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Connection of Steel Beams to Concrete-Filled Tubular Columns

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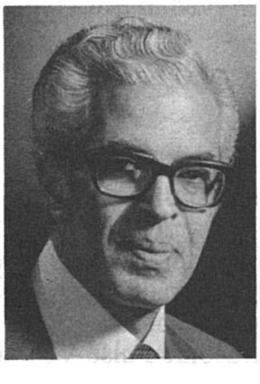

Hassan Shakir-Khalil received his BSc and MSc degrees in Civil Engineering from the University of Cairo, Egypt. He obtained his PhD degree from the University of Cambridge, England, UK. He has been researching in the field of concrete-filled tubular columns for the last 15 years.

Summary

Tests have been carried out on 36 full scale beam-to-column connections. The connections were manufactured by connecting steel beams to concrete-filled tubular columns through either finplate or T-cleat connections. The columns used were either circular or rectangular (CHS & RHS) hollow steel sections. Except for the last eight specimens, all the other test specimens were symmetrically loaded.

Experimental Work and Numerical Analysis

Table 1 gives a summary of all 36 specimens tested in this experimental investigation. The column tubing of all specimens is 2.8m long, and the column lengths have 15mm thick end plates. The side beams connected to the test specimens of series A-E were symmetrically loaded. However, the eight specimens of series 'F' had either one side beam, or their side beams were unsymmetrically loaded. The webs of the side beams of series A-D were bolted to 10mm thick finplates which had been welded to the columns. Finplates were replaced by T-cleats in series E&F as a result of the large out-of-plane deformations of the RHS walls to which the finplates were welded. Both types of connections are shown in Fig 1.

Figure 2 shows a schematic view of the test rig and test specimen. The rig consists of a base and an upper cross-head connected together by four vertical ties of steel hollow section. The rig is self contained, and the base is securely bolted to the laboratory strong floor. The rig has a head room of about 3m. The loads applied to the side beams by the hydraulic jacks are transferred to the beams through a platform and load cells. The loading platform was used in order to maintain the location of the jacks and at the same time to be able to apply the beam loads at any required eccentricity by simply moving the load cells to the new locations. The beam loads were applied at varied distances from the centre of the column. The beam and column loads, P_2 and P_1, were increased proportionately, and the beam-to-column load ratio was mainly taken either 1:8 or 1:5.

The rig was originally designed for testing the symmetrically loaded specimens of series A-E, and was thus provided with no lateral bracing. A triangulated, stiff in-plane bracing, not shown in Fig. 2, was therefore welded between the vertical ties in order to ensure the lateral stability of the test rig before testing the unsymmetrically loaded beam-to-column connections of test series F. During the test procedure, all specimens were also laterally restrained at mid-

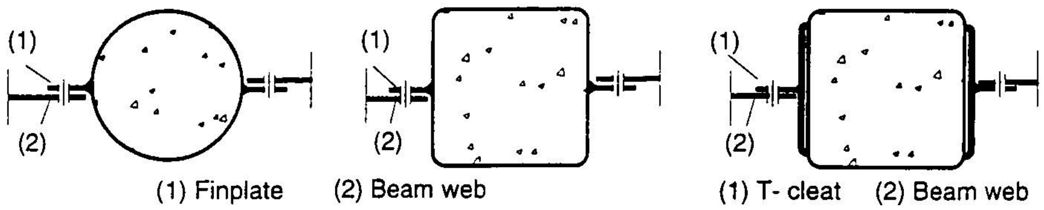

Fig.1 Finplate and T-Cleat Connections

height as shown by '7' in Fig. 2. This lateral restraint was connected at its other end to a stiff bracing system which was securely connected to the strong floor.

Series	Column Size	Type of Connect.	No. of Spec.	Connect. Loading
A	168.3x5CHS	Finplate	8	e2=e1
B	150x150x5RHS	,,	8	,,
C	219.1x6.3CHS	,,	2	,,
D	200x200x6.3RHS	,,	2	,,
E	150x150x5RHS	T-Cleat	8	,,
FI	150x150x5RHS	,,	4	e2=0.0
FII	150x150x5RHS	,,	4	e2<e1

Table 1 Sumary of Test Series

The test specimens were provided with electric resistance strain gauges and displacement transducers. The displacements were measured in the plane of loading and also transverse to the loading plane. Displacement transducers were also placed against the column end plates to record the column shortening and end rotations. The strain measurements were carried out over distances equal to three times and twice the lateral dimension of the steel hollow section above and below the finplate/T-cleat positions respectively, an arrangement that was found to be satisfactory.

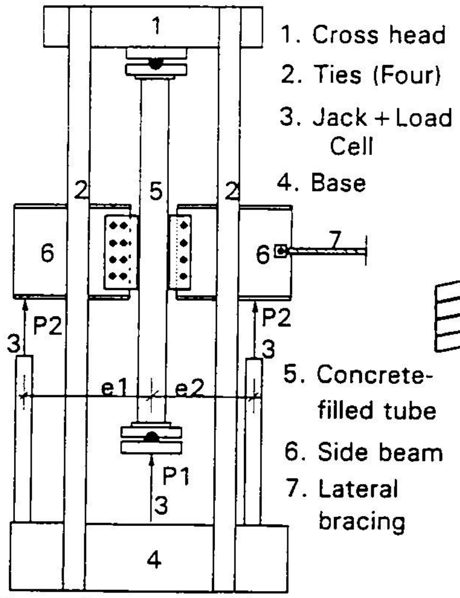

Fig.2 Test Rig and Specimen

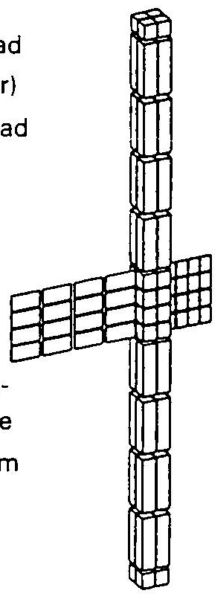

Fig.3 Num. Model

The ABAQUS software package was used to model the test specimens of series 'F'. It can be seen from the numerical model shown in Fig. 3, that the side beams were not modelled, and neither were the bolt holes in the connection. The T-cleat stem was extended to model the beam, and the numerical model was only used to predict the overall column failure. The boundary conditions at the top of the numerical model were similar to the experimental end conditions in which the top end of the column was fixed in position, and was allowed to rotate freely only in the plane of loading. However, the central nodes at the lower end of the model, and also at its mid-height, were allowed to move vertically, thus allowing for column shortening.

The numerical model has 48 concrete brick elements (C3D20), 96 steel shell elements (S8R) for the RHS steel tube, 16 steel shell elements (S8R) for the T-cleat flanges, 32 steel shell elements (S8R) for the T-cleat stems and 8 rigid brick elements (C3D20) for the end loading plates. In all, the model has 200 elements and 1081 nodes.