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LINEAR ANALYSIS FOR PROGRESSIVE COLLAPSE ON MULTISTROREY STEEL FRAME UNDER DIFFERENT TEMPERATURE

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ABSTRACT

Progressive collapse is one of the main reasons for the failure of structure. It occurs due to removal/ damage of a column by fire, blast or vehicle impact. The present study investigates the comparative behaviour of 2D, three bay, four storey moment resisting steel frame using ABAQUS to predict the sensitivity of the structure in progressive collapse due to fire loads. Columns at different levels were given different temperature with reduced material properties and yield strength. Progressive collapse load combination was adopted as per GSA guidelines. Corner, middle and intermediate columns were subjected to fire load separately. The study covers linear analysis of steel frame due to different temperature. In linear analysis columns were subjected to different temperature and their results were studied. The results for displacement, stress, shear force and axial force were captured and discussed.

Keywords: temperature conditions, linear static analysis, deflection, axial forces.

INTRODUCTION

Progressive collapse occurs, when any one of the major structural load carrying members is removed suddenly from a building due to any unfavorable situation or condition and if the remaining structural elements are not capable of supporting the whole weight of the building. For example, if a column is damaged due to fire, manmade or natural hazards, the whole weight of the building (gravity load) inclusive of imposed loads are displaced to adjacent columns of the structure. If these adjacent columns are also not that much strong and stiff to carry the additional loads, they would have also been failed. As a consequence, the vertical load carrying elements may loose their strength and thus the massive collapse of the structure occurs. The progressive collapse behaviour of steel-frame buildings under fire load has been studied by lot of researchers for the past two decades. The General Services Administration (GSA) (2003) guidelines suggested some general expressions and conditions to predict the members which may be prone to the progressive collapse. The reason is in real buildings, structural elements form part of a continuous assembly and therefore the higher temperature due to fire often remains localized, by receiving significant restraint from the surrounded cool areas Static analysis can be used to trace the behaviour of the structures at elevated temperature until the instability happened. After the instability of the analyses is identified, the non linear transient procedure is followed to extract results.. As stress strain relationships are not idealized in design codes and manuals, these relationships available from the literature on the few experimental works with suitable correlations have to be relied upon.

STRUCTURAL MODELLING

A four story 2D steel frame is modeled first in ABAQUS software which can perform design and analysis of structures. Type of Building was a steel moment resisting space frame. The beam and column are steel I section which are chosen from the Steel Tables respectively (By trial and error process). The section can also be a built up section. For simulation purpose the I section for beams and columns are modeled as same frame elements. The section which is been chosen for analysis is ISHB 400. The section satisfies all the check and it is a plastic section in web and flange. The sectional properties of the steel section are given in table 1 The analysis were carried for the steel frame for the case as per GSA guidelines The spans for beam and column vary due to their variable section. Column comprises a span of 3.3m and the span of column is taken as 13.6m which runs throughout the floor are shown in Figures 1(a) and 1(b) as mentioned above the beam and column sections are taken as same for simulation purpose but the span for section varies. The beams and column were assembled as a framed structure for 3 bays and 4 storey. After creating the steel frame interaction property at the joins are to be specified so that the structure acts as a rigid frame. The structure is tied at the joints which will make the frame rigid at joints.

Table-1. Section properties.

Section	ISHB 400
Area	10466mm^2
Depth of Section	400mm
Width of Flange	250mm
Thickness of Flange	12.7mm
Thickness of Web	10.6mm
Moment of Inertia I_{xx}	28823.5x10^4 mm^4
Moment of Inertia I_{yy}	2783x10^4 mm^4
Modulus of Section Z_{xx}	1444.2x10^{3}mm^3
Modulus of Section Z_{xx}	221.3x10^{3}mm^3
Radius of Root r_1	14mm
Radius of Root r_2	7mm

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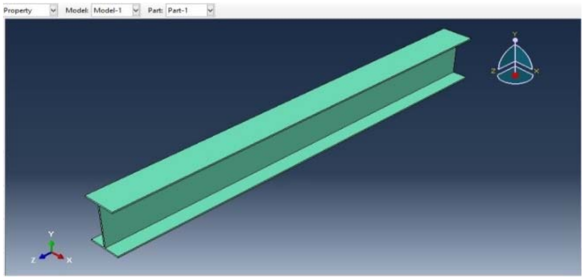

Figure-1(a). Column section.

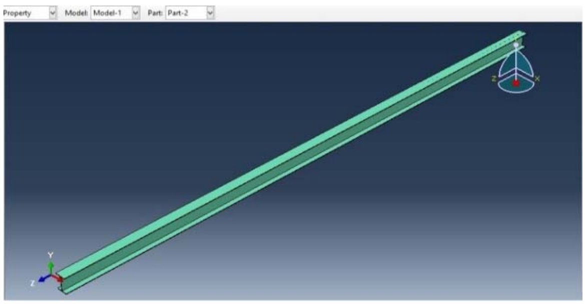

Figure-1(b). Beam section.

LINEAR STATIC ANALYSIS

Linear static analysis represents the most basic type of analysis. The term "linear" means that the computed response of displacement or stress at the elastic limit. The term "static" means that the forces do not vary with time.In linear static analysis displacements, strains, stresses, and reaction forces under the effect of applied loads are calculated. When loads are applied to a body the body deforms and the effect of the loads are transmitted throughout the structure. The external force induce forces and reaction to render the body into a stat of equilibrium. Some assumptions for linear static analysis are

- All loads are applied gradually and slowly until they reach their full magnitude
- After reaching full magnitude the loads remain constant
- Inertial and damping force to small velocities and acceleration are neglected.

A linear static analysis for the corner, middle and intermediate columns were carried out by applying different fire load conditions such as 300.C 500.C 800.C This loads were applied to the columns separately and the results were captured It was done to observe the displacement, temperature reach, stress, axial force and shear force in a structure. The linear properties for the steel frame in fire analysis has to specified in the software. For this type of analysis software requires only modulus of elasticity and poisson ration for different temperatures for analysis which are given in table 2(a). The results for every column at the different temperature were compared and discussed.

Table-2(a). Material properties.

Young's modulus	Poisson ratio	Temperature
200000	0.3	30
192000	0.3	150
206000	0.3	240
186000	0.3	360
178000	0.3	460
180000	0.3	540
154000	0.3	660
96000	0.3	800

Load applied at the different column are shown in below Figure 2(b), 2(c) and 2(d) the edges of four columns are fixed and the load were applied.

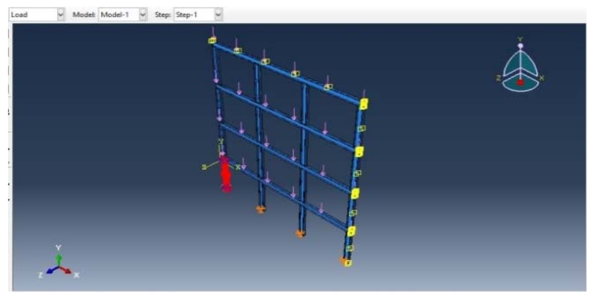

Figure-2(b). Fire load at corner column.

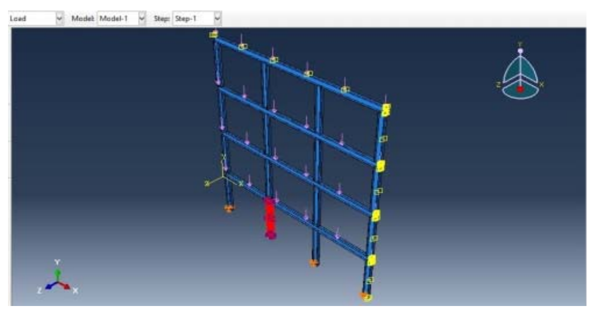

Figure-2(c). Fire load at middle column.

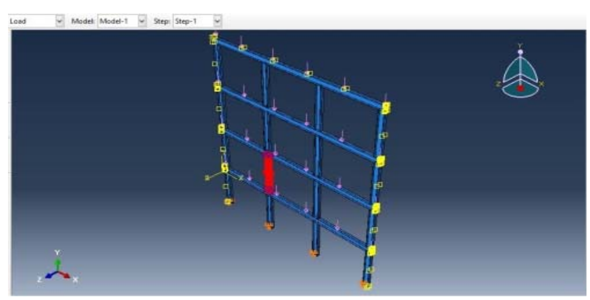

Figure-2(d). Fire load at intermediate column.

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RESULTS

Linear static analysis of the three fire different load in corner middle and intermediate columns were carried out under the action of self weight and live load in the frame specified in GSA guidelines. The corresponding maximum resultants force in columns and beams of are compared in this section. The results for displacement stress shear force and axial force are explained below for different column, these results were presented graphically and figures are used

DISPLACEMENT

A displacement is a vector that is the shortest distance from the initial to the final position of a point in structure. The displacement values were observed for corner middle and intermediate columns where which the load is applied, the particular column in a storey is removed and respective displacements were captured. The below given Figures 3(a), 3(b) and 3(c) shows the displacement at corner middle and intermediate columns due various temperature. It is seen that the middle column undergoes larger deformation than all the other columns at 800·c. At this point the material will begin to soft and undergo larger deformation.

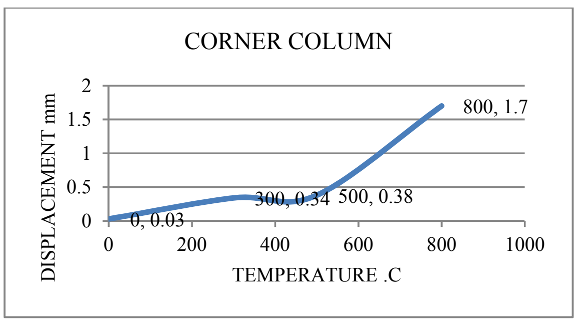

Figure-3(a). Displacement at corner column.

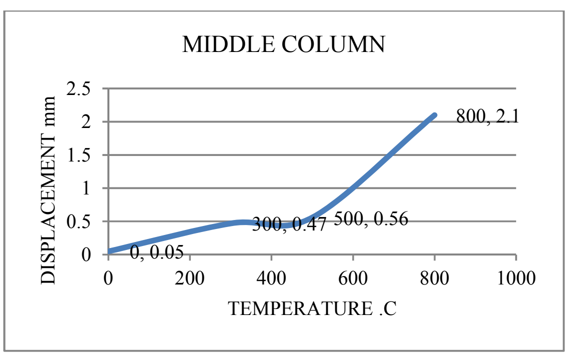

Figure-3(b). Displacement at middle column.

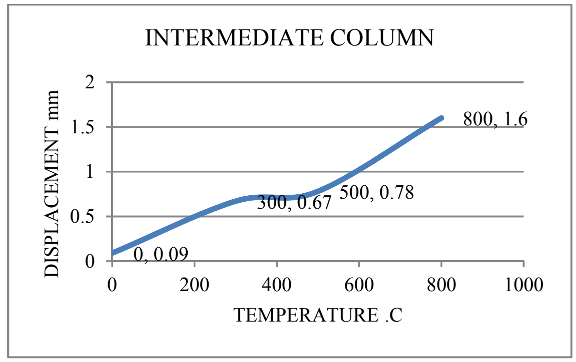

Figure-3(c). Displacement at intermediate column.

STRESS

The stress were observed for corner middle and intermediate columns where the load is applied, the particular column in a storey is removed and respective stress were captured. The below given Figures 4(a), 4(b) and 4(c) shows the stress at corner middle and intermediate columns due various temperature. It is seen that in 800·c at all the column the stress at all the columns begins to reduce because the structure tends to attain non linearity.

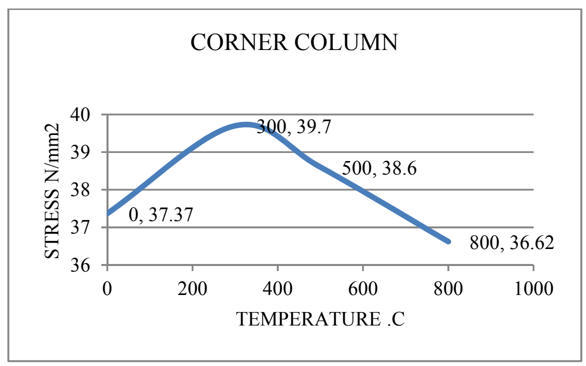

Figure-4(a). Stress at corner column.

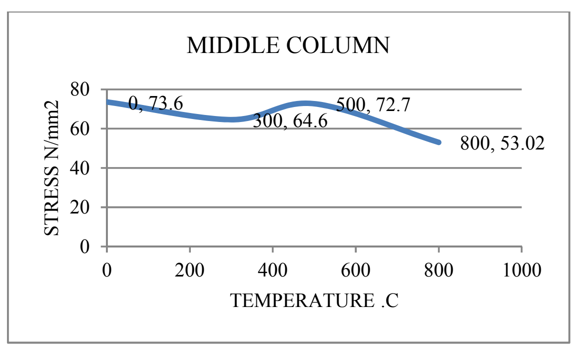

Figure-4(b). Stress at middle column.

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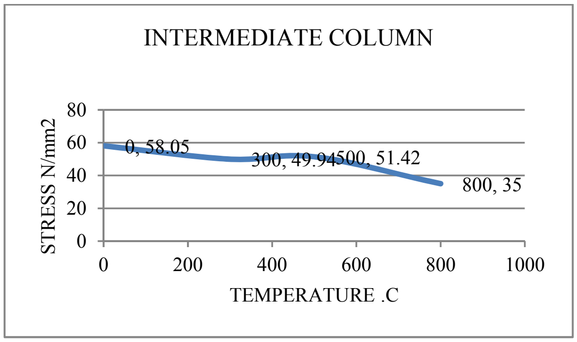

Figure-4(c). Stress at intermediate column.

SHEAR FORCE

Shear force is the force in the beam acting perpendicular to its longitudinal (x) axis. The shear force at the support of column were observed for corner and middle columns where which the load is applied. There is no shear force at the intermediate columns because reaction forces can be obtained only at the support**.** The below given figures 5(a) and 5(b) shows the shear force at corner and middle columns due various temperature. It is seen that in 800·c at all the column the shear force at all the columns begins to reduce because the structure tends to attain non linearity.

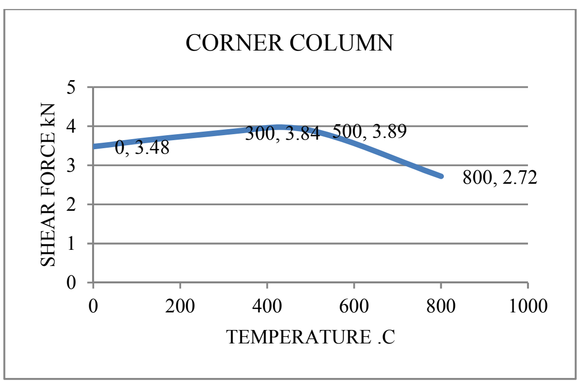

Figure-5(a). Shear force at corner column.

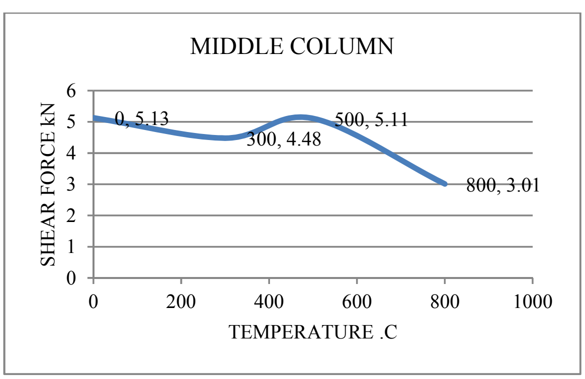

Figure-5(b). Shear force at middle column.

AXIAL FORCE

Axial force is the force in the beam acting parallel to the longitudinal axis axial force is the *compression or tension* force acting in a member. The force at the support of column were observed for corner and middle columns where which the load is applied. There is no axial force at the intermediate columns because reaction forces can be obtained only at the support. The below given figures 6(a) and 6(b) shows the axial force at corner and middle columns due various temperature. It is seen that in 800·c at all the column the axial force at all the columns begins to reduce because the structure tends to attain non linearity.

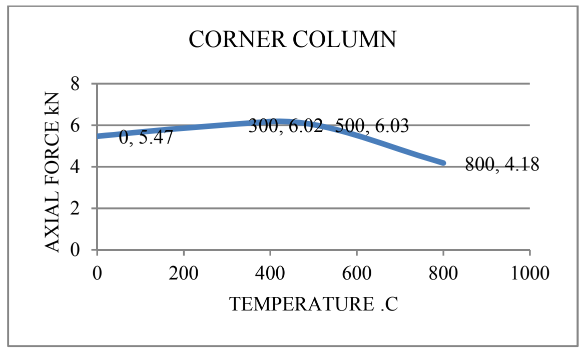

Figure-6(a). Axial force at corner column.

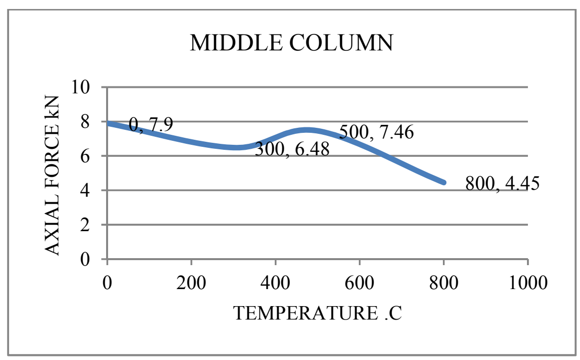

Figure-6(b). Axial force at middle column.

EFFECT OF TEMPERATURE

The effect of temperature in the frame due to applied fire load at the particular columns has to be know which are shown in the below Figures 7(a), 7(b) and 7(c) that shows the result of 800·C at various columns, since this results shows maximum spread of fire in the structure and has higher influence in results.

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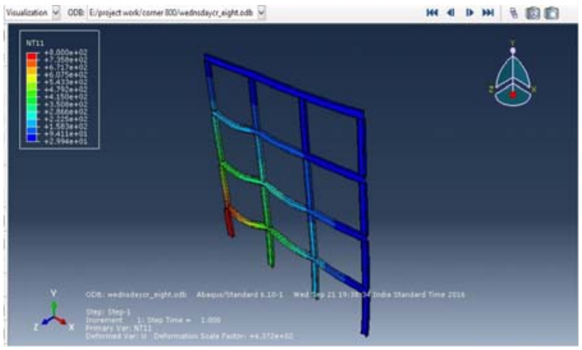

Figure-7(a). Effect of temperature at corner column.

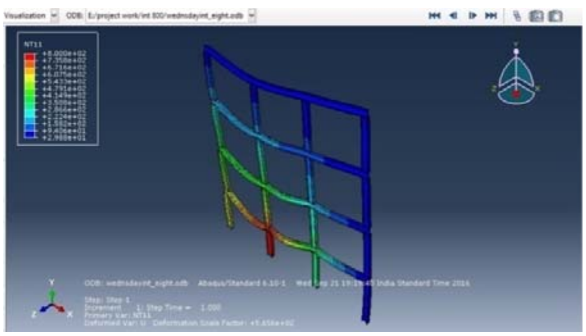

Figure-7(b). Effect of temperature at middle column.

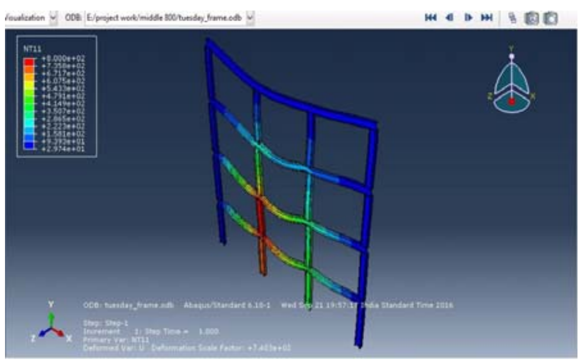

Figure-7(c). Effect of temperature at intermediate column.

CONCLUSIONS

This study demonstrated the progressive collapse behavior of a steel frame building using ABAQUS software. The following conclusions have been made based on the results obtained from analytical investigations. The section for beam and column has been chosen from the steel table and the steel frame was designed and assembled. Self weight and live load for the frame was given at the whole span of beam and the support condition were given to the frame which is assumes at fixed at all the bottom of columns. Linear analysis was carried out by applying fire load of 300.c 500.c and 800.c at corner middle and intermediate columns separately and analysed. The results for displacement stress shear force axial force and temperature reach in the frames were captured.

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