Seismic performance improvement of steel frames using friction damping bracing systems

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ABSTRACT

The damages observed in recent earthquakes show that it is necessary to choose new methods for improving the seismic response of structures. Energy dissipation capacity of structures subjected to strong earthquakes plays a vital role to protect the primary structural members from severe damage or failure. This study investigates a friction damping bracing system in order to improve the response of steel frames designed only for gravity loads. A simplified model describing the behaviour of the friction damper device was developed for global analyses of steel frames. Parametric analyses based on numerical simulations were carried out to evaluate the slip force with the aim of minimizing the values of top displacement and hysteretic energy dissipated by the steel frame. The main results of nonlinear dynamic analyses performed on steel frames incorporating friction damping bracing systems are presented and compared with the response of the unprotected counterpart. The effectiveness of the protection system was also assessed by examining the seismic response of the frame equipped with traditional braces, without friction devices. The results of the numerical investigations showed that the use of the friction damping bracing system caused an increase of the dissipative capacity of the frame, above all for severe seismic actions. The plastic deformation concentrated inside the device, protecting the main structural elements from severe damage. The formation of the plastic hinges at the column base was delayed with respect to the unprotected frame. Numerical analyses indicated that the introduction of supplemental damping by using friction devices in steel bracings is very effective for seismic protection of steel frames subjected to severe seismic actions.

Key Words: Steel frames, dissipative devices, energy dissipation, numerical models

1 INTRODUCTION

Supplemental passive energy dissipation systems have been successfully used for reducing the dynamic response of structures subjected to seismic actions. To this aim, special devices are incorporated within the structure to absorb a portion of the input seismic energy. As a result, the energy dissipation demand on primary structural members is often considerably reduced, along with the potential for structural damage. Several energy dissipation systems of various kinds have been studied and tested by numerous researchers in recent years, either for seismic retrofitting, or for new construction. This paper presents some results of a numerical research study on a friction damping bracing system in order to improve the seismic response of steel moment resisting frames during severe earthquakes. The friction damping device consists of diagonal brace elements with a friction interface at their intersection point, which are connected together by horizontal and vertical link elements, as shown in Figure 1, Pall (1982). The friction resistance of the device requires a normal force on the sliding interface, and this is achieved through a bolt at the intersection of the diagonal arms. During seismic excitations, the device slips at a predetermined load, before any yielding of the main members has occurred.