

CHAPTER 7 SUMMARY AND CONCLUSIONS

An innovative structural system for resisting lateral forces under severe ground motions called Buckling-Restrained Knee Braced Truss Moment Frame (BRKB-TMF) is investigated. A design procedure for BRKB-TMF was developed and applied to an example 4-story steel structure. The system was designed by a performance-based procedure called Performance-Based Plastic Design (PBSD) method.

Nonlinear analyses including static pushover and time-history analyses were performed to evaluate structural response. Collapse evaluation was also performed using an incremental dynamic analysis (IDA) approach in accordance with FEMA P695 (2009) methodology. The methodology in FEMA P695 covers performance evaluation which accounts for the spectral shape effect and total system collapse uncertainty.

Conclusions regarding the results from nonlinear static and dynamic analyses, collapse evaluation per FEMA P695, and performance sensitivity analysis are as follows.

- 1) The PBSD procedure presented in this research can be used to design BRKB-TMFs. For the example structure, the PBSD procedure results in the frame with excellent response with all the inelastic activities confined to only the designated elements. The median value of maximum interstory drifts was lower than the design target drift at both MCE and 2/3 MCE levels. It was found that there was approximately 50% probability that the drift would be less than or equal to the target values.
- 2) BRBs are the heart of the BRKB-TMF system. The fracture of a set of BRBs dramatically reduces lateral force resistance and induces instability or collapse of the structure. Both static and dynamic analysis results indicated that when the story drifts reached approximately 6%-7%, the collapse occurred. The failure pattern was typically the fracture of a set of BRBs leading to excessive rotation of the plastic hinges in the columns or in the top chords of the trusses. Therefore, it is important to prevent an early failure of the BRBs. This can be done by selecting the target drift and the configuration of the frame corresponding to the deformation capacity of the BRBs
- 3) The results of the collapse evaluation indicated that the probability of collapse for the MCE ground motions was less than 10%.
- 4) *ACMR* value of the BRKB-TMF designed by the PBSD method passed the FEMA P695 criteria for an individual archetype structure. However, further evaluation of a group of structures is still required. Frame with various heights (e.g. 6, 10 or 12 story height) must be evaluated in order to fully validate BRKB-TMF system.
- 5) The ductility of the system depends on BRB deformation capacity. Large ductility in the BRBs enhances the performance of the structural system. BRBs with 4% core strain capacity appear to be optimum for the BRKB-TMF system. For frames using more ductile BRBs (with strain capacity more than 4%), the performance would be governed mainly by other components such as column,

and truss top chords. This 4% strain capacity is certainly achievable within current technology

Although further investigations are required before this system can be fully validated, this study strongly demonstrates the potential of the proposed system. Currently, large-scale subassemblage tests as well as further detailed analytical studies are being planned as part of an international collaborative research project. The findings from these studies will provide full-fledged validation for this framing system.