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Research on Performance of Vertical FRP Concrete Members

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Abstract: In this paper, the theoretical research on the mechanical properties of FRP concrete vertical stressed members is described. The research progress on the mechanical properties of FRP concrete columns is summarized from three aspects: types of fiber-reinforced composites, applications in civil engineering and development prospects. Finally, the advantages of mechanical properties of FRP concrete column are studied by comparing with concrete filled steel tube column, and the further research direction of FRP concrete column is supplemented.

Keywords: FRP, Mechanical property, Future development trend.

1. Introduction

FRP is a kind of novel material which is made of reinforced fiber and building body as raw material and processed by certain process. Compared with traditional engineering materials such as concrete-filled steel tube columns, FRP has more good characteristics, including high specific strength, resistance to corrosion under extreme conditions, and large and flexible design space. When the reinforced concrete structure occurs in the following circumstances, the structure needs to be strengthened in terms of strength and ductility:

(1) In the humidity, high salinity environment of the work of steel bars easy to rust or with the passage of time, the development of concrete micro cracks caused by structural bearing capacity reduction:

(2) Structural bearing capacity caused by earthquakes, typhoons and other natural disasters

The lower;

(3) the actual load borne in the use process is too much than the design load value;

(4) Due to design errors or construction quality, the actual bearing capacity of the structure is less than the design bearing capacity.

To solve these problems, researchers put forward a new concept of using external constraints to improve the strength and ductility of concrete. Concrete-filled steel tube (CFST) is a kind of constrained concrete that has been widely used. FRP is mainly divided into two categories: synthetic and natural fiber reinforced composites. The synthetic fiber reinforced composites are CFRP, GFRP, AFRP and BFRP. Natural fiber reinforced composites include FFRP and JFRP. At present, GFRP, CFRP and AFRP are widely used.

2. FRP Research Progress

There are four main types of synthetic fiber reinforced composites: CFRP, GFRP, AFRP and BFRP. These four reinforcement fibers can be used for structural repair and reinforcement.

(1) Aramid fiber (AFRP) performance Aramid fiber (aromatic polyamide fiber), is a kind of artificial synthetic fiber with high performance, formed by aromatic polyacyl compounds in a single direction, there are three main types: Kevlar, Twaron, Technora. Aramid fiber has good properties such as high strength, high elastic modulus and not easy to be corroded at high temperature, but its compressive strength is low. In addition, ultraviolet light and moisture have great influence on aramid fiber.

(2) Glass fiber (GFRP) properties Glass fiber is divided into E-glass fiber, C-glass fiber, A-glass fiber, S-glass fiber and M-glass fiber, etc. E-glass fiber and S- glass fiber are commonly used in the field of soil woodworking construction. Glass fiber cost is low, can be widely used, elastic modulus is poor, easy to alkaline corrosion, easy to crack. Due to the above disadvantages and shortcomings, scholars have conceived a solution to produce a high alkali resistant glass fiber - AR fiber by increasing the amount of alumina. It has been found that glass fiber cloth (GFRP) has a better effect on the ductility of concrete columns, while carbon fiber cloth (CFRP) has a better effect on the ultimate bearing capacity of concrete columns. Therefore, glass fiber cloth (GFRP) can play a great role in enhancing the ductility of concrete columns.

(3) Performance of carbon fiber (CFRP) carbon fiber has Pitch, viscose and PAN based three kinds of carbon fiber, PAN based carbon fiber is the most widely used. According to the mechanical properties of carbon fibers, they can be divided into two categories: high strength carbon fibers and high elastic modulus carbon fibers. Different from the hexahedral structure of graphite, the graphite microcrystalline structure of carbon fiber is preferentially oriented along the fiber axis. The classification standard of carbon fiber and graphite fiber dimension depends on the carbon content of the fiber. When the carbon content of the fiber is greater than 99%, it is called graphite fiber, and when the carbon content of the fiber is 80%~ 95%, it is called carbon fiber. Because carbon fiber is anisotropic and the cost of manufacturing is high, how to further reduce the cost for large-scale application remains to be studied.

3. Natural Fiber Reinforced Composites

There are two main types of natural fiber reinforced composites: flax fiber (FFRP) and jute fiber (JFRP). These two reinforcement fibers are mainly used for structural confinement. Libo Yan et al. [1] first proposed the application of natural fiber reinforced composite materials to restrained

concrete and natural fiber concrete, and conducted a series of experimental and theoretical studies. The tensile properties of FFRP were improved by treating flax fiber with alkaline solution. The compressive and flexural performance tests of FFRP constrained concrete and FFRP constrained coconut shell fiber concrete are also carried out, and the theoretical analysis models of compressive and flexural performance are put forward. Yan et al. found that the restraint of FFRP pipe can significantly improve the ductility of plain concrete and coir fiber reinforced concrete. In terms of compressive strength, the restraint effect of GFRP pipe and FFRP pipe on concrete has little difference. However, due to the low compatibility between natural fiber composites and current production methods, it is prevented from being widely spread and applied, so how to widely apply and develop natural fiber reinforced composites still needs further research and exploration.

3.1. Application of FRP in Civil Engineering

At present, FRP materials are mainly applied in two ways. One is to wrap FRP around columns in a circular direction, which is mainly used for repair and reinforcement [2]; the other is to pour concrete in FRP pipes, which is mainly used in new projects. Sticking FRP on the tensile side of the concrete column can bear greater load and effectively avoid further crack expansion. There is obviously a big difference between repairing and strengthening the damaged part of concrete column by FRP and repairing and strengthening the common concrete column by adhesive steel, and the method of calculating the bearing capacity is not the same. The main research direction of domestic and foreign scholars is the flexural section performance, failure deformation degree, load bearing calculation, and the section deformation degree and crack cracking of concrete beams strengthened by FRP. In addition, some scholars have carried out some experimental research and theoretical analysis on FRP prestress reinforcement technology under different loads, such as FRP prestress tension technology, anchorage at the fixed end, loss of prestress and calculation load, transfer of interface stress and improvement of fatigue resistance, and started the practical application in civil engineering.

3.2. Comparative Analysis of FRP and Steel Tubular Confined Concrete Columns

The comparative analysis of the two concrete columns shows the following two points: First, steel pipe can not only constrain the annular direction, but also bear the axial pressure, while FRP is an orthotropic material, which can only bear the pressure and provide the annular constraint. Second, steel is elastoplastic material, can actively constrain concrete; While FRP material is a linear elastic material, the stress-strain curve is approximately an oblique line through the origin, and its constraints on concrete are passive constraints [3]. Since the end of the 20th century, the research focus has shifted to FRP constrained solid concrete columns. This is the most fundamental and typical combinatorial state. In addition, with the enhancement of people's concept of environmental protection, green and sustainable development, the research of natural fiber reinforced composite FRP has been gradually paid attention to. Zeng Jingcheng et al. [4] obtained that the strength of jute fiber reinforced composite (JFRP) was lower than that of glass fiber, but its specific strength was higher because of its low specific gravity. Rong Zheng et al. [5] obtained that the specific strength of JFRP was 1.1~ 1.2 times that of aluminum alloy.

4. Application Prospect of FRP

The future research directions are as follows:

① Study on the stress-strain relationship of FRP constrained concrete columns.

② Comparative study on the performance of natural fiber FRP constrained concrete columns and synthetic fiber FRP constrained concrete columns.

③ The numerical simulation and experimental study of FRP constrained concrete columns are combined.

④ The mixed use of different kinds of FRP will become a new research direction in the future.

⑤ Experimental study on the performance of various new FRP concrete composite structures.

5. Conclusion

Because of its light weight, good hardness, high strength, corrosion resistance and other advantages, FRP as restraint material made of FRP restraint concrete column has a broad application prospect in civil engineering. At present, the research on man-made synthetic fiber FRP has been relatively extensive at home and abroad, but the research on natural fiber FRP binding concrete columns is less, and the reinforcement constraints of mixed FRP need to be further studied.

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