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Editorial

New Advances in Seismic Design and Assessment of Steel Structures

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In recent years, rapid advances have taken place in earthquake engineering as applied to steel structures with major emphasis given to (1) development of advanced procedures for seismic performance assessment, (2) development of advanced design procedures for plastic mechanism control, (3) improvements in structural design detailing, (4) better modeling of members and connections for dynamic non-linear analyses, (5) development of new damping devices for supplementary energy dissipation, (6) development of self-centering structural systems, (7) development and testing of new design strategies for reducing structural damage under severe ground motions. Even though such advances have reached in some cases a refinement level justifying their introduction in seismic codes, the updating of Eurocode 8 with design criteria and new design strategies reflecting newly developed knowledge is still in delay. In the actual version of Eurocode 8, some advances, such as new structural typologies like braced frames equipped with buckling restrained braces and dissipative truss moment frames, are still not codified even if they have already gained space in American codes.

Because of these rapid advances, weaknesses of Eurocode 8 and new structural typologies to be codified have been recognized and a document focusing on such weaknesses and new research needs has been published [1]. In particular, the sharing of knowledge obtained has been recognized to be critical to improve the seismic design of steel structures. Therefore, a Thematic Issue on "New Advances in Seismic Design and Assessment of Steel Structures" can be considered timely.

Many researchers, all joined by the common interest in design, testing, analysis and assessment of steel structures in seismic areas, have accepted to contribute to this special issue. As a result, this thematic issue is composed by eleven contribution covering important design topics for seismic resistant steel structures.

Two works [2, 3] are devoted to the seismic design of Concentrically Braced Frames (CBFs), pointing out the drawbacks of the design provisions suggested by Eurocode 8 and also reported in the Italian Technical Code for Constructions. In particular, the need to revise the design procedure suggested for columns of CBFs is discussed showing that both the stability and resistance indexes of columns are often exceeded. The results obtained are in agreement with those presented by other researchers [4-8] who recommended design procedures based on a rigorous application of capacity design principles. Also the third manuscript of the thematic issue is devoted to CBFs, but aiming to the development of a new buckling restrained system which can be easily dismounted [9]. As it is well known, buckling restrained braces (BRBs) are basically constituted by two parts: an internal slender steel member, known as the "core" and a restraining member, known as the "casing". The core component has the key role of dissipating energy, while the casing component restrains the brace core from overall buckling in compression. The buckling restraining mechanism can be obtained by enclosing the core (rectangular or cruciform plates, circular rods, etc.) either in a continuous concrete/mortar filled tube or within a "all-steel" casing. Despite of the use of such braces allows to obtain wide and stable hysteresis loops, thus overcoming the main drawbacks of traditional braces due to the poor cyclic response resulting from overall buckling, and their design is already codified in ANSI/AISC 341-10 [10], their use is still not codified in Europe testifying an important weakness of Eurocode 8.

Two papers of the present thematic issue are devoted to beam-to-column connections [11, 12]. The first one [11] presents the results of a wide experimental program recently carried out at Salerno University dealing with extended end plate connections, with and without Reduced Beam Section (RBS), connections with bolted T-stubs and, finally, innovative connections equipped with friction dampers. The second work [12] is mainly devoted to the theoretical development of the analysis of the influence of gravity loads on the seismic design of RBS connections. In particular, it deserves to be underlined that such influence is commonly neglected in codified rules, such as ANSI/AISC 358-10 [13], because experimental tests constituting the base of the recommended design procedures are typically based on cantilever schemes where gravity loads are not applied.

It is well known that the problem of preventing undesired failure modes is of primary importance in the seismic design of structures. It is universally recognized that the best seis-

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mic performances are obtained in case of structures able to develop a complete side sway mechanism. Such global mechanism cannot be obtained by means of codified rules, i.e. by means of the beam-column hierarchy criterion, which constitute only a rough approximation of capacity design principles. To overcome this drawback sophisticated design procedures need to be applied. To this aim the Theory of Plastic Mechanism Control has been developed. In the present thematic issue, a wide state-of-the-art [14] on TPMC is presented, covering the most important structural typologies.

Aiming to reduce the structural damage to the primary seismic load resisting system, the strategy of supplementary energy dissipation has been developed for many years and a lot of damping devices have been proposed. Within this framework some structural typologies can be considered, where passive protection systems are based on the use of metal shear panels, representing an effective way for achieving a significant improvement of the seismic response of buildings. Such metal shear panels are investigated in one of the presented manuscripts [15] within an original perspective similar to the one of buckling restrained braces. In fact, the dissipative capacity of shear panels could be limited by buckling phenomena. Therefore, in order to reduce their influence, "Buckling Inhibited Shear Panels" have been recently introduced as an innovative and convenient solution where steel plated elements are adopted to restrain the out-of-plane displacements of the shear plate, thus acting similarly to the casing element of buckling restrained braces. The outcomes of an extensive experimental campaign on the proposed system are shown [15].

The use of passive control devices can be particularly effective in the seismic retrofitting of existing buildings. In particular, the use of friction damped tension-compression diagonal braces is presented in [16] for the seismic upgrading of moment resisting frames. Nonlinear time history analyses are carried out on a set of representative frames with and without friction dampers. The results obtained clearly highlight the effectiveness of braces equipped with friction dampers in reducing the damages to the main structural elements, thus significantly upgrading the frame seismic response.

A design procedure aiming to a controlled structure capable to resist the design earthquake remaining in elastic range, and thus without damage, is proposed in [17]. The idea behind this philosophy is that one portion of earthquake loading will be resisted by the control system while the rest will be resisted by the structure. Obviously, the initial cost for buying and installing the control devices has to considered in cost/benefit analyses.

Regarding analysis methods, the work presented in [18] deals with the reliability of advanced nonlinear static procedures to estimate deformation demands of steel moment-resisting frames under seismic loads. Both conventional methods, based on invariant lateral load patterns, and refined adaptive and multimodal pushover procedures are investigated. In particular, the results obtained by static advanced methods, used in the form of different variants of the original Capacity Spectrum Method and Modal Pushover Analysis, are compared with the results of nonlinear response history analyses. Both effectiveness and accuracy of these methods are presented and discussed.

Finally, the progressive collapse resisting capacity of earthquake-resistant steel moment-resisting frames subjected to column failure is investigated in [19] by properly modeling column removal to represent a situation where an extreme event may cause a critical column to suddenly lose its load bearing capacity. This abnormal loading condition is most likely to be dynamic and nonlinear, therefore both nonlinear pushdown and nonlinear dynamic analyses are carried out. The load-displacement relationships obtained from pushdown analyses are compared with the results of incremental nonlinear dynamic analyses and the results are used to evaluate the dynamic amplification factor to be applied in pushdown analysis for a more accurate estimation of the collapse resistance.

Despite of the works presented in this thematic issue, obviously, are able to cover neither all the design topics which need further investigations nor all the new structural steel typologies deserving a codification for promoting their practical use, it is believed that they can provide a contribution to the improvement of codified rules in view of the forthcoming development of the new chapter of Eurocode 8 dealing with the seismic design of steel structures.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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