Closure to "State-of-the-Art Review on Seismic Design of Steel Structures" by Chia-Ming Uang and Michel Bruneau

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The writers thank the discussers for their interest in the paper. It is understood that, while they have not found technical errors in the material presented, their opinion is that the presented state-of-the-art review should have been broader in scope, namely, addressing issues related to the dynamic response of steel structures and the effect of uncertainties in ground motion characteristics and other parameters on this dynamic response—particularly as addressed through performance-based design (PBD).

In developing a state-of-the-art paper, authors must scope their efforts to fit the constraints of journal papers. In this case, as stated in the "Introduction" of the original paper, the authors elected "to provide an overview of how the philosophy of steel seismic design has evolved in recent decades, as driven by new developments, the occurrence of significant earthquakes, and changes in earthquake engineering practice." Hence, the objective was not to provide a comprehensive review of all research and perspectives (which was not possible), but rather "to provide the reader with an appreciation of the current seismic design requirements for steel structures as currently framed," using the AISC Seismic Provisions (AISC 2016) for this purpose. The authors believed that this would enlighten past decisions and the process by which the comprehensive steel design specifications have evolved—something presumably of interest to those who have not been closely involved in such activities.

The topic of PBD was briefly touched upon in the paper, solely to highlight that PBD is progressively finding more use in practice, but, as stated in the paper, "a review of research, developments, and codification in this area is beyond the scope of this paper." Arguably, a state-of-the-art paper on PBD would be desirable, recognizing that the features of PBD are actually broader than just how it pertains to steel structures alone.

With respect to the use of *low-damage*, the authors purposely left the term undefined in the text, hoping it would entice readers to download the free report documenting the Christchurch reconstruction (Bruneau and MacRae 2017), which is a valuable reference for engineers having an interest in the seismic design of steel structures. However, in answer to the request for clarification, the following text taken from that report is provided here:

> In New Zealand, structural systems that are specifically designed to limit seismic damage in structures and that do not need to be fully replaced immediately after a major event have been termed "low-damage technologies/structures." Not all low-damage systems are equal in terms of construction cost, expected performance (structural and non-structural), post-event inspection requirements/costs, or post-event reinstatement requirements/costs. (. . .) Some engineers have argued that low-damage/replaceable technology structures include nominally elastic systems, conventionally designed systems properly designed and constructed, EBF systems with replaceable links, BRB systems, systems with axially yielding devices, systems with flexural yielding devices, systems using lead dissipators, systems using friction dissipators, viscously damped systems, base isolation (using sliding friction systems, lead-rubber dissipators, or both), and rocking systems (MacRae et al. 2016).

The concept of low-damage structures is not new. For example, readers can refer to Wada et al. (2004) for the similar concept of damage-controlled structures and the applications in Japan.

References

AISC. 2016. *Seismic provisions for structural steel buildings*. ANSI/AISC 341. Chicago: AISC.

Bruneau, M., and G. MacRae. 2017. *Reconstruction of Christchurch: A seismic shift to steel buildings*, 170. Canterbury, New Zealand: Quake Center, Univ. of Canterbury.

MacRae, G. A., G. C. Clifton, and M. Bruneau. 2016. "Some NZ earthquake lessons and better building construction." In *Proc., Australian Earthquake Engineering Society Conf., Paper 390*. Melbourne, Australia: Australian Earthquake Engineering Society.

Wada, A., Y. Huang, and V. V. Bertero. 2004. "Innovative strategies in earthquake engineering." Chap. 10 in *Earthquake engineering: From engineering seismology to performance-based engineering*, edited by Y. Bozorgnia and V. V. Bertero, 10.1–10.32. Boca Raton, FL: CRC Press.

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