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Review on fire resistance of reinforced concrete columns

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Abstract

The article firstly introduces the importance of structural fire resistance, summarizes the historical status of the research on fire resistance of ordinary concrete columns at home and abroad; analyzes the factors affecting the fire resistance of reinforced concrete columns, and finally summarizes the shortcomings in the research on the fire resistance of reinforced concrete columns and the future development trend.

Keywords

Reinforced concrete column; fire resistance; influencing factors.

1. Introduction

In recent years, fire has brought great loss to human life and property, and the fire prevention of buildings has been paid more and more attention in building disaster prevention. The high temperature of fire has a significant effect on the properties of structural materials, especially the mechanical properties. In the case of fire, once the column is suddenly destroyed, it will directly lead to the overall collapse of the structure. Unprotected structures are therefore highly vulnerable to damage in a fire. Zhao Guofan et al. [1] discussed that reinforced concrete columns are important supporting components in building structures, and loss of bearing capacity may lead to partial or even overall damage of buildings, and bring difficulties to post-disaster structural restoration. Column is one of the main load-bearing components of building structure, and its fire resistance has great influence on the fire safety of the whole structure. Therefore, it is very important to study its fire resistance。

2. Research status at home and abroad

2.1. Study on fire resistance of ordinary concrete column at high temperature

Yang Zhinian, Zhu Huanran et al. [2] studied the effect of bursting degree on the fire resistance of NC columns by changing the surface moisture content through full scale fire test of 6 NC columns. The results show that the curing time of NC column is short, the fire resistance of NC column is greatly reduced by the concrete burst degree, the water content of concrete surface decreases with the curing time, the surface burst degree decreases, and the fire resistance of NC column is significantly increased.

Wang Huanli et al. [3] compared and analyzed the mechanical properties of prefabricated NC column with bolt connection of steel plate hoop at high temperature, and the research results showed that the ultimate bearing capacity of the structure at high temperature was related to factors such as column axial compression ratio, compression eccentricity, thickness of protective layer, fire surface and fire time.

Long-yuan Li et al. [4] summarized the mechanical properties of NC at high temperature from different literatures and obtained the stress-strain full curve model under high temperature conditions.

Martins et al. [5-6] conducted an experimental study on the fire resistance limit of reinforced concrete columns, and explored the influence of parameters such as reinforcement ratio,

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slenderness ratio, constraint conditions, load level, heating rate and eccentricity on the fire resistance of reinforced concrete columns.

2.2. Study on fire resistance of ordinary concrete column after high temperature

Li Yan, Zhang Youming et al. [7] conducted uniaxial compression tests on NC at different temperatures from 100℃ to 800℃, compared the effects of different fire temperatures, cooling time and methods on the stress and strain-related properties of NC, and obtained the results that the peak strength and elastic modulus of NC decreased with the increase of temperature.

Huang et al. [8] established a nonlinear layered finite element model to simulate, analyze and predict the structural response of reinforced concrete members after a fire, and the correctness of the model was proved by comparison with the test results.

Li Fengbin et al. [9] verified the influence of different fire temperature, cooling method and constant temperature time on the mechanical properties of coagulation through experiments, and concluded that when the fire temperature of NC was reduced, the pressure resistance performance increased. The mechanical properties tend to decrease when the constant temperature time increases.

3. Study on fire resistance of reinforced concrete columns

The research on fire resistance of reinforced concrete columns includes fire resistance limit and mechanical performance of reinforced concrete columns after high temperature action. The greater the fire resistance limit of reinforced concrete columns or the better the mechanical performance of reinforced concrete columns after high temperature action, the better the fire resistance.

3.1. Fire resistance limit

The fire resistance limit of a component is a measure of the time required for a component to reach a state of failure under fire. The bearing capacity, integrity and heat insulation of concrete column are the three main factors to achieve the fire resistance limit state.

3.2. The mechanical properties of reinforced concrete columns subjected to high temperature

The research on the mechanical behavior of reinforced concrete columns under high temperature action mainly focuses on the residual bearing capacity, axial compression stiffness, failure characteristics and deformation law of reinforced concrete columns under axial and eccentric compression after high temperature action.

4. Factors affecting fire resistance of concrete columns

According to a large number of experiments, the factors affecting the fire resistance of reinforced concrete columns include :(1) fire time and temperature; (2) fire mode; (3) section size; (4) Concrete strength, aggregate type; (5) axial compression ratio and load eccentricity; (6) longitudinal reinforcement; (7) Concrete protective layer thickness, stirrup, slenderness ratio, column end constraints, etc.

4.1. Fire time and temperature

The fire temperature is generally more than 1000 degrees or even higher, but the temperature of different component sections is different, from the surface to the interior is generally gradually reduced, so after heating at different temperatures, the mechanical properties of reinforced concrete columns are of great significance. The influence of temperature and fire time on the fire resistance of reinforced concrete columns is significant. With the increase of

temperature or fire time, the strength of reinforcement and concrete decreases, and the residual compressive capacity of reinforced concrete columns decreases.

4.2. Fire mode

The cross-section temperature distribution of reinforced concrete columns with different fire modes is different, and the damage degree of steel and concrete in different areas is also different. The high temperature damage degree of reinforced concrete columns subjected to uniform fire, three-sided fire, two-sided fire and single-sided fire is different.

4.3. Section size

Concrete is a heat-inert material with small thermal conductivity, so the larger the cross-section size of reinforced concrete column under the same conditions, the lower the average temperature in the cross-section of reinforced concrete column, the smaller the relative high temperature damage area, and the better its fire resistance. Su Nan et al. [11] and Martins et al. [5] showed through the fire resistance test of reinforced concrete columns that the larger the section size, the higher the fire resistance of reinforced concrete columns.

4.4. Concrete strength

The fire resistance limit of reinforced concrete column of ordinary strength concrete is much higher than that of high-strength concrete column, because the reinforced concrete column of high strength concrete has obvious high temperature burst under the action of fire, while the high temperature burst degree of ordinary strength concrete column is weak.

4.5. Axial compression ratio and load eccentricity

Under fire action, the internal stress of reinforced concrete column is mainly the transverse stress caused by temperature stress and axial load. The two kinds of stress together make concrete burst, and increasing the axial load will aggravate the burst degree of concrete.

The increase of eccentricity means that the bending moment of the reinforced concrete column increases. The researchers have found that the residual compressive capacity of the biased reinforced concrete column decreases with the increase of eccentricity.

4.6. Longitudinal reinforcement

Martins[5] et al. 's experiments show that the fire resistance of reinforced concrete columns can be increased by increasing the longitudinal reinforcement ratio, and the fire resistance of reinforced concrete columns can be increased by increasing the longitudinal reinforcement ratio.

4.7. Concrete protective layer and stirrup

1) The thickness of concrete protective layer affects the fire resistance of concrete column, and the protective effect of concrete is weakened when the temperature is higher than 500℃.

2) Stirrup can restrain concrete and restrain the transverse deformation of concrete; However, when the temperature of the stirrup in the reinforced concrete column is higher than 400℃, the strength of the stirrup decreases obviously, and the restraint effect on the core concrete is greatly weakened.

5. Conclusion and prospect

This paper discusses the development of fire resistance of reinforced concrete columns in recent years and the influencing factors and research programs, and finally summarizes the following conclusions and prospects for the future:

Appropriate increase of section size and thickness of concrete protective layer, use of small diameter reinforcement and selection of appropriate aggregate type are beneficial to the

improvement of fire resistance of reinforced concrete columns. However, the research on axial compression ratio, for example, is shallow and needs further research.

The research results of mechanical properties of concrete at high temperature and after high temperature are almost all aimed at unidirectional loading. The research results of multi-axial mechanical properties at high temperature are far from the actual needs, and need further research. In the past, most fire resistance tests were based on the standard temperature rise curve, but the standard temperature rise curve is very different from the real fire temperature rise curve, so attention should be paid to the study of the fire resistance of structural members under real fire.

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