Dissipative Braced Frames with Steel and Concrete Active Links

Portiques entretoisés dissipatifs avec poutres en acier et béton

Dissipative Rahmen mit aktiven Aussteifungen aus Stahl und Beton

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1. INTRODUCTION

The structural system of eccentrically braced frames with steel and steel-concrete dissipative links is an alternative to the two traditional structural system adopted in steel structure multi-storey buildings to withstand seismic actions, i.e. rigid joint frames and bracing trusses. The adoption of this structural typology for multi-storey residential buildings has shown the following advantages: (a) possibility of free spaces for openings and passages especially helpful in the aseismic adaptation of existing buildings; (b) characteristics of strength and stiffness in elastic field typical of bracing trusses with moderate $P-\Delta$ effects also for multi-storey tall structures; (c) capability of wasting energy dissipation under a seismic event of high intensity thanks to the remarkable ductility of the link. This ductility is due to the presence of large shear and moment plastic deformations and to the possibility of a stable cyclic behaviour in elastoplastic range. The structural system can be so designed as to let the columns and diagonal remain in elastic range up to the full link collapse. Therefore the link becomes the controlling element of the structure behaviour during the seismic event.

2. RESEARCH PROGRAM

Eccentricity, i.e. the link length, is a basic factor in the elastoplastic response of the structural system. The use of greater eccentricities allows the reduction of the plastic deformations required from the link, while for small eccentricities the system gets more rigid in the elastic phase but the demand for shear and moment plastic deformation is also greater. The deformation depends on the type of mechanism and therefore corresponds either to an angular deformation in the case of "shear link" or to a plastic hinges rotation in case of "moment link". The dimensioning and checking of multi-storey frames through a dynamic analysis in elastoplastic range [1] have shown that very good results are possible in relation to strength, stiffness and ductility characteristics, if the mechanical characteristics of the link are continuously varied by using welded plated girders instead of rolled beams and if great eccentricities are adopted.
Experimental investigation on the links [2] carried out by means of welded plate girders and concrete flanges allowed to determine:

- the choice criteria of geometrical and mechanical parameters of the link;
- the collapse mechanisms of the links and the respective "structural factors" in conformity with Eurocode EC8;
- constructive solutions to optimize the dissipating capability of the cyclic loads structural system when large plastic deformations are present.

The collapse behaviour of the links essentially depends on a correct design of the web stiffening and of the link-column connection. A range between two ribs equal to the web height, for $a/t_w = 40$, and a bolted flange connection have been adopted for the experimental research, Fig.1.

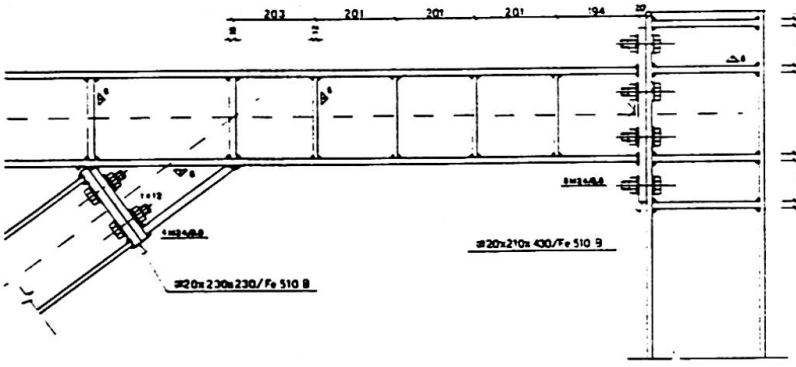

Fig. 1 Details of the active links

The tests have been carried out on five welded girders with flanges of two different dimensions and with a concrete slab in order to investigate about the collapse mechanism and the characteristic parameters of ductility, stiffness reduction and absorbed energy in compliance with ECCS indications for cyclic test. The experimental tests have proved that a stable cyclic behaviour is obtained whenever the web shear yielding precedes the flange yielding and the link ductility increases when the bending plastic hinges are contemporarily present at the link ends. These objects are attained either by increasing the flange thickness or by setting a concrete slab; both solutions reduce the web local instability phenomena. The results of experimental tests have helped to find the link F.E. in DRAIN-2D program modelled as a sandwich beam and also to set up the cyclic load code when the link hardens with web shear yielding.

3. COMMENTS OF RESULTS

The force-displacement hysteretic loops obtained by a test beam with displacement imposed in elastic and elastoplastic range are sketched in Fig.2 as well as loops obtained by sandwich-modelling the link.

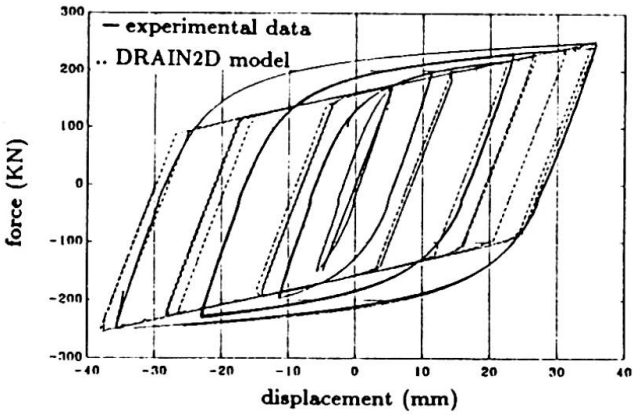

Fig.2 Hysteretic loops of a test beam

The ratio between the slope of Young's coefficient in plastic and elastic range (hardening ratio ρ) has given values included between 0.038 and 0.041. The shear collapse has proved $1.4 \div 1.6$ times greater than the value corresponding to the web primary yielding, when the imposed displacements were $9 \div 10$ times greater than at elastic limit. On applying the experimental and numerical results to the design of industrial and residential buildings, the structural system proved excellent under acceleration histories of simulated or recorded earthquakes. As a matter of fact the links built with welded or composite beams allow to set "dissipative valves" which lower down to 6 or 7 times the seismic inertial forces in the structural steel.

REFERENCES

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