STIFFENER REQUIREMENTS IN STIFFENED STEEL PLATE SHEAR WALLS

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ABSTRACT

The 6-story Olive View Medical Center in California and the 35-story Kobe City Hall tower, both of which showed good performance while withstanding earthquakes, are two examples of structures that were constructed using stiffened steel plate shear walls as a lateral load resisting system. Stiffeners are used in such lateral load resisting systems to improve the buckling stability of the shear panel. However, using plate girder equations often leads to uneconomical and, in some cases, incorrect design of stiffeners due to major differences between plate girders and steel plate shear walls (SPSWs).In this paper, the effect of the rigidity and arrangement of stiffeners on the buckling behavior of plates is studied using the finite element method (FEM). Subsequently figures covering curves for the design of stiffeners in various practical configurations are presented.

INTRODUCTION

A steel plate shear wall (SPSW) is made of an infill steel plate surrounded by horizontal boundary elements (beams) and vertical boundary elements (columns). It is a relatively new lateral load resisting system, and over the last three decades, because of its excellent performance, has attracted designers' attention in areas of high seismicity. Some of the features of the SPSW system are its high initial stiffness, excellent ductility, robust resistance to cyclic degradation and significant energy dissipation.

SPSWs were first used, along with stiffeners, in the 1970's, since out-of-plane buckling of infill panel was considered at design limitation.Laboratory tests, conducted by Takahashi et al. (1973), on plates with various thicknesses and different stiffener dimensions, indicated that by effectively reinforcing the shear panel using stiffeners, hysteresis loops of an SPSW can be transformed from s-shaped in the thin SPSW to spindle-shaped in the stiffened SPSW as shown in Fig. 1. This transformation increases the area under the hysteresis loops, which increases the energy dissipation of the wall and simultaneously improves its performance. Some distinguished practical uses of this system are as follows: a 20-story office building in Tokyo, Japan (Thorburn et al., 1983); a 53-story high rise in Tokyo, Japan (Astaneh-Asl, 2001); a 30-story hotel in Dallas, Texas (Astaneh-Asl, 2001); a 6-story hospital in Los Angeles, California (Astaneh-Asl, 2001); and a 35-story office building in Kobe, Japan (Astaneh-Asl, 2001).

After the construction of the last two buildings was completed, they were exposed to the 1994 Northridge and the 1995 Kobe earthquakes respectively. Both buildings performed well during the earthquakes, and only experienced minor structural damages (Naeim and Lobo, 1994; Fujitani et al., 1996).

Current design specifications (AISC 341-10; Sabelli and Bruneau, 2007) have not properly addressed the issue of stiffened SPSW, and because the boundary elements in an SPSW are different from those in a plate