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A Study on the Structural Performance of CFT Column with Inner-sided Corrugated Rib

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Abstract. There were number of studies about unprotected CFT columns for improving their fire resistance through reinforcing bars or plates being placed inside the steel tube. But it was also known that the flat type of reinforcing plates need stiffeners in a certain distance to avoid their buckling failure so it costs as much as their used amounts consequentially.This paper investigates the contribution of rib elements attached inner side of steel tube for higher bond strength between steel and concrete and fire performance with no protections. Test results also present the work of corrugated rib's shape against fire, the microstructure of concrete and the benefit of a paper drain being able to let the redundant water out through some points of holes on the tube. Discussions on rib's design could be followed after some more fire tests accordingly conducted within this series of project.

Keywords: CFT Column, Corrugated Rib, Fire Resistance, Bond Strength, Paper Drain

1. Introduction

Concrete-filled in tube(CFT) system is not widely applicable for real buildings due to its limitations and specification according to resistance to fire, even it is known that the system of CFT is more economical and workable than the reinforced concrete structure. CFT sections are used as compressive and flexural members for high-rise buildings and long-span bridges. Since the steel skin confines the outward deformation of the filled-in concrete and concrete resist the inward stress, both steel and concrete enhance the strength of CFT sections. However, there is substantial post-buckling strength in the local mode, and this should be accounted for in estimating the strength of the steel tube. Since the steel skins for CFT columns are usually thin, they are subjected to local buckling.

The local buckling of the steel plate which occurs before the collapse of filled-in concrete can affect the ultimate strength of CFT sections. However, most tests have been focused on the behavior and stability of compact CFT sections under axial loading and on the use of high-strength steel and concrete. Fire protection being used as a solution for the fire resistance increases the construction cost, and possibly cause toxic gas when it is subjected to fire. This study focuses on the inner sided corrugated

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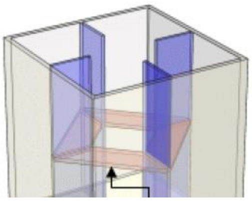
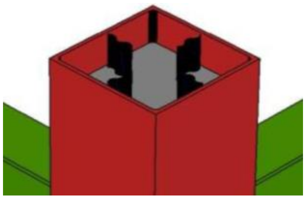
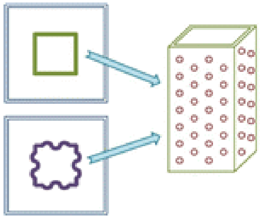
rib reinforcement which contribute bond strength and also resist to fire for over 2 hour even with no fire protections in the CFT column system.

2. Corrugated rib for reinforcement

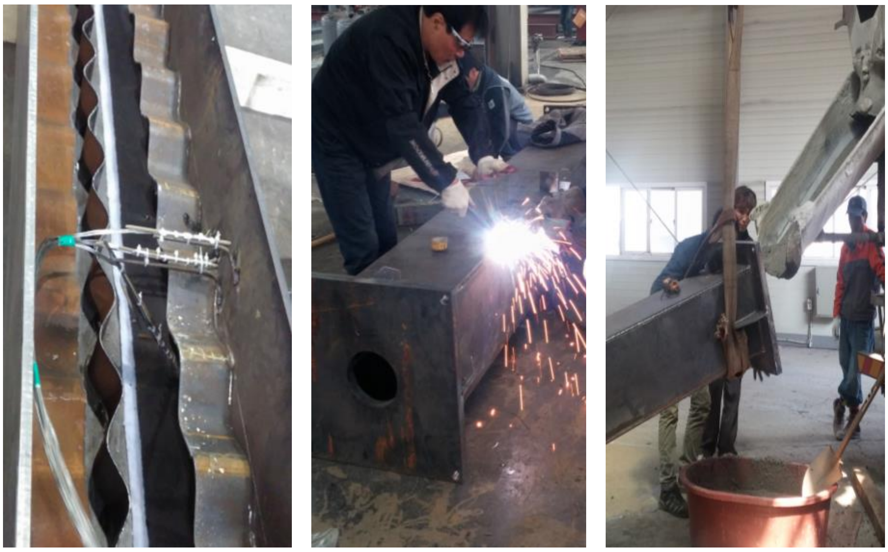
In general, because of the enhancement of the local buckling strength of the steel skin by filled in concrete, thin steel skins are often used for CFT section columns. Therefore, the local and distortional buckling can occur with overall buckling in rectangular CFT sections in compression or combined compression. The distortional buckling mode for large-scale box section columns can occur when the bond strength between concrete and longitudinal stiffeners is not sufficient to resist the resulting force from the outward expansion of concrete. Table 1 shows various types of web reinforcement beams.

Table 1. Types of inner reinforcement for CFT column

Flat plate	Corrugated plate	Double layered tube
 stiffener		

In practice, distortional buckling is rarely found in structures. If a flat stiffener of sufficient length is used, then this type of buckling does not happen. For the accurate estimation of the member strength of those CFT columns with local buckling, there is a need for a rational design strength formula that can account for the local buckling of the steel tube and its effect on concrete strength.

Figure 1. represent the process to fabricate CFT column specimen. The corrugated rib attached inner side of column tube was considered including that rib length, thickness and curvature to improve column's behavior in the elevated temperature through the higher bond and buckling strength. 20 thermo-couples(TC) were also placed to measure steel and concrete's temperature in the fire test. Concrete was poured through the hole on the top plate of the column.



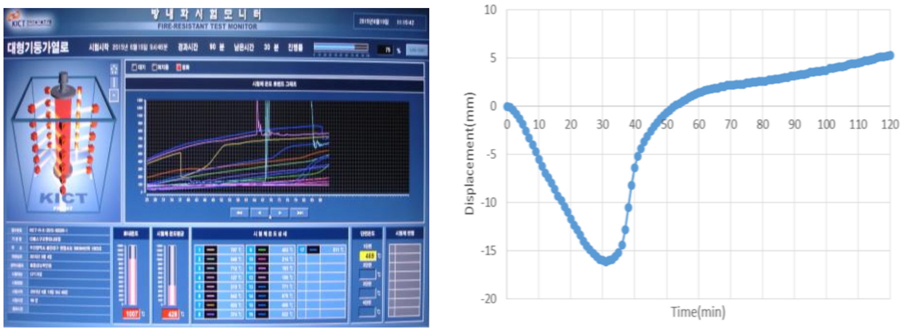
(a) corrugated rib and TC (b) welding to close (c) placing concrete

Fig. 1. Process to fabricate CFT specimen

3. Loaded fire resistance test

3.1. Standard fire test

The standard fire test was conducted with the CFT column specimen. The gas temperature in the furnace was controlled as ISO834 fire temperature for 180min. The axial load, which being calculated 1,800kN as 15% of column's ultimate strength, was also imposed on the column for the whole test time. Figure 2 represent the control the furnace temperature and the graph of displacement in axial direction recorded by UTM system. All thermal data from TC in CFT were also logged during the test(2.a). The specimen expanded in early stage (up to 30min) was followed by reducing in length related with reduction in strength.(2.b)



(a) Monitoring the temperatures (b) Axial displacement during the test

Fig. 2. Controlling the furnace and UTM for fire test

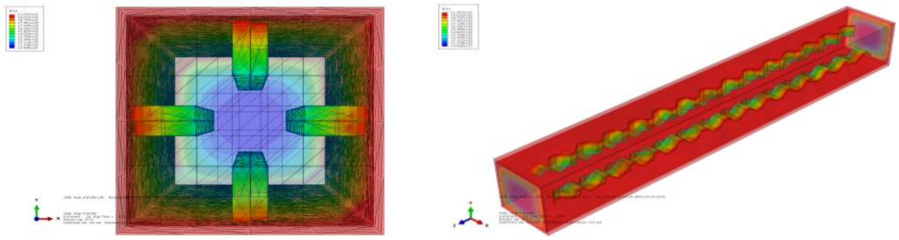
Another major topic in this study is that the improving water draining efficiency from the concrete during its curing stage and at the event of fire. Due to permeability of the paper drain system, the redundant water or unhydrated water can be released out causing reduce laitance and vapor pressure. Figure 3 is showing some evidence of water flow at the elevated temperature. These pictures also support the fact that draining system reduces the chance of explosive spalling of concrete and therefore bond failure as well that is closely related causing local buckling in steel tubes.

(a) Furnace opening (b) Cooled specimen (c) Ordinary specimen

Fig. 3. Comparing the failure mode between this study and ordinary CFT columns

3.2. Heat flow analysis

The thermal action was simulated through the heat flow analysis which was conducted with ABAQUS software. Figure 4 present the temperature distribution along the column section and whole member in length. It also shows the corrugated rib's temperature relatively stayed cooled as buried in the concrete so it could provide stiffness for the longer stabilities in the fire conditions.



(a) CFT section (b) Column member

Fig. 4. Temperature distribution analysis on the CFT specimen

4. Conclusion

This paper investigates the contribution of rib elements attached inner side of CFT for higher bond strength between steel tube and concrete and fire performance with no protection. Test results also present the work of rib's shape to fire resistance, the microstructure of concrete and the benefit of a paper drain that can be letting the redundant water out through the holes drilled on the tube plate. Discussions on beam's design could be followed after some more fire tests accordingly conducted within this series of project.

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