USE OF DEFORMABLE POLYMERS BETWEEN RC FRAMES AND MASONRY INFILLS FOR IMPROVED SEISMIC PERFORMANCE

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1. Introduction

Damage to masonry infills in r.c. frame structures during earthquakes may occur at relatively modest earthquake intensity because the stiff infills are rigidly connected to the flexible frames. The infills contribute to lateral stiffness as well as resistance of such construction systems. In an attempt to alleviate the problem of premature damage to infills but still retain the structural interaction between the structural elements, an idea of using flexible polymer PM between the r.c. frame and masonry infill was born. The flexibility of the polymer could serve to reduce the stress concentrations and thereby reduce damage to infills on one hand, and provide a high amount of damping and ductility on the other. Despite the flexibility of the polymer, the brick-to-concrete joint would be capable of transferring significant loads during in-plane and out-of-plane excitations. To test the validity of this idea, a joint from flexible polymer was tested and numerically modelled.

2. Methods

The problem is tackled using experimental research and advanced numerical methods. In the experimental research part, the behavior of the polymer is studied with cyclic shear tests of the joint. The specimen consists of two joints between three concrete elements. The side concrete elements are fixed, whereas the middle element, where the load is applied, is free to move vertically (Fig. 1). The cyclic shear test was carried out at the same specimen by repetition of load series with various frequencies: 0.05, 0.1, 0.5 and 1 Hz. At the beginning of each cyclic test, the initial load of 200 kN was applied and next 30 cycles in the load range 10-390 kN were performed on the double joint with dimensions 308x20x2 cm to obtain data on hysteretic behaviour and damping properties of the joint. Because of the small stiffness of the polymer (E≈4MPa) compared to brick or concrete such tests may provide adequate information for numerical simulation of the polymer joint in r.c. frames with masonry infills during earthquakes.

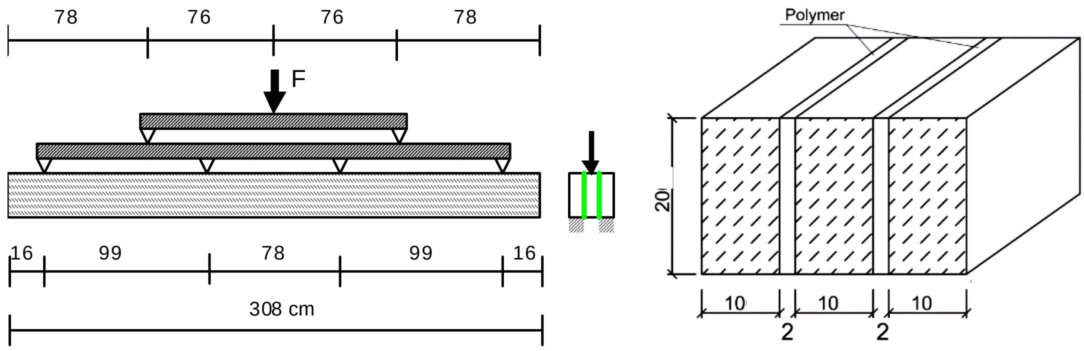

Figure 1. Test setup

In the numerical research part, the material is modelled using for the purpose developed hyperviscoelastic finite element. In order to properly account for finite strains in the PM material, the so called Darijani-Naghdabadi [1] family of strain measures $\mathbf{E}^{(\alpha,\beta)}$ is used (Eq. 1):

(1) $$\mathbf{E}^{(\alpha+\beta)} = \frac{1}{\alpha+\beta}\left(\mathbf{U}^{\alpha} - \mathbf{U}^{-\beta}\right)$$

Where α and β are real numbers and $\mathbf{U}$ is the right stretch tensor. Note that for $\alpha + \beta = 0$ the model simplifies to logarithmic strains (also called Hencky's model [2]). It has been shown that the Darijani-Naghdabadi model gives accurate results up to 40 % of tensile strain, if proper α and β are found [3], whereas the Hencky model, is only accurate up to about 10 % tensile strain. In addition to using special strain measures, the viscosity of the material was also considered in order to better simulate the response of the polymer material.
The finite element model was coded in the AceGen/AceFEM program [4].

3. Results

The results of the test shown in Figure 2 and numerical simulations demonstrate that the proposed model can be used with reasonable accuracy to model the response of flexible polymer joints in very high strains (even up to 40%). The authors plan to use this model in the future for simulating response of r.c. frames with masonry infills, where the joints between the wall and the frame are filled with the polymer.

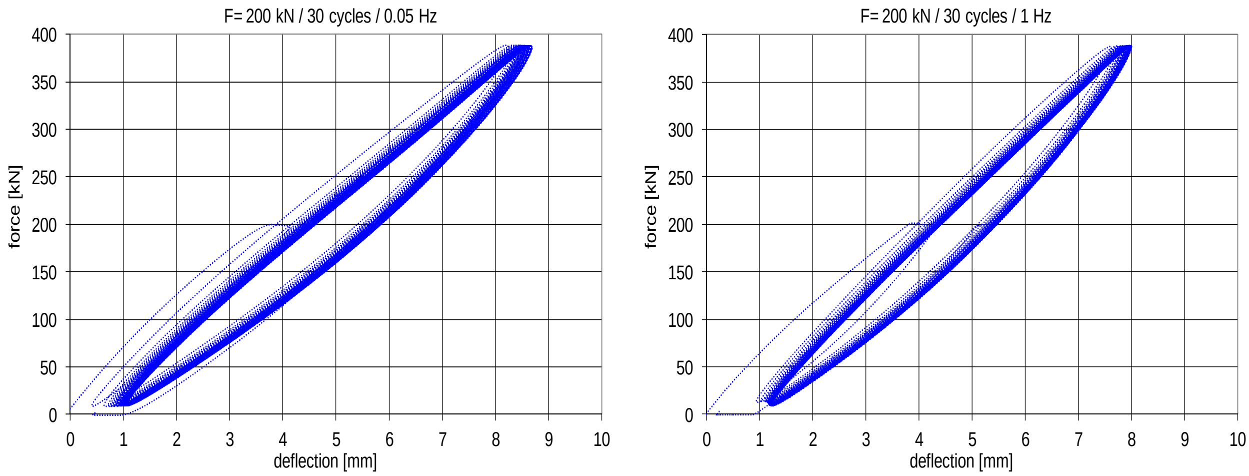

Figure 2. Test results.

6. References

[1] H. Darijani, R. Naghdabadi, Constitutive modeling of solids at finite deformation using a second-order stress-strain relation, *International Journal of Engineering Science*, **48**, 2010, 223-236.

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[3] A. Kwiecień, M. Gams, B. Zając. Numerical modelling of flexible polymers as the adhesive for FRPs. V: WU, Zhishen (ur.). *Joint Conference of the 12th International Symposium on Fiber Reinforced Polymers for Reinforced Concrete Structures (FRPRCS-12) & the 5th Asia-Pacific Conference on Fiber Reinforced Polymers in Structures (APFIS-2015), Nanjing, China December 14-16, 2015 : FRPRCS-12/APFIS-2015*. Nanjing, China: Southeast University, 2015, p. 1-6

[4] AceGen 7.0 and AceFem 7.0 user manual, http://symech.fgg.uni-lj.si/