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A kind of new type composite structure column of research

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Abstract. Steel tube confined concrete structure and FRP-confined concrete structure were researched and widely applied in structure engineering current years. Based on the advantage and disadvantage of the two types of structure, a new type of structure named FRP-steel composite pipe confined concrete is proposed. Moreover, the feasible and advantageous about the application of this new type in structure engineering is stated. The development prospects of this new type of structure are mentioned as well.

Introduction

The concrete-filled steel tube (CFST) was used in civil engineering since more than 100 years. Due to the favorable mechanical properties and good construction performance, CFST is widely applied in many fields [1-3].With the technology development and the higher performance requirements of structures, it is necessary to improve the mechanical properties and construction performances. Therefore， the steel tube confined concrete structure (STCC) and the FRP-confined concrete structure (FCC) appeared one after another. None of the existed types of structure possess perfect performances but owned their certain defects. To overcome the shortage and make benefit of STCC and FCC, a new structure named CFRP-steel composite pipe confined concrete (FSCC) is proposed.

As shown in Fig1, FSCC is composited by tubes with outer FRP sheet and inner steel tube and concrete filled in tube. Furthermore, the tubes of FSCC with do not bear loads. The configuration of beam-column joint is showed in Fig2.

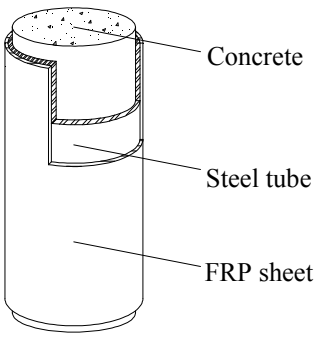

Fig. 1 CFRP-steel composite pipe confined concrete

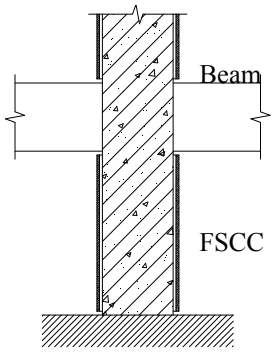

Fig. 2 The configuration of beam-column joint

Steel tube confined concrete structure

Owing to the high bearing capacity，favorable deformability， good energy dissipation and easy beam-column joint construction, STCC is applied in high-rise buildings and bridge construction, structure strengthening and repair in recent years.

Research and application status of steel tube confined concrete structure. The excellent mechanical performance of STCC was found by Gardner in 1967[4]. For preventing shear fracture in reinf-orced concrete framed short column or side column, the tubed reinforced concrete columns

(tubed c-olumn) which were presented by Tomii and Sakinoet.al [5] in 1985 for the first time. Nowadays, there are a large number of scholars investigate the characteristic of STCC in different aspects. At home, the main studies in the follow are: Yuyin Wang[6]studied finite element analysis of axial bearing capacity of circular tube confined concrete short columns, Huilan Guo and Sumei Zhang[7]et.al did the experimental research of concrete-filled square hollow section steel tubes, Yan Xiao and Yurong Guo[8]et.al, retrofit of reinforced concrete columns using partially stiffened steel jackets; Xuhong Zhou and Jiepeng Liu[9] et.al, experimental study and theoretical analysis of steel tube confined concrete on seismic behavior and static behavior.

Currently, the applications of STCC structure increasing widely in structure engineering. In the three northeastern provinces, STCC is used in many constructing and completed projects, such as Dalian Gymnasium, Dalian Stadium, China's oil building in Dalian, Dandong Stadium and Heilongjiang Museum, the super high-rise building structure and bridge. STCC could also be applied in reinforcing or repairing of bridges and housing structure [10].

The shortcomings of the STCC. To bear the heavy loads, STCC needs high bearing capacity. Increasing section dimension of concrete is a way to enhance bearing capacity. The thick wall tube and high-strength tube is needed to provide sufficient constraint for the increased concrete. At the same time, more steel with higher cost is to be demanded. It is an issue to enhance the bearing capacity of STCC without increasing cross section dimension and cost.

FRP-confined concrete structure

Fiber reinforced plastics (FRP) is a new material which composed of fiber and matrix material with high performance such as high tensile strength, good corrosion resistance, light weight, good applicability and so on. FRP is wrapped outside the concrete of FCC to significantly improve compressive strength of concrete [11].

Application status of FCC. Nowadays, FRP is mainly used in reinforcing and confining concrete both in existed structures and constructing structures. With a widely application in civil engineering, the investigation of FCC developed rapidly in last decades. Nevertheless, the high cost of FRP structure lacks its competitive. Due to the characteristics of FRP as brittleness and inadequate ductility, the main failure mode of FCC is rupture of FRP sheet which is wrapped outside the concrete column.

To overcome the shortage of STCC and FCC, a new type of structure named circular CFRP-steel composite pipe confined concrete is proposed. The bearing capacity greatly is improved with less increased section area of FSCC and smaller increased thickness of steel tube than which of STCC. Comparing with FCC, FSCC seems easier to be popularized since the lower costs which induced by the lower usage amount and the improved ductility.

Preliminary analysis of feasibility of FSCC

Preliminary analysis of feasibility. The materials of CFRP sheets and steel tube wrapped outside of FSCC have low Poisson's ratio, high ring stiffness and high strength. Therefore, a good confining force for concrete core could be supplied by CFRP sheets and steel tube. Comparing with steel, FRP sheet possess higher strength but similar Poisson's ratio [12] which seems able to provide a certain confining force for steel tube [13]. Generally speaking, the FSCC proposed above is available.

Other questions and solutions. Since the complex interaction of FRP and steel, the research of FSCC is difficult. There are several key problems in the investigation of FSCC, such as the interaction and relationship of CFRP, steel and concrete, the confine effect, the configuration rate of CFRP, and so on.

The models of material are proposed as follow: linear elastic model for CFRP, five line model for steel (elastic, elastic-plastic, plastic, strengthen, second plastic flow); the model for concrete should be made by experimental results, theoretical calculation and the existed concrete model which is based on the former study of STCC.

According to the existed research of STCC and CFCS [10,14], the interaction between steel and concrete can be measured with confinable effect coefficient of steel (ξ_s):

$$\xi_s = A_s f_y / (A_c f_{ck}) \quad (1)$$

Where A_s is cross sectional area of steel tube, f_y is yield strength of steel, A_c is cross sectional area of core concrete, f_{ck} is compressive strength of concrete cylinder.

So, confinable effect coefficient of FRP to concrete (ξ_{cf}) also present similar concepts:.

$$\xi_{cf} = \eta A_{cf} f_{cf} / (A_c f_{ck}) \quad (2)$$

Where A_{cf} is cross sectional area of FRP tube, f_{cf} is tensile strength of FRP, η is reduction factor.

So, total confinable effect coefficient of steel and FRP is:

$$\xi = \xi_s + \xi_{cf} \quad (3)$$

the Eq (3) could present as follow:

$$\xi = \xi_s (1 + \xi') \quad (4)$$

Where ξ' is the collocation rate of FRP. The FSCC will be close to FCC and STCC with ξ' increasing and decreasing, respectively. The coefficient ξ' can be expressed as :

$$\xi' = \xi_{cf} / \xi_s = \eta A_{cf} f_{cf} / (A_s f_y) \quad (5)$$

Concluding remarks

A new structure named FSCC, which is based on STCC and FCC, is proposed in this article. To avoid the use of thickness or high strength steel tube, lightening the dead weight and reducing the costs in large scale STCC, FSCC is applied. The material of FSCC outer tube, which composited of FRP and steel, can improve the ductility of FRP material in FCC. This new structure named FSCC which has favorable performance is of a good application prospects in civil engineering.

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