Assessment of Structural Performance of Steel Coupling Beams with Corrugated Webs

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Abstract

Nowadays steel coupling beams are considered as efficient alternatives to reinforced concrete coupling beams, which can improve the ductility and seismic performance of the coupled shear wall systems. In this paper, the application of corrugated webs as an alternative to flat webs with stiffeners as a proposition for enhancing structural performance of such beams is investigated through detailed numerical simulations. Several models are developed based on some key geometrical parameters, viz. web-plate shape, web thickness, number of corrugations, and corrugation angle, and the structural performance of these models is evaluated via nonlinear pushover and cyclic analyses. It is shown that application of corrugated web makes it possible to achieve larger rotation capacity compared to that of commonly-used steel coupling beams. Moreover, the results of this study demonstrate that corrugated-web steel coupling beams possess appropriate energy absorption characteristics and are capable of dissipating the input energy in a quite desirable and efficient manner.

Keywords: Steel coupling beams; Corrugated web; Numerical simulation; Rotation capacity; Energy absorption characteristics

1. INTRODUCTION

In the design of tall buildings, coupled shear walls are high-performing, economical, and aesthetically pleasing lateral force-resisting systems. The structural performance of such systems is highly dependent on the design and behavior of the coupling beams which have an effective role in the energy dissipation of the system. Steel coupling beams are a viable alternative to reinforced concrete coupling beams and they may improve the ductility and seismic performance of the coupled shear wall systems (Park and Paulay 1975, and Shahrooz et al. 1993). Steel coupling beams are advantageous, particularly where height restrictions do not permit the use of deep reinforced concrete or composite coupling beams, or where the required capacity and stiffness cannot be developed economically using a conventionally-reinforced concrete coupling beam (Park and Yun 2005).

This paper investigates the use of corrugated plate instead of flat web with stiffeners as a means of improving the structural behavior of steel coupling beams. For this regard, the finite element program ANSYS (2007) was used. In order to verify the accuracy of numerical simulation, the experimental and numerical results of a steel coupling beam, tested by Park and Yun (2005), are compared. Considering the geometrical parameters i.e. web-plate pattern, web thickness, number of corrugations, and corrugation angle, 160 models are simulated and analyzed under monotonic loading. Finally, 36 FE models are selected to investigate the energy absorption characteristics of such beams through cyclic loading.

2. PROPERTIES OF STEEL COUPLING BEAM MODELS

Park and Yun (2005) tested a steel coupling beam, specimen HCWS-SCF. The geometrical properties of the FE models in this study are similar to the specimen. The specimen is in 1/2 scale. Due to symmetry only one half of the coupled shear wall system was tested. The steel coupling beam in this test specimen, HCWS, was considered to behave as a cantilever beam subject to a point load at the end. The dimensions of the steel coupling beam, Specimen HCWS, are shown in Figure 1. By replacing the flat stiffened web of the specimen, with flat and corrugated web-plates of various geometrical properties, a series of flat and corrugated-web steel coupling beams is generated. The geometrical properties of the corrugated web-plates are shown in Figure 2, in which a = flat (or horizontal) sub-panels width, b = horizontal projection of inclined sub-panels width, c = inclined sub-panel width, d = corrugation depth, h_w and t_w = web height and thickness respectively, w = maximum fold width, R = radius of corrugation curve, θ = corrugation angle, and x,z = coordinate axes.