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Discussion on Bond Connection Test of GFRP Sleeve

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Abstract

Because of its many technical advantages and material properties, GFRP materials are becoming more and more popular in the engineering field. However, because the anchoring strength of GFRP bolt is far less than its tensile strength, its application in geotechnical engineering is limited. Based on this, this paper uses steel sleeve bond anchorage, adopts three kinds of GFRP bolts with different diameters, and pull-out tests with sleeve anchorage. The following main conclusions are drawn as follows：(1) The whole process from the beginning of loading to the ultimate load is elastic deformation. When the ultimate load is reached, the specimen breaks, which is a kind of brittle failure.(2) Under the same anchorage length, the displacement of GFRP bolt increases with the increase of diameter, but the increasing rate slows down.(3) In the anchorage end of sleeve cementation with planting bar glue, the chemical adhesive force and mechanical bite force of GFRP and planting bar glue are greater than the ultimate tensile strength of the rod itself, and the sleeve bonding anchorage is an effective anchorage method.

Keywords

FRP, GFRP anchor, Sleeve bond, Anchorage strength.

1. Introduction

In recent years, steel bolt is almost used in all aspects of civil construction, but there are some outstanding problems in its application, such as: serious corrosion of steel bolt, high cost of anti-corrosion treatment, self significant, transportation and installation difficulties. These defects of steel anchor restrict the application of steel anchor to a certain extent, especially the corrosion of steel anchor not only affects the durability of the structure, but also causes serious engineering accidents. Especially in the port and hydraulic structure, bridge, garage, wastewater treatment plant and other water environment conditions, the reinforced concrete structure is usually subject to deicing salt, humidity, temperature change, industrialization In corrosive or exposed environment, corrosion of steel bars is a very serious problem. Corrosion of steel bars will cause early deterioration of concrete structure, leading to degradation of structural strength attenuation and other performance, and then shorten the service life of the structure.

In order to solve the problem of anti-corrosion of steel bolts, FRP bars are introduced to the traditional steel bars of different concrete structures to replace the traditional steel bars under the harsh environmental conditions such as wastewater treatment and chemical plant, seawall and water structure. In Europe, the research and development of GFRP reinforced materials began in the 1980s, and the early research and development work mainly concentrated in Germany. In 1986, the prestressed GFRP reinforcement was applied to a heavy truck bridge in Dusseldorf, and the world's first highway bridge beam with FRP post tensioned cable was built [1]. In the early 1990s, the labor protection and safety administration of the former Soviet Union and the Mining Bureau jointly

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established a project of trial production of anchor bolts with glass fiber as reinforcement material and multi strand polymer material. The first batch of anchor bolts were trial produced in 1991 and underground industrial tests were carried out. In Germany and Austria, GFRP reinforcement has been used to strengthen seven highway bridges and pedestrian overpasses [2]. Hao qingduo [3] et al.the bond performance between GFRP Bars and concrete was studied through pull-out test, and the optimal shape of GFRP Bars was determined. Yan Shilin [4]et al. studied the bond performance between GFRP Bars and concrete through pull-out test. It was found that using GFRP Bars instead of ordinary steel bars in beams can make beams bear higher failure load and better corrosion resistance. Ma Jian [5] et al. found that the failure initiation point of most specimens occurred in the reinforced section of the sleeve when the GFRP reinforcement material strengthened by the cemented sleeve was tested in tension.

However, the anchorage strength of GFRP anchor head is far from the tensile strength of GFRP reinforcement, which may lead to the failure of the anchorage system due to the damage of the anchor head structure. Therefore, it is one of the key factors whether GFRP bolt can be widely used to enhance the anchoring strength of GFRP bolt head.Based on this, this paper uses the steel sleeve adhesive anchorage to improve the stiffness of the anchorage and protect the reinforcement from damage due to the excessive transverse stress. In this test, three kinds of GFRP bolts with different diameters were used, and the pull-out test was carried out with sleeve bonding anchorage. Based on the failure mode and load displacement curve of the test piece, the strength and anchorage mechanism of the anchorage end are analyzed, the bond strength of the anchorage end when the ultimate load is reached is calculated, and the feasible suggestions for strengthening the anchorage strength of the anchorage head are put forward. Through this study, it is hoped that GFRP bolt can be understood by more engineering people and applied to the engineering site, so as to reduce labor cost, reduce engineering cost and the durability of anchoring engineering, and provide some references for GFRP bolt to better serve the rock and soil anchoring engineering.

2. Bond Drawing Test of GFRP Sleeve

2.1 The Experimental Scheme

Referring to the existing FRP reinforced concrete experimental literature, five GFRP bonded sleeve specimens were made in this experiment. The two ends of GFRP reinforcement are inserted into steel sleeve, and the gap is filled and cemented with planting rubber reinforcement. After the cementation strength is fully developed, the drawing test is carried out under WAW-1000 microcomputer controlled electro-hydraulic servo universal testing machine. This test is a failure test to determine the anchoring strength and anchoring mechanism of GFRP Bars.

Figure1. Experimental setup diagram

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2.2 Test Device and Loading

Check the test piece before the pull-out test. If there are test pieces with more broken fibers or manufacturing defects in the test pieces, they shall be discarded.

The test content of this test is to study the bond performance of GFRP reinforcement and planting reinforcement adhesive. The bond length is 17cm, and the bond stress can be considered as uniform distribution. Therefore, the measurement content of this test includes the relative slip of the loading end and the load of the loading end, so as to analyze the anchoring strength of the anchoring end.

This test is a failure test. When the GFRP reinforcement is pulled or pulled out from the anchorage end, the test will be stopped. The bond drawing test of GFRP sleeve was carried out on the hydraulic universal testing machine. The drawing force was controlled by universal testing machine and computer intelligence, and recorded every second.

3. Test Results and Analysis

3.1 Experimental Phenomena

In the process of loading, when the load reaches 40% ~ 50% of the maximum load, the damage of the test piece will be heard to produce a slight cracking sound, which will last all the time; when the load reaches about 60% ~ 70% of the maximum load, the sound of fiber breaking and fiber peeling off from the resin can be heard, and the sound will also increase with the load Then it increases and becomes denser gradually. The white spot crack appears on the surface of the failure part in the middle of the specimen. At last, it suddenly makes a big fracture sound, and the specimen suddenly breaks. After taking out the test piece, it was observed that the glass fiber was separated radially, and the test piece broke into two parts.

3.2 Bond Anchorage Mechanism

The bond performance of GFRP bolt and planting bar glue is the main problem in the study of bond strength of GFRP bolt sleeve. The bond stress between GFRP bolt and planting glue transfers the load to GFRP bolt. Generally, the bond between GFRP bolt and planting glue consists of the following parts: chemical glue force between GFRP bolt and planting glue; friction force between GFRP bolt and planting glue; mechanical bite force between GFRP bolt thread and planting glue; pressure produced by hardening shrinkage of planting glue on GFRP bolt Force, etc. In the early stage of drawing test, chemical adhesive force is dominant. Later, with the increase of load and displacement, the strength of chemical adhesive began to be destroyed, friction and mechanical engagement gradually developed, and gradually became the main part of bonding. For GFRP anchor specimens, at the initial stage of loading, the load is mainly borne by the chemical bond and friction between the substrate and GFRP anchor surface. Later, with the increase of load, the GFRP bolt was pulled out, but at the anchorage end, the bolt was not pulled out. In this process, friction and mechanical engagement were dominant.

Figure2. Failure diagram of test piece

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3.3 Failure Mode Analysis

In this test, there is only one kind of tensile failure of GFRP Bars and anchor bolts, and the fracture of the test piece becomes two parts, but there is no pull-out failure of anchor bolts at the anchorage end of the sleeve, which shows that the chemical adhesive force and mechanical bite force of GFRP Bars and the planting adhesive at the anchorage end of the sleeve are greater than the ultimate tensile strength of the rod itself, and the bonding and anchoring of the sleeve is an effective anchoring method.

4. Conclusion

The application of GFRP anchorage technology in engineering practice is based on the fact that the anchorage end strength of GFRP anchor is greater than the tensile strength of steel bars. In recent years, some foreign experts and scholars have made some achievements in the research and engineering application of GFRP bolts. The domestic research in this field started late, and the practical application in engineering is basically blank. In this paper, based on the pull-out test, the bond pull-out specimen of GFRP sleeve is studied. Observe the stress process and failure form of the specimen, measure the load displacement curve and bond strength; analyze the bond performance and anchorage strength of GFRP bolt sleeve bonded by different loading rates under the same diameter, and draw the following main conclusions:

(1) The whole process from the beginning of loading to the ultimate load is elastic deformation. When the ultimate load is reached, the specimen breaks, which is a kind of brittle failure.

(2) Under the same anchorage length, the displacement of GFRP bolt increases with the increase of diameter, but the increasing rate slows down.

(3) In the anchorage end of sleeve cementation with planting bar glue, the chemical adhesive force and mechanical bite force of GFRP and planting bar glue are greater than the ultimate tensile strength of the rod itself, and the sleeve bonding anchorage is an effective anchorage method.

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