Analysis and Study on Mechanical Properties of GFRP Tubes

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Abstract. Glass fiber reinforced polymer (GFRP) is a new kind of composite material, which combines the advantages of steel bar and concrete, and has the advantages of high strength, strong corrosion resistance and anti-fatigue, etc. In recent years, it has been more and more applied in civil engineering, port, channel and coastal engineering, bridge engineering and other special structures. GFRP material can significantly improve the corrosion resistance of concrete material, and solve the problem that concrete material is prone to corrosion and lead to structure failure in complex environment. At present, the technology is developing rapidly at home and abroad, but in our country, to really apply it widely in engineering construction, we need to further study and analyze the properties of GFRP pipe - concrete composite structure. In this paper, it is concluded that with the increase of eccentricity, the bias bearing capacity of the specimen decreases gradually. With the increase of concrete strength grade, the ultimate bearing capacity is improved. The concrete grade has a great influence on the performance of the specimen. The higher the concrete strength, the stronger the bearing capacity of the structure. The bending performance of GFRP tube composite structure is good.

1. Introduction

At present, due to the limitation of poor corrosion resistance of concrete and weak compressive resistance of steel reinforcement in the field of construction, the advent of fiberglass reinforced composites has found a solution to the disadvantages of the single use of the above materials. GFRP tube is a combination of high strength, corrosion resistance, good tensile performance, light weight, playing an increasingly large role in engineering construction. People's attention is increasing, and they put forward higher requirements for the study of mechanical properties of GFRP tube. Through experiments and discussions, this paper will further study the axial compression performance, bias bearing capacity, bending performance of GFRP tube, and further understand and master the mechanical properties and change rules of GFRP tube, so as to promote the application of GFRP steel tube in engineering construction.

2. Study on mechanical properties of GFRP tubes

GFRP tube is a combination of high strength and light weight, so knowing its axial compression performance, bias bearing capacity and bending performance can promote the application of GFRP steel tube in engineering construction.

2.1. Research and analysis on the bias bearing capacity of GFRP pipe long column

The bias bearing capacity of long column has a great influence on the stability of GFRP tube structure. In the literature[1], Haixia Zhang investigated the influencing factors of the bias bearing capacity of the long column of the internal steel GFRP concrete structure. In this test, through the bias
test of 7 concrete columns with built-in steel GFRP pipes, the calculation formula of the reduction coefficient of bearing capacity affected by eccentricity was established by controlling the strength of concrete, the values of eccentricity and the ratio of length to thickness. On the basis of finite element analysis, the formula for calculating the reduction coefficient of bearing capacity considering the effect of the ratio of length to thickness is derived, and the practical formula for calculating the bearing capacity of combined column bias is established. The theoretical value of the bias bearing capacity formula is in good agreement with the experimental value. From the experimental data in table 1, the variation of the ultimate bearing capacity of components under different value combinations can be obviously obtained.

Table 1 Test parameters and test results

| Number | L/mm | Strength of Concrete | e/mm | Nmin/kN | Nmax/kN | Nmax/Nmin |
|--------|------|----------------------|------|---------|---------|-----------|
| L10-E0-P | 1 000 | C30 | 20 | 30 | 1 553 | 1 026.35 | 1.047 |
| L10-E0-P | 1 000 | C30 | 40 | 20 | 1 130 | 1 226.52 | 1.094 |
| L10-E0-P | 1 000 | C20 | 0 | 20 | 575 | 575.68 | 1.001 |
| L10-E0-G | 1 000 | C30 | 20 | 20 | 1 477 | 1 877.12 | 1.000 |
| L10-E0-G | 1 000 | C30 | 40 | 20 | 1 265 | 1 236.75 | 0.977 |
| L10-E0-P | 1 200 | C30 | 40 | 24 | 1 046 | 1 141.87 | 1.092 |
| L10-E0-P | 1 600 | C30 | 40 | 32 | 849 | 865.52 | 1.013 |

From the experimental phenomena in the literature, it can be concluded that,

1. When the slenderness ratio is changed, as the ratio of length to thickness increases, the bias bearing capacity of the specimen decreases gradually.

2. When changing eccentricity, the results show that the bias bearing capacity of the composite column decreases with the increase of slenderness ratio and eccentricity.

3. At the same eccentricity and slenderness ratio, the increase of eccentricity reduces the influence of concrete strength on the ultimate bearing capacity of the specimens.

Through the experimental analysis, it can be concluded that with the increase of eccentricity, the circumferential restraint effect of GFRP tube on the specimen decreases, so that the bias bearing capacity of the specimen gradually decreases.

2.2. Performance analysis of GFRP tube under axial compression

The GFRP tube can effectively improve the properties of steel bars under axial compression. Based on the results of experimental research and numerical analysis in reference 2, when the GFRP pipe thickness, steel pipe diameter thickness ratio and hollow rate are the same, the ultimate bearing capacity increases with the improvement of concrete strength grade. In reference 2, the larger the pipe diameter is, the greater the increase in bearing capacity will be. That is, the greater the influence of concrete grade on the performance of specimens.
Figure 2 Curve diagram of axial load changing with concrete strength grade

The effects of different parameters on axial compression properties have been discussed in different aspects such as diameter, thickness and winding Angle of GFRP tubes\cite{4}. According to the change curve in the literature, with the increase of the diameter of GFRP tube, its axial pressure also increases, and the ultimate bearing capacity increases with the increase of the wall thickness. Compared with ordinary concrete-filled steel tube columns, the ultimate load and ductility are obviously improved.

Figure 3 The curve of axial load changing with the thickness of steel tube

In the research of axial bearing capacity, the theoretical analysis\cite{4}, experimental study and finite element simulation of GFRP tube concrete column under axial compression are carried out, and the mechanical properties of GFRP tube concrete column under axial compression are mainly studied, as well as the axial compression capacity under water immersion environment and seawater immersion environment. The results show that the three formulas for calculating the axial bearing capacity of GFRP tube concrete based on GFRP tube yield criterion, Hoffman yield criterion and tsay-hill yield criterion modified by Zhenming Wang can be used to calculate the axial bearing capacity of GFRP tube confined concrete column. The ultimate bearing capacity and deformation performance of GFRP tube concrete short column are influenced by water and seawater immersion environment. The conditions of water immersion and seawater immersion reduced the bearing capacity of the short columns to some extent. The fiber winding Angle, the thickness of GFRP tube and the strength of concrete have effects on the axial bearing capacity and deformation capacity of GFRP tube concrete short column.

2.3. Effect of concrete strength on mechanical properties of GFRP tubes

The strength of concrete has a certain influence on the bearing capacity of GFRP pipe. In the literature\cite{5} of GFRP tube steel reinforced concrete composite column under axial compression test and numerical simulation research, according to the results of the test and numerical analysis to study the
effect of concrete strength of composite column size effect, and ultimately determine the concrete strength of specimen size effect exists, the specimens under the condition of the same size, the higher the concrete strength is, the stronger the carrying capacity of the structure will be, but the ductility is poor; With the increase of concrete strength, the limit stress of the specimen decreases. That is, the increase of concrete strength will weaken the effect of bearing capacity size effect. With the increase of concrete strength, the decrease of failure strain of specimen also decreases.

2.4. Study on bending properties of GFRP tubes

The literature[6] mainly studies unidirectional tensile test of GFRP, mechanical analysis of composite beam GFRP tube, whole-process analysis of flexural performance of composite beam, analysis of two theoretical failure modes of composite beam and flexural performance of composite beam. Literature 5 analyzes the whole process of flexural performance of hybrid fiber concrete composite beams with GFRP tubes in compression zone, and concludes that this new structure has a great effect on the ultimate load of beams, and composite beams also have good secondary stiffness. GFRP tube structure is conducive to the development of structural ductility, so as to ensure the safety and practicability of composite beam structure, thus extending the durability of the structure.

3. Conclusion

As a new composite structure, GFRP tube has the advantages of convenient construction, high strength and strong ductility. In this paper, the factors influencing the long column bias bearing capacity, axial compressive properties and bending properties of GFRP tubes are analyzed, and the mechanical properties of GFRP are further elaborated based on theoretical analysis and experimental data, which provides certain theoretical basis for subsequent applications. In order to accelerate the application of GFRP tubes, the following aspects need to be further studied,

(1) Researchers should strengthen the research on catastrophic effects of GFRP tube structures under strong earthquakes and typhoons, so as to ensure the reliability of the application of such composite structures.

(2) Researchers should strengthen the research on the dynamic response characteristics of GFRP tube composite members and structures under the accidental action of impact and explosion load, so as to promote the application of GFRP tube in building structures.

(3) Researchers should strengthen the research on the stability of GFRP tubes and seek solutions to increase the structural stability.

Reference

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