Residual Bearing Performance of RC Beam Supporting Column Joint after Fire

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Abstract. In this paper, the residual load bearing performance of RC beam supporting column joint after fire is studied. Using the finite element analysis method, considering the influence of heating time, the thickness of the longitudinal reinforcement protective layer and the additional reinforcement, the bearing performance of the beam supporting column joint specimen after fire is analyzed respectively. The results show that the shorter the duration of high temperature, the smaller the change rate of the deflection of the beam supporting column joint under static load, and the lower the deformation of the beam supporting column joint under load can be reduced by the setting of additional steel bar, which plays a beneficial role in the residual bearing performance of the joint.

1. Introduction
In recent years, the research on fire resistance of structural components has become a hot research topic for experts and scholars at home and abroad [1-6]. For the high-rise buildings with structural transfer layer, the transfer layer plays an important role in the whole structure. In the fire, once the damage occurs, it will pose a threat to the safety of the whole structure. In this paper, on the basis of the experimental research, the finite element software is used to carry out the expansion analysis, to investigate the influence of different parameter setting on the bearing performance of the beam supporting column joint after the fire action, and to analyze the bearing performance of the RC beam supporting column joint after fire.

2. Finite element parameter values
The finite element analysis was carried out with Abaqus software. Among them, the density of concrete was taken \( \rho = 2400 \text{kg/m}^3 \), the elastic modulus after high temperature was obtained according to reference [8], and the compressive strength was Wu Bo’s model for simulation calculation [8]. The compressive constitutive relation is based on the Lu zhoudao proposed formula values [9]. Tensile Strength use the recommended values by Hu Cuiping [10]. The mass density of the steel bar is taken \( \rho_s = 7850 \text{kg/m}^3 \), and the elastic modulus is taken according to the reference [11]. Constitutive relationship according to Han Linhai recommended formula values [12]. Yield strength according to the reference [11].
3. Analysis of Parameters Affecting Residual Bearing Performance
This numerical simulation mainly considers the influence of heating time, the thickness of protective layer and the additional reinforcement arrangement on the bearing performance of the beam supporting column joint after fire. The specific parameter settings are shown in table 1, where number 1~8 is a room temperature contrast model.

Table 1 Model Parameter Setting for Beam Supporting Column

| Number | Name        | Heating curve | Number of surfaces | Time/min | Protective layer/mm | Additional reinforcement |
|--------|-------------|---------------|--------------------|----------|---------------------|--------------------------|
| 1      | TZHA        | Room temperature | ---               | 0        | 25                  | Yes                      |
| 2      | TZHB        | Room temperature | ---               | 0        | 25                  | Yes                      |
| 3      | TZHA-wuDJ   | Room temperature | ---               | 0        | 25                  | No hanging bars          |
| 4      | TZHA-wuFJ   | Room temperature | ---               | 0        | 25                  | No                       |
| 5      | TZHB-wuDJ   | Room temperature | ---               | 0        | 25                  | No hanging bars          |
| 6      | TZHB-wuFJ   | Room temperature | ---               | 0        | 25                  | No                       |
| 7      | TZHA-bh40   | Room temperature | ---               | 0        | 40                  | Yes                      |
| 8      | TZHA-bh50   | Room temperature | ---               | 0        | 50                  | Yes                      |
| 9      | TZHA3-60    | ISO834         | 3                 | 60       | 25                  | Yes                      |
| 10     | TZHA3-90    | ISO834         | 3                 | 90       | 25                  | Yes                      |
| 11     | TZHA3-120   | ISO834         | 3                 | 120      | 25                  | Yes                      |
| 12     | TZHA4-60    | ISO834         | 4                 | 60       | 25                  | Yes                      |
| 13     | TZHA4-90    | ISO834         | 4                 | 90       | 25                  | Yes                      |
| 14     | TZHA4-120   | ISO834         | 4                 | 120      | 25                  | Yes                      |
| 15     | TZHB3-60    | ISO834         | 3                 | 60       | 25                  | Yes                      |
| 16     | TZHB3-90    | ISO834         | 3                 | 90       | 25                  | Yes                      |
| 17     | TZHB3-120   | ISO834         | 3                 | 120      | 25                  | Yes                      |
| 18     | TZHB4-60    | ISO834         | 4                 | 60       | 25                  | Yes                      |
| 19     | TZHB4-90    | ISO834         | 4                 | 90       | 25                  | Yes                      |
| 20     | TZHB4-120   | ISO834         | 4                 | 120      | 25                  | Yes                      |
| 21     | TZHA3-wuDJ  | ISO834         | 3                 | 90       | 25                  | No hanging bars          |
| 22     | TZHA3-wuFJ  | ISO834         | 3                 | 90       | 25                  | No                       |
| 23     | TZHB3-wuDJ  | ISO834         | 3                 | 90       | 25                  | No hanging bars          |
| 24     | TZHB3-wuFJ  | ISO834         | 3                 | 90       | 25                  | No                       |
| 25     | TZHA3-bh40  | ISO834         | 3                 | 90       | 40                  | Yes                      |
| 26     | TZHA3-bh50  | ISO834         | 3                 | 90       | 50                  | Yes                      |
3.1. Effect of heating time on post-fire load-bearing performance of beam supporting column joint

ISO834 [12] international standard rise and fall temperature curves, three heating time periods of 60 min, 90 min and 120 min are selected for calculation. The resulting reduction coefficient of residual bearing capacity of RC beam supporting column joint is shown in figure 1, and the relation curve of maximum vertical displacement and load is shown in figure 2. From figure 1, it can be seen that for the beam supporting column joint with different number of fire surfaces and different load conditions, there is a linear downward trend of bearing capacity after fire with the increase of heating time. As can be seen from figure 2, the deflection drop rate of the beam supporting column joint after fire is obviously larger than that of the member under room temperature, and the longer the heating period, the faster the deflection decrease rate after the fire.

![Figure 1 Reduction coefficient](image1)

![Figure 2 Load-displacement curve](image2)
3.2. Effect of the thickness of the steel bar protective layer on post-fire load-bearing performance of beam supporting column joint

For the specimen TZHA, the protective layer thickness 25mm, 40mm, 50mm of the transfer beam is selected for simulation analysis. The resulting reduction coefficient of residual bearing capacity of the RC beam supporting column joint is shown in figure 3, and the relation curve of maximum vertical displacement and load is shown in figure 4. It can be seen that the change of the thickness of the protective layer of the tensile longitudinal bars has obvious influence on the residual bearing capacity of the beam supporting column joint after fire. Under the same fire condition, the larger the thickness of the protective layer, the more obvious the bearing capacity of the beam supporting column joint decreases after the fire.

![Figure 3 Reduction coefficient](image1)

![Figure 4 Load-displacement curve](image2)

3.3. Effect of additional steel bar on post-fire load-bearing performance of beam supporting column joint

For the joint TZHA3 and TZHB3, respectively, the analysis and calculation are carried out with additional steel bars, separate removal hanging bars and no additional steel bars. The residual bearing capacity reduction coefficient is shown in figure 5, and the relation curve of maximum vertical displacement and load is shown in figure 6. It can be seen from the diagram that the setting of the additional reinforcement has no obvious effect on the residual bearing capacity reduction of the transfer joint after fire. However, it has a great influence on the change of the deflection of the joint under the load after fire, and the deflection increases significantly with the increase of the load. Therefore, the setting of additional reinforcement can reduce the deformation of the beam supporting column joint under load after fire, and play a beneficial role in the residual bearing performance of the joint.
Figure 5 Reduction coefficient

Figure 6 Load-displacement curve

4. Conclusion
(1) For the beam supporting column joint in RC transfer structure, the heating time increases and the residual bearing capacity decreases linearly after fire.

(2) The decreasing rate of the deflection of the beam supporting column joint after fire is obviously greater than that of the room temperature member under the load, and the longer the heating period is, the faster the deflection decreases after fire.

(3) The larger the thickness of the protective layer of the tensile longitudinal bars of the transfer beam, the more obvious the bearing capacity of the beam supporting column joint decreases after fire.

(4) The setting of additional reinforcement can reduce the deformation of the beam supporting column joint under load after fire, and play a beneficial role in the residual bearing performance of the joint.

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