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The Evaluation of Compressive Behavior of Column Exposure to Fire using Abaqus

T. Ram Prasanna Reddy[1*], DVSP Rajesh[2]

[1] Department of Civil Engineering, Malla Reddy group of Institutions, Hyderabad, India
[2] Department of Civil Engineering, Guru Nanak Institutions Technical Campus, Hyderabad, India

Corresponding Author Email: tr*amprasanna.128@gmail.com*

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ABSTRACT

In this paper, an attempt to validate the results of an experimental study with an analytical model undertaken to understand the percentage loss in compressive strength of reinforced concrete column (RCC) before and after exposure of fire as per ASTM E 119 between experimental work and software (ABAQUS). The results of experimental work is taken from the standard journal having specified column dimensions, material properties and loss in compressive strength before and after exposure of fire. Using software, the above column is modelled, analyzed and compared results of NSC and HSC with experimental work.

1. INTRODUCTION

After several fire accidents happened around the world, people and authorities has realized the seriousness of the problem, and included fire safety as one of the key criteria for design of structures. Especially for Concrete structures fire safety is very important because of it varies with different parameters like exposure time, quantity of exposure, grade of concrete, type of aggregate used etc., so it is very important to understand the behaviour of concrete before and after exposure of fire in different conditions [1].

Over last three decades there have been significant research and development activity is going on to understand the behavioral differences in properties of concrete before and after fire. Several experiments and numerical methods are performed to improve performance of concrete structure under exposure of fire. By using this knowledge it is time to understand and evaluate results with latest technologies which are available like software's (ABAQUS, ANSYS etc.,) and validate results with the experimental results. This process gives approximate but quick results to get an idea about the effected element in structure. Many researchers have been doing experimental work worldwide, few papers from these research articles have been taken as reference papers for this article [2].

2. LITERATURE REVIEW

M.Mohame Bikhiet, has done research on concrete column and found ultimate failure load, for column which were expose to fire are 20-40% less than the column not exposed to fire.

Column not exposed to fire shows 1st crack occurs at load at 80 % of failure load while column exposed to fire the crack occurs at the 50% of column failure load [3-5].

N K Raut et. al worked-on comparison study of response of high strength column (HSC) with normal strength column (NSC), states that Concrete permeability and load level have significant influence on spalling and fire resistance. HSC has less permeability so; HSC has more fire resistance but brittle that causes sudden failure compared to NSC [6].

From the existing literature study, it is seen that, load carrying capacity of elements of structure decreasing after exposure to fire and fire resistance increases with increase in grade of concrete. Lot of experimental work is carried out in fire resistance of reinforced concrete structures (RCS) and compared results with numerical models. The present study deals with comparison of results of experimental work (ref 13) with the model analyzed using ABAQUS software [7-9]. The model is created as isotropic model to simulate the actual experimental conditions. In pre-processing, parts have to be created, then assign the properties and assembling of column reinforcement has been carried out. In the initial step, interaction between steel and concrete surfaces has to be done and create the boundary conditions for RC column. Apply compression load on the top surface and heat loading on four sides of column as per ASTM E119.

3. DATA

The input data of reinforced concrete column for ABAQUS software is taken from the journal(ref 13) which is mentioned that RC column of dimension 203*203*3350 mm of charactrestic compressive strength of 40 Mpa for Normal Strength column and 90 Mpa for High strength column having properties as shown in Table 1.

Table 1. Table of input parameters

Parameters	Value
Dimensions	203*203*3350
Main Steel	4no's-20mm Dia bars
Stirrup's	17no's10mm@200 mm c/c
Clear Cover	40 mm
Grade of Steel	Fe415
Density of NSC	2429 Kg/m^3
HSC	2490 kg/m^3
Thermal Conductivity of Concrete	1900 Joule/K

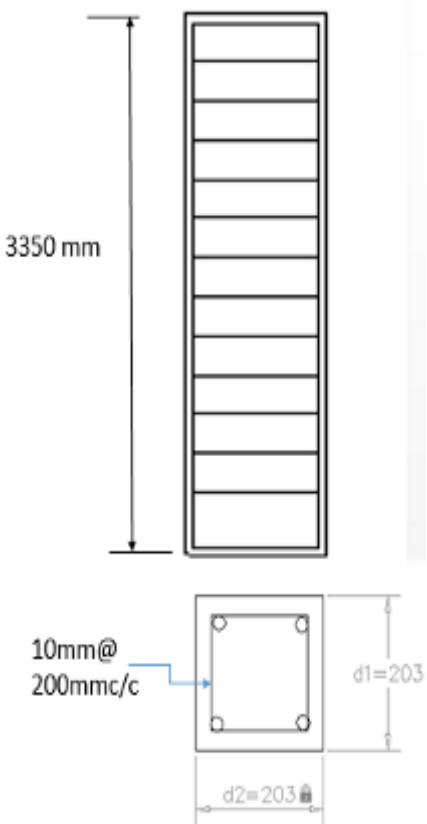

Figure 1. Detailing of RC column

$$\frac{f}{f_0} = 2.1\left(\frac{\epsilon}{\epsilon_0}\right) - 1.33\left(\frac{\epsilon}{\epsilon_0}\right)^2 + 0.2\left(\frac{\epsilon}{\epsilon_0}\right)^3$$

Where

f_o= Characterstic compressive strength of NSC and HSC

e_{min}=0%

e_{max}=0.35%

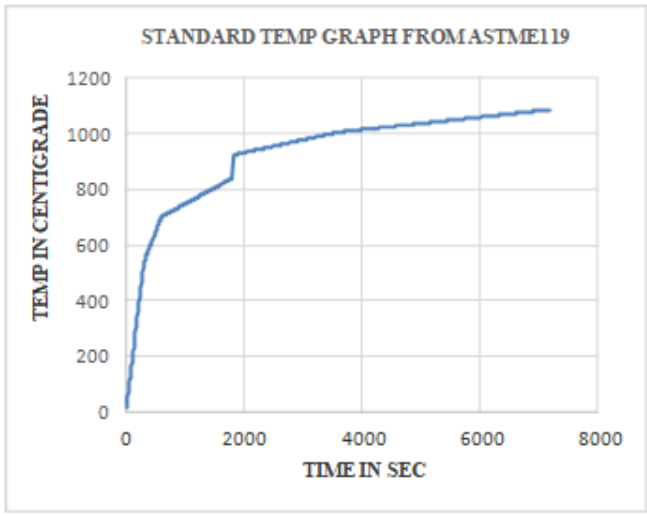

Figure 2. Application of temperature as per ASTM E 119

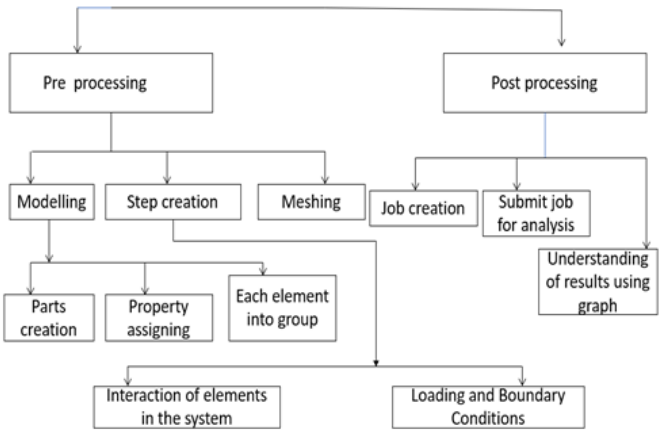

Figure 3. Flow chart for analysis rccolumn exposed to fire using ABAQUS

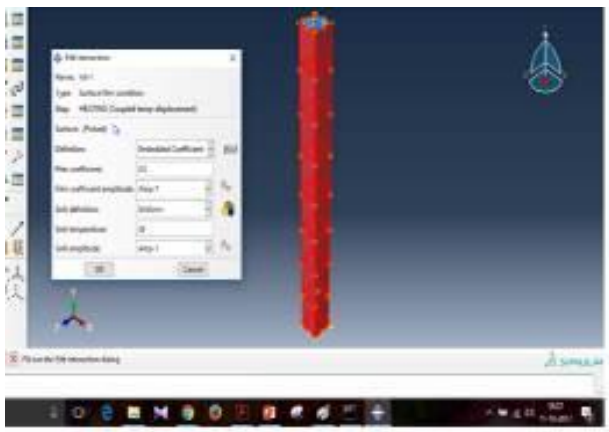

Figure 4. Heat loading on 4 surfaces of column

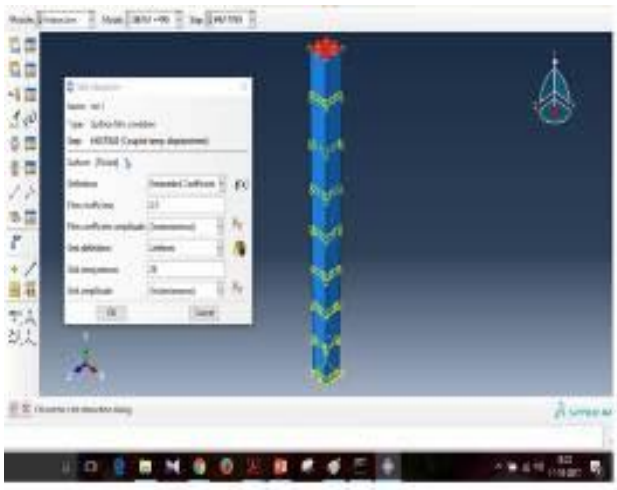

Figure 5. Compression on top surface

3.1 Force vs. Displacement Graphs:

For Normal Strength Column, boundary conditions at compressive loading face is allowed for 5 mm displacement, analyzed and obtain results of reaction force with respect to displacement as shown in Figures 5,6 and converted into stress values. The linearity in graphs showed because of results are shown for very small interval of displacement than actual one [10].

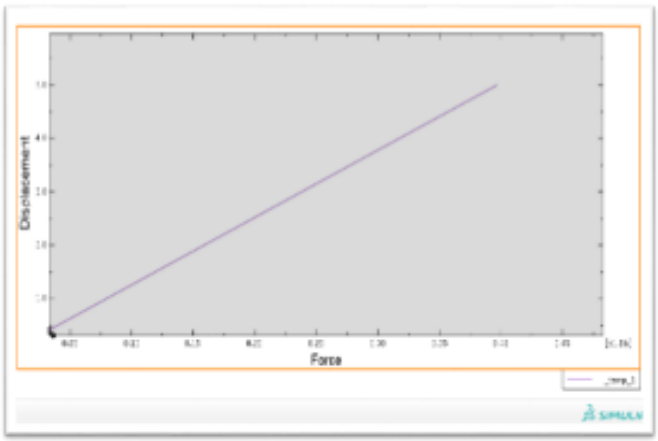

Figure 6. NSC with compression load

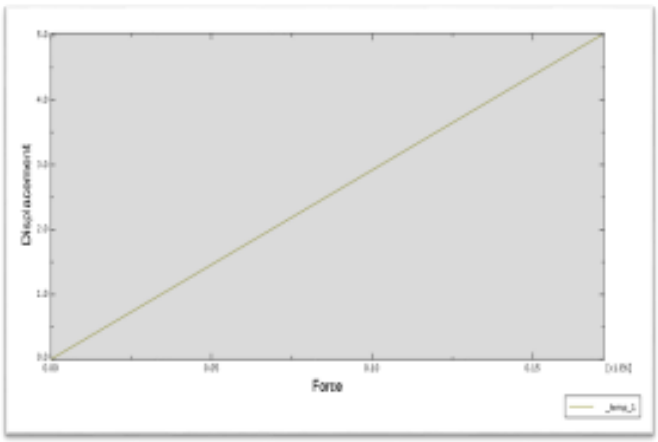

Figure 7. NSC with compression and Fire loading

For High Strength Column, boundary conditions at compressive loading face is allowed for 5 mm displacement, analyzed and obtain results of reaction force with respect to displacement as shown in Figures 7 and 8 and converted into stress values. The linearity in graphs showed because of results are shown for very small interval of displacement than actual one [11-13].

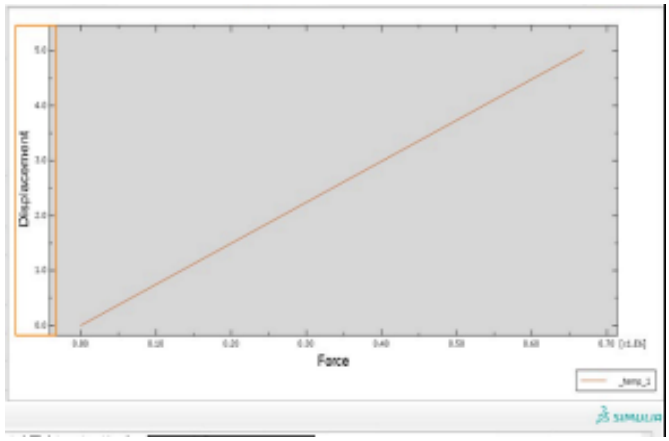

Figure 8. HSC with compression load.

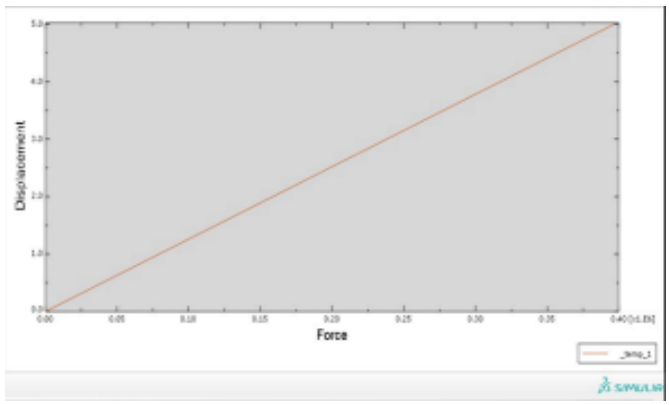

Figure 9. HSC with compression and fire load.

4. CONCLUSION

The results obtained in the study of analyzing compressive strength RC column of dimensions 203*203*3350 mm exposed before and after fire using ABAQUS, the percentage loss in compressive strength of NSC and HSC are 62.5 and 42.8 are validated with experimental work. From above study it is concluded that, after fire accident strength of critically damaged reinforced column can be analyzed using ABAQUS to get an approximate idea without testing it. Comparison between results of experimental work and ABAQUS software.

	Reduction In Compressive Strength %	
	NSC	***HSC***
EXPERIMENTAL WORK	60	40
ABAQUS SOFTWARE	62.5	42.8

REFERENCES

[1] Lie, T. T. (Ed.). (1992, January). Structural fire protection. American Society of Civil Engineers.

[2] ASTM, E. (2008). 119, Standard methods of fire test of building construction and materials, Test Method E119a-08. *American Society for Testing and Materials, West Conshohocken, PA*.

[3] Kodur, V. K. R., & Dwaikat, M. B. (2011). Design equation for predicting fire resistance of reinforced concrete beams. *Engineering Structures*, *33*(2), 602-614.

[4] Dwaikat, M. B., & Kodur, V. K. R. (2008). A numerical approach for modeling the fire induced restraint effects in reinforced concrete beams. *Fire Safety Journal*, *43*(4), 291-307.

[5] Dwaikat, M. B., & Kodur, V. K. R. (2009). Hydrothermal model for predicting fire-induced spalling in concrete structural systems. *Fire safety journal*, *44*(3), 425-434.

[6] En, B. S. (1991). 1-2: 2002 Eurocode 1: Actions on structures—Part 1-2: General actions—Actions on structures exposed to fire. *British Standards*.

[7] Feasey, R., & Buchanan, A. (2002). Post-flashover fires for structural design. *Fire safety journal*, *37*(1), 83-105.

[8] Harmathy, T. Z. (1967). A comprehensive creep model.

[9] Harmathy, T. Z. (1993). Fire safety design and concrete.

[10] Han, L. H., Zhou, K., Tan, Q. H., & Song, T. Y. (2016). Performance of steel-reinforced concrete column after exposure to fire: FEA model and experiments. *Journal of Structural Engineering*, *142*(9), 04016055.

[11] M. Mohamed Bikhiet1, Nasser F. El-Shafey2 , Hany M. El-Hashimy3 ,(2011) "behaviour of reinforced concrete column exposed to fire".

[12] Raut, N., & Kodur, V. (2009). Behavior of High Strength Concrete Columns under Design Fire Scenarios. In *Structures Congress 2009: Don't Mess with Structural Engineers: Expanding Our Role* (pp. 1-10).

[13] N. K. Raut1 ,V. K. R. Kodur2 ,2015 "Response of high strength concrete column under design fire exposure" published 2015.