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Research on Steel Reinforced Stainless Steel Tube Ultra High Performance Concrete Columns

Jingkai Qin

School of Urban Construction, Yangtze University, Jingzhou, China

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Abstract: Ultra high performance concrete has high compressive, flexural, and flexural strength, as well as good mechanical properties. Compared with ordinary steel pipes, stainless steel pipes have good corrosion resistance. In addition, the addition of internal steel ribs prevents premature lateral displacement and shear cracking of ultra-high performance concrete inside. Ultra high performance concrete improves the stability of the wrapped steel pipe and delays or avoids the overall expansion and damage of the specimen. The interaction between steel pipes, steel ribs, and ultra-high performance concrete effectively improves the overall mechanical properties of the specimens, which has important guiding significance for later research and practical engineering applications.

1. Introduction

This article studies the interaction between steel reinforced stainless steel tube and ultra-high performance concrete columns to improve the overall mechanical properties of specimens. The selection of materials and the direction of research are very innovative and prominent. Replace ordinary concrete with ultra-high performance concrete because steel fibers are added to the ultra-high performance concrete under the constraint of wrapped steel pipes, which improves the ductility of the concrete. In addition, ultra-high performance concrete also has advantages such as high compressive strength, good seismic and blast resistance, and low production cost. Therefore, the method of replacing ordinary concrete with ultra-high performance concrete is feasible. In addition, this steel-concrete composite structure inevitably faces many complex environments. Ordinary carbon steel pipes have poor rust resistance and are prone to rusting in harsh environments. The failure of the outer steel pipe of the composite structure directly affects the mechanical properties of the entire specimen. The most common method to improve the rust resistance of steel pipes is coating or spraying rust resistant paint, but the process is cumbersome and can cause pollution to the environment. Replacing this ordinary carbon steel with stainless steel pipes can effectively avoid the impact of steel pipe corrosion on the overall mechanical properties of the specimens.

2. Current research status of ultra-high performance concrete

The research on ultra-high performance concrete in our country started relatively late, but after the efforts of scholars to explore, the progress of research on ultra-high performance concrete is still very fast. In 1993, Huang Zhengyu et al.[1] successfully prepared ultra-high performance concrete with a strength exceeding 200MPa by adding water reducing agents, steel fibers, and some admixtures to Portland cement. In 1999, Professor Qin Weizu from Tsinghua University [2] first introduced a new material - reactive powder concrete to China. After receiving the news, most universities in the country began to invest in in-depth research on this new material. In addition, a steel fiber plant in Anshan began large-scale production of steel fibers. At the same time, Cao Feng and Qin Weizu [3], starting from the perspective of material mix proportion, continuously adjusted the proportion of each material, and finally developed an ultra-high performance concrete with a higher flexural strength grade of C230. Wang Wufeng [4] improved the ductility of ultra-high performance concrete by adding steel fibers. By analyzing the entire mechanical mechanism of the concrete by adding different amounts of steel fibers, it was found that with the continuous increase of steel fiber parameters, the flowability of ultra-high performance concrete gradually weakens, but the compressive and flexural strength continue to increase. Long Guangcheng and Xie Youjun [5] added steel fibers to ultra-high performance concrete and obtained a strength grade of C200 through conventional preparation and curing. They also studied the influence of a series of parameters on the mechanical properties of ultra-high performance concrete. Compared with ordinary concrete, ultra-high performance concrete has better durability and higher strength. The biggest difference between the preparation process and ordinary concrete is the removal of coarse aggregates in the material, filling the gaps between materials as much as possible, and then adding some fiber materials and mineral materials to the concrete to improve its ductility and strength [6] [7].

3. Steel reinforced concrete columns

Placing steel bars of different shapes in reinforced concrete structures forms steel reinforced concrete structures. The three materials complement each other, greatly improving the stiffness and ultimate bearing capacity of steel reinforced concrete. Due to the addition of different types of steel in reinforced concrete, the steel ratio of steel reinforced concrete structures is much higher than that of reinforced concrete. Therefore, the bearing capacity of steel reinforced concrete is also increased by more than twice the former, effectively reducing the cross-sectional area of columns in engineering and avoiding the situation of fat beams and columns in engineering. Compared to ordinary steel structures, pouring a layer of concrete outside the steel to form a reinforced concrete structure can not only prevent corrosion of the internal steel, but also delay or even avoid the occurrence of bulging and cracking of the internal steel when it reaches yield, greatly improving the mechanical properties of the structure. At the same time, due to the strong load-bearing capacity of steel sections, they can serve as templates for load-bearing structures during construction. Due to their significant advantages, they are also widely used in construction.

Compared to Japan, which is prone to earthquakes, the research direction and approach of Japanese scholars are different from those of Western countries. After the Great Kanto Earthquake, scholars found that compared to other buildings, buildings built with steel tube concrete columns suffered relatively little damage. Since then, Japanese scholars have begun to focus on the study of steel reinforced concrete columns. This structure has been extensively utilized in the reconstruction of disaster areas. With continuous exploration and development, H-shaped steel has been adopted for steel reinforcement, and the seismic performance of steel reinforced concrete columns has been greatly improved, laying a solid foundation for their excellent seismic performance. The research on steel reinforced concrete columns in China started in the 1950s, but it officially began to pay attention to the use of such specimens. Initially, research on open web steel reinforced concrete columns was mostly focused on. Xi'an University of Architecture and Technology and the Architecture Research Institute of the Ministry of Metallurgy conducted a study on the overall mechanical properties of columns with different forms of steel ribs added. Song Zhanhai studied the mechanical properties of steel reinforced concrete columns. By observing the failure characteristics of multiple steel reinforced concrete columns, he analyzed the different mechanical properties of specimens with different axial compression ratios, and derived an approximate calculation formula. Zheng Desheng et al. provided a detailed introduction to the design method of the normal section of steel reinforced concrete columns through the analysis of calculation examples.

4. Steel tube concrete column

Steel tube concrete column is a composite structure formed by pouring concrete into the steel tube, and the outer steel tube has a good restraining effect on the internal concrete. This combination structure has extremely high bearing capacity, and its ductility, stiffness, and strength are all very good. Widely used in various high-rise structures, super high-rise structures, and offshore engineering. Steel tube concrete originated in Western countries in the 1880s. Furlong [8] found through axial compression tests that the interaction between the outer steel tube and the inner concrete can be ignored. Based on the analysis of the test results, a calculation method for the ultimate bearing capacity of steel tube concrete columns was derived. Neogi et al. from the UK proposed a bearing capacity formula for steel-concrete considering external steel pipe constraints by studying the interaction between concrete under triaxial compression and external steel pipes, making the bearing capacity formula closer to real-life engineering. Kenji and Sakino et al. [9] conducted axial compression tests on multiple steel tube concrete columns, controlled the cross-sectional shape, diameter to thickness ratio, and concrete of the steel tube concrete columns, analyzed the multiple columns, and derived a modified bearing capacity calculation.

5. Steel reinforced steel tube concrete columns

Steel reinforced stainless steel tube ultra-high performance concrete column is a composite structure composed of an outer steel pipe, an inner steel frame, and internally poured concrete. The synergistic work of the three materials greatly improves the mechanical properties of this composite structure. When the external steel pipe is longitudinally compressed, the steel pipe will also apply transverse compressive stress to the internal concrete, and the internal concrete can also play a role in preventing rust and corrosion of the steel pipe. According to the above introduction, the composite structure of steel reinforced stainless steel tube ultra-high performance concrete columns has very high axial compression bearing capacity, convenient construction, and good mechanical properties.

At the beginning of the 20th century, the structure of steel reinforced concrete filled steel tube columns was proposed by some experts, and significant contributions were made to the research and development of this structure through extensive experiments and research.

In 2006, as the earliest experts in China to propose the structure of steel reinforced concrete filled steel tube composite columns, Xu Yafeng and Jiang Guilan et al. [11] [12] analyzed the bearing capacity and stiffness of steel reinforced concrete filled steel tube composite short columns under axial and eccentric compression conditions, and conducted relevant stress mechanism analysis.

In 2008, Guo Jian and Xu Yafeng [13] analyzed the stress performance of steel reinforced concrete filled steel tube composite columns under eccentric loading.

In 2009, Zhao Tongfeng et al. [10] made unprecedented contributions to the mechanical properties of steel reinforced square steel tube concrete columns and developed a nonlinear program to study this structure. After verification by the program, simplified formulas for axial compression, single bias, and bidirectional bias of this structure were obtained.

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