EXPERIMENTAL INVESTIGATION ON BOND STRENGTH IN COVENTIONAL CONCRETE FILLED STEEL TUBE-A REVIEW

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Abstract

In this paper, the bond behavior between the steel tube and the conventional concrete in concrete-filled steel tubes (CFST) is investigated. A series of push-out tests on circular CFST specimens going to be conducted, and the main parameters considered in the test program were: (a) cross-sectional dimension; (b) steel type (galvanized steel); (c) concrete type (normal with addedd glass fibres); (d) concrete age (28 days); and (e) L/D ratio. To conduct the following push out test to find out the bond strength of conventional concrete filled steel tube the review on the following paper is cared out in this paper.

Keywords: Bond strength, Concrete filled steel tubes, Push out test

I. Introduction

Composite steel concrete construction has been widely used in many structures such as building and bridge. The concrete encased composite column is one of the common composite structural elements. At the same time, due to the traditional separation of structural steel and reinforced concrete design and construction, this type of column has not received the same level of attention as steel or reinforced concrete column. Composite structures from concrete steel section show considerable larger stiffness, stability and load carrying capacity in comparison with steel construction. An increase of corrosion and fire resisting is an addition advantage of concrete element. Recently many studies have examined the behavior and strength as well concrete encase composite column.

In the mid-1980s several buildings constructed in Seattle, Wash., became well known for use of concrete filled-tube column. Most of these building were high rises that utilized CFT as primary column in the lateral load resisting frame. The notoriety of these building systems was due to the large diameter CFTs used ranging from 2.3 to 3.2 m, and to the use of high-performance concrete, with target strength of 96 MPa and cylinder strength of 130 MPa. The depth to wall thickness ration of these large dimension columns ranged from 180 to 250 and length- to-depth ratios ranging from 2 to 14. Although stiffness was the primary concern for these large columns, the calculation strength of these CFTs was extrapolated from result of small-scale test specimen with quit different material and column properties. Although these large composite columns are beyond the scope of current design specification, smaller CFTs were also used in low to mid-rise construction project. CFTs were used in braced frames, and smaller percentages were used in moment resisting frames.

II. Review of literature

M. Hunaiti1 1991, Tests on 135 battened composite specimens are performed to investigate the bond between concrete and steel in battened composite columns. Several factors believed to affect the bond between the two materials are investigated, including age and size of specimen, curing, and temperature. The test results of this investigation show that the battened composite section offered less bond strength than the concrete-filled tubes tested elsewhere. Experimental evidence also shows that age of concrete is a major factor of bond reduction. The strength of bond at the age of one year is about 30% of that at the age of three weeks. The size of the specimen, which affects the shrinkage and the confinement of the concrete, proves to be a significant factor of bond reduction. Curing of concrete also proves to be a contributing factor to the strength of bond. Increase in temperature reduces the strength of bond. The reduction is significantly higher for high temperatures. At 600° C the bond strength is less than 20% of that at room temperature.

Chang Xu 2007, The expansion/shrinkage behaviors and bond carrying capacities of 17 short, pre-stressing concrete filled circular steel tube columns by means of expansive cement and three short, conventional concrete filled circular steel tube columns are experimentally investigated. The results indicate that both concrete mixes and dimensions of the steel tube have important influence on expansive behaviors of PCFST specimens. The pre-stress in concrete core is a sensitive parameter to the bond strength as well as the load–slip relationship. The current work also indicates that PCFST columns have much higher bond strength than CFST columns and this recommends a new method to improve the bond strength of composite structures. Finally, an empirical equation for predicting the bond strengths of PCFST columns is proposed.

Zhong Tao 2010, Push-out tests were carried out on 64 concrete-filled steel tubular columns, which had been exposed to ISO 834 standard fire for 90 min or 180 min, respectively. At the same time, 12 unheated specimens were also prepared and tested for comparison. The variables investigated in the bond tests were selected as fire exposure time, cross-section type, cross-sectional dimension, interface length to diameter ratio, concrete type, fly ash type and, concrete curing condition. The effects of the above different parameters on the bond behavior are discussed. The test results indicate that fire exposure had a significant effect on the bond between a steel tube and its concrete core. A decrease in bond strength was generally observed for specimens after a fire exposure of 90 min however, bond strength recovery was found when the fire exposure time was extended to 180 min. Other factors also had influence to some extent.

Xiushu Qu 2012, Load-reversed push-out tests have been carried out on 6 rectangular concrete-filled steel tubular columns with the aim of investigating the nature of the bond between the concrete infill and the steel tube, the contribution of each bond stress component and the development of macro locking within four half-cycles of loading. The contribution of micro locking to the total bond strength was obtained from the comparison between the ultimate strength of normal specimens and lubricated specimens, which also revealed the detrimental effect of lubrication on the bond strength. The macro locking contribution was obtained from the comparison between the ultimate strength achieved in the first half-cycle of loading and the ultimate strength achieved in the third half-cycle of loading of the non-lubricated specimens. The developed bond mechanisms were explained and details of the interface bond stress distribution were obtained from the recorded axial strain gradients in the steel tube. Finally, the concept of a critical shear force transfer length was introduced, and its implications on practical design discussed.

Xiushu Qu 2015, Push-out tests have been conducted on 18 rectangular concrete-filled steel tubular (CFST) columns with the aim of studying the bond behavior between the steel tube and the concrete infill. obtained load-slip response and the distribution of the interface bond stress along the member length and around the cross-section for various load levels, as derived from measured axial strain gradients in the steel tube, are reported. Concrete compressive strength, interface length, cross-sectional dimensions and different interface conditions were varied to assess their effect on the ultimate bond stress. The test results indicate that lubricating the steel-concrete interface always had a significant adverse effect on the interface bond strength. Among the other variables considered, concrete compressive strength and cross-section size were found to have a pronounced effect on the bond strength of non-lubricated specimens for the range of cross-section geometries considered, which is not reflected in the European structural design code for composite structures, EN 1994-1-1. Finally, based on nonlinear regression of the test data generated in the present study, supplemented by additional data obtained from the literature, an empirical equation has been proposed for predicting the average ultimate bond strength for SHS and RHS filled with normal strength concrete.

Zhong Tao 2016, In this paper, the bond behavior between the steel tube and the concrete in concrete-filled steel tubes is investigated. A series of push-out tests on circular and square CFST specimens were conducted, and the main parameters considered in the test program were cross- sectional dimension, steel type, concrete age and interface type. The experimental results indicate that stainless steel CFST columns have lower bond strength compared with carbon steel counterparts, and the bond strength decreases remarkably with increasing cross-sectional dimension and concrete age. To enhance the bond strength, welding internal rings onto the inner surface of the steel tube is the most effective method, followed by the methods of welding shear studs and using expansive concrete.

Yu Chen 2016, This paper presents the repeated push-out tests on concrete-filled stainless steel circular hollow section (CHS) tubes with different values of height-to- diameter ratio, diameter-to-thickness ratio and concrete strengths. The bond-slip behavior of all specimens and the strain distribution on the exterior of stainless-steel tubes along the longitudinal height direction were carefully investigated. It was found that the shear failure loads of bonding slip decreased successively with more loading cycles of the repeated push-out test employed in the same direction. Hence, the mechanical interlock force and friction force of the interface elements gradually decreased. Furthermore, the bond-slip failure of the interface elements between the inner concrete and outer stainless-steel tube of the specimens consists of the adhesive stage, the sliding stage and the friction resistant stage. It can be generally concluded that 70% of the shear resistance of the bonding strength is taken by the interface friction force, while the remaining 30% of the shear resistance of the bonding strength is sustained by the chemical adhesive force and the mechanical interlock force. On the other hand, it was demonstrated that the height-to-diameter ratio and the diameter-to-thickness ratio of the stainless- steel tube as well as the concrete strength have insignificant influence on the shear resistance of the bonding strength of the interface elements. It was also shown from the comparison that the current design rules of concrete-filled carbon steel CHS tubes are inapplicable to the shear resistance of the bonding strength of concrete-filled stainless steel CHS tubes.

Zhong Tao 2017, Extensive studies have been conducted into the bond behavior in concrete-filled steel tubes at ambient temperature. However, the bond behavior of CFST columns subjected to fire is still unclear. A total of 24 push-out tests were conducted to investigate the bond strength of CFST columns at elevated temperatures, 12 reference specimens at ambient temperature, and 16 postfire specimens were also tested for comparison. The main test parameters explored in this test program include: steel type, concrete type, cross-section type, interface type, temperature level, hold time period of heating, and applied axial load during heating. The experimental results indicated that the bond of specimens with normal interface could be completely broken in fire. However, welding internal rings or shear studs onto the inner surface of the steel tube can effectively retain a portion of the bond strength in fire.

Ran Feng 2018, A total of 32 push-out tests were conducted in this paper on concrete- filled stainless-steel square hollow section (SHS) tubes with different values of height- to-width ratio, width-to-thickness ratio and concrete strength. The bond-slip behavior of all specimens and the strain distribution on the exterior of stainless-steel tubes along the longitudinal height direction were carefully investigated. Shear failure loads of bonding slip and the interface friction resistance generally decreased with more loading cycles of the repeated push-out test employed in the same direction. It can be concluded that 70% of the bonding strength at the interface was taken by the friction force of the interface elements, while the remaining 30% of the bonding strength at the interface was sustained by the chemical adhesive force and the mechanical interlock force. Furthermore, the strains at the locations close to the free end and loading end of the specimens increased with the increase of the axial load, in which the increase of the strains at the location close to the free end is much greater. On the other hand, it is demonstrated that the height-to-width ratio and the width-to- thickness ratio of the stainless steel SHS tube have insignificant influence on the shear resistance of the bonding strength of the interface elements, which generally decreased with the increase of the concrete strength. In addition, the current design rules of concrete-filled carbon steel SHS tubes were found to be inapplicable to the shear resistance of the bonding strength of concrete-filled stainless steel SHS tubes.

III. Inference

following inferences were taken out from the above review on CFST columns papers.

1. 70 % Bond strength of the CFST steel tubes is mainly taken by the friction force of the interface elements and remaining 30% of the bonding strength at the interface was sustained by the chemical adhesive force 2. The expansion/shrinkage behaviors of the concrete used in CFST columns have reasonable effect on bond strength. If concrete shrinks more the bond strength of the CFST columns will decrees. If concrete used is an expansive concrete it will incorporate internal stress which will increase the internal friction between concrete and steel tubes surface which increase the bond strength of concrete 3. The temperature effects will also disturb the bond strength of CFST columns were increase in the temperature will reduce the bond strength 4. The cross-sectional dimensions like thickness and internal diameter of the steel tubes will affect the bond strength of the CFST columns were increasing in internal diameter of steel tube will digress the bond strength of the concrete of same length 5. Length by depth ratio of the CFST columns as a significant effect on the bond strength. were bond strength increase with the increase of L/D ratio of CFST column 6. Type of internal inter face of the steel tube will also affect the bond strength of column 7. And also, the mix design of concrete has a reasonable effect on the bond strength

by following methods, the bond strength of concrete filled steel tubes cane be increased

1. By increasing L/D ratio
2. By using expansive concrete
3. By increasing the strength of Concrete
4. And by increasing internal perforation of the interlocking surface of steel tubes by means of welding internal rings in intervals and providing welding dotes inside the steel tubes

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