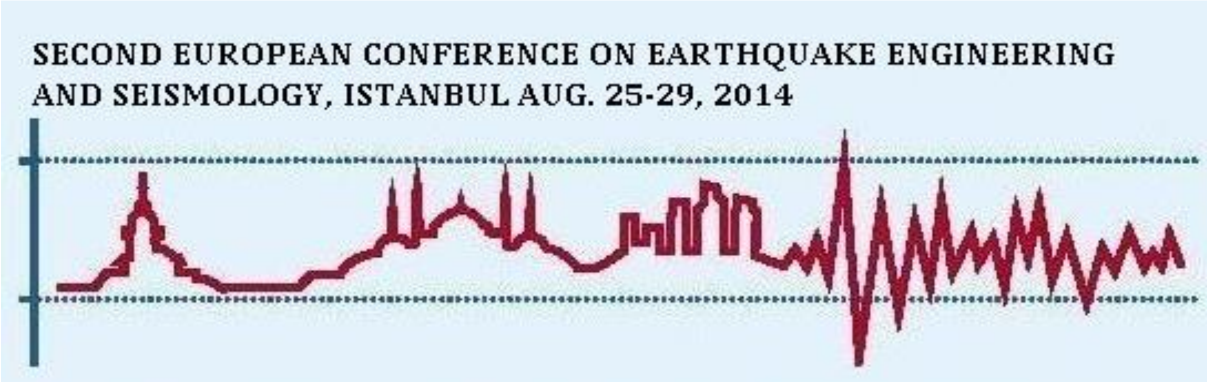

PERSPECTIVES FOR EN 1998 EVOLUTION REGARDING STEEL STRUCTURES

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This contribution considers changes that might be needed to future generations of the seismic Eurocode, EN 1998, with regard to the design of earthquake-resistant steel structures. It is essentially based on a comprehensive review that has been carried out by the Technical Committee "Seismic Design" of the European Convention for Constructional Steelwork (ECCS – TC13), chaired by Prof. R. Landolfo from University of Naples and including 21 members from 9 different European countries. This review has been published in 2013 under the title "Assessment of EC8 Provisions for Seismic Design of Steel Structures". As stated in its Preface, this document intends to "…trace the guidelines for updated European seismic codes according to the worldwide research activities…" It represents so far the most consistent document heading towards such an objective for steel structures, elaborated over five years by four working groups and synthetized during plenary meetings of the Technical Committee. It describes in a comprehensive way, including relevant scientific references, a series of issues that would need clarification and/or further developments, and is organized in twelve sections that are listed hereby with a summary of the future needs identified for each of these issues. Some of these needs are likely to be handled in the second generation of Eurocode (revision currently under preparation) but it is clear that some other are still requiring intensive preparation work and are thus to be seen as perspective for a third generation.

1. **Material overstrength**: definition of normative values of material overstrength factors should be provided, taking into account such aspects as steel grade, type of steel products… Implementation of steel grades with guaranteed upper bound yield strength should also be taken into consideration.

2. **Selection of steel toughness**: Guidance is needed on values of strain rates and design temperature in the seismic conditions. Studies on realistic strain rates including local mechanisms (size of plastic zones, formation of crippling, notch effects…) need to be carried out.

3. **Local ductility**: Cross-section classification based on different criteria than the common b/t ratios should be used for members in bending. Alternatively the influence of the cyclic loading on the local ductility should be taken into consideration and hence the limit values of the walls slenderness should be adapted for use in seismic design context. The possible use of slender cross-sections (and specifically of cold-formed members) along with a behaviour factor larger than 1.0 could also be investigated. Finally, specific criteria should be proposed for rectangular and circular hollow sections as well as acceptance criteria for plastic deformations in braces of concentrically braced frames.

4. **Design rules for connections in dissipative zones**: A set of rules for seismic-resistant joints should be compiled. More detailed information should be provided on the experimental procedure used to qualify beam to column joints, including guidelines in performing the qualification

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tests and processing the results, as well as guidelines for typical braced connections (e.g. gusset plates). Provisions for lateral restraints at plastic hinge region and along the beam in the seismic design situation are also needed.

5. **New links in eccentrically braced frames**: Extension of code provisions and development of design guidelines for new types of links, such as tubular links or replaceable (bolted) links is needed.

6. **Behaviour factors**: Behaviour factors associated with V-braced configurations should be reconsidered and values for braced frames configurations other than X or V could be included. The concept of dual frames should be clarified.

7. **Capacity-design rules**: Background studies on the efficiency of capacity design rules of EN 1998-1 with consequent simplifications and homogenisation of code provisions should be carried out. Further studies are needed to assess the influence of axial forces in columns on the local and global ductility of frames as well as to assess the necessity to consider the possibility of plastic hinges to form away from the beam ends when determining design shear forces in beams. Overstrength requirements for column base anchoring would need to be specified explicitly in the code.

8. **Design of concentrically braced frames**: The appropriate model for compression diagonals in CBFs for elastic analysis deserves further attention. Guidance on the structural modelling in the case of spectral analysis is needed. Extension of code provisions to built-up cross sections (double-angle or double-channel) is required and guidance on design and detailing of brace to beam and column connections needs to be provided.

9. **Dual structures (Moment Resisting Frames combined with Concentrically or Eccentrically Braced Frames)**: Further studies are needed to establish the necessity to provide a minimum level of strength and/or stiffness to MRFs in dual structures. The effect of sequential development of plastic mechanisms shall be in addition investigated.

10. **Drift limitations and second-order effects**: A number of shortcomings are identified regarding the account for P-Delta effects through the inter-storey drift sensitivity coefficient (in particular regarding its interaction with the behaviour factor) as well as regarding the damage limitation criteria (inconsistency with UBC, limitation based only on the deformation capacity of non-structural elements, arbitrary choice of the return period…). All these aspects should be reconsidered.

11. **New structural types**: Design provisions for CBFs with buckling restrained braces (BRBs), steel plate shear walls (SPSWs), truss moment frames (TMFs) and CBFs with dissipative connections should be included. More generally, a comprehensive methodology to find out the seismic design parameters of innovative structural systems should be provided.

12. **Low-dissipative structures**: A need is identified for the development of specific simplified rules and design aids for designing structures in low and moderate seismic regions, e.g. development of intermediate rules, less severe than DCM and DCH rules allowing the justification of a moderate but sufficient ductility of the structures. Background studies are also needed to detect the possible weaknesses of DCL design in moderate to high seismic regions and to define the required elastic overstrength required to provide a safety level equivalent to a DCM or DCH design, together with the definition of clear criteria allowing demonstrating the post-earthquake operability of a structure.

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