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EXTENDED ABSTRACT

Development of an Orthotropic Model for Cyclic Behavior of Steel Shear Walls having Trapezoidal Corrugated Web Plate

Mahsa Safarnourallah, Parham Memarzadeh*

Department of Civil Engineering, Najafabad Branch, Islamic Azad University, Najafabad, Iran

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1. Introduction

The steel plate shear wall is a lateral force resisting system, of two types of stiffened and unstiffened. The manufacturing of the stiffened type is time-consuming, costly, and needs more supervision; because of many executive details. Steel plate shear wall with a corrugated web is a new system that has been considered as an alternative for all types of stiffened walls. Corrugated sheets have complex geometry and their modeling is difficult in existing conventional software. To overcome the complexity of the modeling of corrugated sheets, flat sheets with orthotropic material properties can be replaced instead of these sheets by the help of material mechanics science. This research aims to provide a specific process for calculating the mechanical properties of an alternative orthotropic flat sheet to the corrugated sheet, and to study the accuracy of the orthotropic model in predicting the monotonic and cyclic behavior of corrugated shear walls. For this purpose, the results of the analyses of the orthotropic and trapezoidal corrugated models of the steel plate shear wall with different characteristics of the waves are compared and the accuracy of the proposed method is examined.

2. Methodology

Based on the geometric characteristics of corrugated sheets, the flexural stiffness of corrugated sheets (D_x, D_y and D_{xy}) (Tong et al., 2015) is calculated; then, using the same flexural stiffness of corrugated sheet, the elastic and shear modulus (E_x , E_y and G_{xy}) of the orthotropic sheet are calculated based on relationships 1 to 3. Therefore, these relationships ensure that the flexural stiffnesses of corrugated and orthotropic models are the same.

The E_x modulus is obtained using Eq. (1) as follows:

$$E_x = \frac{12D_x}{t^3} \tag{1}$$

Then, the modulus E_y is obtained using Eq. (2) as follows:

$$E_y = \frac{12D_y}{t^3} \tag{2}$$

Also, the G_{xy} shear modulus is calculated using Eq. (3) as follows:

* Corresponding Author
E-mail addresses: safarnourollah.mahsa@gmail.com (Mahsa Safarnourallah), p-memar@iaun.ac.ir (Parham Memarzadeh).

$$G_{xy} = \frac{12D_{xy}}{t^3} \tag{3}$$

In orthotropic sheet modeling using conventional finite element software, in addition to the need to specify the elastic and shear modulus of E_x, E_y and G_{xy}, it is necessary to introduce G_{xz} and G_{yz} values as input data to the software. The shear modulus values G_{xz} and G_{yz} are equal to G_{xy}. It should be noted that one of the advantages of the equivalence process presented in this paper is the same thickness of corrugated sheet and equivalent orthotropic sheet; however, in most of the existing equivalence processes reviewed by the authors, there is a step of calculating the equivalent thickness.

3. Results and discussion

By examining the effect of variables such as sheet thickness, several semiconductors and cross-sectional angles of life sheets on the degree of conformity of the results of numerical analysis of steel shear wall model with the corrugated sheet and orthotropic flat sheet under uniform and cyclic loading is investigated. Cycle loading is according to the AC154 protocol (Fig. 1). The value of AED (Approximate Elastic Displacement) according to the reference (Emami et al., 2013) is equal to 20.3 mm, and the results of orthotropic and trapezoidal models of steel shear wall traction with different wave characteristics are compared.

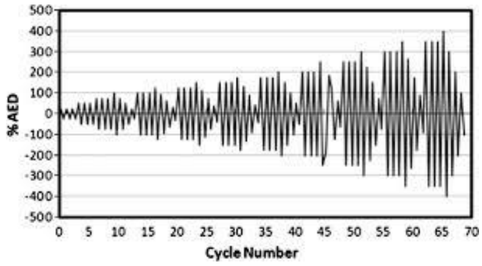

Fig. 1. Cyclic loading protocol (Emami et al., 2013)

4. Conclusions

This paper presents a method for comparing the corrugated sheet of a steel shear wall with an orthotropic flat sheet. To evaluate the adequacy and accuracy of the proposed method in assessing the behavior of steel shear walls, orthotropic models of corrugated shear walls with different variables of thickness, wavelength and some of semiconductors analyzed were compared with the corresponding corrugated shear wall results. The following can be deduced from the studies:

The method proposed in this paper has sufficient adequacy and accuracy to predict the uniform and cyclic behavior of steel shear wall with trapezoidal corrugated sheet. In all the studied models with the mentioned variables, the amount of final strength and initial stiffness obtained from the proposed method are slightly less and more than the results of corrugated models, respectively. In most of the cases studied, the proposed method for models with lower thickness gives more accurate results. Also, reducing the wavelength angle and increasing the number of waves increases the accuracy of the results of this method. In the models studied in this study with the mentioned different variables, the maximum difference observed between the results of orthotropic models is equivalent to the results of the corresponding corrugated models for the final strength and energy absorption rate is about 15%.

5. References

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