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Analysis of Steel Structure Subjected to Fire

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Abstract: In the present Study, The steel structure is analysed which is subjected to fire damage. The response of the structure is find out due to loss of column due to fire load. The comparison are drawn for the before and after effect of fire. The static strength of the structure is found for fire loading. And also actual static strength required for existing fire damage structure. The static and Progressive collapse analysis are performed and the conclusions are drawn are Effect of fire on steel structure is a significant factor in order to achieve safety and serviceability aspects, since an uplift movement or deformation has been observed in case of static analysis. The effect of fire at ground floor has significant change in DCR values at upper levels which indicates the redistribution of moments of columns at different levels. Columns moment carrying capacity decreases with the increase in fire temperature loads hence strengthening has to be done in order to enhance the its moment carrying capacity, which is evident from the present study.
Keywords: Deformation, Progressive Collapse, Demand Capacity Ratio, Temperature, Etabs

I. INTRODUCTION

Structural steel is used widely all over the world. It has its own advantage of customizing of its own kind. It avoids brittle failure because of its ductile behaviour and discrete sizes available in a range, which allows plastic deformation upon yielding. In Reinforced Concrete structures, steel improves the concrete tensile strength by alone carrying the tensile forces. It will be also commonly used to reinforce- timber constructions. In spite of its many advantages, steel has its own is vulnerable in fire. Raised up temperatures in the structural steel cause decrease in strength and also in stiffness which ultimately leads to failure of structure due to excessive deformations. This is critical in steel structures in compared with other RC concrete or timber members. Fire has always been a very disparaging natural phenomenon. People have lost valuable goods, lives, estates on number of occasion, because of fire accidents. In other way, fire has also been used as weapon contrary to enemy structure, fortification, and houses. It is severing damaging effects on the structure, which could be range from a building being functionally deactivated up to the collapse, has being known from centuries.

If it is not properly treated then the fire has boundless capacity to harm human life. It may lead to loss of human life / property. In recent days usage of steel structure is more and its industries is booming, which intern requires more careful treatment to fire and also care shall be taken and studied further. In this segment a brief review on aspects of structural steel work, which is subjected to fire is provided. If the temperature increase, the engineering properties of all the materials undergoes reduction. Steel is no exception. However, key advantage of structural steel is, it is an incombustible and it can easily fully recover its strength after fire accident. Many a times during a fire structural steel absorbs a substantial amount of thermal energy. After this exposure to fire, steel returns to its stable condition after cool down to ambient temperature.

II. OBJECTIVES AND METHODOLOGY

A. Objectives

1) To analyses the steel structure subjected of fire damage
2) Analyze the response of structure due to loss of column due to fire load
3) To compare the structural response before and after fire
4) To find the static strength of structure subjected to fire load
5) To find the actual static strength required for existing fire damaged structure

B. Methodology

1) Types of Analysis- static analysis, progressive analysis collapse
2) In the present chapter, the general step by step procedure of modelling the building is explained. The similar modelling procedure is used to models various other models and for different height builds. There are 6 models has been done in this project.

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a) Model 1- steel structure
b) Model 2- steel structure with fire load (500 degrees) for bottom column location as per GSA Specification
c) Model 3- steel structure with fire load (700 degrees) for bottom column location as per GSA Specification
d) Model 4- steel structure with fire load (1500 degrees) for bottom column location as per GSA Specification
e) Model 5- steel structure with loss of bottom column (location as per GSA Specification)
f) Model 6- steel structure with additional steel section for bottom column (location as per GSA Specification)
i) Material properties- M30 grade concrete, Fe 500 grade reinforcing steel, Fe 350 grade structural steel

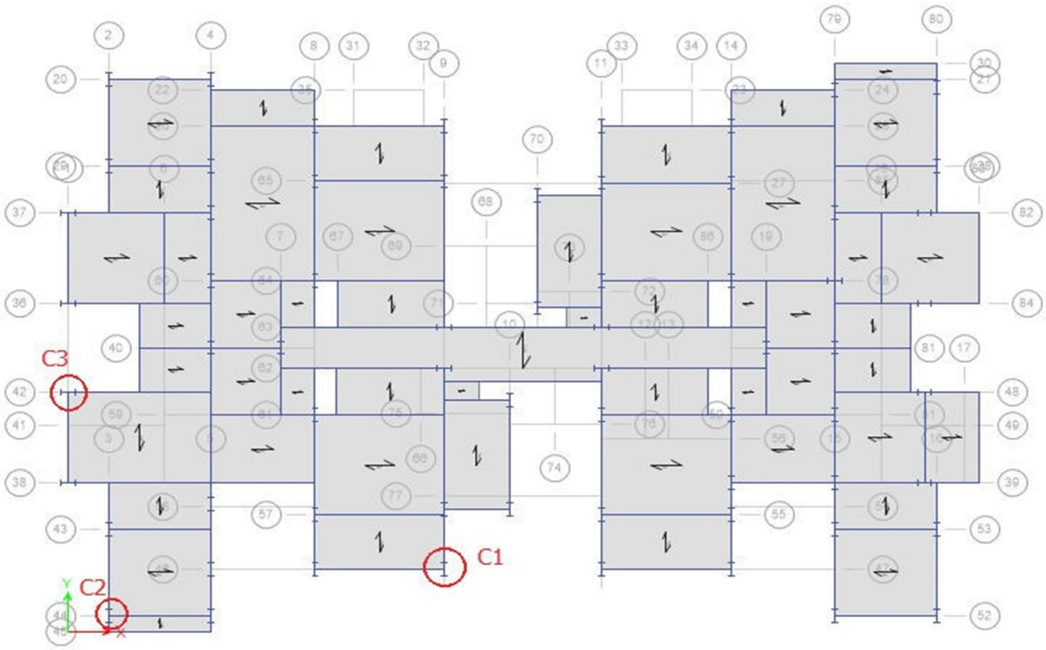

Figure 1: Columns under Fire loading at ground floor as per GSA specifications

III. RESULTS AND DISCUSSIONS

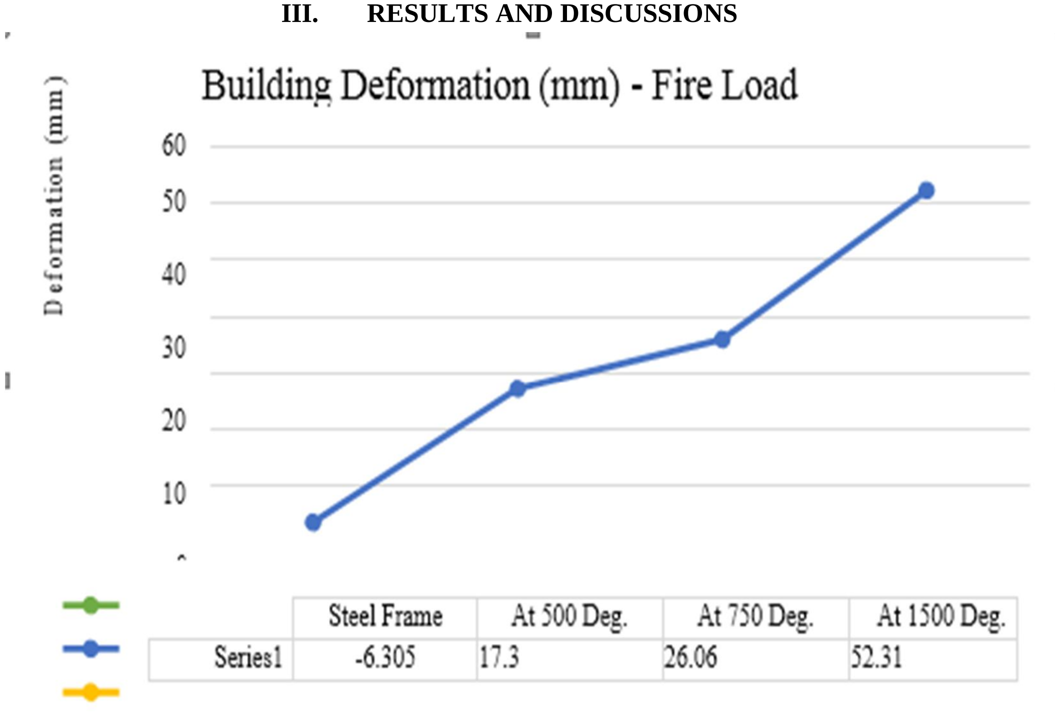

Figure 2: Maximum Building Deformation mm (Due to Fire)

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A. Progressive Collapse

Table 1: DCR values of Columns at 500 degrees

DCR - Columns at 500 degrees										
Storey	**1**		**2**		**3**		**4**		**5**	
	No Fire	**500**	**No Fire**	**500**	**No Fire**	**500**	**No Fire**	**500**	**No Fire**	**500**
C-1	0.101	0.691	0.127	0.856	0.122	0.573	0.124	0.473	0.149	0.463
C-2	0.098	0.477	0.077	0.485	0.069	0.470	0.053	0.348	0.038	0.359
C-3	0.196	0.410	0.162	0.481	0.140	0.455	0.115	0.447	0.118	0.480

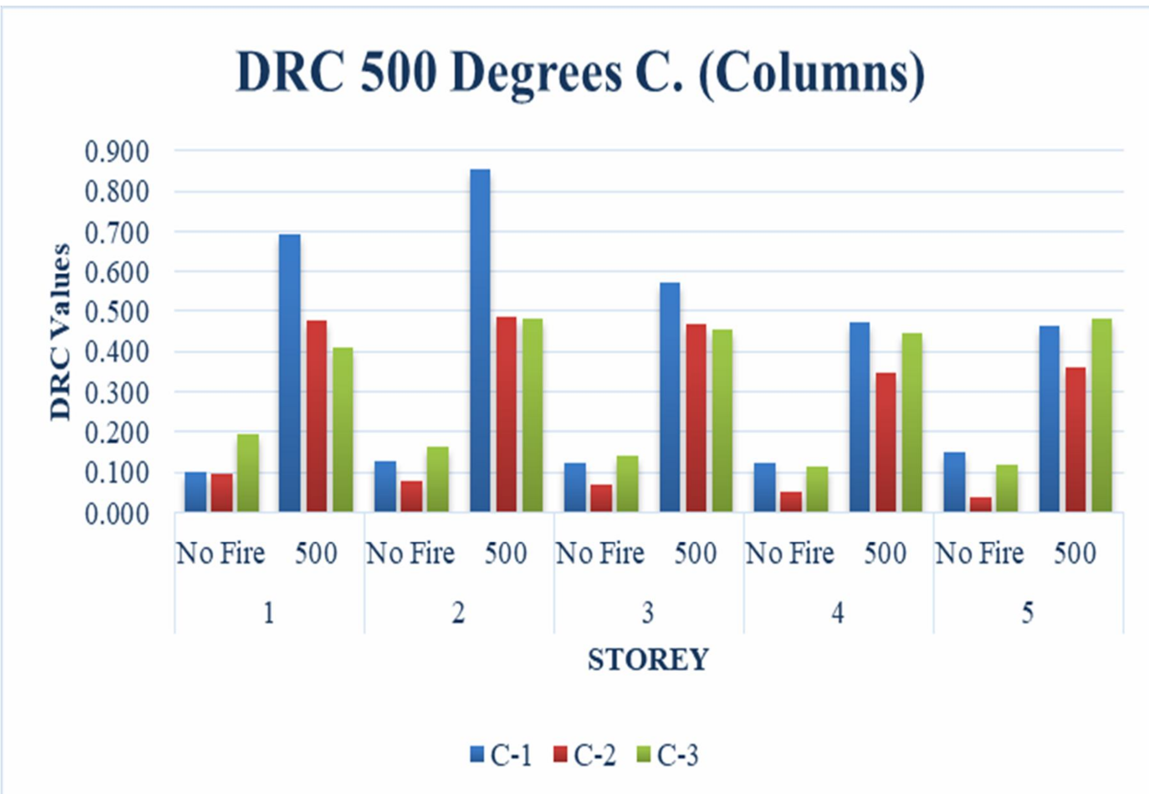

Figure 3: Variation of DCR - Columns at 500 degrees

Due to increase in temperature from 25 degrees to 500 degrees, DCR values are found to increase more than 200% at all the levels particularly at level 2 as shown in Fig. 2.

Table: 2 DCR values of Columns at 750 degrees

DCR - Columns at 750 degrees										
Storey	1		2		3		4		5	
	No Fire	750	No Fire	750	No Fire	750	No Fire	750	No Fire	750
C-1	0.101	0.982	0.127	1.198	0.122	1.020	0.124	0.661	0.149	0.636
C-2	0.098	0.725	0.077	0.696	0.069	0.589	0.053	0.533	0.038	0.569
C-3	0.196	0.537	0.162	0.719	0.140	0.680	0.115	0.668	0.118	0.716

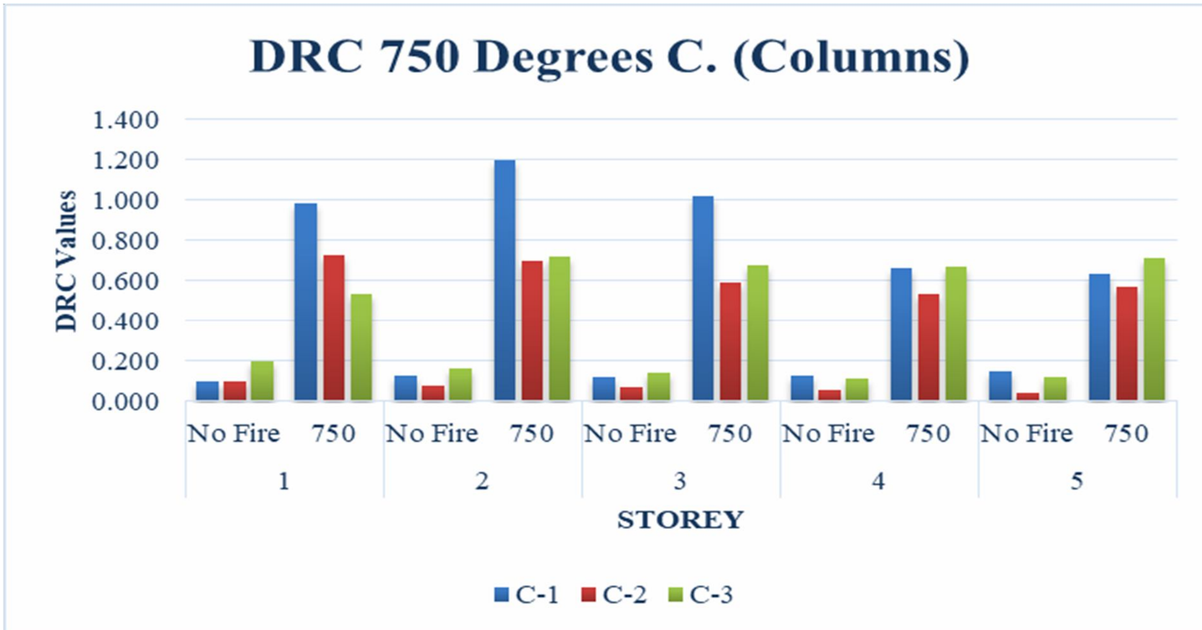

Figure 4: Variation of DCR - Columns at 750 degrees

Table: 3 DCR values of Columns at 1500 degrees

DCR - Columns at 1500 degrees										
Storey	1		2		3		4		5	
	No Fire	1500	No Fire	1500	No Fire	1500	No Fire	1500	No Fire	1500
C-1	0.101	1.840	0.127	**2.223**	0.122	1.876	0.124	1.645	0.149	1.223
C-2	0.098	1.438	0.077	1.898	0.069	1.672	0.053	1.156	0.038	1.189
C-3	0.196	1.155	0.162	1.479	0.140	1.363	0.115	1.337	0.118	1.426

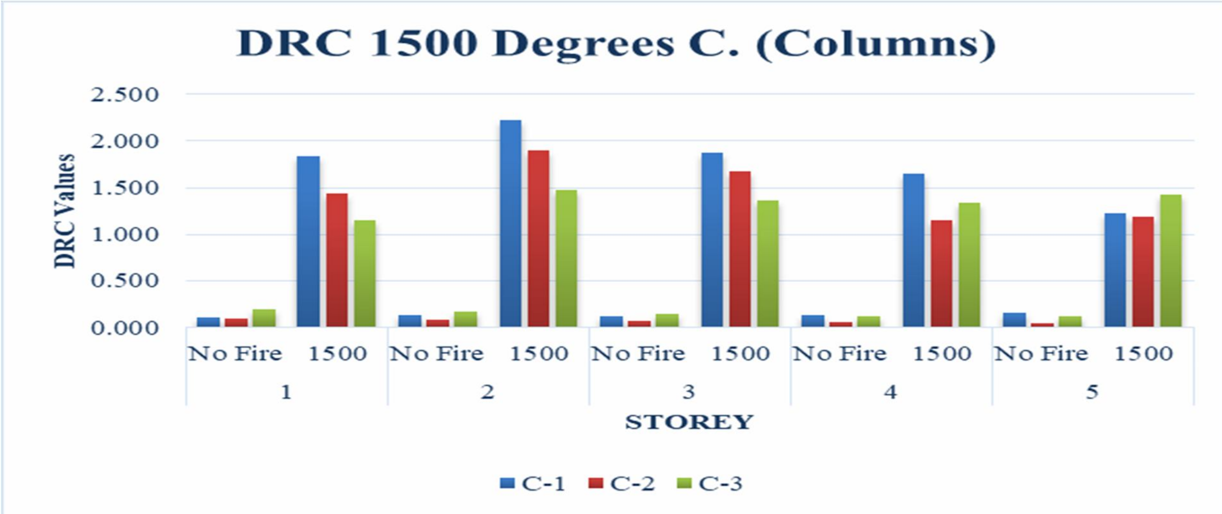

Figure 5: Variation of DCR - Columns at 1500 degrees

DCR values are observed to increase with increase in temperature for 750 degree and 1500 degrees. A progressive collapse condition exists due to increase in DCR values at C1 column as shown in Table 3.

Table: 4: DCR values of Columns at 1500 degrees after column strengthening

DCR - 1500 Degrees after Column Strengthening										
Storey	1		2		3		4		5	
	1500	Col. Strn.	1500	Col. Strn.	1500	Col. Strn.	1500	Col. Strn.	1500	Col. Strn.
C-1	1.840	1.024	2.223	1.805	1.876	1.940	1.645	1.635	1.223	1.212
C-2	1.438	1.421	1.898	1.889	1.672	1.665	1.156	1.159	1.189	1.196
C-3	1.155	1.113	1.479	1.431	1.363	1.357	1.337	1.332	1.426	1.419

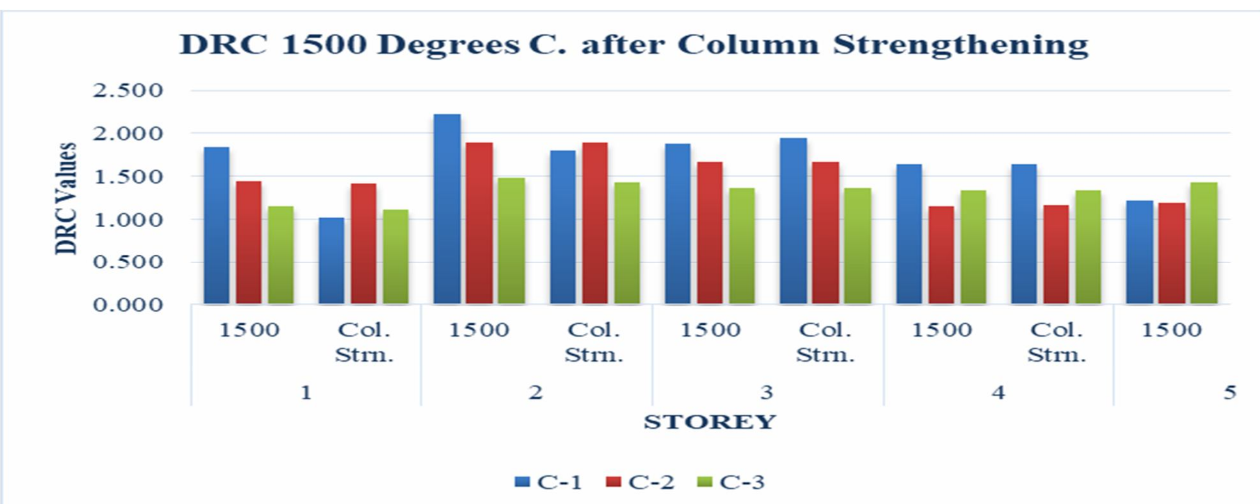

Figure 6- Variation of DCR values of Columns at 1500 degrees after column strengthening

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From the Fig.6 is can be observed that due to column strengthening, progressive collapse can be avoided since DCR values are below 2.

IV. CONCLUSION

Based on the results and discussions, the following conclusions are drawn,

A. Effect of fire on steel structure is a significant factor in order to achieve safety and serviceability aspects, since an uplift movement or deformation has been observed in case of static analysis.
B. From the progress collapse analysis, it can be concluded that, DCR values are most significant in predicting the stability of the overall structure.
C. The effect of fire at ground floor has significant change in DCR values at upper levels which indicates the redistribution of moments of columns at different levels.
D. Progressive collapse analysis critical columns can be identified and strengthened prior to accidental incidents which avoids the collapse of the partial or entire structure.

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