Composite Behavior of Concrete Filled Tube with Large Width-Thickness Ratio of Steel Plate

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Summary

Present study is to investigate mechanical behavior of concrete filled steel tube members (CFT) with thinner steel plate than specified in considering practical application to either new or strengthening existing members. Asymmetric four-point static loading test have been conducted for beam type specimens with a square cross section. Test parameters were shear-span ratios of 1.0 to 2.0 and steel tube width-thickness ratios of 65 to 200. Three dimensional nonlinear finite element analyses have been also conducted for test results.

Keywords: CFT, Large Width-Thickness Ratio, Shear Span Ratio, Composite Member

1. Introduction

Concrete filled steel tube (CFT) member has been widely applied to not only infrastructures but architectural building structures. Many studies have been actively carried out. However most of them are focusing on the member with small width-thickness ratio or diameter-thickness ratio of steel plate. Accordingly, larger width-thickness ratio or diameter-thickness ratio employed is considered as rational for structural design of infrastructures. In these background, authors have carried out flexural shear loading tests of model specimens with test parameters of shear-span ratio a/d of 1.0 or 2.0 and of width-thickness ratio B/t of 65, specified limited value, and 125 or 200 focusing on nonlinear behavior up to the ultimate loading capacity. Three dimensional finite element nonlinear analyses have been carried out to predict experimental results with modeling not only material nonlinearity in both steel and concrete but bond slip action between both materials as well.

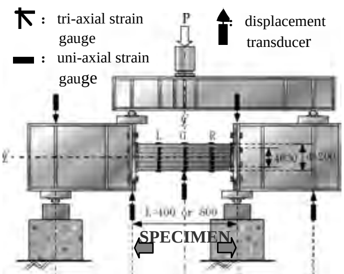

Fig. 1: Test Setup and Measurement Devices

Table 1: Summary of Specimens

Tag	t_0 (mm)	t_s (mm)	B (mm)	B/t_s	a (mm)	a/d
T32-S1	3.2	3.10		65	200	1
T32-S2	3.2	3.10		65	400	2
T16-S1	1.6	1.57	200	127	200	1
T16-S2	1.6	1.57		127	400	2
T10-S1	1.0	0.95		210	200	1
T10-S2	1.0	0.95		210	400	2

Note: t_0: nominal thickness; t: measured thickness; B: cross-sectional breadth; *a: shear span length;* d: effective depth

2. Experiment

2.1 Outline of Experiment

Model specimens are of square cross section with 200 mm side length. As illustrated in Fig.1, load application is an asymmetric four-point static loading method so as to apply a uniform shear force where end bearing plate is bolted with the side beam. Three kinds of measurement devices are instrumented as shown in the figure. Test parameters

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are shear-span ratio and width-thickness ratio. Table1 summarizes dimensions of specimens.

2.2 Failure Mode

After the loading test completed, cracking pattern of the filled concrete was observed peeling the tube off as shown in Fig.2. As shown in figure 2 (1), diagonal crack is observed in the mid section of shear-span ratio of one specimens, independent on width-thickness ratio. Yet, as shown in figure 2(1) (b), flexural crack is observed at both ends in the T32-S1 specimen with higher loading capacity. In the shear-span ratio of two specimens with a local buckling occurrence in the compressive flange, some flexural cracks are observed at end section.

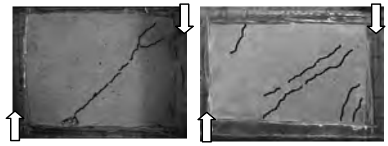
3. Finite Element Nonlinear Analysis

3.1 Outline of Analysis

Three dimensional finite element nonlinear analyses are conducted with using computer program FINAL. Half model, which is consisted with test specimen and elastic side beam, is analyzed with considering asymmetric geometry.

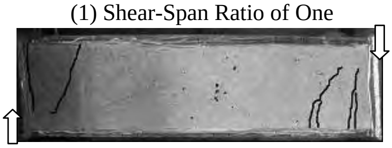
3.2 Load-Displacement

In figure 3, analytical load-displacement relationships are shown in comparison with experimental results. In the specimen of shear-span ratio of one, good agreement is obtained in maximum load capacity between analytical and experimental results among all specimens except T32-S1 specimen. In the specimen of shear-span ratio of two, good agreement is obtained between both results among all specimens.



(a) T16-S1 (b) T32-S1

(1) Shear-Span Ratio of One



(2) Shear-Span Ratio of Two : T16-S2

Fig. 2: Cracks in Core Concrete

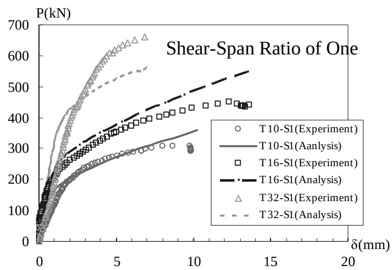
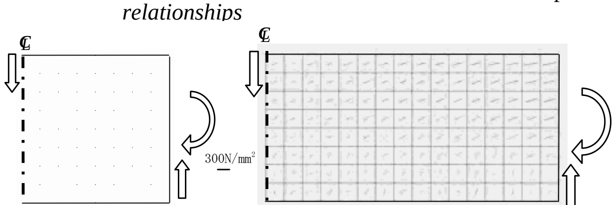


Fig.3: load-displacement relationships



(a) T16-S1 (b) T16-S2

Fig. 4: Maximum principal stress

3.3 Stress Flow

Fig.4 illustrates analytical maximum principal stress flow. In the T16-S1 specimen, these diagonal stresses uniformly distribute, that suggests predominance of shear stress. On the other hand, in the T16-S2 specimen, these stresses horizontally dominate at right end section, that suggests predominance of flexural tensile stress, while less diagonal stress appears at middle section.

4. Concluding Remarks

1) As for failure pattern, shear-span ratio of one specimen provides shear failure with significant diagonal crack to the filled concrete and shear yielding to the steel tube. On the other hand, shear-span ratio of two specimen provides flexural failure with flexural crack of concrete and local buckling to the end section.

2) Finite element nonlinear analysis provides good agreement with the experimental results for both shear and flexural failure types except T32-S1 specimen, in which some difference obtained in measured displacement at asymmetric point.