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Mechanical properties of high strength concrete and its application in concrete filled steel tube

Weiyue Cao, Haibin Chen

School of architectural engineering, North China University of Technology, Tamgshan, Hebei 063200, China

Abstract

The rapid development of the global economy and the continuous progress of social civilization promote the rapid development of the construction industry and continue to move towards construction modernization. As the inevitable research trend of building materials in the future, high-performance materials briefly summarize the application of high-strength concrete and high-strength concrete in concrete-filled steel tubular in recent years, review the axial compression characteristics and ductility of high-strength concrete and high-strength concrete-filled steel tubular, combined with the shortcomings of high-strength concrete research, point out the future development direction and the problems still existing in practical engineering.

Keywords

High strength concrete; Concrete filled steel tube; Ductility; Axial compression performance.

1. Introduction

Although the development history of concrete is not long, as one of the building materials that mainly bear the load of building structures in various countries, the pursuit of high-performance concrete research and preparation has become a hot direction all over the world. High strength concrete generally refers to the concrete with cube compressive strength greater than 60MPa, which has good durability and strength, so as to reduce the self weight of the structure and better impact resistance. Therefore, as the development trend of concrete in the future, this paper summarizes the compressive strength and ductility of high-strength concrete in recent ten years.

Concrete filled steel tube (CFST) is a kind of composite structure with good ductility and high bearing capacity, which fills the concrete into the steel tube. Its bearing capacity exceeds the sum of the individual bearing capacity of steel tube and concrete, giving play to the excellent characteristics of "1 + 1 > 2" at the beginning. According to incomplete statistics, since the 1980s, more high-rise and super high-rise buildings and bridges in China have adopted concrete filled steel tube columns as bearing columns. In recent years, With the continuous increase of material properties, high-performance concrete-filled steel tubular composite members composed of high-strength concrete and steel tubes have achieved outstanding results in the fields of high-rise buildings, long-span bridges and wind power engineering. Therefore, this paper summarizes the future development trend of axial compression performance and ductility of such high-performance composite members, so as to provide reference and theoretical support for theoretical analysis and engineering practice in the future.

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2. Research status of high strength concrete

2.1. Compressive strength

Zhao Shuqin[1] conducted the strength, elastic modulus and flexural strength tests of high-strength concrete. Combined with the test results, as shown in Figure 1, it is proposed that when the compressive strength is greater than 80MPa, it needs to be corrected to ensure the accurate application of high-strength concrete.

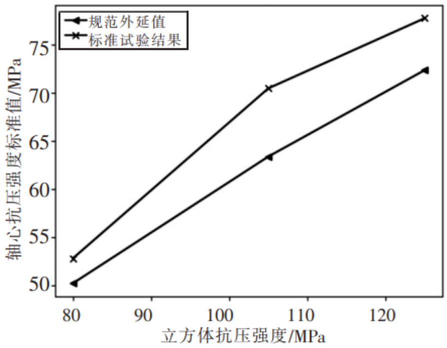

Fig. 1 Comparison of standard values of concrete compressive strength

Chen Yongfu[2] proposed that when determining the compressive strength of high-strength concrete, the high-strength rebound method is more accurate. The estimated value of component concrete strength detected by the high-strength rebound method is higher than that detected by the core drilling method, and its ratio is between 1.00 and 1.02. Its detection results are basically close, and its error range is ≤ 14%, meeting the requirements of industry standards.

The rebound method is also applicable to the strength measurement of high-strength concrete after high temperature. Chen Zongping[3] changed the water binder ratio and the temperature holding time of the test block after the highest temperature and reached the highest temperature, carried out the compressive strength test of high-strength concrete prism, and regressed the functional relationship between the rebound value and the compressive strength value:

$$f_c^{\,c} = 19.317 - 0.708\ 64R + 0.03529R^2$$

Fire accidents have a significant impact on human life and property safety. Li Guanghui[4] designed three concrete beams to study their internal temperature field at high temperature, and compared the internal temperature gradient of 108 high-strength concrete cubes to obtain the variation law of residual compressive strength.

2.2. Ductility

Wang LINRONG[5] conducted experimental research on high-strength concrete columns above C80 and pointed out that the axial compression ratio of the column is limited by the ductility of the specimen, and the hoop characteristic value can effectively change the adverse effects brought by the high axial compression ratio, so that the high-strength concrete column can be transferred from brittle failure to ductile failure.

Ke Xiaojun[6] proposed a calculation method for the limit value of axial compression ratio of high-strength concrete columns under different influencing factors based on the limit failure theory of eccentric compression, which is in good agreement with the code value.

Xiao Yan[7] suggested that under the action of constant force, the hoop design formula of displacement ductility under horizontal reciprocating loading should be determined, the seismic grade corresponding to the minimum hoop characteristic value should be grade I, and the fixed limit value should be given.

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3. Application of high strength concrete in concrete filled steel tube

3.1. Axial compression performance

Wei Jiangang[8] pointed out that the length diameter ratio is an important factor affecting the stability of axial compression performance of high-strength concrete-filled steel tubular. Seven circular concrete-filled steel tubular columns are designed. The high-performance concrete columns show the bulging and expansion of steel tubes in the columns, and finally tend to the overall instability state. The stability coefficient in the bearing capacity calculation formula of circular steel-filled high-performance concrete columns is proposed through the finite element method φ, The calculation results are more accurate.

Li Guochang[9] conducted biaxially biased flexural member tests on six high-strength concrete-filled square steel tubes. Combined with the finite element method, she pointed out five stages of the whole failure process of high-performance concrete-filled square steel tubes. Under the action of biaxially biased compression, the middle part of the specimen appeared bulging, the steel tube was pressed through, and the tensile side showed good ductility. The bearing capacity of specimens is greatly affected by yield strength and steel content.

Li Song and Jiao Chujie[10] explored the ultimate bearing capacity of such members in combination with CFRP confined high-strength concrete-filled steel tubular short columns, and pointed out that the failure form of CFRP CONFINED HIGH-STRENGTH columns is the same as that of ordinary columns, and the high strength and brittleness of the internal core constitute the main differences of the specimens. The specimens mainly go through the stages of elasticity, elastoplasticity, hardening and strengthening in the process of axial compression, and CFRP confined high-strength concrete columns have high ultimate bearing capacity.

3.2. Ductility

Chen Zhenxin[11] configured spiral stirrups in the square steel tube ultra-high strength concrete column to increase the ductility and seismic performance of such members, effectively reduce the stiffness degradation of ultimate bearing capacity after peak load, give better play to the characteristics of high-strength concrete, and enhance the energy consumption capacity of the whole specimen.

Qiu zengmei, Li Guochang, etc[12]. made six high-strength concrete-filled square steel tubular columns. Taking the slenderness ratio as the change parameter, it is concluded that the slenderness ratio is negatively correlated with the bearing capacity of the specimen and has little effect on the ductility coefficient of the specimen

Wei Jiangang and Zhou Jun[13] conducted seismic tests on 8 high-strength concrete-filled steel tubes by changing the axial compression ratio, steel content and material strength. They concluded that the specimens of high-strength steel tube ultra-high performance concrete were mainly compression bending failure, and the axial compression ratio had a significant impact on the energy consumption of the specimens. They concluded that the current calculation method of flexural stiffness was not suitable for high-strength materials.

4. Prospect of high performance materials

As a building material widely used in modern engineering, high-performance materials have high bearing capacity, ductility, energy dissipation performance and stiffness, which bring enough safety to the building structure. As a key research object in the new century, compared with traditional materials, their excellent characteristics bring lasting benefits to the social economy and convenience to social life. The improvement of mechanical properties leads to the reduction of specimen section and self weight, which is more widely used in long-span bridges In high-rise buildings, however, the research on high-performance materials is still in the preliminary stage. The following summarizes the problems brought by high-performance materials.

1) The strength of ultra-high performance materials is lack of the same specification and correction. There are few experimental studies on concrete with material properties above C80, and the scope of application of the specification should be further increased.

2) The influence of temperature on high-strength materials is complex. Factors such as cooling mode and fire resistance time have varying degrees of damage to the interior of the materials. High temperature cracking is still a problem to be solved for high-strength concrete. Doping different hybrid fibers or applying fire retardant coatings is not an economic solution for practical projects. The material property loss after cooling needs to be reasonably evaluated.

3) The proportion of high-performance materials in practical application is still low, and the total production of high-strength concrete is less than 1% of the total production of concrete. The popularization and application of such high-performance materials are also restricted by different factors. The loss caused by high mechanical properties is brittle and poor shrinkage. Improving such key problems can further promote and develop high-strength concrete in the field of concrete.

5. Conclusion

1) High performance concrete brings good economic benefits to the society. It is the development trend of concrete building materials in the future and a good material to solve the lack of building bearing capacity.

2) There are still few experimental studies on concrete above C80, and there is a large deviation between the measured strength and the current specifications. It is suggested to reasonably revise the calculation method of compressive strength and bearing capacity of high-strength concrete.

3) There are few studies on fire resistance, earthquake resistance and eccentric compression performance of high-performance concrete-filled steel tubular columns, mainly focusing on the axial compression performance. The internal situation of high-strength concrete-filled steel tubular after fire is more complex. Therefore, further tests are still needed to summarize the working mechanism of this kind of members.

4) The axial compression bearing capacity formula of high-strength concrete-filled steel tubular is an important field for further judgment and research in the future. For example, the experimental research under the condition of large width thickness ratio is difficult to summarize and study with finite element model and theoretical analysis model. Therefore, it is necessary to unify and standardize the axial compression bearing capacity formula of high-strength concrete-filled steel tubular.

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