Numerical Analysis of corrugated steel shear walls with and without rectangular opening

Alireza Farzampour[1] and Jeffrey A. Laman, PhD, PE[2]

[1]Graduate Student Department of Civil Engineering, Virginia Tech

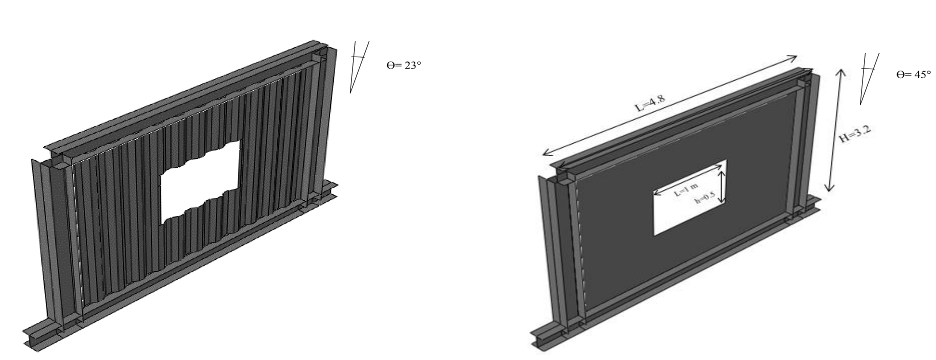
[2] Professor of Civil Engineering, Department of Civil and Environmental Engineering, The Pennsylvania State University

ABSTRACT:

The widespread usage of corrugated steel plates as girders and steel shear walls necessitates the need for further investigation of these efficient structural members. Having significant initial stiffness, high capability of energy dissipation and special geometry are the fundamental reasons for this study. The nonlinear behavior of trapezoidal corrugated steel shear walls with rectangular opening has been studied in this paper. A series of corrugated and simple shear walls with and without opening regarding different angles of corrugation and different infill plat thicknesses have been investigated. This analytical study was conducted to compare the initial stiffness, ultimate strength, energy dissipation and force-displacement curves of corrugated steel shear walls. Additionally, the results show that utilizing trapezoidal corrugated panels increase initial stiffness, capability of energy dissipation and ductility, while reducing the ultimate strength of shear wall system with opening.

INTRODUCTION:

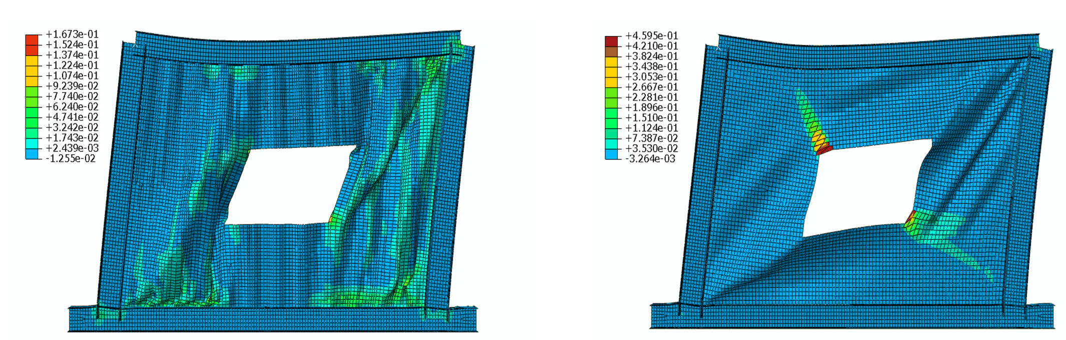
An extensive, numerical, parametric study of steel shear walls was conceived to include the variables most commonly considered over the most common range of each variable. A total of 540 single story CSSWs and SSWs with different opening positions, opening sizes, plate thicknesses and angles of corrugation have been investigated, failure modes and force-displacement curves have been evaluated (Figure 1) as well. The five different plate thicknesses and the three corrugation angles are considered based on common values mentioned in the literature.



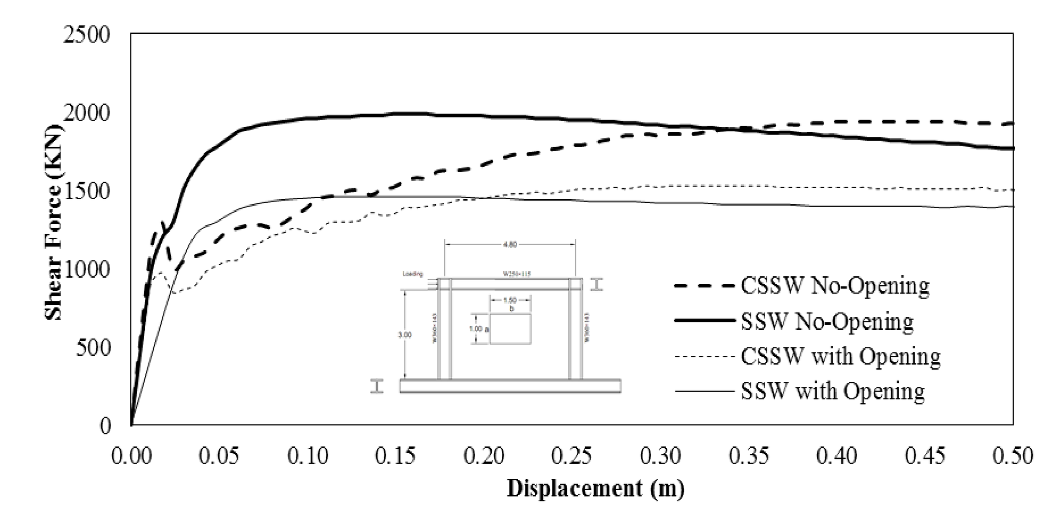
a) CSSW with opening (α=90)   b) SSW with opening

EXPLANATION AND RESULTS:

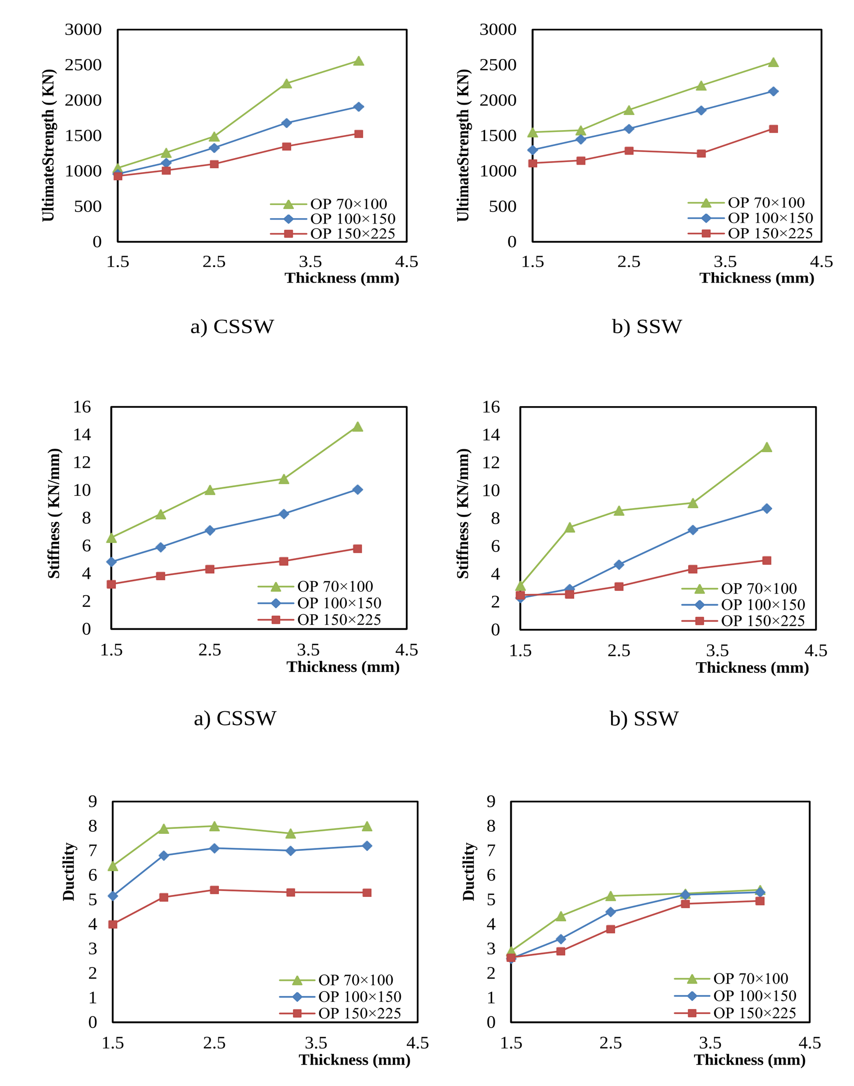
The height and length of the story panel are 3.2 m and 4.8 m, centerline to centerline, respectively, simulating the conventional residential building. The moment frame is modeled as rigid frame construction with regard to girder-to-column connections. The SSW and CSSW without openings are designed based on the PFI method in which the plate-frame interaction is precisely considered; thus, the effect of vertical load was ignored. The plastic strain contours and push over curves for these shear walls are indicated below.



a) CSSW with Opening   b) SSW with Opening



CSSW VS SSW:

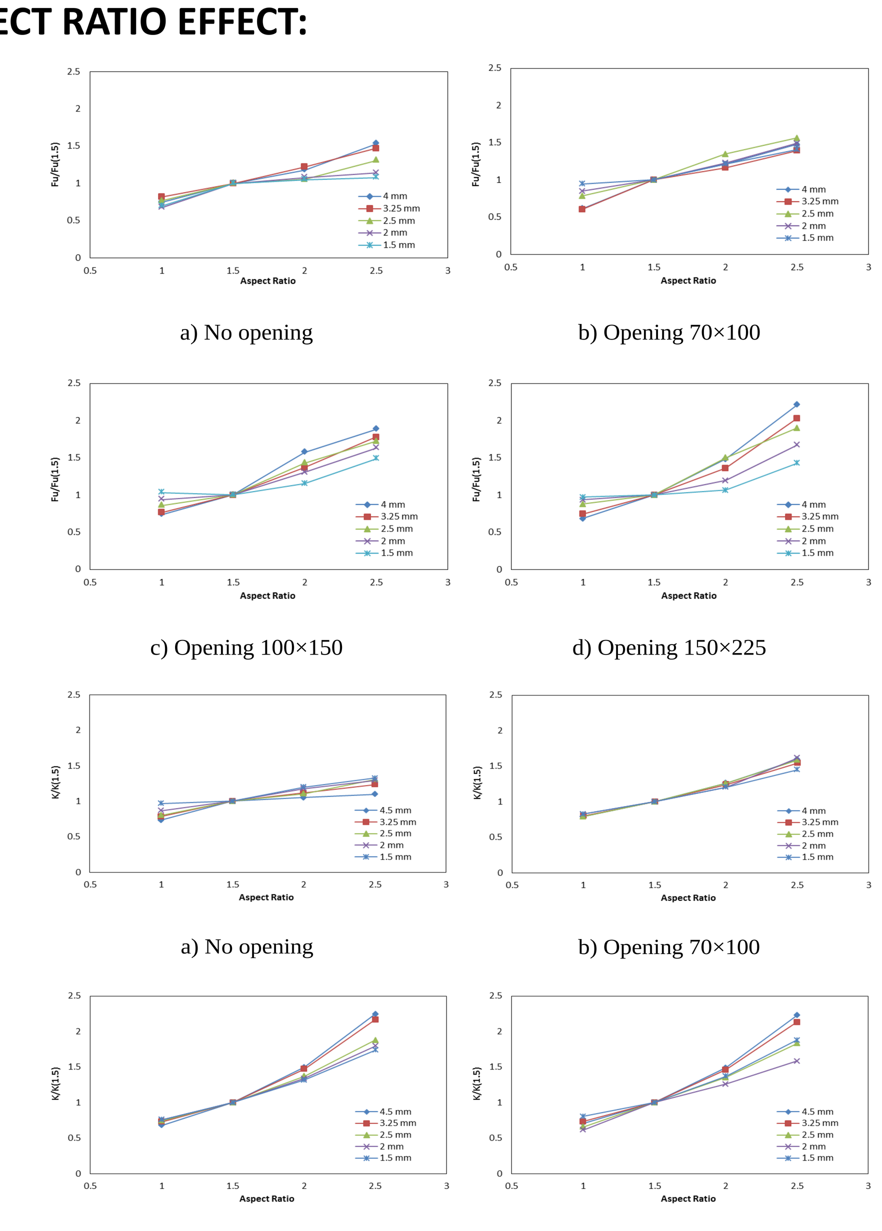


a) CSSW   b) SSW

a) CSSW   b) SSW

a) CSSW   b) SWW

ASPECT RATIO EFFECT:



a) No opening   b) Opening 70×100

c) Opening 100×150   d) Opening 150×225

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LATERAL STRENGTH AS A FUNCTION OF OPENING:

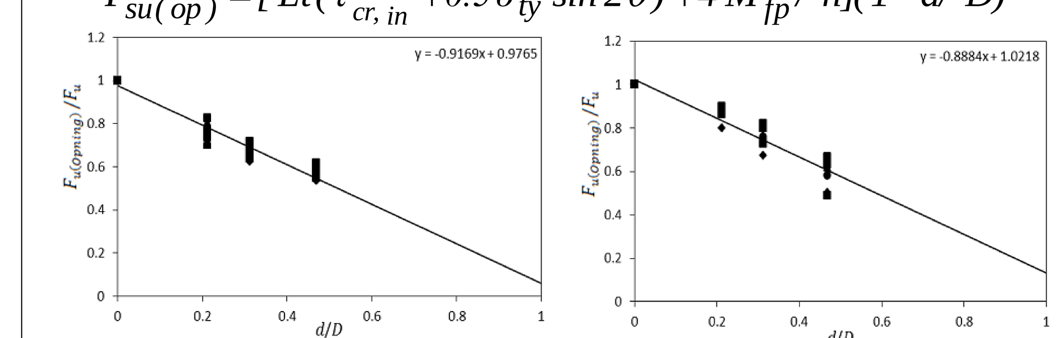
To better understand the effect of openings, the ratio of ultimate shear strength of each configuration to that of a solid wall has been evaluated.

The ultimate strength F_U(Opening) /F_U (ultimate shear strength of single opening to no opening) is plotted as a function of d/D in figures below, where d is the diameter of a rectangular opening and D is the diameter of the shear wall. It is observed that the ultimate ratio has a linear variation with diameter ratio.

$$F_{su} = [F_{pt} + F_{fu}] \qquad F_{su(op)} = F_{su}(1 - d/D)$$

Therefore, The CSWW ultimate is calculated as follows

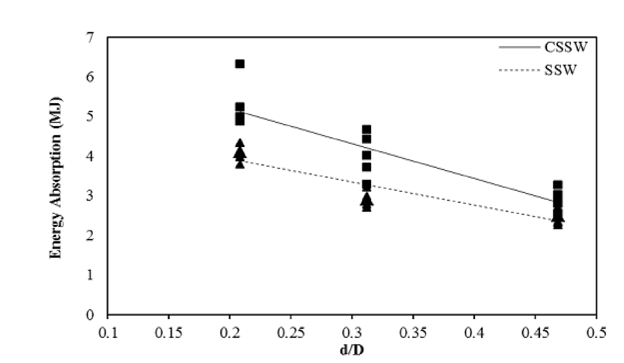
$$F_{su(op)} = [Lt(\tau^{e}_{cr,\,in} + 0.5\sigma_{ty}\sin 2\theta) + 4M_{fp}/h](1 - d/D)$$



Effect of diameter ratio on ultimate strength ratio

Energy absorption:

The load-displacement region between onset of inelastic and a half cycle load with 30% drift ratio can be approximated as the energy absorption capacity of the system. Utilizing this definition, figure below presents the energy absorption capacity of CSSW and SSW, with an opening, under lateral shear loading. The solid and dashed lines of this figure represent the average shear wall energy absorption with a centrally located opening as a function of opening size. It is observed that the absorption energy decays with increasing opening size for both CSSW and SSW. The SSW energy absorption capacity is consistently less than that of CSSW. Moreover, the CSSW energy absorption capacity for all plate thicknesses is larger than SSW.



SUMMARY AND CONCLUSIONS:

The behavior of the unstiffened and corrugated steel plate shear walls with and without an opening have been investigated. In general, corrugated panels postpone the ultimate strength and degradation point leading to better performance under seismic loads. Energy dissipation capacity. ductility and initial stiffness could be improved using corrugated panels.

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