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External Beam-Column Joints - The Importance of Stirrups

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Abstract

This paper presents the results of experimental tests on reinforced concrete external beam-column joints (T joints). The seven test specimens were designed planning to have real practical dimensions avoiding major size effects and at the same time suiting the rig arrangements that simulates the points of contraflexure in framed structures – see Figure 1. The concrete strength, the beam and the column reinforcement were intended to be the same for all the specimens. Different reinforcement details were used in the joints and in some tests the columns were axially loaded to simulate other floors in the building. The Beam-Column-Joint (BCJ) and the corresponding control specimens were tested the same day.

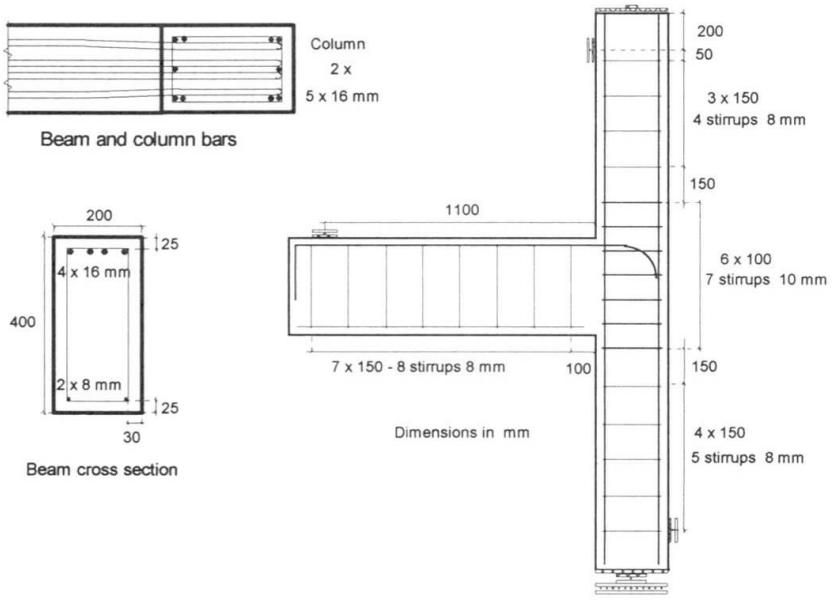
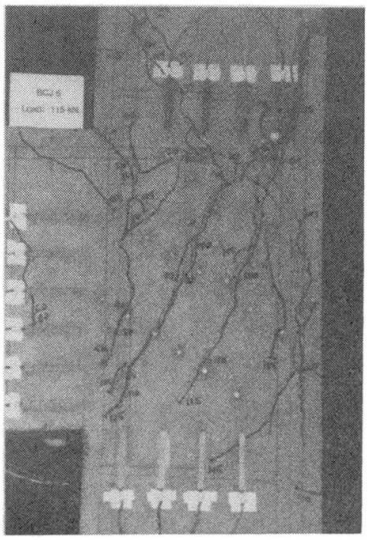


Figure 1 - Details of BCJ7

The aim of the tests was to study the internal mechanisms of stress transfer in the joints and the effects of the stirrups in the connection. The tests were carried out accompanied by strain measurements on the most important sections and on several points of the reinforcement. The crack patterns were observed and marked at each step of the tests.

Based on the measurements and on the observations during the tests, a strut-and-tie modelling is developed showing how the stirrups work.

A resistance analysis is developed based on the shear that acts in the connection (beam bars tension minus column shear) and the vertical forces coming from the column. This analysis shows that the transverse reinforcement has an important role at the ultimate resistance of the connection – see Figure 2 - but has no influence at the first thin crack appearance.



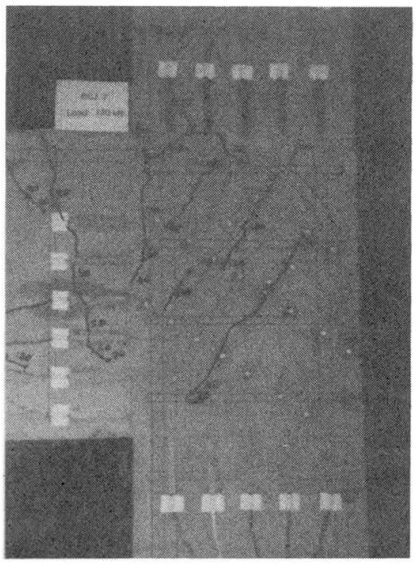


Figure 2 - a) BCJ6 – without stirrups – 115 kN *b) BCJ7 – with stirrups – 120 kN*

The effect of the stirrups is limited by the concrete resistance of the joint – concrete strength and connection dimensions. Any excess of transverse reinforcement does not increase the strength of the joint.

A theory is proposed to analyse the shear strength and to design the transverse reinforcement (stirrups) for this type of joint.

These tests have shown that the active stirrups have to be evenly distributed between the direction of the top of the beam chord and the main beam bars (at the top of the beam). At least two extra stirrups should be located up to half column depth above the connection to guarantee the region to where the cracks tend to run.

The observations, conclusions and analysis of this work have been seen to concur with published test results.