Performance and Analysis of Reinforced Concrete Structure under Fire

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Abstract - The study involves applying temperature loads through static analysis to facilitate a comprehensive comparison of diverse metrics within the G+6 RCC building. This encompassed assessing of shear forces, displacements, and bending moments across various stories, columns, and beams. The analysis considered for models A to F are subjected to temperatures ranging from ambient to 600˚C. By employing ETABS software and adhering to IS: 456 standards, the effects of temperature variations on structural integrity were quantified. The investigation provides the insights on how increasing temperature impacts the structural elements when exposed to higher temperature and enhance its resilience and performance in varying thermal conditions.

Key Words - Storey Displacement, Storey Shear Force, Storey Bending Moment, ETABS, Temperature load

I. Introduction

Concrete is the most commonly used building material because of its affordability, which makes it the best choice for construction. Structures with high temperature load are taken in account due to action in recent time. Indian standard IS-456 must be followed, and the proper steps must be taken into account for the construction of RC structures for temperature. The methods to be followed for designs and the load factors are to be taken into account in a layout combination of temperature load and gravity loads. In addition to live load and dead load, concrete structures are also subject to temperature fluctuations that are seasonal, daily as a result of environmental interactions, solar radiation exposure and fire accident.

When exposed to higher temperatures for an extended period of time, concretes compressive, tensile, and elastic modulus often tend to decrease. Repeated thermal cycling also increases the non-recoverable maximum strain and has an impact on the bonding between the steel reinforcement and concrete. Concrete deteriorate as its mechanical and physical properties subjected to higher temperatures.

Temperature fluctuations drive structural expansion and contraction, variably affecting members. High temperatures, sourced from solar radiation, fires, and equipment also induce effects. Such thermal loads, akin to dead/live loads, generate comparable stresses in concrete structures. This underscores the significance of considering temperature-driven stress in structural design, as its influence parallels that of conventional loads.

II. Methdology

The temperature loading from minimum to maximum of 40˚C, 100˚C, 200˚C, 400˚C and 600˚C is being considered. An investigation of multi-storey frame of G+ 6 storey is performed using ETABS.

1. ETABS software

The ETABS, engineering software, is pivotal for analyzing and designing multi-storey buildings. It accommodates grid-like layouts inherent to such structures, using modeling tools, load codes, and analysis methods for both simple and intricate designs. Developed by CsiAmerica, ETABS empowers engineers to create a wide range of civil engineering structures. While renowned for beam and column design, it also encompasses slab and footing design, making it a comprehensive tool for structural analysis and design.

2. Modelling and analysis

Description of Structure

Structure is exposure to temperature variations from ambient temperature to 40˚C, 100˚C, 200˚C, 400˚C and 600˚C. All parameters are kept constant.

- Size of column = 400mm x 600mm
- Size of beam =300mm x 400mm
- Slab thickness =150mm
- Storey height = 3m
- Wall thickness = 200mm
- Live load = 3kN/m^2
- Floor finish load = 1.5kN/m^2
- Roof live load = 1.5kN/m^2
- Wall load applied on beam = 10.4kN/m
- Grade of concrete = M30
- Grade of steel = HYSD 500

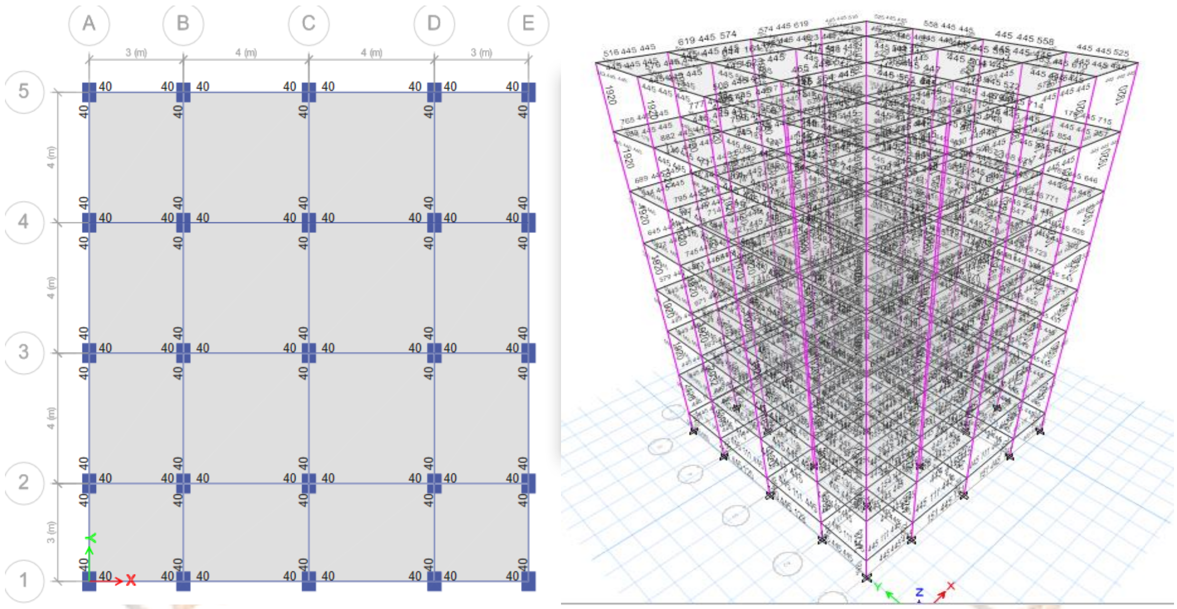

Fig.1 Assigning of temperature (40˚C) and Design check of structure in ETABS

III. RESULTS AND DISCUSSIONS

This section presents results obtained through static analysis using the commercial ETABS software, encompassing storey displacement, bending moment and shear force for different stories for Models A to F. These outcomes represent diverse scenarios with varying temperature load effects, providing a comprehensive understanding of the structural response to thermal influences.

1. Comparison of Storey Displacement for Model A to Model F in both X & Y direction

The storey displacement for the structure represented as model F (600˚C) is greater than the other models in both X and Y direction. And displacement at ambient temperature in X and Y direction is almost nil as represented in [Figure 2] and [Figure3].

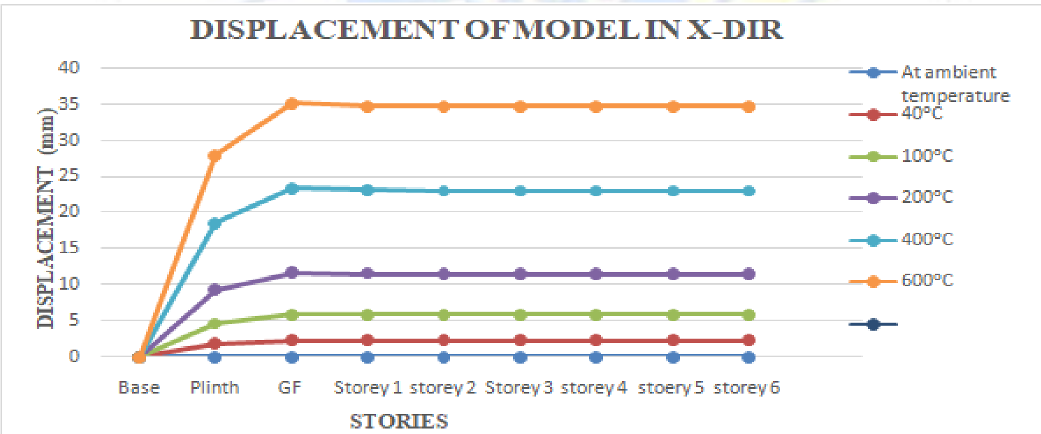

Fig.2 Displacement of models in X-Direction

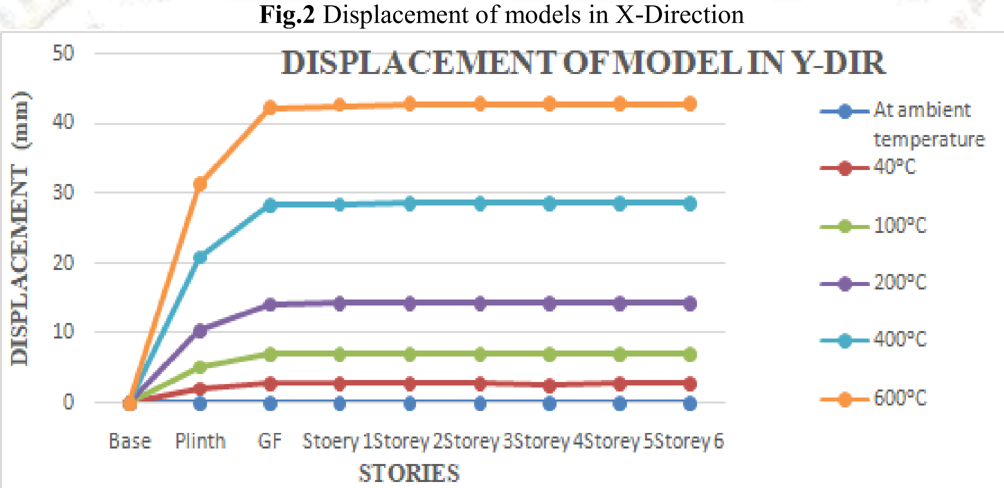

Fig.3 Displacement of models in Y – direction

2. Comparison of Bending Moment and Shear Force for Beams

The comparison of bending moment and shear force for the symmetric structure with increasing temperature load for storey 1, storey 3 and storey 6 is represented in [figure 4], [figure 5] and [figure 6]. The bending moment and shear force is directly proportional to the temperature as we can observer in [figure4]. As temperature increases, the values of bending moment and shear force at storey 1 increases. For storey 3 the beams at ambient temperature showed lesser value for bending moment and shear. For the temperature above 40°C BM & SF were observed to be constant [figure 5]. Minimum shear force and bending moment is observed at B37 10.80kN and 5.68kN in storey 3 whereas maximum BM and SF was found to be 18.96kN-m and 32.62kN in storey 6 at 600°C in [figure 6].

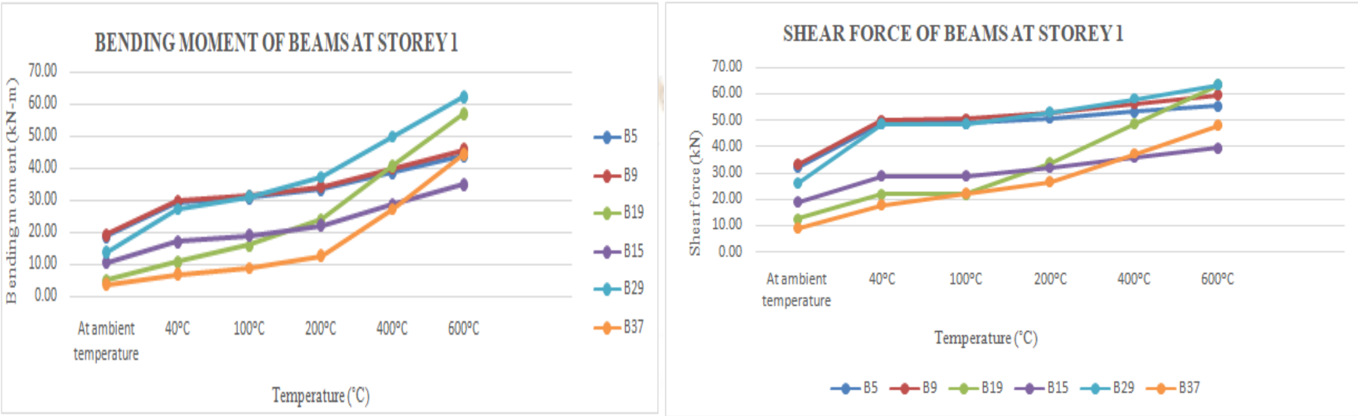

Fig.4 Bending moment and shear force of beams at storey 1

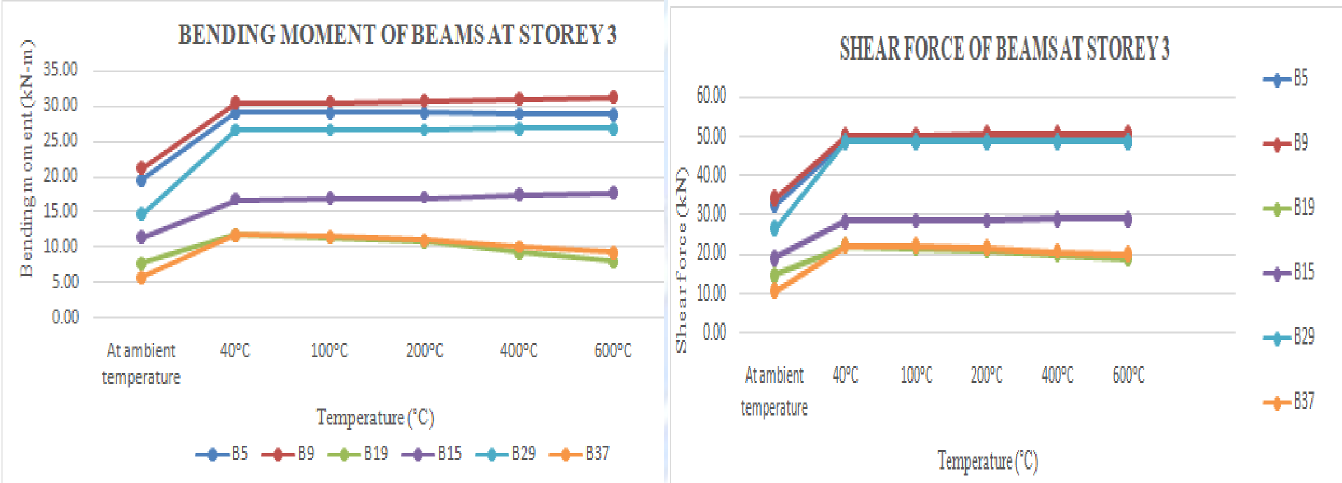

Fig.5 Bending moment and shear force of beams at storey 3

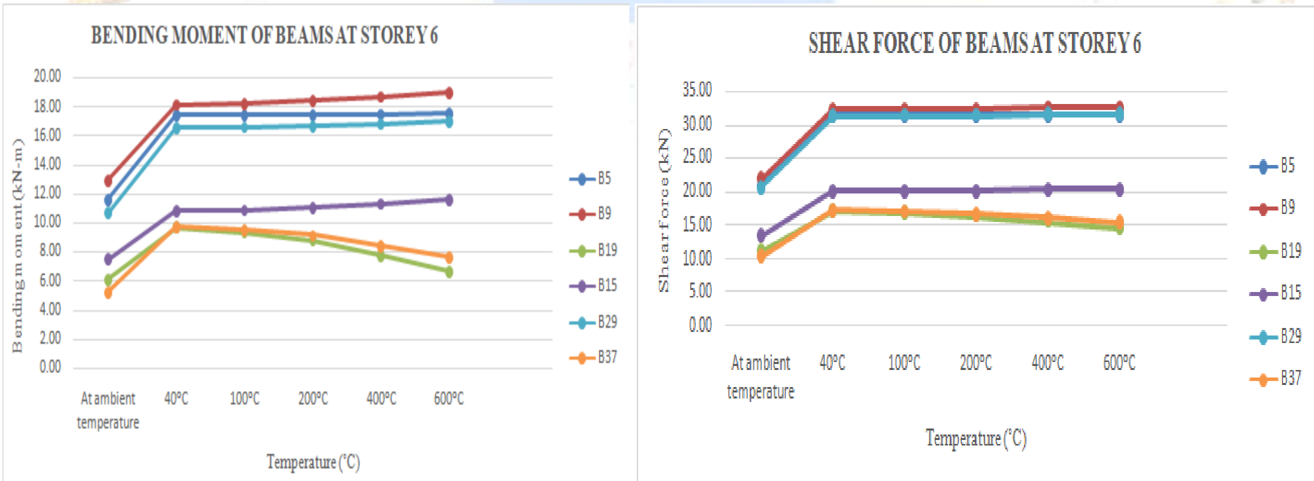

Fig.6 Bending moment and shear force of beams at storey 6

IV. CONCLUSIONS

The results show that the RC structure is affected by temperature load, and the design of heat and fire resistance of concrete is influenced by various factors. From results, it can be concluded that,

- Storey displacement is maximum for Model F (600˚C), when compared to all the other Models in both X and Y direction. Displacement increases with the increases in temperature.
- Storey bending moment for beams is almost constant for storey 3 and storey 6 for all temperature load, and in base level there is maximum bending moment for beams at 600˚C.
- Storey shear force for beams is constant for storey 3 and storey 6 for all temperature loads and storey 1 is has the maximum shear force at 600˚C.
- It was observed that storey 1 is more prone to temperature when compared storey 3 and 6 for beams.

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