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EXTENDED ABSTRACTS

Investigation into the Effect of Residual Stresses on the Performance of Corrugated Trapezoidal Steel Shear Panels

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Keywords:
Corrugated trapezoidal infill panel, Finite element analysis, Residual stress, Steel shear panel.

1. Introduction

In the present study, the effect of residual stresses on the performance of braced corrugated steel shear panels (Akbari Hamed and Mofid, 2015a; 2015b; 2015c; 2016; 2017; Amiri et al., 2023) was investigated using numerical modeling, and its results were presented. For this purpose, after validating the finite element modeling method by ABAQUS software, the effect of considering the residual stress on the performance of 12 steel shear panel models with different sizes of sub-panel width, the corrugation angle and the panel thickness was investigated by evaluating some important parameters such as the initial stiffness, the dissipated energy and the strength.

2. Methodology

To ensure the accuracy of the considered modeling procedure, the obtained results of an experimental study of two one-story and one-span frames were used in which HEB140, HEB200 and HEB160 were assigned to the upper beam, the lower beam and the columns, respectively. Moreover, the thickness of the infill panel was 2mm, the specimen's height was 1650mm and the span length was 2320mm. The S4R shell elements were assigned to the considered numerical models and they were analyzed using ABAQUS software through nonlinear quasi-static analysis under cyclic loading protocol based on the ATC-24. In order to consider the residual stress in finite element modeling, first, the bending process to convert a flat steel plate into a corrugated panel was modeled (Fig. 1) and then the obtained stress was applied to the steel shear panel models using the predefined field stress option in ABAQUS.

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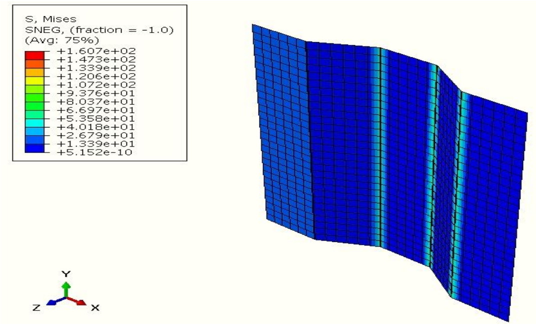
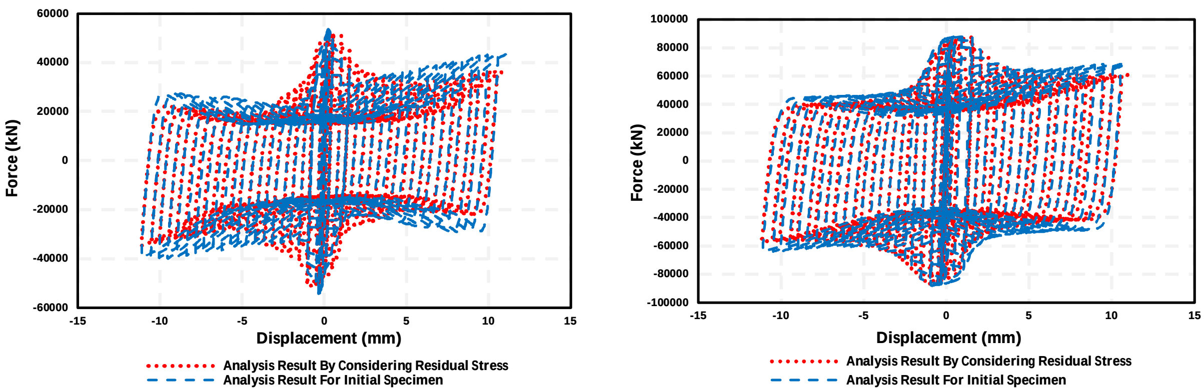


Fig. 1. The distribution of the Von-Mises stress in the corrugated steel panel after the bending process

3. Results and discussion

As an example, the nonlinear analysis results for SSP-2 and SSP-6 models are shown as force-displacement curves (i.e. hysteretic curves) for the models with and without residual stress in Fig. 2. The changes caused by considering these two parameters can be seen in these figures. The enclosed area by the hysteretic curves depicted in Fig. 2 was slightly reduced by considering the effect of residual stress; therefore, it can be concluded that the amount of dissipated energy in this case is less than the initial base model. Fig. 3 shows the deformation status and the distribution of the Von-Mises stress of the shear panel with horizontal corrugated panel at the drift ratio of 2.5%. In order to make a better comparison, the bar graphs related to all the considered models, for the four parameters of the amount of dissipated energy, the strength, the initial stiffness and the ductility with and without considering the effect of residual stresses are presented in Fig. 4. It is observed that the residual stress reduces the amount of dissipated energy, the strength, the initial stiffness and the ductility between 4%-9%, 4%-7%, 3%-10%, and about 4%, respectively.



(i) SSP-2 specimen

(ii) SSP-6 Specimen

Fig. 2. Force-Displacement diagram of two specimens

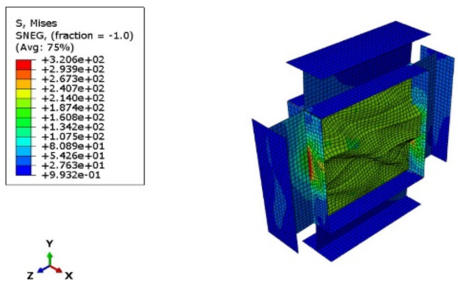


Fig. 3. Deformation and distribution of Von-Mises stress distribution of the SSP-6 shear panel model under the applied cyclic loading

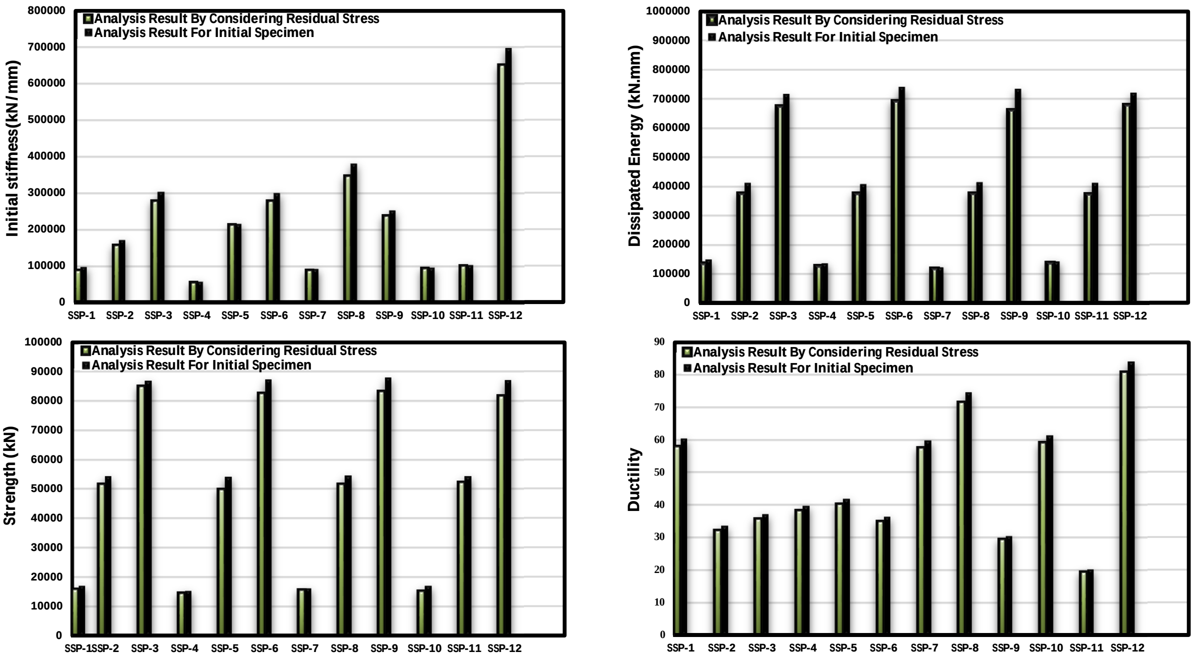


Fig. 4. The effect of residual stress on the performance of corrugated shear panels

4. Conclusions

Regarding the obtained results in this study, it is concluded that considering the effects of residual stress in the corrugated steel panel reduces the amount of dissipated energy, the strength, the initial stiffness and the ductility between 4%-9%, 4%-7%, 3%-10%, and about 4%, respectively. Moreover, the estimated buckling shear strength value of the considered models with the residual stress is reduced in average by 4.5%. Therefore, it is recommended to consider the initial residual stress values in the finite element modeling using the described procedure in this study or apply a reduction factor based on the obtained results in this research.

5. References

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