Validation of Experimental and Analytical Results of Foamed Concrete Beam and Conventional Concrete Beam using ANSYS Workbench 14.5

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Abstract- This study presents a numerical analysis using ANSYS Workbench finite element program to simulate the conventional reinforced concrete beam (NWC) with foamed concrete beam (FA Coarse 1400) under four point loading condition. The size of beam is having length 2m, width 0.2m, depth 0.3m which is simply supported and modeled by using ANSYS Workbench software. The models are tested under first crack loading condition with two point loads. Also, the purpose of this study is to validate the experimental results in comparison with ANSYS Workbench results for the same beam and to find out the percentage error between the two results. The consequences of changes in experimental and ANSYS models are discussed and satisfactory results may be obtained from limited models. The results obtained from this study should be represented in the form of deformation, stress intensity and strain intensity.

Keywords – Conventional concrete beam, foamed concrete beam, first crack load, ANSYS Workbench.

I. INTRODUCTION

Foamed concrete is a vast majority of concrete containing no coarse aggregates, only fine sand and with lightweight materials containing cement, water and foam. It can be considered relatively homogeneous when compared to normal concrete, as it does not contain coarse aggregate phase. However, the properties of foamed concrete depend on the microstructure and composition, which are influenced by the type of binder used, methods of pre -foamation and curing. The main advantage of foam concrete is its lightweight, which ensures economy of walls of the lower floors and foundations. It has several advantages and since it is porous in nature, it provides thermal insulation and considerable savings in the material. The important applications of foamed concrete include structural elements, non-structural partitions and thermal insulating materials. Manufacturers developed foam concretes of different densities to suit the above requirements and these products were used in trench reinstatement, bridge abutment, void filling, roof insulation, road sub base, wall construction, tunneling etc. The objective of this paper is to discuss the possibilities of different reinforced concrete models in practical use. It reports the results of some analyses performed using the reinforced concrete model of the general purpose finite element code ANSYS. A series of analysis of the same structure has been performed, exploring different aspects of material modeling. The main purpose of this study is to validate the experimental results in comparison with ANSYS Workbench results for the same beam and to find out the percentage error between the two results.

Objectives of the Study

1. To validate experimental results in comparison with ANSYS Workbench results for the same beam.
2. To find out the percentage error between both the beams such as NWC beam & FA coarse 1400 beam.
3. To calculate the values of stress intensity and strain intensity for the NWC beam & FA coarse 1400 beam.

II. ANALYTICAL METHODOLOGY

The size of conventional reinforced concrete beam and foamed concrete beam is having length 2m, width 0.2m, depth 0.3m which is simply supported and modeled by using ANSYS Workbench software. The beams provided with 2 numbers of 8 mm and 2 numbers of 6 mm diameter HYSD bars in bottom and top portion of the beam respectively. To analyse any structure in ANSYS, software required some inputs like material property, element type, boundary conditions, proper meshing, to get the precise results.

Problem Statement

For the validation purpose, the RC beam model used by M.R. Jones [2] is considered. The flexural analysis, for both the beams is carried out using ANSYS Workbench 14.5software. The geometry of the beam is shown in Fig. 1 & 2. The FE model in ANSYS Workbench 14.5 is shown in Fig. 3. The properties of steel and concrete are given in

Table 1.

Table. 1 Material Properties required in ANSYS workbench

Sr. No.	Name of Material	Property	Value
1	Steel	Modulus of Elasticity (E)	200000 MPa
		Density(ρ)	7850 kg/m^3
		Poisson's Ratio(μ)	0.3
2	Conventional Concrete Beam (NWC)	Modulus of Elasticity (E)	18742 MPa
		Density(ρ)	2370 kg/m^3
		Poisson's Ratio(μ)	0.2
3	Foamed Concrete Beam (FA $_{coarse}$ 1400)	Modulus of Elasticity (E)	8555 MPa
		Density(ρ)	1400 kg/m^3
		Poisson's Ratio(μ)	0.18

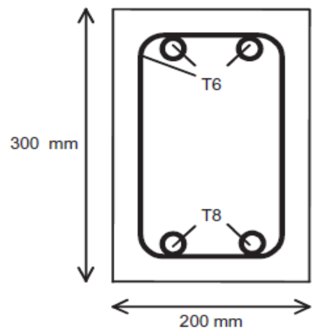

Figure.1 Beam cross-section

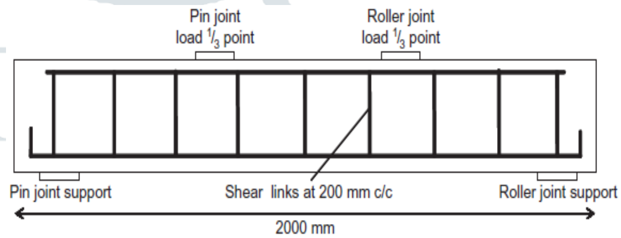

Figure.2 Experimental loading arrangement

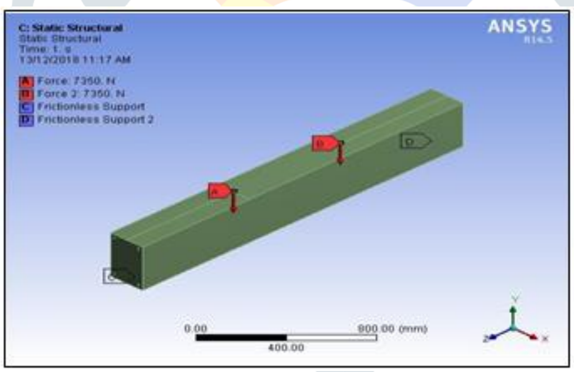

Figure. 3 Loading arrangement in ANSYS Workbench 14.5

III. RESULTS AND DISCUSSION

The NWC beam and FA coarse 1400 beam is tested under four point loads to determine deflection, stress intensity and strain intensity. The percentage error between two specimens is to be calculated by using experimental results and ANSYS workbench software. The density of foamed concrete is less as compared to conventional concrete beam therefore, self-weight of the beam get reduced. Due to the reduction in self-weight the deflection is maximum in case of foamed concrete. The percentage error is obtained 16.90 % for NWC beam and 13.92 % for FA Coarse 1400 beam. The obtained error between both the beams is due to difficulties in mix proportion, casting error and loading conditions. The following table shows the percentage error in deflection obtained under first crack load for both the specimens. The stress intensity & strain intensity shows good results using ANSYS Workbench 14.5 software.

Table. 2 Percentage error in deflection

Beam Type	First crack load (KN)	ANSYS Deflection (mm)	Experimental Deflection (mm)	% Error
NWC	29.4	3.61	3.00	**16.90**
FA Coarse 1400	14.7	3.95	3.40	**13.92**

Table. 3 Results of strain intensity & stress intensity

Beam Type	First crack load (KN)	ANSYS Strain Intensity	ANSYS Stress Intensity (MPa)
NWC	29.4	0.003333	52.056
FA Coarse 1400	14.7	0.003650	26.028

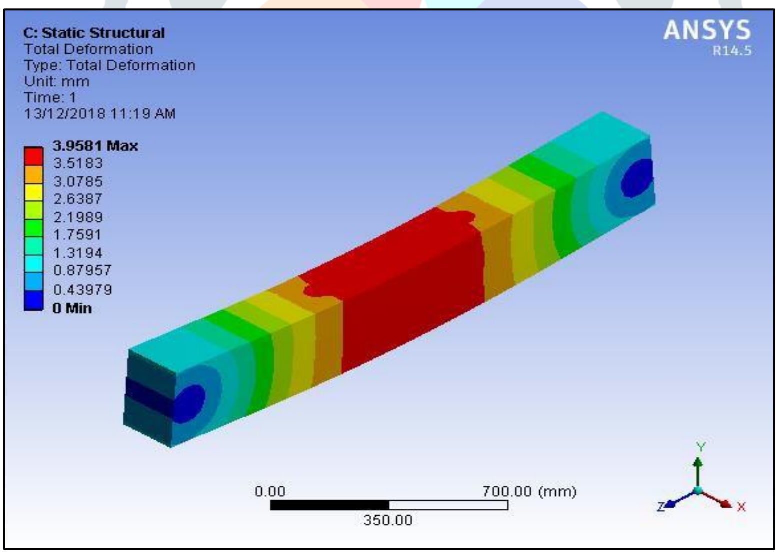

Figure. 4 Total deflection for FA Coarse 1400 Beam

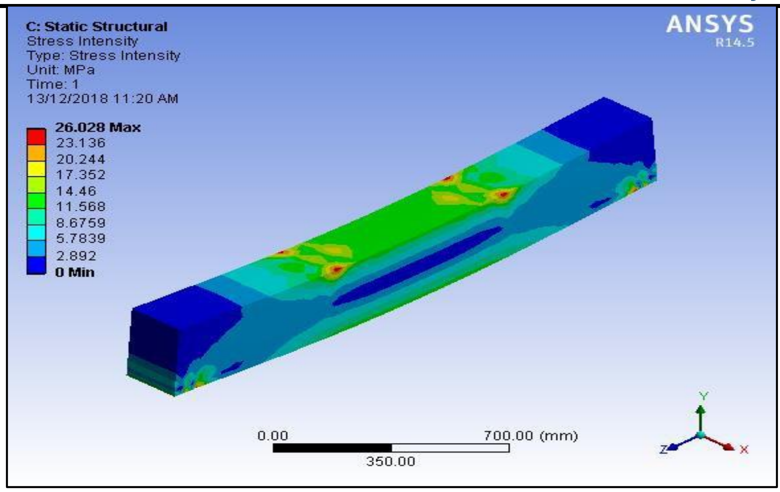

Figure. 5 Stress intensity for FA Coarse 1400 Beam

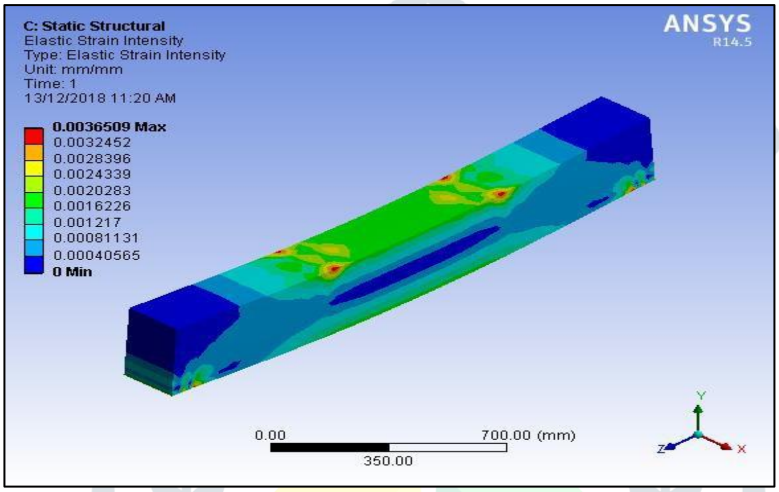

Figure. 6 Strain intensity for FA Coarse 1400 Beam

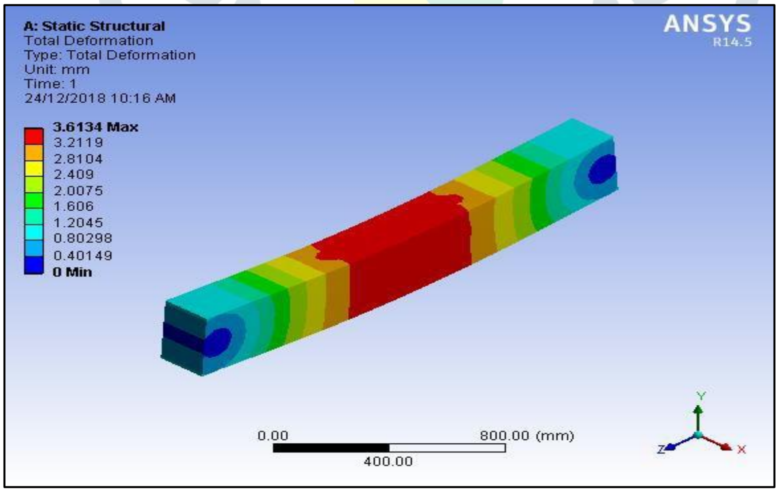

Figure. 7 Total deflection for NWC Beam

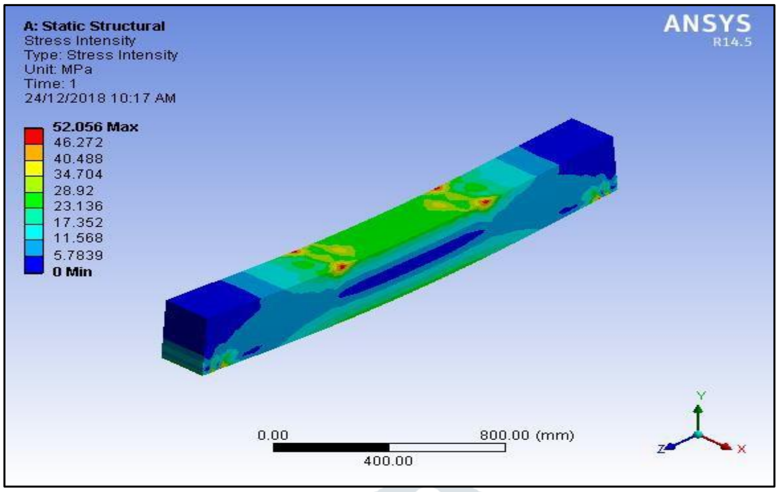

Figure. 8 Stress intensity for NWC Beam

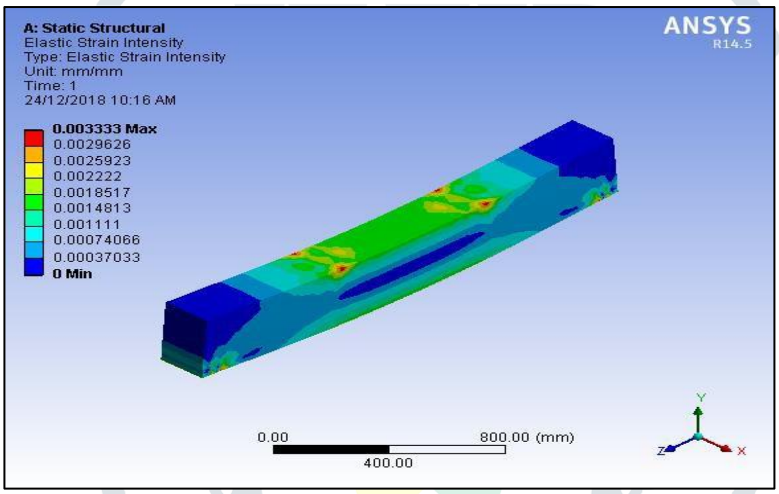

Figure. 9 Strain intensity for NWC Beam

IV. CONCLUSIONS

This study carried out to investigate the possibilities of performing nonlinear finite element analysis of conventional reinforced concrete beam in comparison with foamed concrete using ANSYS concrete model. Preliminary tests on reinforced foamed concrete beams indicated satisfactory load behaviour with similar failure mode to equivalent 25 N/mm^2 normal weight concrete elements. However, the deflections at first crack load is up to the 30 to 40% lighter FA coarse section is up to 1.1 times greater than that of the NWC beam. Due to the reduction in self-weight the deflection is maximum in case of foamed concrete. The percentage error is obtained
16.90 % for NWC beam and 13.92 % for FA Coarse 1400 beam. This study shows that approximately 15 % average error in between experimental and analytical results for the NWC & FA coarse 1400 beam. The percentage error is reduced by taking the proper care during casting of specimens and testing for maintaining exact density and self-weight of the beam. The stress intensity of the foamed concrete beam is half than that of conventional concrete beam. The strain intensity of foamed concrete beam is greater than conventional concrete beam. The analysis procedure used in this paper and various outputs constructed by FEA have provided a
deeper insight for future application of FEM software for the non-linear analysis of RC beams. Based on the
analyses carried out on the both the beams using ANSYS, it is found that results are more sensitive to mesh size, materials properties, loading conditions etc.

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