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Theoretical analysis of Lateral load responses on self-centering concrete walls with vertical dampers

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ABSTRACT

Self-centering concrete wall is a kind of aseismic system which is formed by introducing unbonded post-tensioning technology into rocking precast concrete walls. This system has attracted wide investigation in recent years, since it has good aseismic ability and reparability. The set of vertical dampers can further improve the energy dissipation ability of this system. This paper focuses on the lateral load responses of self-centering walls (SCW) with vertical dampers (VDs). A modified limit state calculation method is proposed for this VD-SCWs, which has better prediction precision than conventional description method. Some original experimental data in other literatures are utilized to verify the proposed method. Parametric analysis is conducted to investigate the influence of damper and tendon parameters on the performance of VD-SCWs. The results show that appropriate initial stress in PT tendons can improve the self-centering capacity of the wall, but large elasticity modulus of the PT tendons will reduce the energy dissipation capacity.

1. Introduction

Ductility design concept is usually adopted in many seismic codes, which implies extensive structural damage after a design level earthquake. The importance of economic considerations in the field of repair costs has triggered many researchers to investigate different categories of self-centering structures without any damage in the beam or column and residual drift, such as: self-centering beam-column connections (Wolski and Ricles 2009, Tsai and Chou 2008), self-centering moment-resistant frames (El-Sheikh and Sause 1999, Kim and Christopoulos 2008), self-centering braced frames (Tremblay and Lacerte 2008) and self-centering walls (Clayton and Berman 2013, Xiaobin and Yunfeng 2012). Self-centering walls (SCWs) are an aseismic system

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by introducing unbonded post-tensioning technology into traditional precast concrete rocking walls, which is also called unbonded post-tensioned precast concrete walls (UPT Walls).

There were no energy dissipation elements in the original concept of SCWs. Armouti (1993) investigated the hysteretic performance of SCWs, and the experimental results demonstrated SCWs have excellent self-centering capability. Kurama *et al* (1999) researched the behavior of SCWs under cyclic lateral loads and developed a seismic design approach for SCWs. After that, they analyzed the seismic responses of SCWs and verified the design methodology to prevent shear slip along horizontal joints in walls (Kurama 2002). Results demonstrated that the tendon area, initial force and tendon eccentricity have significant influence on the self-centering capability. They also indicated that the method for estimating wall drifts need to be improved. Perez *et al* (2004a, 2007, 2013) derived a series of closed-form expressions on the behavior of SCWs and then proposed a design method for SCWs by combining experimental results and numerical simulation. Moreover, they investigated the mechanical performance of SCWs with vertical joint connectors (Perez 2004b). In these researches, skeleton curves of SCWs are all described as four limited states: Decompression (denoted as DEC), Effective Linear Limit State (denoted as ELL), Yielding of Post-Tensioning Steel (denoted as LLP) and Crushing of Confined Concrete (denoted as CCC). Note that the calculation of DEC and CCC is accurate by their equations, but the prediction of ELL has large deviation due to the ignorance of gap opening effect along the horizontal joint at the wall base. Meanwhile, the calculation of LLP usually adopts a complicated iterative strategy and has a poor accuracy.

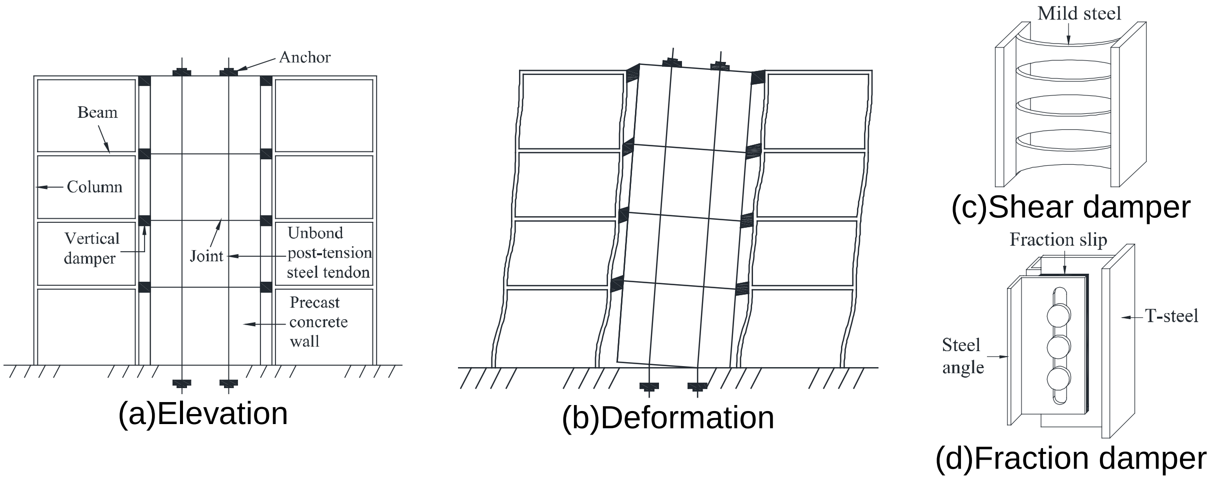

Fig. 1 The concept of frame-SCW system with Vertical dampers

Then some researchers developed the structural system by integrating energy dissipators into SCWs to increase energy dissipation capacity of SCWs. Kurama (2000) added liner viscous fluid dampers as a supplementary passive energy dissipation system into SCWs. He proposed a design approach to control the maximum roof drift of SCWs with viscous dampers and verified the performance of wall systems through nonlinear dynamic time-history analysis. Kurama (2001)[0] added supplementary friction

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