Principle and overview of steel pipe sleeve grouting connection

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Abstract

With the continuous acceleration of urbanization in China and the continuous improvement of building structure design and construction level, the concrete-filled steel tubular structure has been greatly developed. At the same time, the safety and reliability of concrete-filled steel tubular joints has become a key technical issue and an important determinant of the widespread application of fabricated CFST structures. This paper describes the form and failure mode of steel pipe sleeve grouting connection and introduces the research status of the industry.

Keywords

Assembled structure; steel pipe sleeve grouting connection; failure mode.

1. Preface

Since the beginning of the 21st century, with the continuous acceleration of China's urbanization process and the continuous improvement of building structure design and construction level, the prefabricated concrete structure has been increasingly used in practical engineering for its unique advantages such as industrialization.

A fabricated steel tube concrete structure is one of the assembled structures that has emerged in recent years. Injecting concrete into steel pipes takes advantage of both materials. Assembled structures produce a large number of seams and joints during installation. The mechanical properties of these joints determine the stability and seismic performance of the entire fabricated structure. Therefore, the stability of the node determines whether the fabricated structure can be put into use in large quantities.

2. Connection form and damage form

Conventional concrete-filled steel tubular column connections are often welded or flanged, but are difficult to use due to more restrictions during installation. The sleeve grouting connection has the advantages of safe construction, simple operation and reliable connection.

2.1 Connection form

The sleeve grouting was initially applied to the connection of the pile legs and the foundation steel pipe piles in the offshore platform, as shown in Figure 1. The cement-based grout is poured between the steel pipe and the sleeve to reduce the flexural deformation of the steel pipe and prevent corrosion. The strength of the joint depends mainly on the bond strength of the steel pipe and the grouting contact surface. The bonding force between the steel pipe and the grouting material is mainly composed of three parts: chemical bonding force, friction force and mechanical biting force between the steel pipe and the cement slurry. The sleeve grouting connection mainly has three configurations of a semi-sleeve type, an inner sleeve type and an outer sleeve type.

The sleeve grouting connection includes two configurations of setting the anti-shearing key and not setting the anti-shearing key, as shown in Fig. 1.

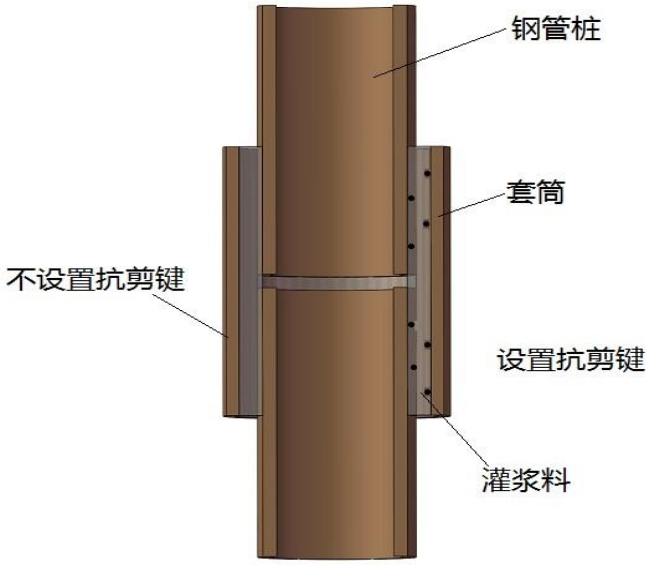
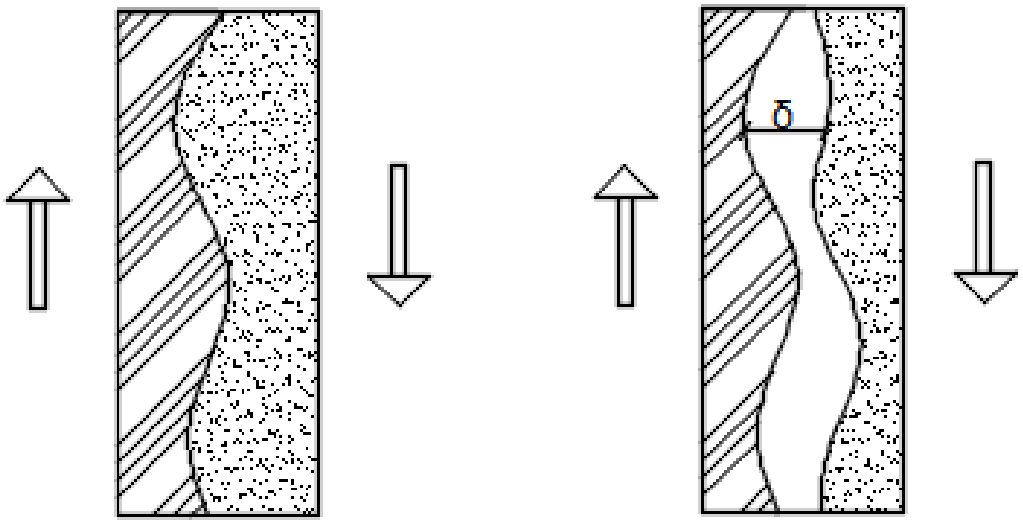


Fig. 1 Grouted sleeve connection diagram with and without shear keys

2.2 Destruction form

When the shear key is not set, the damage is usually the slip between the outer side of the steel pipe and the contact surface of the grout. Generally, it is divided into two stages under the action of axial force: the first stage is before the bond failure; the second stage is after the bond failure (as shown in Fig. 2).



(a) Before the bond breaks (b) After the bond is destroyed

Fig. 2 The failure models in different stages of grouted sleeve with shear keys

When the load-free joint of the non-shearing key sleeve is subjected to the load, the cementing force acts first. When the shear stress between the grout and the steel pipe exceeds the bond stress, the bond is broken and cannot be recovered, and the sleeve without the shear bond is The bearing capacity of the barrel grouting connection can only be borne by the mechanical bite force and friction generated by the unevenness of the surface of the steel pipe.

When the sleeve grouting connecting member with the shearing key is subjected to the load, the damage is mainly divided into four stages [1, 2] as shown in Fig. 3.

(1). Cracking stage: In the 0 ~ τcr section of the figure, the stress growth mode of the connection increases approximately linearly. As the load value increases, the grouting begins to break. At this time, the chemical adhesion of the steel pipe and the grouting material fails at the anchoring length.

It is converted into the bearing capacity of the joint by the friction between the grout and the steel pipe and the mechanical bite between the shear bond and the grout.

(2). Development stage: τcr ~ τu section in the figure, the load value has reached about 90% of the ultimate bearing capacity, which is very close to the ultimate bearing capacity. At this time, the growth rate of the bearing capacity is once again reduced, and it enters a slow growth stage. From the development of the horizontal axis at this stage, the displacement growth rate of the connection is intensified.

(3). Falling section: In the figure τu ~ τr, the load value has been added to the ultimate load, but the loading is still continuing. At this time, the bearing capacity of the joint is reduced, and only the mechanical bite between the steel pipe and the grout is taken.

(4). Residual section: As the loading continues, the grout between the steel tube and the sleeve is crushed, the load value is reduced, and finally stabilized at a small load value until the steel tube is completely separated from the grout.

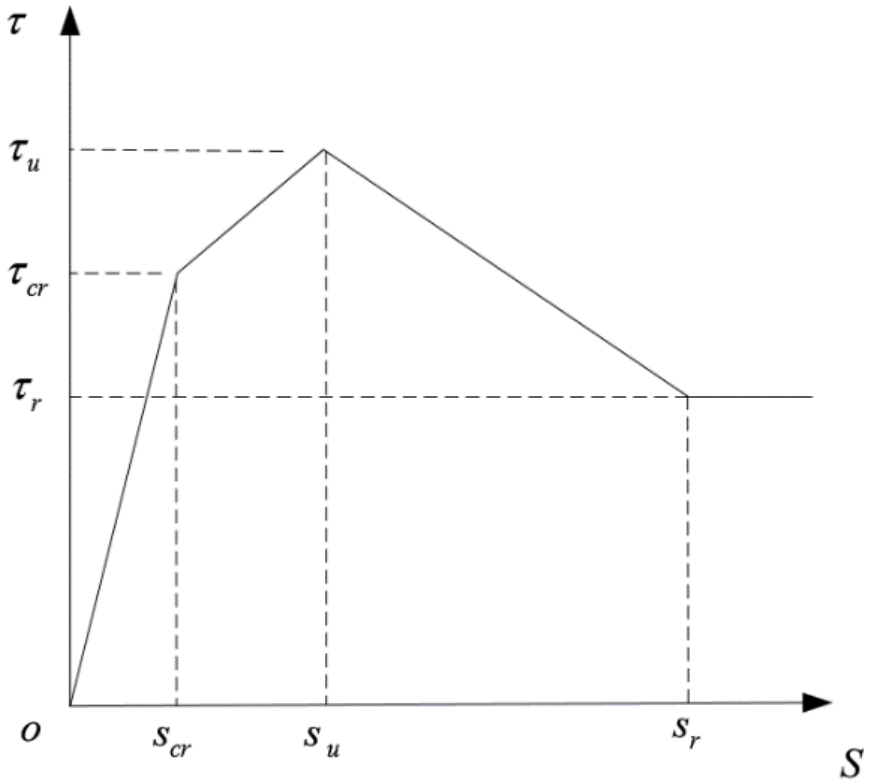


Fig. 3 Bond slip relationship of sleeve grouting joint

3. Research status

Jiang Shouchao [3] and other experimental and finite element analysis of the perfusion expansion cement slurry casing under the two conditions of pure bending and bending shear. Through experiments, it is found that the perfusion expansion cement slurry casing joint has high bearing capacity under static load and has good ductility. A reasonable analytical model is established in the finite element analysis study, and the perfusion expansion cement slurry casing is obtained. The stress distribution of the grouting body and the inner and outer tubes under external load is compared with the test results, and the reliability of the analytical model is verified.

Based on the theory of elastic mechanics, Jiang Shouchao [4] derived the initial stress distribution caused by the expansion of cement slurry in prestressed grouting casing, and gave its analytical solution. The initial stress with cement slurry was discussed through an example. The law of variation of body free expansion rate, steel pipe size, cement slurry thickness and other factors.

4. Conclusion

The steel pipe sleeve grouting connection has excellent performance and also has great advantages in terms of cost. This connection method is also very convenient to construct. Steel pipe sleeve grouting connection has important engineering value and theoretical significance for the development of fabricated steel tube concrete structure and will bring considerable economic benefits.

References

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