V－32 Cost Performance of New CFT Column-CFT Beam Frame Structure

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1 Introduction

A concrete filled steel tube (CFT) structure has the merits of the high tensile strength and ductility of steel in addition to the high compressive strength and stiffness of concrete. Conventional concrete can be introduced to CFT column; however, it impossible to be introduced to CFT beam due to need of vibrating compaction work. Self-compacting concrete (SCC) can be compacted into every corner of a formwork purely by means of its own weight without need of vibrating compaction (1). The character of SCC makes it possible to be applied to CFT beam.

Experimental work was done in order to investigate the seismic behavior of the new CFT column-CFT beam structure. The experiment result shows that CFT column-CFT beam frame can be made using self-compacting concrete and sufficient deformation capacity was able to be obtained in PC bar jointed CFT column-CFT beam specimens. Besides the seismic behavior, cost performance is also an important investigation object. This paper describes the cost estimation and comparison result of the new CFT system and steel structure.

2. Building Frame Design

In order to look for the cost performance of the new CFT column-CFT beam system, building frame design was performed. Two 9-story office buildings made of CFT system and steel system respectively were treated in the research, as shown in Fig1. Hollow steel tube is used for column and H-shaped steel is used for beams in the steel system. The framing floor plan is shown in Fig2. The design was based on Japanese steel structure design code (2) and CFT guideline (3).

The design complied with the concept of weak beam and strong column, which means plastic hinges only formed in beams, all columns remained elastic until the mechanism state was reached. All the joints were assumed to be rigid joints.

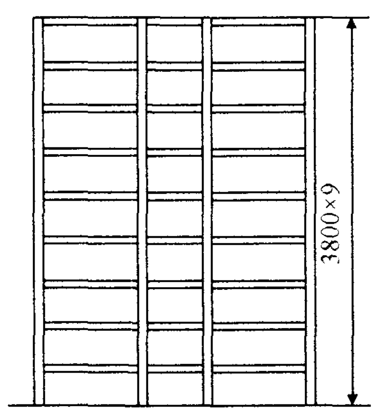

Fig1. Framing Elevation

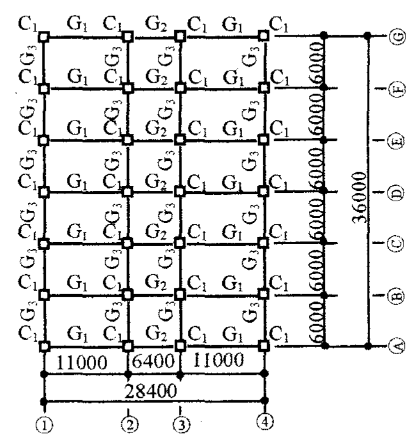

Fig2. Framing Floor Plan

Table1. Design Loads

	Dead load (N/m²)	Live load (N/m²)	
		For vertical	For seismic
Roof	3800	1000	300
Office	2700	1600	700

Table2. Column Members List of Steel and CFT Structure

Story	Steel structure			CFT structure		
	Dimension (mm)	M_u (kN·m)	A_s (cm²)	Dimension (mm)	M_u (kN·m)	A_s (cm²)
8,9	□-300×300×9	244	105	□-250×250×6	230	58.6
6,7	□-300×300×19	381	232	□-300×300×12	480	138.2
4,5	□-400×400×19	741.4	290	□-350×350×16	850	213.8
2,3	□-450×450×25	1138	425	□-450×450×16	1410	277.8
1	□-550×550×25	1820	525	□-550×550×16	2114	341.8

Story drift angle was kept within 1/200 under the design load. Table1 shows the design loads employed in this design. The material properties are as following: yield strength of steel is 235MPa; compressive strength of concrete is 80MPa. Column and beam member lists for steel structure and CFT structure are shown in Table2 and Table3 respectively. Story drift angle for steel structure and CFT structure under seismic load is shown in Table4. Almost same drift angle was obtained from steel structure and CFT structure.

Table3. Beam Members List of Steel and CFT Structure

	Steel structure			CFT structure		
Story	Dimension (mm)	M_u (kN·m)	A_s (cm^2)	Dimension (mm)	M_u (kN·m)	A_s (cm^2)
9-7 (G_1,G_2)	H-390×300×10	457	133	□-400×200×6	335	70
6-5 (G_1,G_2)	H-582×300×12	790	169	□-450×150×12	574	138
4-1 (G_1,G_2)	H-692×300×13	1141	208	□-600×200×9	899	141
9-7 (G_3)	H-600×200×11	592	132	□-400×200×6	335	70
6-5 (G_3)	H-692×300×13	1141	208	□-600×200×9	899	141
4-3 (G_3)	H-792×300×14	1472	240	□-600×200×12	1123	186
2-1 (G_3)	H-900×300×13	2110	306	□-650×300×12	1563	222

3. Cost estimation

The cost estimation is based on Japanese price. Unit cost of steel is 635$ per ton including cost of material, transportation and fabrication. Unit cost of concrete is 244$ per cubic meters including cost of material, transportation and construction. Cost estimation of main frames including columns, beams, weld and PC bar are shown in Table5. The result shows that CFT structure exhibit cost merits compared with pure steel structure.

Table4. Story Drift Angle under Seismic Load

Story	CFT		S		CFT/S	
	X	Y	X	Y	X	Y
9	1/292	1/292	1/287	1/293	0.98	1.0
8	1/276	1/278	1/269	1/277	0.97	0.99
7	1/276	1/287	1/266	1/280	0.96	0.98
6	1/275	1/285	1/260	1/276	0.95	0.97
5	1/284	1/290	1/267	1/281	0.94	0.97
4	1/292	1/298	1/276	1/292	0.95	0.98
3	1/313	1/342	1/319	1/333	1.02	0.97
2	1/340	1/363	1/332	1/348	0.98	0.96
1	1/462	1/439	1/419	1/456	0.91	1.04

Table5. Cost Estimation of Main Frames

	CFT	S	CFT/S
Steel (t)	451.95	668.99	0.68
Concrete (m^3)	400	----	----
Weight of structure (t)	1412.84	668.99	2.11
Cost of material ($)	384,816	425,012	0.91
Cost of weld and PC bar ($)	27,034	32,740	0.83
Sum ($)	411,850	457,752	0.90

4. Conclusion

1). According to the building frame design, almost same drift angle of each story was obtained form the new CFT structure and pure steel structure.

2). The cost estimation result shows that the new CFT structure is a cost-effective structure compared with pure steel structure.

Reference

(1) Okamura, H., Ozawa, K. and Ouchi, M. Self-compacting Concrete. Structural Concrete 2000; 1(1), 3-17.

(2) Specification for Structural Steel Design. Architectural Institute of Japan (AIJ), 1986.

(3) Recommendations for Design and Construction of Concrete Filled Steel Tubular Structures. Association of New Urban Housing Technology, 2002.