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Electromechanical Finite Element Modeling of Unstiffened Smart Steel Shear Walls (SSSWs)

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Abstract

In this research, electromechanical finite element modeling of unstiffened smart steel shear walls (SSSWs) is investigated using ANSYS®. The SSSWs are made of an elastic host plate and piezoelectric active layers. In this approach, the piezoelectric pieces are used parallel to the diagonal direction of steel plate. In other words, the piezoelectric segments will be placed parallel to the tension field of plate which happens after buckling. This new combination can be imaged as combination of SSWs with diagonal piezoelectric braces. Load bearing capacity of plate will be increased after post-buckling when an electric field intensity vector is applied.

Keywords: Finite Element modeling, Steel Shear Walls, Actuator, Smart structure, ANSYS®

1. INTRODUCTION

Steel shear walls (SSWs) are one of the options of lateral force resisting systems. Using SSWs has increased due to the fact that this system is more cost-effective compared to the moment frame system. The SSWs can be used in both new and retrofitted structures in seismically high risk zones. In this system, buckling of the plate which is completely connected to the main frames will not be considered as a structural failure. In other words, the post buckling strength of the plate is several times that of the elastic. Steel shear walls (SSWs) are constructed in two forms of unstiffened and stiffened forms. The unstiffened form is the best passive choice for designers, because of its simple constructional details and lower cost.

Three design approaches has been proposed up to now. The first is the Canada code method [1]. The second is the truss equivalent element which was proposed by Elgaaly who modeled SSWs as some strip elements which are just affected by tension forces. The main problem of this method is that the interaction between columns and SSWs has been neglected [2]. In real conditions, the interaction exists. Although the columns are designed for 100% of bending moment, a portion of the moment is carried by the SSWs. If SSWs are thin, they will exhibit out of plate buckling, even for such a little moment. In these conditions, the behavior of shear wall panels is erratic. The third method was suggested by Saboori and Roberts [3]. The method is based on plate frame interaction (PFI). In PFI method, the interaction was taken into account, but they neglected the moment bending effect for SSWs.

Also, some experimental studies for evaluating SSWs behaviors have been executed. Takanashi and Takemoto et al. [4], Mimura and Akiyama et al. [5] implemented cyclic vibration experiments on twelve 1 and 2 storey buildings. Caccese and Elgaaly et al. [6] set up lateral cyclic vibration experiments on eight 3 storey and seven 2 storey specimens. Timler et al. announced that SSWs are more economic than concrete shear walls. They also recognized that the design cost ratio of steel structures to the concrete ones is 0.66 and for the total cost of construction the ratio is 0.96. Berman and Bruneau did cyclic vibration experiments on six 1 storey specimens [7].

Piezoelectric stack actuators have been widely used to control large structures which require high control forces. Some reported cases of usage of piezoelectric stack actuators in large structures include that of Aizawa et al. [8] for response control of a four story structural frame by inserting the actuators into the