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PERFORMANCE OF FILLED STEEL TUBULAR MEMBERS UNDER AXIAL COMPRESSION LOADS

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INTRODUCTION

Present trend in composite construction is towards the use of concrete-filled steel tubular structures in bridge piers and high-rise buildings.[1,2] Such structures exploit the best attributes of both steel and concrete, thus allowing the engineer to maintain manageable member sizes while obtaining increased stiffness, strength and ductility; particularly essential for earthquake resistance. In light of the severe structural damage caused by the 1995 Great Hanshin-Awaji earthquake in Japan, studies are presently being conducted on the performance of various types of filled steel composite members, in an attempt to supplement efforts geared towards evolving earthquake resistant structures. Part findings of these studies, namely strength and ductility of filled steel stub columns under compressive load, are presented herein.

EXPERIMENTATION

Various types of filled circular steel stub columns (Fig. 1) were gradually subjected to axial compressive load until failure, while recording load, strain and displacement measurements at suitable load increments. The test specimens comprised four different sizes (expressed as diameter/thickness ratios) of filled circular steel members, each type filled with carbonic grout at 6 days age (C1), carbonic grout at 25 days age (C2), rubber at 6 days age (R1) and rubber at 25 days age (R2). In addition, separate components corresponding to each type of stub column were prepared. Table 1 illustrates the details of the specimens, while Tables 2 and 3 give material properties for the steel and fill materials.

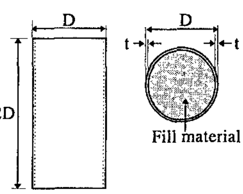

Fig. 1 Filled circular steel

Table 1 Specimen details

Specimens identification	D (cm)	t (cm)	D/2t	As (cm^2)	A_{fill} (cm^2)
(S,C1,C2,R1,R2,S/C1,S/C2,S/R1,S/R2) - 20	10.4	0.26	20	8.593	76.36
(S,C1,C2,R1,R2,S/C1,S/C2,S/R1,S/R2) - 30	9.6	0.16	30	4.905	67.47
(S,C1,C2,R1,R2,S/C1,S/C2,S/R1,S/R2)- 40	9.6	0.12	40	3.661	68.72
(S,C1,C2,R1,R2,S/C1,S/C2,S/R1,S/R2)- 50	10.0	0.10	50	3.173	75.37

Nomenclature Specimen identification e.g. S/C2-40 implies composite member of steel (S) and carbonic grout type 2 (C2), and of D/2t ratio equal 40. As, A_{fill} are cross-sectional areas of steel and fill material, respectively.

Table 2 Properties of the steel

t (cm)	E (10^3 kgf/cm^2)	ν	σ_{sy} (kgf/cm^2)
0.26	2151	0.2868	2311
0.16	2155	0.3365	2245
0.12	1981	0.3565	1891
0.10	2110	0.3371	2304

Table 3 Properties of the fill materials

Fill material	E (10^3kgf/cm^2)	ν	σ_{fill} (kgf/cm^2)
C1	118.7	0.2389	145.5
C2	131.3	0.2218	211.0
R1	0.009867	0.4514	-
R2	0.01395	0.4546	-

Symbols
E-Modulus of elasticity, ν-poisson's ratio, σ_{sy}-steel yield stress, σ_{fill}- Cylinder strength of fill material

Keywords Filled steel columns, strength and ductility
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RESULTS AND DISCUSSIONS

From Figures 2,3 and 4, it is observed that ultimate strength of carbonic grout-filled steel stub columns is much higher than for hollow steel stub column, and (for fill material C2) is even 1.15 to 1.25 times higher than the combined capacity of the components acting alone. Ductility of carbonic grout-filled steel member is considerably higher than of the steel acting alone (Fig. 5). The significant increase in strength and ductility of carbonic grout filled-steel member may be attributed to mutually enhancing interaction between the grout and the steel tube. The steel tube reinforces the carbonic grout longitudinally and laterally, and induces a tri-axial stress condition.

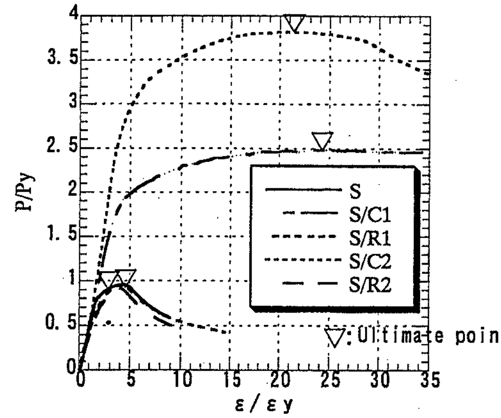

Fig. 2 Load versus strain, for D/2t = 50
(P is load on member while, Py is yield load of steel)

When the steel thickness is either very low or very high, higher strengths of carbonic grout-filled stub columns are noted . For low thickness, the carbonic grout prevents or delays the inward local-plate buckling of the outer steel tube, while for high thickness, there is strain hardening of the steel, with consequent increase in strength of the stub column.

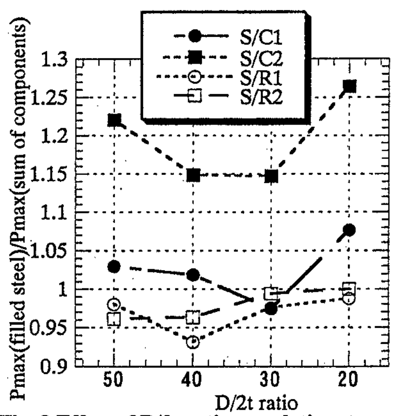

Fig. 3 Effect of D/2t ratio on relative strength
(Pmax is the maximum compressive load)

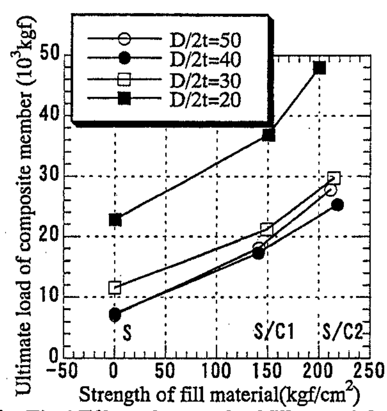

Fig.4 Effect of strength of fill material

Rubber as a fill material seems to have no effect on the strength of the composite member, possibly due to its low stiffness as indicated by its very low modulus of elasticity.

CONCLUSION

Compressive strength and ductility of the carbonic grout-filled steel stub columns are considerably higher than of the steel acting alone. However, use of rubber as a fill material has no effect on the strength or ductility of the stub column.

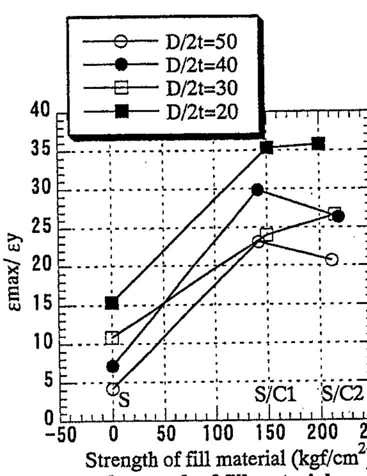

Fig. 5 Effect of strength of fill material on ductility

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