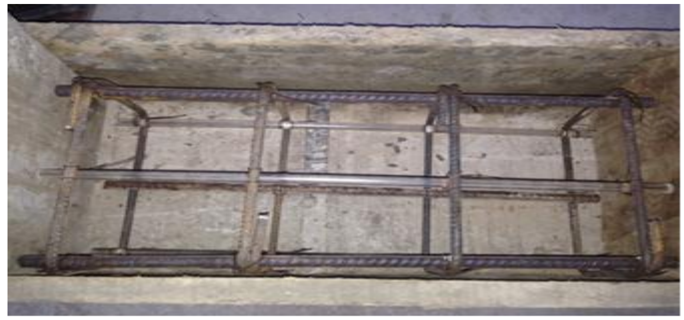

Fig.8 Reinforced with 50% Acrylic rods

The beams are casted using conventional wooden moulding. The beams are casted and cured for 28days.

Fig.9 Casted beams

2.5 Experiment and recordings:

The columns were cured for 28 day and then tested in UTM for its flexure by 4 point loading. With the help of 4 point loading the loads can be transferred throughout the beam. In this type of testing beams has to be marked for its loading.

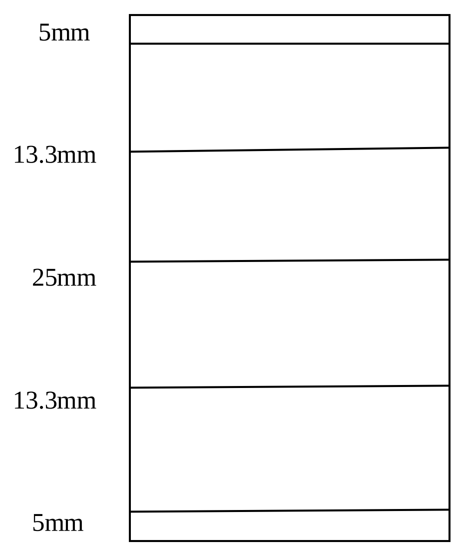

Fig.10 Points were loads are applied in beam

TABLE 2: PEAK LOAD AND DISPLACEMENT

Beam no	Peak load (KN)	Displacement (mm)
1	197.00	2.4
2	181.00	3.7
3	124.25	3.5
4	122.90	4.7
5	117.95	2.7

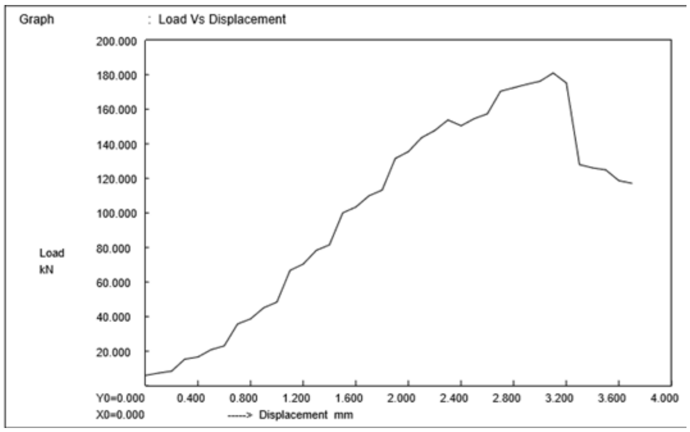

Fig.11 Load Vs displacement graph for beams 100% reinforced with steel

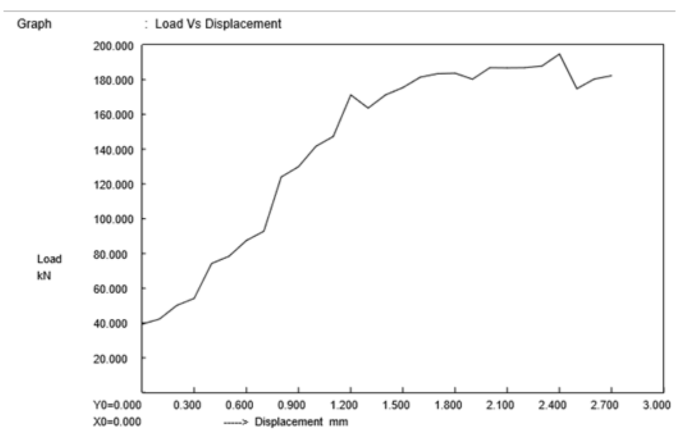

Fig.12 Load Vs Displacement graph for beam 25% reinforced with polypropylene rods

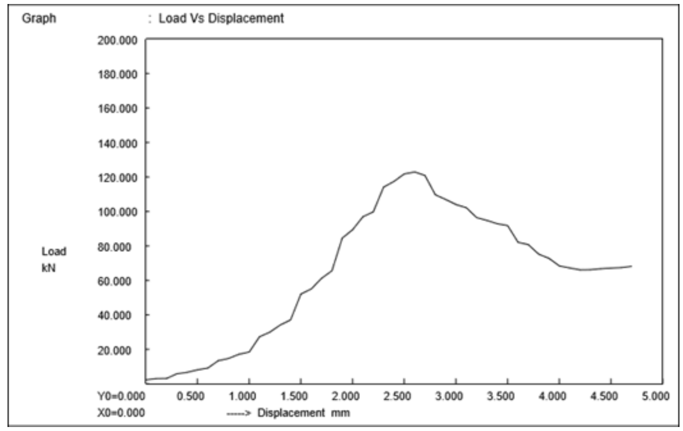

Fig.13 Load Vs displacement graph for beam reinforced with 25% Acrylic rods

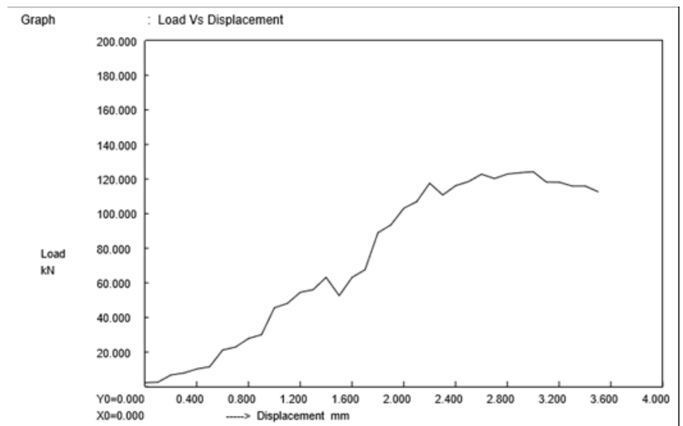

Fig.13 Load Vs Displacement graph for beam reinforced with 50% polypropylene rods

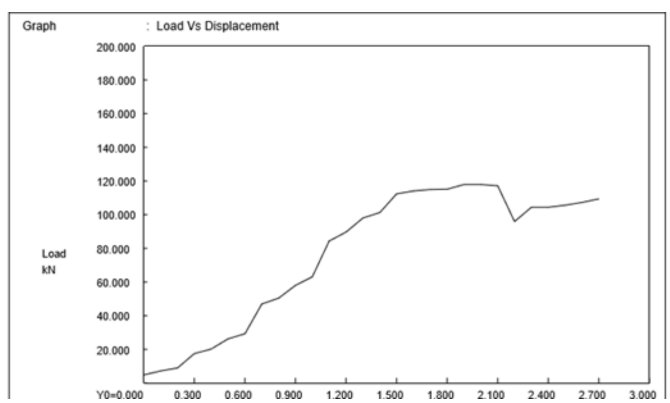

Fig.14 Load Vs Displacement graph for beam reinforced with 50% Acrylic rods

TABLE 3 FRACTURE STRESS AND MAX FLEXURAL STRENGTH

BEAM NO	FRACTURE STRESS N/mm²	MAX FLEXURAL STRENGTH N/mm²
1	6.305	9.7
2	6.018	9.05
3	4.131	6.2125
4	4.087	6.145
5	3.922	5.898

3. CONCLUSION:

The experimental results prove that the flexural strength for steel reinforcement is high compared to the other combination of reinforcements.The second beam which is the combination of both polypropylene and iron has flexural strength which is very nearer to the whole steel reinforcement. Comparatively of both polypropylene and acrylic polypropylene combines well with the increase of clear cover and the rebars.

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