Influence of design criteria on the seismic response of single-storey steel buildings

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Abstract

Structural design in seismic areas could be based on either dissipative or non-dissipative concepts, as for example allowed in European and Italian codes. In the first case, capacity design is the basis of structural dimensioning; both strength and ductility verifications are required. In the second case, structural elements are designed to remain in the elastic field under the assigned design seismic input; ductility verifications are not enforced. In steel structures, these two design approaches might lead to very different seismic structural performances, depending on the role that the non-ductile elements and connections have in the non-dissipative design. This situation might represent a source of weakness and lead to premature failures. In the present work, with reference to a single-storey steel industrial building with moment-resisting frames in the transverse direction and concentric braces in the longitudinal direction, the critical issues encountered when modelling the post-elastic behaviour of a non-dissipative steel structure are discussed. Subsequently, a comparison is made with a structure with the same geometry, designed with dissipative structural behaviour.

Keywords: Nonlinear finite element models, Seismic analysis, Steel structures.

1 Introduction

Structural codes such as the Eurocodes allow constructions in seismic areas to be designed according to two different strategies. The first way foresees capacity design and dissipative structural behaviour, i.e., selected members and/or connections are dimensioned to evolve in the plastic field and, hence, dissipate seismic energy. Accordingly, the demand resulting from the seismic action is calculated considering the dissipative capacity related to material nonlinearities. This type of seismic design accepts structural damage in case of design-level seismic accelerations. The second way, included in Eurocodes as well as in the latest update (2018) of the Italian Building Code, is based on the adoption of a non-dissipative behaviour of the building: all the members and connections are required to remain in the elastic field for the given design seismic input. The seismic demand is evaluated in the linear elastic range without considering the non-linearities of the material; in this case the structure favours strength rather than ductility.

In the present study, the critical issues that have been faced when modelling the post-elastic behaviour of a non-dissipative steel structure are discussed. A single-story steel structure for non-