Analysis of the Whole Deformation of the Beam-support Column Transfer Structure Model under Fire

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Abstract

The whole finite element model of beam column transfer structure is established by Abaqus software.The whole deformation of the transfer structure under different fire conditions is analyzed.It is found that the deflection of the transfer beam and the upper beam is increased in different degrees, the deformation of the frame column bending to the outer side of the frame is produced, and the maximum deformation usually appears on the floor of the fire room.

Keywords

Reinforced concrete; Beam column transfer structure; Under fire; Deformation analysis.

1. Introduction

At present, there are four types of transfer structure: girder type, truss type, box type and plate type[1-3]. According to the current application of the transfer structure, the reinforced concrete beam-type transfer structure has the advantages of direct force transfer, good mechanical performance and simple structure. In the transfer structure, the column is directly supported on the transfer beam, and the transfer beam is different from the common bending member, but it is often a stretch bending member. The cross-section force and the joint of the transfer beam and the column are more complex, and the shear force influence is large[2].

With the continuous development of society, the fire as one of the major disasters threatens people's life and property more and more seriously. The fire resistance of building structure has become an important research topic in the field of fire safety[4-6]. The high temperature performance of reinforced concrete materials was studied by GUO Zhen-hai et al [7]. The influence of fire time and temperature on ordinary concrete was studied by ZHU Jia-ning et al [8]. WU Bo et al [9] studied the temperature field of cracking concrete under fire by means of test and finite element analysis, and proved the effectiveness of the simplified numerical method to calculate the temperature field of cracking specimen. BA Guang-zhong et al [10] studied the effect of cracks on internal heat transfer of reinforced concrete structures by experimental and finite element analysis of several beam and column members and frame structures, the results showed that the heat transfer rate of the crack area increased obviously. WU Bo et al [11] studied the fire performance of "+" type cross section column under axial and rotational restraint. The results showed that under the action of fire, the axial constraint made obvious additional axial force on the "+" section column, and the existence of the rotational constraint changed the impact of the load eccentricity on the fire resistance of the column. ZHENG Yong-qian et al [12] studied the behaviour of steel reinforced concrete beams considering overall fire stages. The results showed that with the external temperature decreases, the temperature and deflection of the beam would continue to increase in a short time. WEN Bo et al [13] studied post-earthquake fire performance of reinforced concrete columns. ZHANG Chao et al [14] did experimental research on the behaviour of eccentrically loaded SRC columns subjected to the ISO-834 standard fire including a cooling phase. The experiment phenomena and mechanical response of the SRC column specimens during experiment, specifically loading, heating, cooling and post-fire loading were observed. The residual load bearing capacity, failure modes and vertical deformation were studied. HAN Lin-hai et al [15] studied fire performance of steel-reinforced concrete beam-column joints, a finite-element analysis (FEA) model was developed to investigate the influence of important parameters that determine the mechanism of the composite joints under fire. HAN Lin-hai et al [16] did the experimental research on behaviour of reinforced concrete (RC) beam to concrete-filled steel tubular (CFST) column frames subjected to ISO-834 standard fire. Up to now, there are few research results on the fire resistance of the reinforced concrete beam column transfer structure. Therefore, it is of great theoretical and practical significance to study the fire resistance of reinforced concrete beam column transfer structure under high temperature.

2. Finite element modeling

2.1 Analysis Model

This paper designs a 5 layer 6 span frame model of large space in the bottom layer reinforced concrete beam column transfer structure. The total height of the structure model is 22.0 m, the first layer height is 6.0 m, the rest layer height is 4.0 m, the total span is 24.0 m, the single chamber span is 4.0 m, and the bottom large space span is 16.0 m. Model dimensions and node numbers are shown in Figure 1, Figure 2. The reinforcement of member sections was shown in Fig. 3.

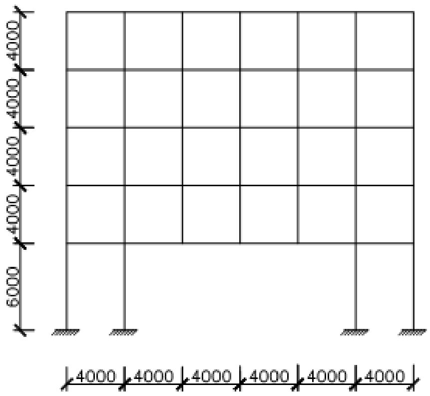


Fig. 1. The transfer structure mod

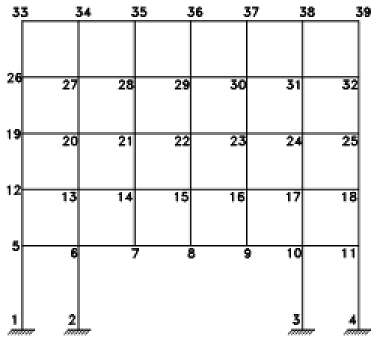
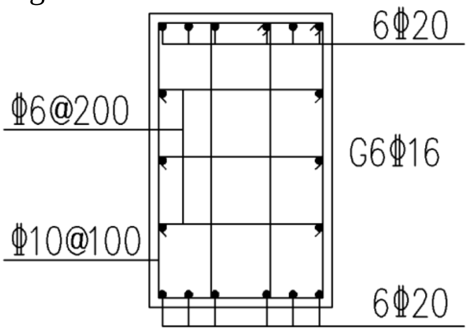
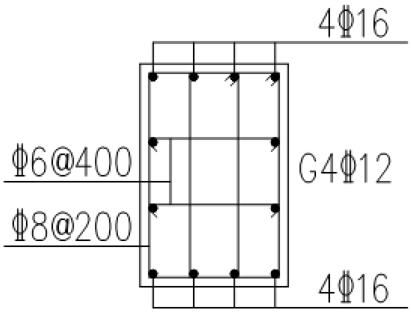


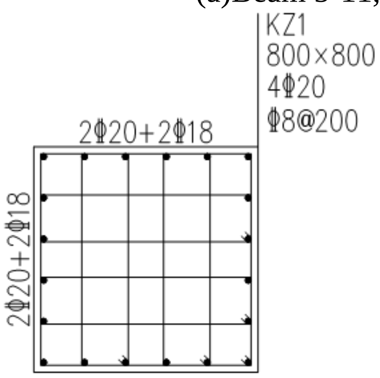
Fig.2 The number of members



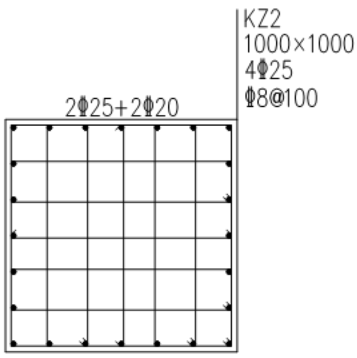
(a)Beam 5-11, 12-18, 19-25



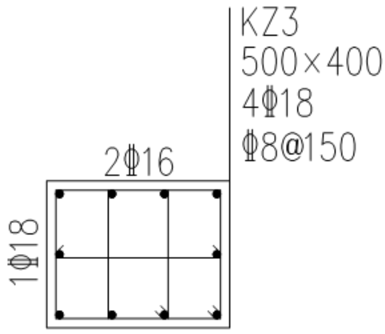
(b) Beam 26-32, 33-39



(c)Column 1-33, 4-39



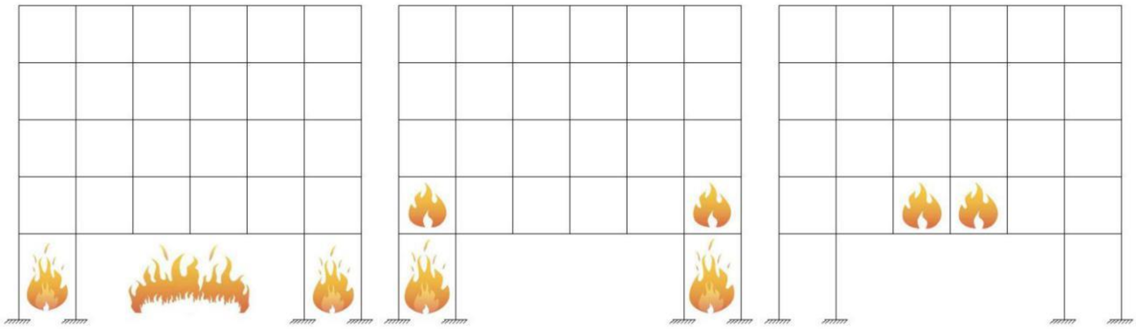
(d) Column 2-34, 3-38



(e) Column 7-35, 8-36, 9-37

Fig. 3. The reinforcement of member sections

Considering the complexity of the fire conditions of the transfer structure, three fire conditions are set up respectively, as shown in Fig .4.



(a) Fire condition I (b) Fire condition II (c) Fire condition III

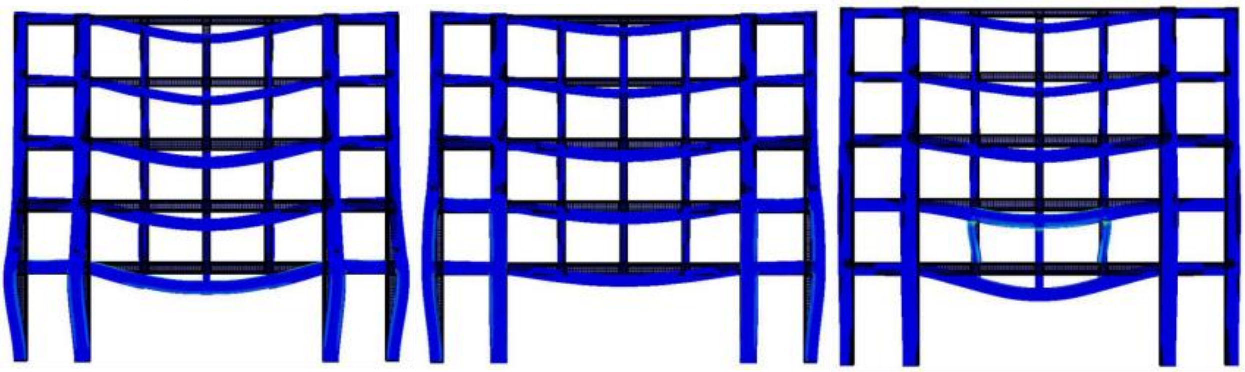
Fig .4 Fire conditions

2.2 Finite element model parameter setting

In the material parameter setting of Abaqus finite element model, the density of concrete is set as $\rho = 2400 kg/m^3$, and the coefficient of thermal expansion is set as: $\alpha_c(T) = (0.008T + 6) \times 10^{-6} m/(m \cdot {}^oC)$ [18]The heat conduction coefficient and specific heat capacity of concrete are obtained with reference to reference [18]. The elastic modulus of concrete at high temperature is taken according to the recommended formula of reference [19]. The compressive strength reduction coefficient of concrete at high temperature is calculated according to the formula recommended in reference [20]. The compressive constitutive relationship is calculated according to the model in [20], which contains high temperature creep and has been proved to be able to better simulate the high temperature performance of concrete. The concrete tensile strength is calculated using the recommended formula in reference [21].The density of steel bar is taken as $\rho_s = 7850 kg/m^3$. The thermal expansion coefficient of steel bar at high temperature is $\alpha_s(T) = \left(0.004T + 12\right) \times 10^{-6}$. The reduction coefficient of elastic modulus at high temperature according to the reference [22]. The constitutive relation is based on the recommended formula [20], which can be proved to be good for simulating the high temperature performance of steel bars.

3. Analysis of the whole deformation of the transfer structure

The overall deformation mode of the reinforced concrete beam column transfer structure when the heating reaches 180 min under each fire condition is shown in figure 5. The deformation is magnified 20 times for easy observation.



(a) Condition I (b) Condition II (c) Condition III

Fig .5 Overall deformation mode of beam column transfer structure

It can be seen from the picture that the deformation of the whole structure occurs under the interaction of the components in the transfer structure, although the position and quantity of the fire chamber are changed under each fire condition.There are some similarities in the deformation mode of the whole structure under each fire condition. That is, the transfer beam and the corresponding upper beam have different degrees of deflection increase, the frame column has produced the deformation bending to the outer side of the frame, and the maximum deformation usually appears in the corresponding floor where the fire room is located.

4. Conclusions

(1) The overall deformation mode of the beam column transfer structure is symmetry of the central axis of the structure.

(2) The deflection curves of each beam are similar in shape and numerical size under fire condition I.

(3) The overall deformation of the structure is not obvious when the room is less exposed to fire and the location of the fire room is in the middle.

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