

## RC Transfer Structure with Superimposed Vierendeel Truss Internal Force Analysis in Fire

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### Abstract

**A model of RC structure with large space at bottom. The nonlinear FEM software ABAQUS is used to analysis internal forces of the model which is exposed to fire and coupling with vertical loads. Based on the simulation results of 3 fire cases, the internal force of member section and heating-up time curves are plotted. The numerical results show that based on the internal forces under vertical loads at room temperature, the transfer structure models produce different levels of internal force redistribution with heating-up time increasing. Internal forces of some sections just have changes in size and other sections also have changes in direction. The internal force redistribution is the most obvious in first 90 minutes of ignition, and the range and trend of internal forces vary with the different fire conditions and member sections. The internal force analysis shows that during the whole process of fire, Internal forces of transfer members vary with the additional internal forces, especially the internal force superposition in some member sections may exceed expectations which are designed for normal temperature, so that it could impact section security. Therefore, the potential fire implications should be considered in designing key structures like transfer structure.**

### Keywords

**RC; transfer structure; fire; Internal force analysis.**

### 1. Introduction

With the development of urban process, the form of architectural structure is becoming more and more complex. The urban complex integrating shopping, catering, office and residence emerges at the historic moment. This kind of building requires different space separation for different floors, so it is necessary to set structural transfer floors between different floors to ensure effective transmission of upper and lower layers of stress [1-2]. The transition layer plays an important role in the overall structure. In a building fire, once its damage occurs, the safety of the whole structure will be seriously threatened. 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 [3-5]. However, there are few researches on the fire resistance of transfer structures. This paper analyzes and calculates the change of internal force of RC transfer structure with superimposed vierendeel truss under ISO834[6] fire conditions. And discusses the change and redistribution of internal force of this kind of structure under fire.

### 2. Model establishment and fire conditions

The transfer structure model was a 3-story reinforced concrete structure with a beam supporting column floor at the bottom layer. The model and the member number were shown

in Fig. 1. The heating curve adopted the ISO834 international standard heating curve, as shown in Fig. 2. The reinforcement of member sections was shown in Fig. 3.

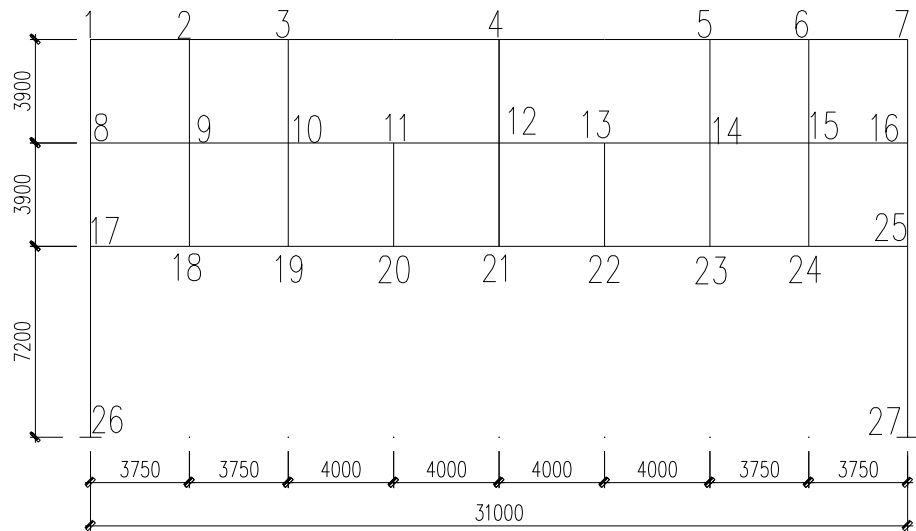


Fig 1. Model size and numbers of member

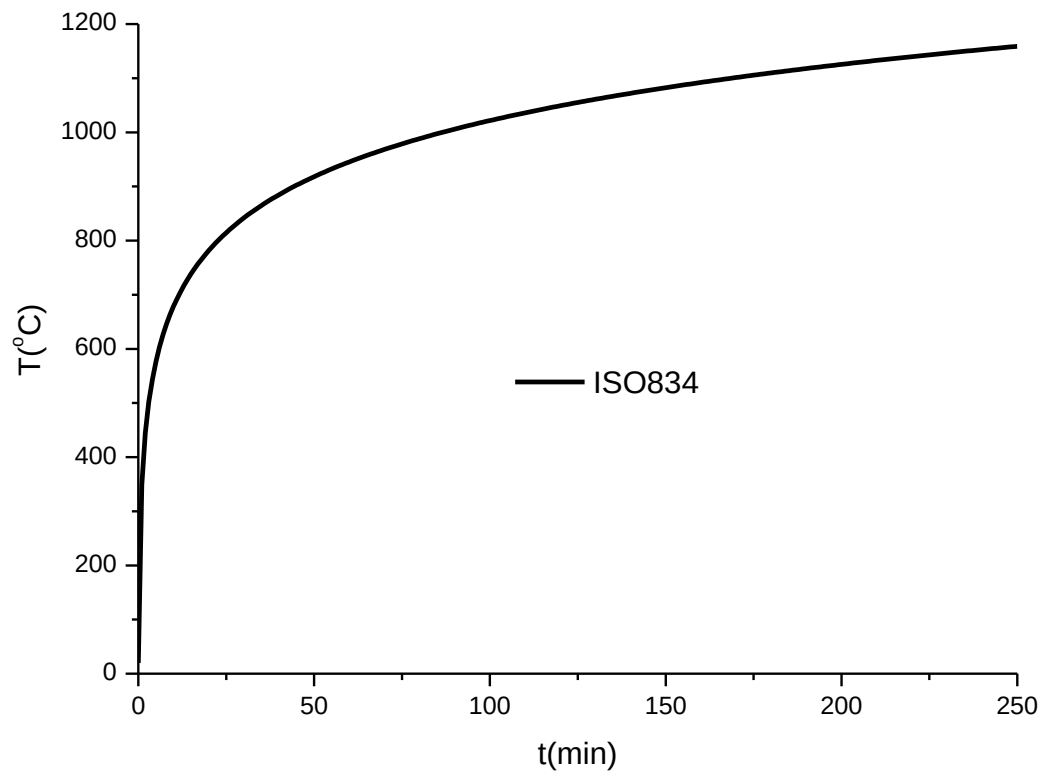


Fig 2. ISO 834 time-temperature curve

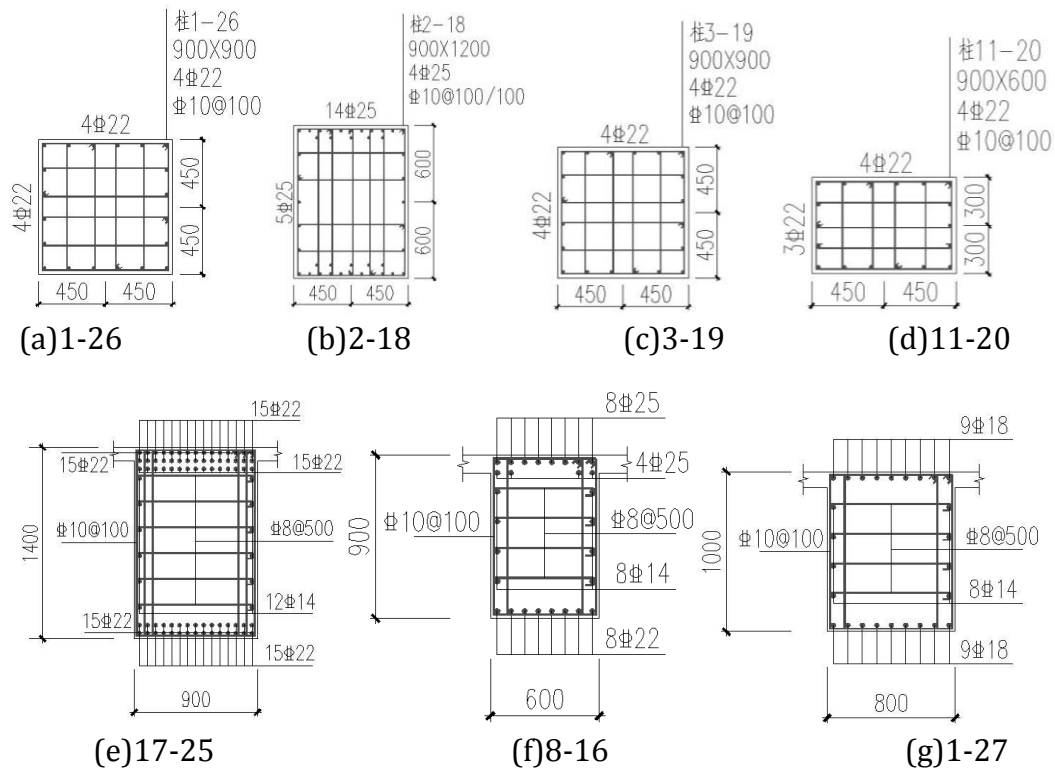


**Fig 3.** Reinforcement of member sections

Considering the contingency of a fire, three kinds of fire conditions were designed, which were the large opening space at bottom on fire (condition 1), the second floor on fire (condition 2), and the bottom two floors all on fire (condition 3), as shown in Fig.4.

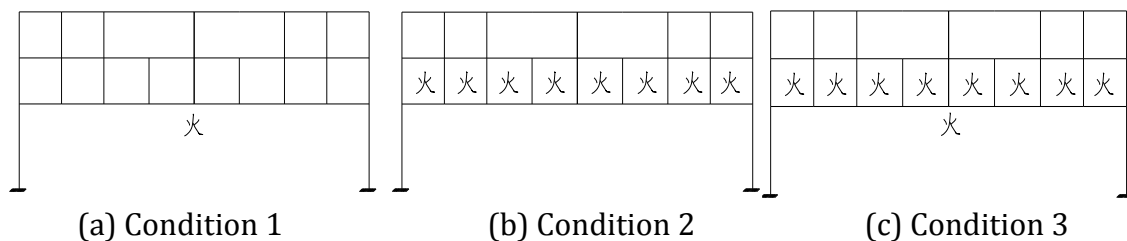


**Fig 4.** Fire cases

### 3. Internal Force Analysis

#### 3.1. Direction of Internal Force

The internal force directions were defined as follows: The shear force was positive for the clockwise around the member section, negative for the anticlockwise around the member section. The axial force was positive for tension and negative for pressure. The bending moment was positive for the clockwise around the left section of members and anticlockwise around the right section of members, negative for the clockwise around the right section of members and anticlockwise around the left section of members.

#### 3.2. Shear Force

The relation curves between each section shear force and heating time for the 3 kinds of fire conditions are shown in Fig. 5. Among them, V1, 26 represents the 1 end shear force of member 1-26, and so on.

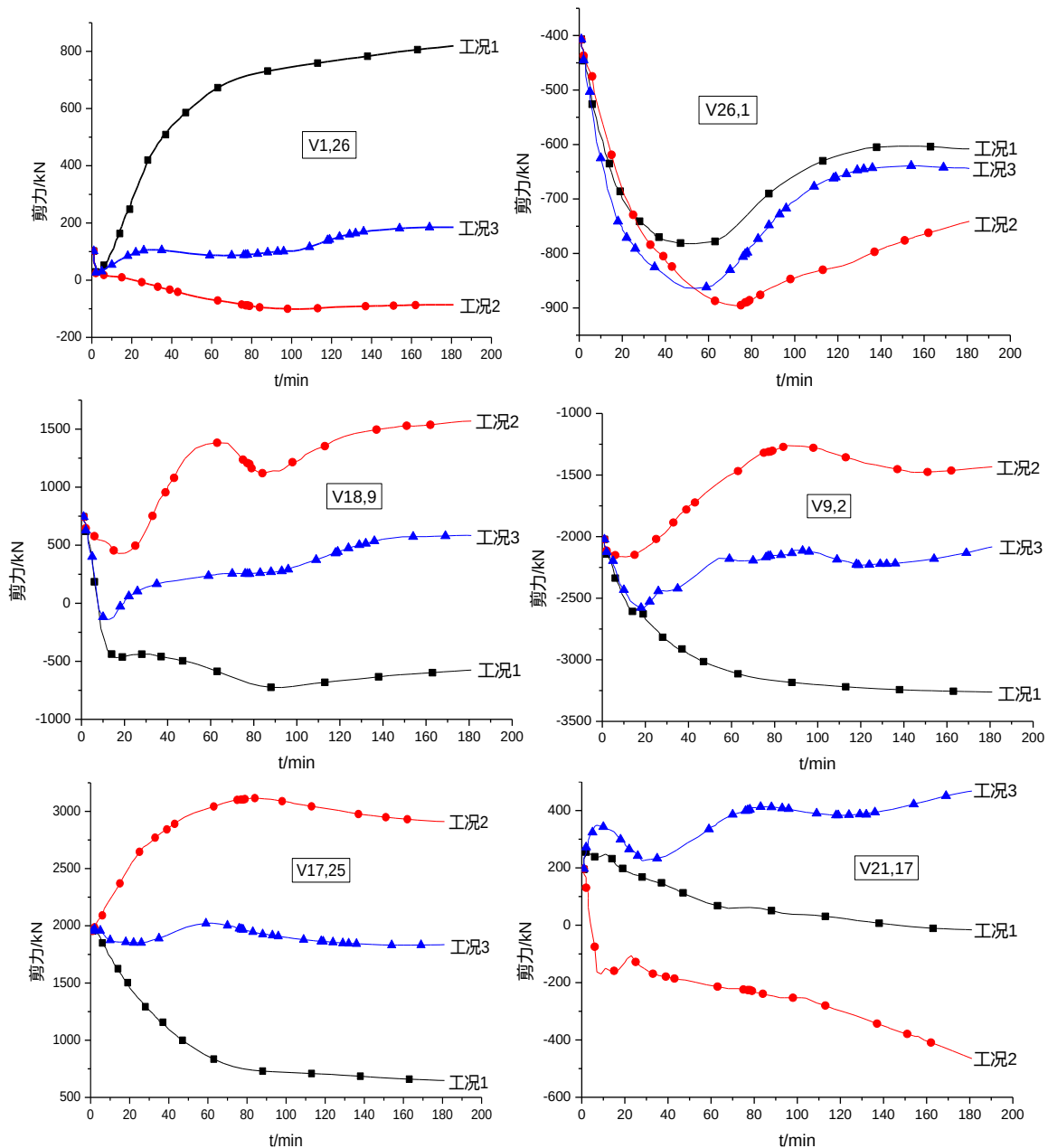


**Fig 5.** Shear force of member sections and heating-up time curves

The shear force V1,26 is greatly affected in fire condition 1. And the shear change mainly occurred in 60 minutes after the heating start, which first increased gradually and then remained basically unchanged. For V26, 1, the change trend of shear force caused by the three working conditions was similar. In all cases, the absolute value of shear force gradually increased and peaked at the beginning of heating up, and then decreased slowly. V18, 9 in fire condition 1, the shear force decreased rapidly and changed direction within 10min after heating up. For V9, 2, the absolute shear value increases in working condition 1, decreases in working condition 2, and basically remains unchanged in working condition 3. The shear force of V17, 25 changes in working condition 1 and working condition 2 have opposite trends. In other words, within 60min of temperature rise, shear force gradually decreases in fire condition 1, increases in fire condition 2, and then remains unchanged, while working condition 3 has little influence on shear force change. As symmetry exists in all three fire conditions, the shear force of V21,17 does not change much compared with other sections.

### 3.3. Axial Force

The relation curves between each section axial force and heating time for the 3 kinds of fire conditions are shown in Figure 6. Among them, N1, 26 represents the 1 end axial force of member 1-26, and the rest can be done in the same manner.

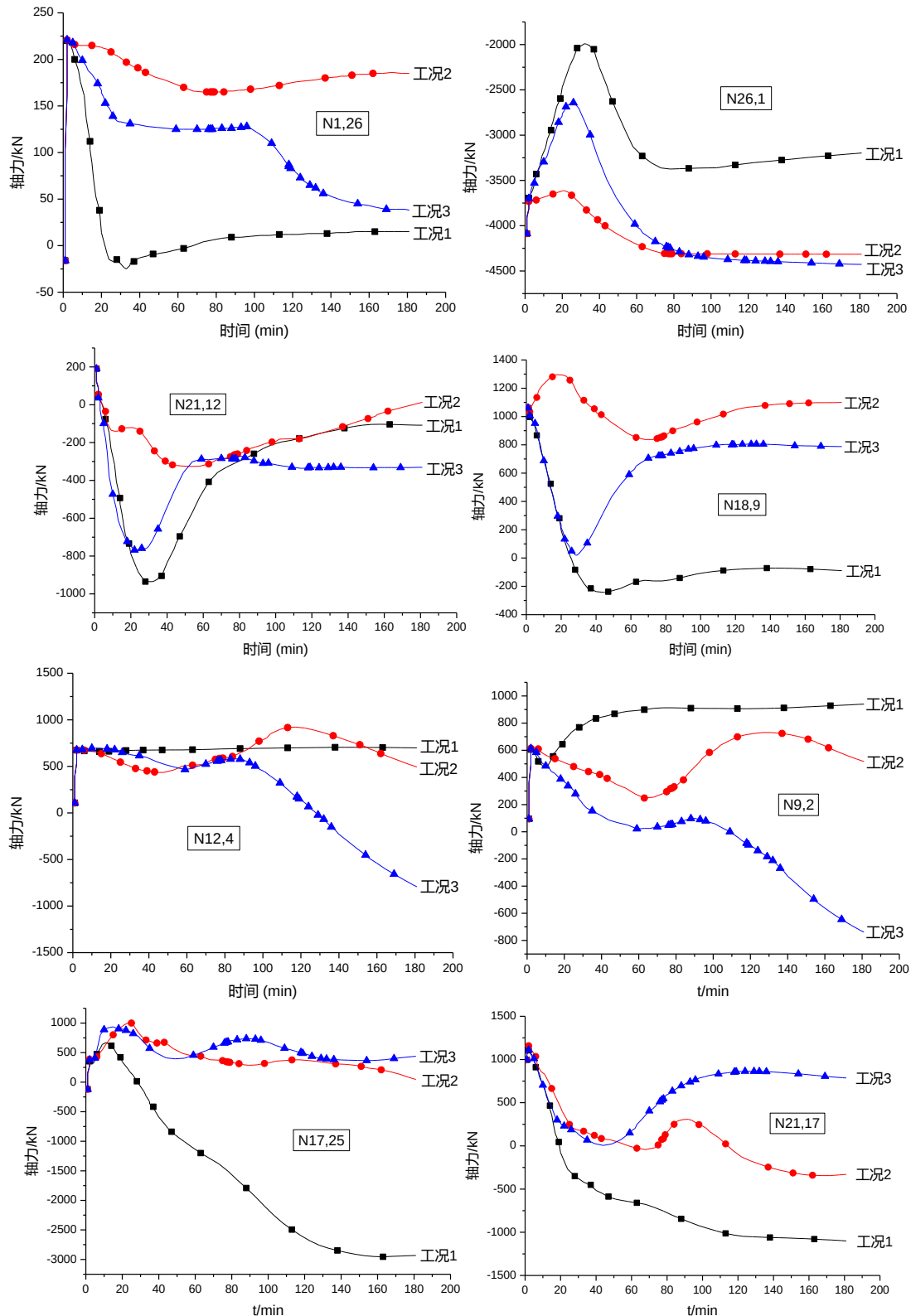
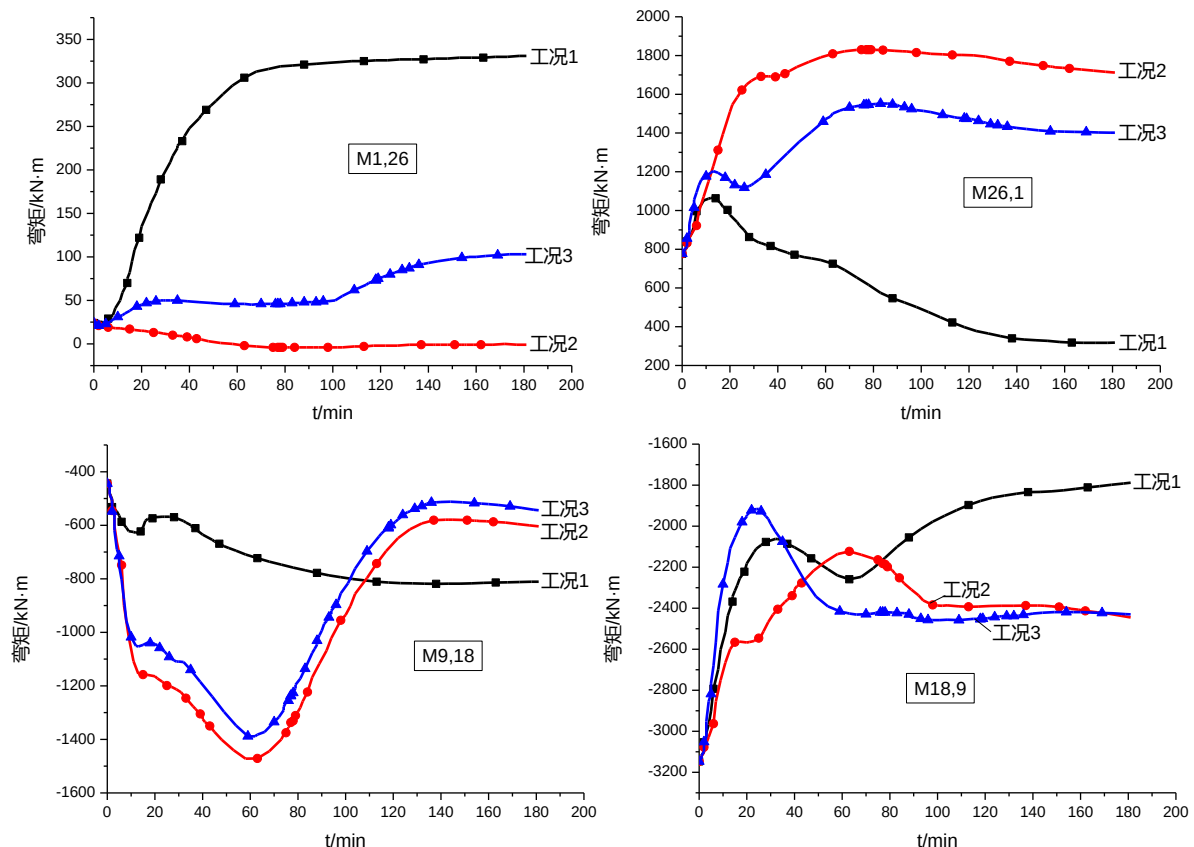


Fig 6. Normal force of member sections and heating-up time curves

Axial force N1,26 in fire condition 1, the distance from the fire location is the furthest, but the change of axial force is the greatest, It indicates that ground floor large space fire has a great influence on the whole structure. For N26, 1, the order of variation amplitude in three fire conditions is  $1 > 3 > 2$ . In fire condition 1 and 3, the change trend of axial force of N21, 12 is the same. Both of them change from tension to pressure in a short time at the beginning of heating up and keep increasing. The change trend of N18,9 in fire condition 3 is basically consistent with that of N21,12. However, in fire condition 1, it gradually decreases in 40min after heating, and from tension to pressure, then it basically stays the same. For N12, 4 and N9, 2, the change trend of axial force in fire conditions 2 and 3 is basically the same. But the N12,4 vary more than the N9,2. N17,25 in fire condition 1, the tension appeared at the beginning of heating up, then changed from tension to pressure, and kept increasing until it became stable after heating up for 140min. N21, 17 in fire condition 1, the change of axial force is quite obvious. The tension gradually decreases and turns into pressure in 20min after temperature rise.

### 3.4. Bending Moment

The relation curves between each section bending moment and heating time for the 3 kinds of fire conditions are shown in Figure 7. Among them, M1, 26 represents the 1 end bending moment of member 1-26, and the rest can be done in the same manner.



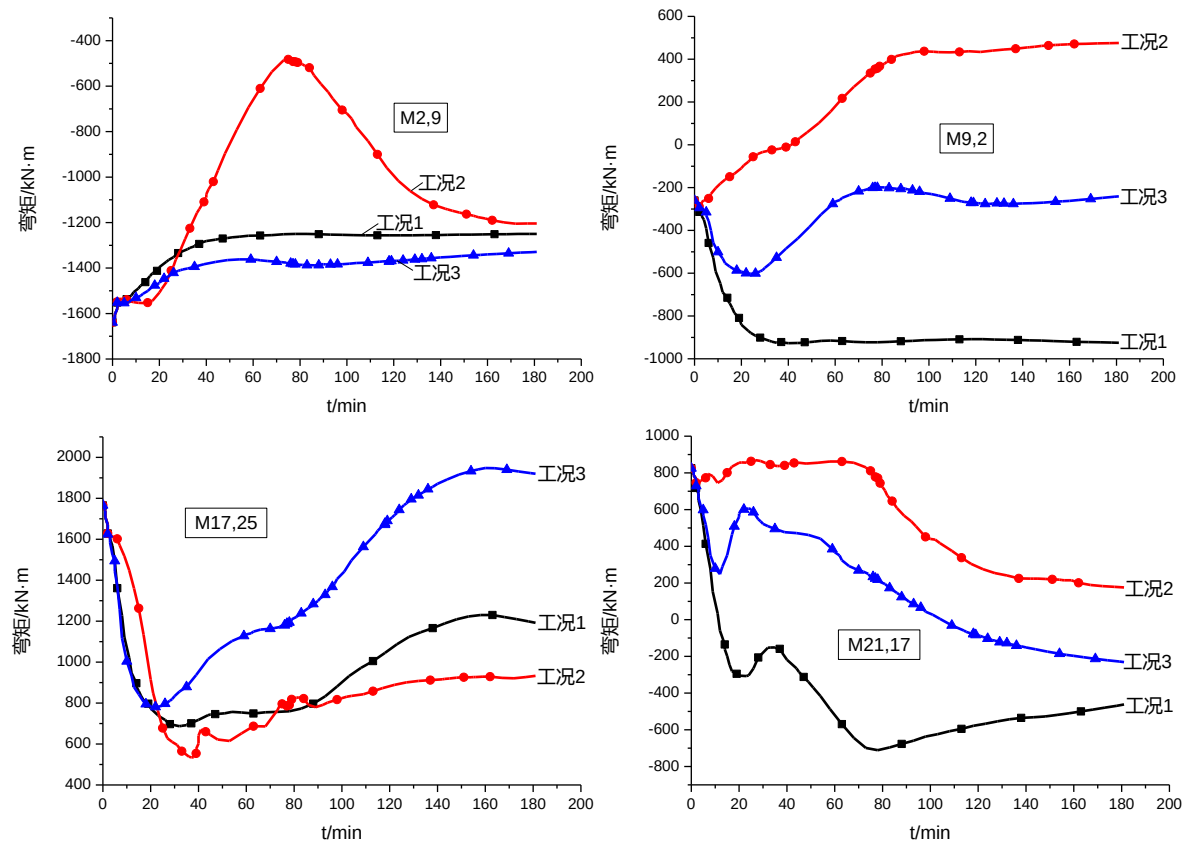


**Fig 7.** Bending moment of member sections and heating-up time curves

In fire condition 1, M1, 26 was greatly affected, which increased in the first 60 minutes and remained basically unchanged after that. For M26, 1, in fire condition 1, the bending moment increased slightly in 10min after heating up, then gradually decreased until 140min; in fire condition 2 and 3, it gradually increased in 70min after the temperature rise, and then basically remained unchanged. For M9,18, in fire condition 2 and 3, the change trend was similar. The absolute value increased gradually at first, then peaked at 60min of temperature rise, then decreased gradually, and basically remained unchanged after 130min of temperature rise. For M2,9, the change was not obvious in fire condition 1 and 3. In fire conditions 2, the absolute value gradually decreased with the increase of heating time, and gradually increased after 75min of heating until the end of heating. For M9,2, the absolute value increased rapidly in the first 20 minutes in fire condition 1. In fire condition 2, the absolute value gradually decreased to 0 in the first 80min and increased gradually after changing the direction. In all three fire conditions, M17,25 decreases first and then increases, of which the increase in fire condition 3 is the most obvious. The change trend of M21,17 is similar in three fire conditions, with the magnitude of change is  $1 > 3 > 2$ .

#### 4. Conclusion

- (1) The shear force in the bottom section of the side column will change in the same trend in three fire conditions due to the fire beam expansion and the constraint action of the ground.
- (2) In fire condition, the axial force of some member sections changes direction, that is, the tension changes to pressure.
- (3) Three fire conditions generally affect the bending moment of each section, and some section bending moments change direction.

## References

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