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Determination of Elastic Behavior of FRC Section by Experimentation and Validation with FEA

KEYWORDS: Elastic behavior, FRC and FEA.

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ABSTRACT *This study represents elastic behavior of FRC section. Initially FRC Six specimens are prepared and tested in universal testing machine at different loading condition. Moreover, percentage of FRC is varied from 0.5% to 1.5% Concrete beam. Effect of percentage of FRC on elastic behavior of specimen is obtained as well as elastic behavior of FRC structure is observed for different configurations of fibers. It is observed that elastic nature of concrete with FRC is enhanced as percentage of FRC increases. Results are validated by using Finite Element Analysis.*

I INTRODUCTION

The value of modulus of elasticity for reinforced cement concrete is more important in finding the parameter of axial stiffness (AE/L) as well as parameter of flexural rigidity (EI) of the member of portal frame. This value is presently calculated by using A as area of concrete only & E for concrete grade. This provides very conservative analysis while using stiffness method. Therefore there is need for accurate determination of AE and EI for RC section.The summery of the work done by the author of this paper is given below, Nine reinforced high strength concrete beams were tested investigate the of concrete compressive strength and flexural tensile reinforcement ration on load deflection behavior and displacement ductility of crack rectangular concrete beams. Concrete compressive strengths of 48, 78 & 102MPa and tensile reinforcement ratio of 1.18,1.77 and 2.37% were used.[1] The summery of the work done by the author of this paper is given below, Reinforcement of concrete with steel fiber increases the tensile strength and ductility of brittle matrix. Therefore, it has been suggested that fiber reinforced concrete might be useful material for construction of defense structure and shelters that might be exposed during they are service life to high intensity impact loading such as explosions.[2] In this study experimental investigation of behavior of reinforced concrete column and a theoretical procedure for the analysis of both short and slender reinforced and composite column of arbitrarily shape cross-section subjected to bi-axial bending and axial load is presented. In the proposed procedure nonlinear stress-strain relations are assume for the concrete, reinforcing steel and structural steel materials[3] The author has invented the use of different properties of FRP in enhancing the axial load carrying of reinforced concrete columns.FRP composites are very attractive for use in civil engineering applications due to their high strength-to-weight and stiffness-to-weight ratios, corrosion resistance, light weight, and potentially high durability[4] In this work the authors have used refined modeling technique for axial /Flexural analysis of reinforced concrete columns and beam cross sections[5] In structural analysis, especially in indeterminate structures, it becomes essential to know material and geometrical properties of members. The codal provisions recommend elastic properties of concrete and steel and are fairly accurate enough. [6] In structural analysis, especially in indeterminate structures, it becomes essential to know material and geometrical properties of members. The codal provisions recommend elastic properties of concrete and steel and these are fairly accurate enough. The stress-strain curve for concrete cylinder or a cube specimen is plotted [7] .This paper reports on a study of flexural behavior of steel reinforcement ductile engineered cementations composite (ECC) members. ECC material shows the extraordinarily levels on strain ductility in tension. Multiples micro-cracking in delays factors localization typically observed in normal concrete [8].Existing concrete structures may, for a variety of reasons, be found to perform unsatisfactorily. This could manifest itself by poor performance under service loading

In present work, the elastic properties of reinforced cement concrete in compressive and flexural loading are studied. The elastic properties of fiber reinforced cement concrete in compressive and flexural loading are studied. The elastic properties of RCC & FRC in compressive and flexural loading using computer aided software are observed. Comparative study between RCC & FRC for compressive and flexural loading is carried out.

II EXPERIMENTATION

In experimentation, 18 no of specimens are prepared and these are tested under different loading conditions. Specimens of RCC structure, FRC are subjected to axial type of loading and flexural type of loading. Combined loading i.e. axial and flexural is applied. Specimen is loaded in universal testing machine. It is fixed at both the ends. While loading the specimen axial alignment of machine axis and

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specimen axis is done carefully so as to avoid eccentric loading. Fig.4 shows experimental set upThe load is gradually applied at 2mm/min ram velocity so as to get effect of static loading. Cross sections of specimens are as shown below.

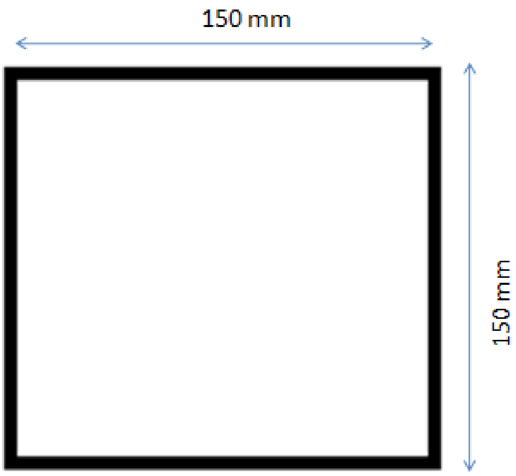

Fig.1 Cross section of FRC specimen

Fig.2 Casted Specimen

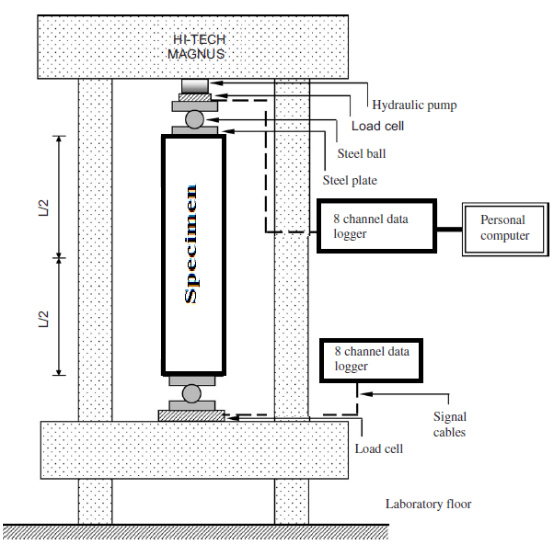

Fig.3 Experimental set up

Fig.4 Flexural loading Test

Table 1 shows specimen numbers, configurations and type of loading

Table No.1 Details of specimen tested and it's Configurations

Configuration	Loading condition	Percentage of fiber	Modulus of elasticity in (N/mm2)
FRC 1	Axial	0.5%	24255
FRC 2	Axial	1%	24503
FRC 3	Axial	1.5%	24807
FRC 4	Flexural	0.5%	24119
FRC 5	Flexural	1%	24397
FRC 6	Flexural	1.5%	24853
Notification	**Description**	**Loading**	
FRC 1	Fiber reinforced concrete for specimen 1	Axial	
FRC 2	Fiber reinforced concrete for specimen 1	Axial	
FRC 3	Fiber reinforced concrete for specimen 1	Axial	
FRC 4	Fiber reinforced concrete for specimen 1	Flexural	
FRC 5	Fiber reinforced concrete for specimen 1	Flexural	
FRC 6	Fiber reinforced concrete for specimen 1	Flexural	

III FINITE ELEMENT ANALYSIS

It consists of Finite element analysis of reinforced concrete and fibers. Elastic properties of FRC are determined by using finite element analysis package ANSYS 14. Compressive strength as well as flexural strength is determined by using ANSYS software.

Table 2 Material Properties used in analysis

Sr. No.	Materials	Steel	Concrete
1	Modules of Elasticity in N/mm^2	200000	22361
2	Poisson's ratio	0.3	0.28
3	Density Kg/mm^3	7850 E-9	2400 E-9
4	Coefficient of Thermal Expansion (aplx) mm/mm ^0C	12 E-6	8 E -6

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Models are freely meshed. Meshed model of each

specimen is as shown in following figures.

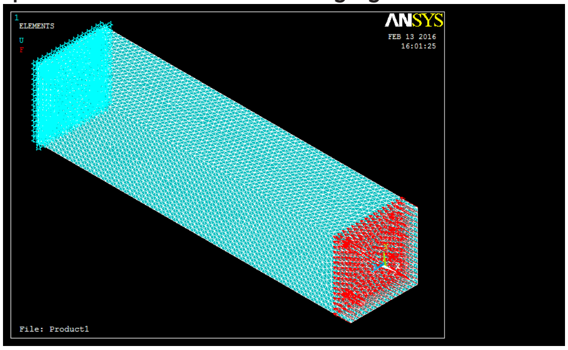


Fig.5 Boundary conditions model1

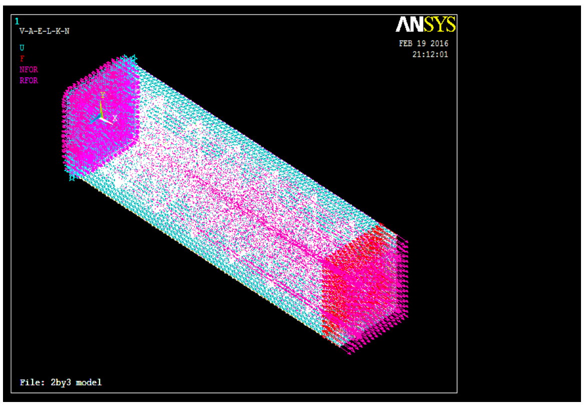


Fig.6 Boundary conditions model 2

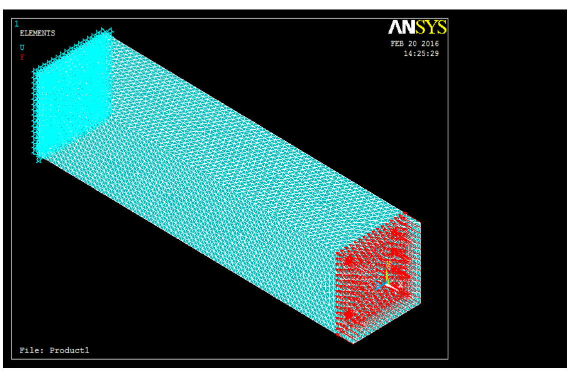


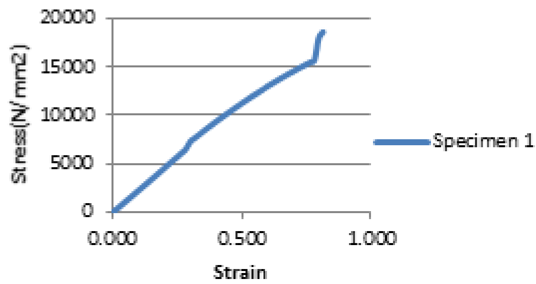
Fig.7 Boundary conditions model 3

All models are freely meshed. Element edge length was 10mm. Denser mesh is applied for meshing bars. Number of elements and nodes generated in each meshing are given in table 3

Table 3 Details of meshing of each model

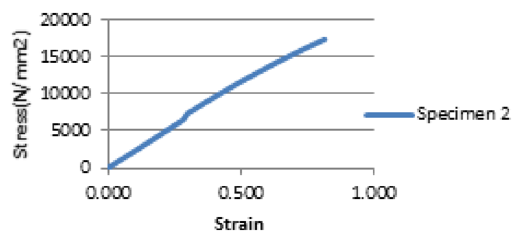
Model No	Nodes	Elements
1	33558	150476
2	33560	150478
3	33555	150474
4	33559	150479

IV RESULT AND DISCISSION



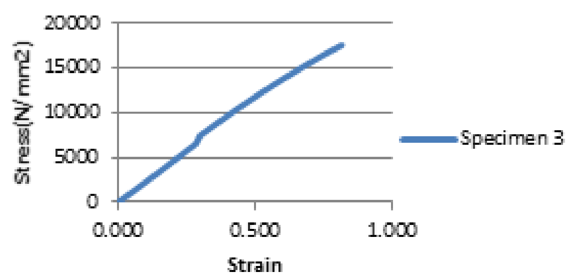
Graph 1. Stress Vs Strain curve for specimen 1(FRC)

Graph 1 shows Stress Vs Strain curves it is obtained for specimen 1. It consists 0.5% Fiber reinforced concrete of total volume. Maximum stress value is 18213 N/mm2and elastic modulus is 24255 N/mm2.



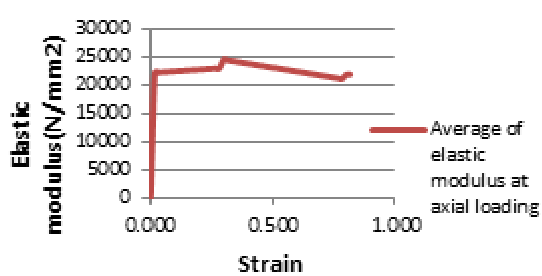
Graph 2. Stress Vs Strain curve for specimen 2(FRC)

Graph 2 Stress Vs Strain curves it is obtained for specimen 2. It consists 1% Fiber reinforced concrete of total volume. Maximum stress value is 18213 N/mm2and elastic modulus is 24503 N/mm2.



Graph 3. Stress Vs Strain curve for specimen 3(FRC)

Graph 3 Stress Vs Strain curves it is obtained for specimen 3. It consists 1.5 % Fiber reinforced concrete of total volume. Maximum stress value is 18013 N/mm2and elastic modulus is 24807 N/mm2.



Graph 4. Average Stress Vs strain curve for axial (FRC)

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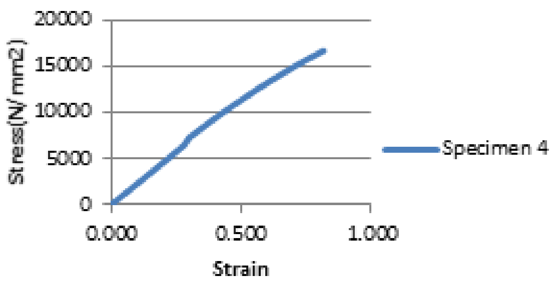
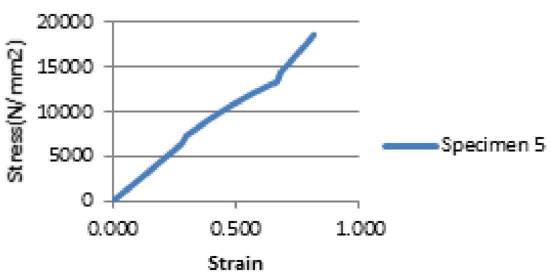
Graph 4 shows Elastic modulus Vs Strain curves. It is obtained by average of specimen 1 to specimen 3. Average elastic modulus is 24305 N/mm2 and elastic modulus varies in between range 24255 N/mm2 -24807 N/mm2.



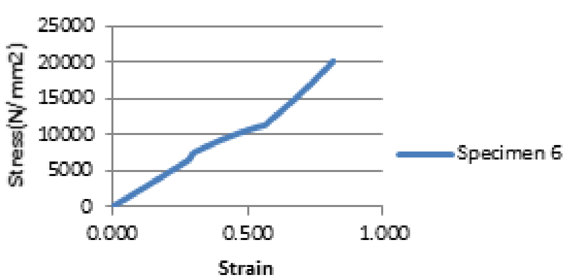
Graph 5. Stress Vs Strain curve for specimen 4(FRC)

Graph 5 Stress Vs Strain curves it is obtained for specimen 4. It consists 0.5 % Fiber reinforced concrete of total volume. Maximum stress value is 17213 N/mm2 and elastic modulus is 24119 N/mm2.



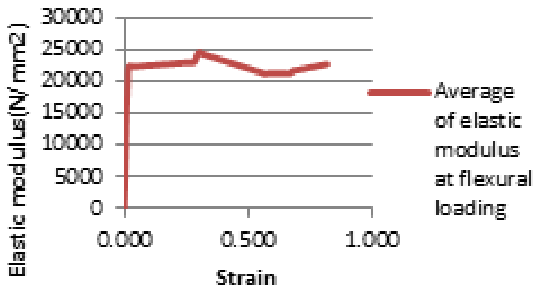
Graph 6. Stress Vs Strain curve for specimen 5(FRC)

Graph 6 Stress Vs Strain curves it is obtained for specimen 5. It consists 1 % Fiber reinforced concrete of total volume. Maximum stress value is 17183 N/mm2and elastic modulus is 24397 N/mm2.



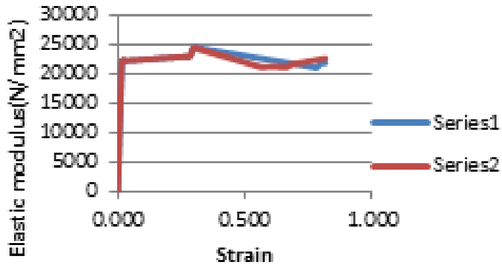
Graph 7. Stress Vs strain curve for specimen 6(FRC)

Graph 7 Stress Vs Strain curves it is obtained for specimen 6. It consists 1.5 % Fiber reinforced concrete of total volume. Maximum stress value is 19113 N/mm2and elastic modulus is 24853 N/mm2.



Graph 8. Average Stress Vs strain curve for Flexural loading (FRC)

Graph 8 shows Elastic modulus Vs Strain curves. It is obtained by average of specimen 4 to specimen 6. Average elastic modulus is 24347 N/mm2 and elastic modulus varies in between range 24119 N/mm2 -24853N/mm2.



Graph 9. Comparative elastic modulus of different configuration of specimen

Graph 9 shows Comparative elastic modulus of different configuration of specimen series 1 shows curve of average elastic modulus from specimen 1 to specimen 3. It is obtained axially loaded specimen. Series 2 shows curve of average elastic modulus from specimen 4 to specimen 6. It is obtained flexural loaded specimen. Series

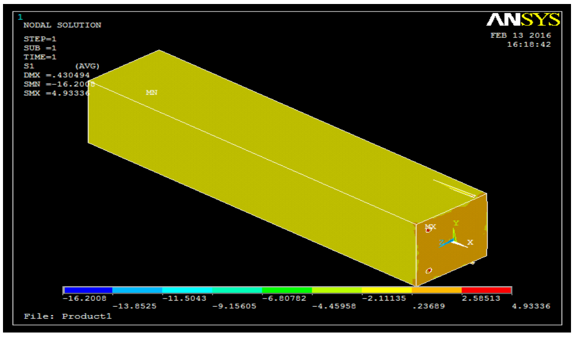


Fig.8 Contour plot of Stress for specimen

Figure 8 shows stress distribution for specimen 1. Maximum stress values 4.9 N/mm2 .It is indicated by red color.

Table 4 Result comparison

Specimen	Stress(KN/mm2)		Percentage Deviation
	Experimental	FEM	
FRC 1	22302	21921	1.70
FRC 2	21103	20103	4.73

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Specimen	Stress(KN/mm2)		Percentage Deviation
	Experimental	FEM	
FRC 3	11503	11231	2.36
FRC 4	19302	19103	1.03
FRC 5	19903	19503	2.01
FRC 6	21103	20987	0.54

IV CONCLUSION

It is observed that elastic modulus FRC increases by 1.01% for specimen 2 and 2.22% for specimen 3 as compared to specimen 1 during axial loading condition.

It is observed that elastic modulus FRC increases by 1.13% for specimen 5 and 2.95% for specimen 6 as compared to specimen 5 during flexural loading condition.

It is also observed that elastic modulus decreases by 10.33% when specimen is made up of FRC only. There is 0.19% deviation in elastic modulus when specimens of same configuration with FRC are tested at axial and flexural loading condition.

Finite element analyses of specimens have been carried out to validate the results of experimentation. There is maximum 4.73 % deviation in results of experimentation and FEM

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