SEISMIC DESIGN OF STEEL STRUCTURES IN CANADA – ACHIEVEMENTS, PRUDENCE AND FUTURE DIRECTIONS

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ABSTRACT: Seismic design provisions for steel structures have been implemented in 1989 in the CSA S16 steel design standard in Canada. The new Clause 27 then included provisions for a few categories of moment frames, concentrically braced frames, and eccentrically braced frames. The latest 2014 edition of CSA S16 contains seismic design requirements for ten steel seismic force resisting systems including steel plate shear walls and buckling restrained braced frames. General provisions have also been incorporated to enhance the response of the different systems including minimum toughness requirements for steels and weld metals used in critical elements as well as requirements for protected zones. Pre-qualified beam-to-column connections are now permitted for moment frames and alternative built-up or replaceable modular link beams have been introduced for eccentrically braced steel frames. A new annex has been created to provide seismic design rules for heavy industrial structures. Those changes will be outlined in the presentation, together with areas where improvements to CSA S16 are needed. Provisions for global stability (P-delta) effects and lateral deformation capacity of the gravity load resisting system are topics that will have to be revisited. Design requirements for heavy industrial structures will likely need refinements as knowledge is gained on the seismic behaviour of these structures and the rules are being used in practice.

Steel is a material of choice to achieve reliable ductile behaviour under inelastic seismic demands and CSA S16 provides comprehensive guidance to achieve cost-effective structures that can safely withstand earthquake effects when using this material. Nevertheless, non-ductile failures or inadequate structural responses are still possible in steel frames subjected to severe reversed cyclic inelastic deformations. Examples will be presented to emphasize the fact that prudence must always be exercised when designing and detailing structures to resist earthquakes through ductile response. In steel frames, localised inelastic demands in connections may result in premature failure that can alter the overall system ductility. Concentration of inelastic deformations in structures or members is also a possibility that must be mitigated to prevent failures. Some framing configurations are also prone to progressive drifting due to gravity loads acting on the yielding structure, a situation that may endanger global seismic stability and result in structural collapse.

The presentation will also touch future directions in earthquake resistance. One aspect that will draw more attention in the coming years is the seismic evaluation and retrofit of existing structures constructed prior to the implementation of seismic designing and detailing provisions. The need for effective and targeted retrofit solutions will encourage the use of advanced analysis techniques and performance-based design procedures. In view of their advantages, it is envisioned that these tools will also become more popular for new constructions, and design standards will therefore need to be adjusted to accommodate this evolution. The conditions will also become more favourable for adopting structural systems that can offer superior seismic performance, both for existing and new structures. Innovative steel systems with replaceable ductile fuses and/or re-centering capabilities are among the solutions that can be used to limit damage and reduce demands on building content under strong as well as smaller, more frequent earthquakes. Implementation of these systems in practice will be eased in view of the high quality fabrication standards and pre-fabrication techniques already in use in the steel industry.