Validation of Non-Linear Time History Analysis Models for Single Storey Concentrically Braced Frames Using Full Scale Shake Table Tests

J. Goggins and S. Salawdeh

Abstract

The concentrically braced frame (CBF) structure is one of the most efficient steel structural systems to resist earthquakes. This system can dissipate energy during earthquakes through braces, which are expected to yield in tension and buckle in compression, while all other elements such as columns, beams and connections are expected to behave elastically. In this paper, the performance of single-storey CBFs is assessed with nonlinear time-history analysis, where a robust numerical model that simulates the behaviour of shake table tests is developed. The numerical model of the brace element used in the analysis was calibrated using data measured in physical tests on brace members subjected to cyclic loading. The model is then validated by comparing predictions from nonlinear time-history analysis to measured performance of brace members in full scale shake table tests. Furthermore, the sensitivity of the performance of the CBF to different earthquake ground motions is investigated by subjecting the CBF to eight ground motions that have been scaled to have similar displacement response spectra. The comparative assessments presented in this work indicate that these developed numerical models can accurately capture the salient features related to the seismic behaviour of CBFs. A good agreement is found between the performance of the numerical and physical models in terms of maximum displacement, base shear force, energy dissipated and the equivalent viscous damping. The energy dissipated and, more particular, the equivalent viscous damping, are important parameters required when developing an accurate displacement-based design methodology for CBFs subjected to earthquake loading. In this study, a relatively good prediction of the equivalent viscous damping is obtained from the numerical model when compared with data measured during the shake table tests. However, it was found that already established equations to determine the equivalent viscous damping of CBFs may give closer values to those obtained from the physical tests.

Keywords

nonlinear time history analysis;concentrically braced frames;shake table tests;equivalent viscous damping