PREFABRICATED STRUCTURES UNDER EARTHQUAKE EXCITATION: DAMAGE AND FAILURE OF CONNECTION JOINTS

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1. Introduction

Prefabricated structures became more and more popular in European countries, including Poland. Many systems used in prefabrication are simply taken from countries with low seismicity, such as Finland or Belgium, and thus are not designed and tested under earthquake excitation. Although there are some recent records of earthquake activity in Poland [1], the strengthening of this type of structures is crucial when constructing in seismic countries, like Slovakia or Romania.

It has been shown, that damage of prefabricated structures during recent earthquakes is usually caused by insufficient connection strength [2]. Many of the structures have been heavily damaged, some of them completely destroyed, showing urgent necessity of further research. Therefore, the aim of this paper is to test an example of a prefabricated structure undergoing strong ground motions, and thus to prepare background for planned laboratory experiments and simulations.

2. Numerical model

The investigation has been focused on the week points of the beam-to-column connections (see Fig.1). As the example, the behaviour of frame of 2-storey frame building with pinned beam-column connection (see Fig. 2) under the El Centro earthquake (1940) has been simulated with ABAQUS commercial software. The non-linear analysis has been conducted, which has been proven to be essential when the structural response under earthquake excitation is investigated (see, for example, [3]). In the study, the behaviour of concrete has been modelled using damaged plasticity model (see [4,5]). Reinforcement has been modelled using layered material with rebar elements embedded into concrete. A non-linear (elastoplastic) strain-hardening model has been used to simulate the reinforcing steel behaviour. All structural members have been modelled by multi-layer shell elements with multiple integration points through the thickness.

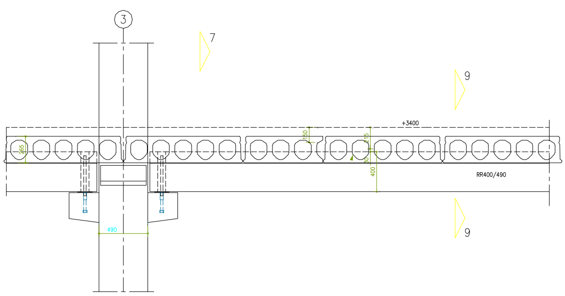

Fig. 1. Example of connection used by Ergon Company in the regions with low seismicity

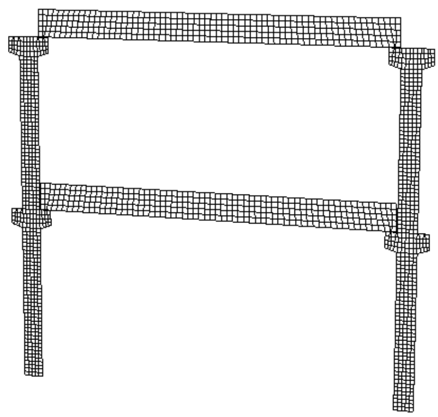

Fig. 2. FEM model of the structure

3. Response analysis

The results of the preliminary analysis in the form of stress distribution in connecting bar are shown in Fig. 3. It can be seen from the figure that failure of the structure is due to plastic flow of the connecting bars. It should be mentioned that, in the connection, neoprene bearing carries mainly compression (vertical) forces, whereas horizontal loads are acting on steel bars, which are rigidly connected with corbel and beam.

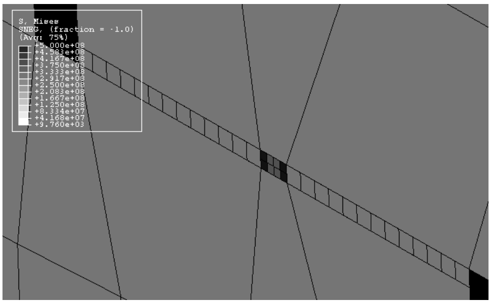

Fig. 3. Stress distribution in connecting steel bar

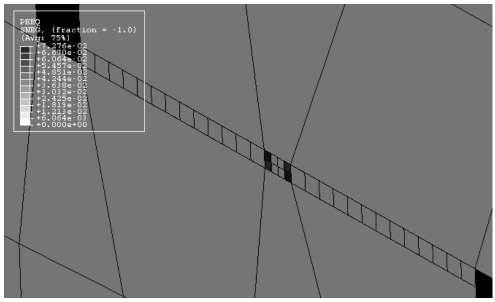

Fig. 4 Equivalent plastic strain in connecting steel bar

4. Conclusions

The stresses in the connection between beam and column due to earthquake excitation have been assessed in this paper. The non-linear analysis has been conducted in order to enhance the accuracy of the study. The results show the need of changes in the investigated part of the structure in order to make it earthquake-resistant. Further numerical simulations and experimental studies are planned to be conducted so as to adapt the system to meet earthquake reliability.

5. Acknowledgements

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6. References

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