

# A Review of the Study on the High-temperature Mechanical Properties of Steel Pipe Concrete Special-shaped Columns

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## Abstract

**This paper proposes to introduce the research status of different types of special-shaped columns at high temperatures, the performance research of high-temperature concrete special-shaped columns to improve or improve the performance of special-shaped columns, and the experimental research results of special-shaped column frame structures in prefabricated buildings, on the basis of which the built-in steel pipe assembly type renewable special-shaped column structure with environmental benefits and reliable performance is proposed and its future development trend.**

## Keywords

**High temperature; Special-shaped column; Prefabricated.**

## 1. Introduction

Fire is one of the most common disasters in people, each fire causes a lot of direct or indirect losses, in order to reduce the loss of fire, we need to conduct fire studies on the performance of structural columns and their frame structures to further grasp its laws to reduce fire losses. Concrete special-shaped column as a structural bearing member to a certain extent has the advantages of saving space, reducing costs and other advantages, many domestic scholars for conventional concrete special-shaped column research more, with the development of society for environmental protection requirements are getting higher and higher, assembly and renewable recyclable has become a hot spot, assembly type with its production and maintenance in the factory and then assembly can produce good economic and environmental benefits. Under the premise of this environment, the application and popularization of prefabricated structures that can combine structural performance and environmental benefits and the research on their post-fire properties can arouse people's attention.

## 2. Research Status of Concrete Special-shaped Columns at High Temperatures

Wu, Xu <sup>[1]</sup> using the analysis method proposed by domestic scholar Shi Xudong et al. and foreign scholar Lie et al. to compile the whole process of high-temperature reaction procedure RCSSCF to simulate the fire on the four sides of the special-shaped column, through the comparison with the conventional reinforced concrete column fire on the four sides of the found that the mechanical properties of the special-shaped column are greatly reduced. Subsequently, Xu and Wu [2] studied the fire performance of concrete special-shaped columns under end constraints, simulated the influence on the high temperature of concrete special-shaped columns under the common constraints of other components, and found that the rotational constraints can improve the fire resistance of columns. Wu and Chen [3] conducted a high-temperature test under axial constraint on four T-shapes and crosses, and found that if the axial pressure ratio

increased, the overall axial deformation decreased if the axial constraint stiffness ratio was the same; the overall axial deformation cross shape was smaller than the T-shape. Shan [4] The two-sided fire test was carried out on the L-shaped sectional steel concrete special-shaped column, and it was found that the high-temperature post-shaped steel concrete special-shaped column still had a large anti-side stiffness, and after the fire, it would change from axial pressure to bias pressure, and the size bias pressure showed a similar super-rib failure mode. Yang [5] Studied the mechanical properties of the T-sectional steel concrete special-shaped column at high temperature, and found that the components after fire still meet the flat section assumption, and the eccentric distance and fire time have a significant impact on the bearing capacity of the T-shaped column, and the cross-section damage after fire will produce eccentricity. Xu [6] Under the premise of considering the constraints of the surrounding components, the study of three-sided fire-T-sectional steel concrete special-shaped columns found that the load ratio and eccentricity had a reverse effect on the fire resistance limit. In order to continue to improve and improve the performance of special-shaped columns and respond to the call for environmental protection, the relevant research on the built-in steel pipe concrete special-shaped columns and renewable concrete special-shaped columns has been paved.

### **3. Research Results of Steel Pipe Concrete Special-shaped Columns at High Temperatures**

#### **3.1. Built-in Steel Pipe Concrete Special-shaped Column**

The built-in steel pipe special-shaped column is composed of reinforced concrete components with inner core part and external constraint, and the binding effect exists between the steel pipe and the internal concrete, as well as between the reinforced concrete external components and the steel pipe, so that the concrete wrapped steel pipe concrete components have high strength, high stiffness and superior ductility. Kang, Qian [7], Liu and Guo [8] studied the built-in steel pipe concrete composite components, analyzed the failure form and stress strain curve of the components, and found that the axial pressure performance of the composite column increased with the increase of the steel pipe distribution rate and the strength of the concrete. Zhou and Han [9] conducted a full-scale fire study on steel pipe concrete composite columns under load, and found that due to the thermal insulation effect of external reinforced concrete, compared with conventional steel pipe concrete columns without concrete externals, concrete external steel pipe concrete columns have higher fire performance and residual strength after fire. Yang [10] Conducted a high-temperature study on the cross-shaped special-shaped column with built-in steel pipe, and found that the internal heating of the built-in core column is relatively slow and can provide higher bearing capacity and better fire resistance and force performance than ordinary reinforced concrete special-shaped columns. Lv and Ren [11] conducted a simulation test on the L-shaped special-shaped column of the built-in steel pipe concrete at high temperature, and found that the steel content has a positive effect on the refractory limit, and the length-to-fine ratio and load have a reverse effect on the refractory limit.

#### **3.2. Steel Pipe Concrete Renewable Column**

Chen [12] Referred to the relevant research on the axial pressure performance after high temperature of wang bing et al., Yang Youfu et al., Han Linhai and other related scholars at home and abroad to carry out the axial pressure performance test and bearing capacity calculation of steel pipe regenerated concrete after high temperature, and the results showed that the mechanical properties, deformation properties and bearing capacity of steel pipe recycled concrete special-shaped columns were similar to those of ordinary steel pipe concrete, and the

change of renewable material substitution rate and high temperature duration did not have a significant impact on the mechanical properties of the specimen. Habib Akbarzadeh Bengar[13] compared steel pipe concrete with no rubber, 7.5% rubber instead of fine aggregate, and 15% rubber instead of fine aggregate with steel pipe constraint and steel pipe constraint without steel pipe constraint, and the member did not drop much in compressive strength at the same temperature while the ductility of the member increased.

#### 4. Concrete Special-shaped Column Frame Study

Wang [14] and Ni [15] studied the assembled integral special-shaped column frame and found that the T-shaped and L-shaped special-shaped column nodes have similar stiffness, bearing capacity and ductility compared with similar node specimens. Experiments show that L-type and T-frame column nodes have better stiffness, bearing capacity and energy consumption capacity than "one" type nodes. The bearing capacity and energy consumption capacity of the prefabricated special-shaped column also meet the requirements, but the cross node is seriously damaged and needs to be strengthened. Wu Bo, Jing Yatao, et al. [16] conducted a fire test on the 3-foot reinforced concrete special-shaped column frame structure, and the test showed that the frame structure damage appeared in the frame beam and the column and node performed well, and the frame beam showed a force pattern similar to the catenary cord when the frame beam was broken. It shows that the treatment at the special-shaped column node has reached a certain level, which can make the special-shaped column structure still meet the requirements of "strong column weak beam, strong node weak component" after experiencing fire; the study also found that other conditions remain unchanged as the stiffness of the beam and column increases the node angle of the special-shaped column space frame in the late stage of the fire, and the growth rate of the vertical line displacement of the beam is accelerated in the later stage of heating. This enables us to have a preliminary understanding of the under-fire behavior of the reinforced concrete heterosexual column frame structure, which can provide reference for the study of the post-fire mechanical properties of the reborn concrete heterosexual column frame of the assembled steel pipe in the future.

#### 5. Summary and Outlook

(1) The built-in steel pipe concrete special-shaped column has a higher constraint effect on the concrete year-on-year, which can greatly improve the problem of insufficient bearing capacity of ordinary concrete special-shaped columns after encountering fire; compared with ordinary concrete, the thermal insulation effect makes the built-in steel pipe concrete special-shaped column have higher fire resistance, but it is necessary to further study the high temperature performance of different types of built-in steel pipe special-shaped columns when they are constrained by other components and under complex stress conditions.

(2) The use of suitable materials and suitable substitution rates to replace concrete aggregates in a certain proportion can increase other aspects of performance and achieve regeneration without much degradation in structural performance. The fire resistance of steel pipe recycled concrete columns is better, and for specimens with short and thick body shape and high strength of constituent materials, under the same external conditions, they are more conducive to fire prevention [17]

(3) The prefabricated special-shaped column frame structure combines the advantages of high assembly efficiency, good environmental benefits, small weight of the special-shaped column, convenient spatial layout, etc., while also meeting the requirements of bearing and energy consumption capacity, and its performance after fire is still in line with the design specification concept, but there is less research on the fire of different types of special-shaped column frames.

(4) The prefabricated steel pipe renewable concrete special-shaped column structure that combines high performance, renewable and assembled has the advantages of environmental benefits and high efficiency on the basis of better mechanical properties and fire resistance, which is more in line with today's development trend and its research at high temperatures is more groundbreaking.

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