EFFECT OF STIFFENERS ON THE ANGLE OF INCLINATION IN STEEL PLATE SHEAR WALLS

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ABSTRACT

Steel plate shear walls (SPSW) are an efficient but largely underused building lateral force resisting system. The system comprises of a moment frame (the boundary frame) with slender steel web plates that are welded or bolted inside the boundary frame. The resulting structure is similar to a vertical plate girder. The system resists lateral load primarily through tension field action of the post-buckled web plate. The magnitude and orientation of this tension field is governed by the relative stiffness of the web plate and boundary frame. The 2010 Seismic Provisions currently require that the tension field inclination angle be either 40° or computed using a formula derived from elastic analysis. This paper presents a new relationship for the diagonal tension angle considering effect of stiffeners. It is demonstrated that the tension field inclination may move, from an initially low angle under an elastic post-buckled state, toward 45° as the plate is loaded plastically.

INTRODUCTION

The steel plate shear wall (SPSW) recently came into view as a commercially executable building lateral system in the United States when it was included in the 2005 American Institute of Steel Construction (AISC) Seismic Provisions for structural steel buildings, in which they are expressed as special plate shear walls. By that time it had been instrumented only sporadically in the United States. The seismic response of SPSWs has not been studied as extensively as other lateral systems and there is limited data available on SPSW earthquake performance. However, a considerable amount of analytical and experimental research from Japan, Iran, Turkey, Canada, the United Kingdom, and the United States has been undertaken since the early 1970s, the majority of which has occurred over the last 15 years. The results of this body of research is that the system has very good ductility and energy dissipation capacity and is a cost-effective lateral system for new construction.

Stiffened SPSWs have been preferred in Japan where elastic buckling of structural elements providing lateral load resistance is not permitted. Given the requirement that steel plates must achieve their full plastic shear strength, other types of structural configurations have emerged in which shear yielding elements are introduced, without being SPSWs in the sense considered in here. Such concepts include small shear-yielding panels connected to beams at midspan or inserted at midheight of special intermediate columns, and designed as hysteretic dampers.

In contrast to these advantages, it is yet to attract expansive acceptance by the design and construction communities in the United States. Furthermore, SPSWs are more challenging to analyze and design than most other lateral-force resisting systems.

The analytical difficulty results from the web plate behavior and its complicated interaction with the boundary frame (the HBEs and VBEs). The web plate is the main lateral-load-resisting component of the wall,