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Effect of the girder-supported steel plate on SPSW's seismic behavior

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Abstract

The conventional type of Steel Plate Shear Wall (SPSW) consists of a steel plate which connected to the surrounding frame. The separation of steel plate from columns is a useful idea developed in order to reduce of column's and foundation's lateral transferred overturning moments. This paper discussed, pushover analyses on the girder-supported panels subjected to monotonic in-plan shear by finite element method. To avoid plate's edges tearing and increase its strength, use of two vertical stiffeners at the ends of plate has been investigated. The most important parameters such as frame aspect ratio, plate width to thickness ratio, covering area of the plate to frame ratio and the dimension of stiffeners in this system have been investigated. As conclusion, behavior of this type of SPSW was comprised with the classic type to find and publish the different aspects, and therefore, appropriate behavior of this system has been studied, specially for rehabilitation and retrofitting the existing buildings and damaged structures.

Keywords: Steel Plate Shear Wall, Girder-supported panels, Surrounding frame, Seismic behavior

1. INTRODUCTION

Steel plate shear walls (SPSW) have been used in buildings as the lateral force resisting system in last four decades. There have been numerous SPSW research programs to help foster a better understanding of this system's behavior, particularly as it relates to earthquake-resistant design.

The typical SPSW system is comprise of un-stiffened or stiffened steel plate connected to both vertical and horizontal boundary elements. The structural elements usually are designed to carry out the gravity loading without considering the steel plate's effects in this system. Elements around the panels consist of SPSW, also should be designed based on the capacity of the steel plate wall due to the development of its tension-field action. This demand is based on the panel's aspect ratio, the steel plate's thickness and the steel plate's expected strength [1]. It makes necessary to design strong columns and large foundations due to their high seismic loadings.

The separation of plate from columns is a useful idea developed in order to reduce the number of main members in lateral resisting structural system. In 1994, Xue and Lu [2], at Lehigh University examined analytically the behavior of SPSW system with different connection configurations. The used models were consisted of three spans and twelve stories frames, with moment resisting beam to column connections in the exterior spans and filled with steel plates in the middle span. They found that, in the specimen which plate was only connected to beams with shear connections, the story shear was distributed symmetrically between four columns. Because of no connection between plate and columns, the girder bending moments was essentially controlled by the tension field action of the plate. Based on these results, the peak bending moment for this system moved away from the beam to column connections and forcing the plastic hinges to occur within the beams. As such, this system was considered more favorable for enhancing the overall ductility of SPSW while reducing deformation demand on the beam to column connections.

Later, in the second paper, they reported a numerical parametric study conducted on the one span, one story girder only-supported SPSW model. They found that the variation of width to thickness ratio has no significant effect on the overall load-displacement response of the structure whereas the aspect ratio of the panels has a significant effect on the behavior of this system. They also presented an empirical equation to predict the yield strength, yield displacement and post-yield stiffness in SPSW system [3].

In 2001, Driver et al. [4] proposed the idea of separation of SPSWs from the moment resisting frame by inclusion of supplementary columns.