Moment-Rotation Characteristic of Joints of Steel-Concrete Composite Frame under Exceptional Events

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Summary

The paper presents studies on experimental investigation of beam-to-column joint behaviour in standard and exceptional events situations, This assessment is done to form a picture of the general the behavior of full scale frameworks at both the level of the global behavior of the framework, in terms of its load-displacement characteristic, and of the local behavior of joints in terms of their moment-rotation characteristics, and evaluates details about the interaction of the joint elements and how they work together in a balanced manner. The paper addresses these problems using two types of joints flush and extended end-plate for the evaluation of joint moment-rotation response when exposed to negative and positive moments together.
Keywords: joints, robustness, composite, redundancy, composite joint, sub-frame test, column loss.

1. Introduction

Building frameworks are usually designed for service loads only [1] despite the fact that they are vulnerable to a certain degree to progressive collapse phenomenon caused by local damage as a result of a column loss due to a vehicle impact, explosion, fire or earthquake, The objective was to investigate the behaviour of steel and steel-concrete composite joints of building frameworks under typical load combinations and exceptional loading due to accidental loss of a column. Four tests were conducted on two steel and two composite frame specimens, with flush and extended end-plate joints. Taking advantage of the inherent ductile behaviour of steel joint components and reinforcement of concrete slab, the requirements for robust joint behaviour may be formulated to allow for force redistribution within the structure so that a progressive collapse of the building framework is prevented and structural safety is ensured, The aim was to investigate robustness of joints whose end-plates, in line with requirements of current Eurocodes, ensured the joint full rotation capacity, Presented paper creates a contribution towards a clarification of some aspects related to joints robustness in view of structural safety and reliability.

2. Experimental investigations description

The most desirable experiments for the robustness assessment of the global behaviour of multi-storey frameworks and the local behaviour of their joints would be those performed on a full scale load bearing system, For this tests were therefore performed on sub-frames of a plane multi-storey and multi-bay framework, consisting of three columns B, C and D, and two full length beams of two neighbouring bays B-C and C-D, shows the way the tested specimens were cut off from a real framework, Detailed description of tested sub-frames and testing procedure was presented in [2] .

3. Procedure of the test

In the flush and extended end-plate joints of composite sub-frame the loading procedure was executed in two stages: Stage 1 simulated the service condition of frame under gravity loading, central column was supported in vertical direction, The gravity load in the form of concrete blocks of dimensions 1.2 x 1 x 0.5 m and average weight of 15 kN. This uniformly distributed loading of value 30 kN/m refer to a typical office building loading, with dead load g = 4.5 kN/m^2 and impose load q = 2 kN/m^2. Stage 2 simulated the event of a static column removal, gravity loading was still active and the central column was connected to the hydraulic jack while the stiff support under the

column was removed, Like in the steel frame test, the displacement was applied downwards in 1÷8 mm step intervals, until a complete damage of the substructure was reached.

4. Results

In case of the flush end-plate joint, first stage of loading caused the vertical reaction in internal column equal to the absolute value of 135.6 kN, the moment value which recorded is 95 kNm and the rotation was 26 mrad see Fig.1b. At this stage, first small cracks in the concrete slab were observed in the vicinity of external column. The joints yielded progressively, mainly by the increased plastic deformations of end-plates in bending, and the column web in transverse compression in external column joints. In the case of extended end-plate joint, the maximum value of vertical load obtained in the test is associated with displacement of the column equal to 187 mm in the stage 59, and the value in the relationship between the moments - rotation when the moments were equal to 210 kNm and the rotation equal to 27 mrad for the internal joint, (see Fig, 1a, 1b).

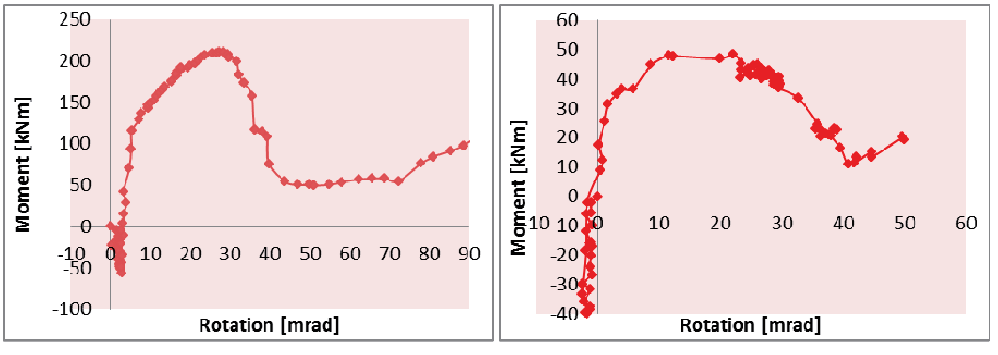

Fig.1. a) Moment-rotation relationship of extended end-plat, (b) Flush end plate

Concluding remarks

Preliminary conclusions from above described tests are as follows:

- It confirms clearly that the isolated flush end-plate joints exhibit a greater ductility than the symmetrical extended end-plate joint, but the lack of strength prevents the structural system from reaching an appropriate degree of robustness.
- Extended end-plate composite joints had much lower ductility with the rotation of 24 mrad that is of lesser value if compared to Demonceau and Jaspart.
- Comparing the results obtained for specimens with flush end-plates and extended end-plates, the conclusion can be drawn that the joint ductility and strength have to be adequately balanced to achieve the robust solution for the framework. Although the isolated flush end-plate joints exhibit a greater ductility in comparison with their extended end-plate counterparts, their lower strength does not allow the structural system to achieve a sufficient degree of robustness.
- The tested composite frame with extended end-plate joints was able to develop fully the stable equilibrium in loading process simulating the column loss.

5. References

[1] EN 1993-1-8, EUROCODE 3: DESIGN OF STEEL STRUCTURES - PART 1-8: DESIGN OF JOINTS, European Committee for Standardization, Brussels.

[2] SALEH B., *Modelling of Beam-To-Column Joint of Steel-Concrete Composite Frames Subjected To Standard and Extreme Load Combinations*. PhD thesis, Warsaw University of Technology, Warsaw 2013.