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Analytical Investigation on Flexural Behavior of Concrete Beams With RHA and Reinforced With GFRP Rebars

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Abstract – *Conventional steel reinforcement provides higher ductility, Glass Fibre Reinforced Polymer (GFRP) rebars give more strength and the use of Rice Husk Ash (RHA) as an admixture also provides ductility and strength in concrete structures. Therefore the combination of conventional steel, rice husk ash and GFRP bars in reinforced concrete structures provides higher strength, durability and serviceability. In this project an analytical study of the flexural behaviour of concrete beams, reinforced with steel, GFRP rebar and with the use of rice husk as an admixture is done. In this analytical study, thirty six concrete beams of dimensions, 150mm width 200mm depth and 1200mm length have been modelled and analyzed till failure under four point bending test, using Finite Element Software ANSYS workbench. The type of reinforcement material, ratio of GFRP to steel rebars, compressive strength of concrete and proportion of rice husk ash are used as main parameters. The deflection, stress and strain of the beams were found and compared for various combinations of reinforcement, compressive strength of concrete and different proportions of RHA.*

Key Words: **Beams, Deflection, GFRP, steel rebar, RHA**

1. INTRODUCTION

Experimental study on flexure behavior of the beam gives the exact behavior of the structure but it is time consuming and expensive. Ansys is one of the tools used to determine the flexural behavior of the beam. Ansys works on finite element method. Finite element analysis is used for evaluation of the structures gives accurate and fast results compared to experimental study. Finite element method is a numerical analysis method that divides the element into smaller parts and analyze the element under given loading conditions and hence evaluates the response of the material. Conventional steel embedded with concrete structures normally provides higher ductility whereas GFRP rebars provide the beams with higher strength and corrosion resistance. In this project we analyze the flexural strength of concrete beams with GFRP rebars. By using rebars we can enhance strength of concrete beams. Rice husk ash is also using as an admixture by partially replacing the concrete. It will reduce the permeability of the concrete structures.

1.1 GFRP

Glass Fiber Reinforced Polymer materials are commonly composed of glass fiber filaments and resin matrix. Glass fiber filaments have a high tensile strength and high modulus of elasticity as compared to other FRP With the rise of corrosion due to global warming, fiberglass reinforcement material has gained considerable popularity. In future, these advanced composite materials would demonstrate their strengths and properties more evidently.

1.2 RHA

Rice husk ash is used in concrete construction as an alternative of cement. The rice paddy milling industries give the by-product rice husk. Due to the increasing rate of environmental pollution and the consideration of sustainability factor have made the idea of utilizing rice husk. To have a proper idea on the performance of rice husk in concrete, a detailed study on its properties must be done. About 100 million tons of rice paddy manufacture by-products are obtained around the world.

2. DETAILS OF SPECIMEN

In this analytical investigation, we are using various journals and web source for collecting required data for the analysis. Since it is a software analysis, ANSYS 15 is adopted for the analysis. The first step to be adopted is to collect the beam details. For that the details such as grades of concrete, reinforcement ratio, diameter of steel and GFRP rebars, replacement percentage of rice husk ash is required.

Table 1 shows the beam details that required for the analysis. It includes grades of concrete, details of reinforcements used and proportion of rice husk ash added to the concrete.

Table 1. Details of Beams

Sl. No.	Grade	Specimen	Dimension of Beam			Reinforcement Details			Reinfor-cement ratio	% of RHA
			Width (mm)	Depth (mm)	Length (mm)	Bottom Reinforc-ement	Top Reinforc-ement	Stirrups		
1	30	B3010S8S R0	150	200	1200	2#10S	2#8S	6@ 130	1.17µ	0
2		B3012G8GR0				2#12G+ 1#8G	2#8G	6@ 130	0.80µ	0
3		B308G8S R0				2#8G	2#8S	6@ 130	1.51µ	0
4		B308G8S R5				2#8G	2#8S	6@ 130	1.51µ	5
5		B308G8S R10				2#8G	2#8S	6@ 130	1.51µ	10
6		B308G8S R15				2#8G	2#8S	6@ 130	1.51µ	15
7	35	B3510S8S R0	150	200	1200	2#10S	2#8S	6@ 130	1.17µ	0
8		B3512G8G R0				2#12G+ 1#8G	2#8G	6@ 130	0.80µ	0
9		B358G8S R0				2#8G	2#8S	6@ 130	1.51µ	0
10		B358G8S R5				2#8G	2#8S	6@ 130	1.51µ	5
11		B358G8S R10				2#8G	2#8S	6@ 130	1.51µ	10

12		B358G8S R15				2#8G	2#8S	6@ 130	1.51µ	15
13		B4010S8S R0				2#10S	2#8S	6@ 130	1.17µ	0
14		B4012G8G R0				2#12G+ 1#8G	2#8G	6@ 130	0.80µ	0
15		B408G8S				2#8G	2#8S	6@ 130	1.51µ	0
16	40	B408G8S R5	150	200	1200	2#8G	2#8S	6@ 130	1.51µ	5
17		B408G8S R10				2#8G	2#8S	6@ 130	1.51µ	10
18		B408G8S R15				2#8G	2#8S	6@ 130	1.51µ	15
19		B4510S8S R0				2#10S	2#8S	6@ 130	1.17µ	0
20		B4512G8G R0				2#12G+ 1#8G	2#8G	6@ 130	0.80µ	0
21	45	B458G8S R0	150	200	1200	2#8G	2#8S	6@ 130	1.51µ	0
22		B458G8S R5				2#8G	2#8S	6@ 130	1.51µ	5
23		B458G8S R10				2#8G	2#8S	6@ 130	1.51µ	10
24		B458G8S R15				2#8G	2#8S	6@ 130	1.51µ	15
25		ULCC10S8S R0				2#10S	2#8S	6@ 130	1.17µ	0
26		ULCC12G8G R0				2#12G+ 1#8G	2#8G	6@ 130	0.80µ	0
27	ULCC	ULCC8G8S R0	150	200	1200	2#8G	2#8S	6@ 130	1.51µ	0
28		ULCC8G8S R5				2#8G	2#8S	6@ 130	1.51µ	5
29		ULCC8G8S				2#8G	2#8S	6@ 130	1.51µ	10

		R10								
30		B458G8S R15				2#8G	2#8S	6@ 130	1.51μ	15
31	HPC	HPC10S8S R0	150	200	1200	2#10S	2#8S	6@ 130	1.17μ	0
32		HPC12G8G R0				2#12G+ 1#8G	2#8G	6@ 130	0.80μ	0
33		HPC8G8S R0				2#8G	2#8S	6@ 130	1.51μ	0
34		HPC8G8S R5				2#8G	2#8S	6@ 130	1.51μ	5
35		HPC8G8S R10				2#8G	2#8S	6@ 130	1.51μ	10
36		HPC8G8S R15				2#8G	2#8S	6@ 130	1.51μ	15

Table 2. Properties of Materials Used

PROPERTY	MODULUS OF ELASTICITY	POISSON'S RATIO	TENSILE STRENGTH	DENSITY
STEEL	200GPa	0.30	400MPa	8002.039kg/m^3
GFRP	55GPa	0.28	1250MPa	2212.0285kg/m^3
M30 CONCRETE	27.386GPa	0.2	-	2500kg/m^3
M30 -5% RHA	29.386GPa	0.2	-	2768kg/m^3
M30 -10% RHA	28.386GPa	0.2	-	3036kg/m^3
M30 -15% RHA	28.136GPa	0.2	-	3304kg/m^3
M35 CONCRETE	29.58GPa	0.2	-	2500kg/m^3
M35 -5% RHA	31.58GPa	0.2	-	2768kg/m^3
M35 -10% RHA	30.58GPa	0.2	-	3036kg/m^3
M35 -15% RHA	30.33GPa	0.2	-	3304kg/m^3
M40 CONCRETE	31.622GPa	0.2	-	2500kg/m^3
M40 -5% RHA	33.622GPa	0.2	-	2768kg/m^3

M40 -10% RHA	32.622GPa	0.2	-	3036kg/m^3
M40 -15% RHA	32.372GPa	0.2	-	3304kg/m^3
M45 CONCRETE	33.541GPa	0.2	-	2500kg/m^3
M45 -5% RHA	35.541GPa	0.2	-	2768kg/m^3
M45 -10% RHA	34.541GPa	0.2	-	3036kg/m^3
M45 -15% RHA	34.291GPa	0.2	-	3304kg/m^3
ULCC CONCRETE	16.5GPa	0.2	-	1459kg/m^3
ULCC-5% RHA	18.5GPa	0.2	-	1779.05kg/m^3
ULCC-10% RHA	17.5GPa	0.2	-	2099.1kg/m^3
ULCC-15% RHA	17.25GPa	0.2	-	2419.15kg/m^3
HPC CONCRETE	45GPa	0.2	-	2731kg/m^3
HPC-5% RHA	47GPa	0.2	-	2987.45kg/m^3
HPC-10% RHA	46GPa	0.2	-	3243.9kg/m^3
HPC-15% RHA	45.75GPa	0.2	-	3500kg/m^3

3. VALIDATION

The validation of this analytical model has been done with the specimen mentioned in the journal "Analytical investigation on flexural behavior of concrete beams reinforced with GFRP rebars" [1] written by Sougata Chattopadhyay, R. Rajkumar and N. Umamaheswari which has been published in International Journal of Civil Engineering and Technology in April 2018.For validation the load verses deflection behavior was compared. The graph below shows the load verses deflection behavior of both beams from journal as well as from our analytical study.

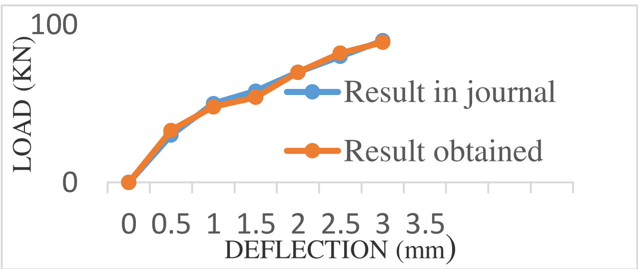

Fig 1.Comparison of Results

4. RESULTS AND DISCUSSIONS

All thirty six beams were modeled and analyzed using ANSYS under four point loading. The mid-span deflection, stress and strain were studied for six different amount of reinforcement ratio and four different grades of concrete. This section consists of plot, discussion and comparison of all significant results. Grade to mid span deflection curve of the analyzed beams which were obtained from non-linear analysis were plotted. The results were compared with conventional RC beams without any GFRP rebars and RHA. The effect of reinforcement ratio and concrete strength on behavior of GFRP replaced beams and RHA were studied. Some important observations have been made in this analytical investigation of flexural behavior of RC beams reinforced with steel rebars only, GFRP rebars only, combination of both the rebars and the combination of both reinforcement with RHA. Ultra Lightweight Cement Composite (ULCC) and High Performance Concrete (HPC) series are also treated as special cases.

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4.1 STRENGTH-DEFLECTION BEHAVIOR

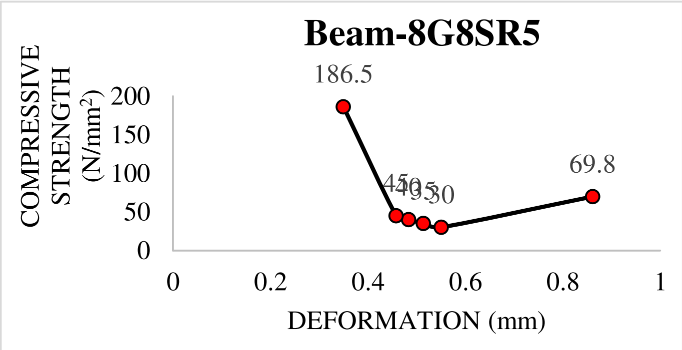

Fig 2. Beam-8G8SR5

Fig 2 shows the graph of compressive strength versus deformation behavior of Beam 8G8SR5 in every series of concrete. Deformation is shown on the X-axis and Compressive strength on the Y-axis. Here we can see that HPC has the least deformation value among all other grades which is about 0.34955 and ULCC shows a larger deformation value among all other grades which is about 0.86131.

ULCC12G8GR0 shows the maximum deformation because of low density and low modulus of elasticity and HPC8G8SR5 shows the least deformation among all the 36 beams.

5. CONCLUSIONS

1. With the increase in grade of concrete, deflection and concrete strain get reduced.
2. Low deflection and low concrete strain are found by the addition of RHA at 5%.
3. Deflection and concrete strain are increasing after the addition of 10% and 15% of RHA, but they are low as compared to the deflection of beams without RHA.
4. Concrete stress follows a similar pattern as that of deflection except that the beam which shows large deflection in each series shows the low stress character.
5. From the results it is found that it is better to use GFRP and steel reinforcement in a combination rather than its individual use.
6. From our project we found that HPC8G8SR5 is the beam with best performance.
7.

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