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Experimental Stress Analysis

Investigation of the Adhesive Joints on the Tram Roof

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Abstract: This paper described investigation of adhesive joints using at a tram roof. Material properties of adhesive joints ware experimentally identified and used in numerical simulation of single joint and of whole complex of adhesive joints on the tram roof. Full scale experiment was made for verification of fatigue life and strength properties of these joints.

Keywords: Adhesive joints, Tram roof

1. Introduction

Tram producers are tasked by costumers for a low-floor tram at present. This requirement means that most of the equipment must be placed on the roof of a tram. Department of mechanics, biomechanics and mechatronics of FME CTU in Prague investigates adhesive joints within the project Modern concept in Public mass transport vehicles. Promoter of this project is the company Variel a. s.. This firm made and supplies the roof of sandwich construction to tram producer. The PVC foam is used as a sandwich core and steel plates as sandwich faces. Adhesive joints are used for connection roof and girder bracket of Ω shape and roof-mounted equipments are fitted to the girder bracket with screws. Investigation program can be divided into experimental and computational parts. Material properties of used adhesive ware experimentally identified and this properties ware used in numerical simulations. Experiments and computations on design detail ware done also and full-scale experiment was made for fatigue-life properties of investigates joints finally.

2. Experimental part

2.1. Material properties

Adhesive used for joining grinder bracket on a roof is polyurethane adhesive with moister curing. Material properties ware investigate for tensile and shear loading. Universal test machine TIRA 2300 was used for these tests. Shear test (Fig. 1) was made according standard ČSN EN 1465 [1]. Tensile test was made by means designed preparation and it can be seen in Fig. 2. Elastic material properties like a shear modulus G and Young's modulus E ware obtained from this experiment. Ultimate shear and tensile strength ware not determined with regards to different modes of failures.

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Fig. 1. Setup of shear test of adhesive

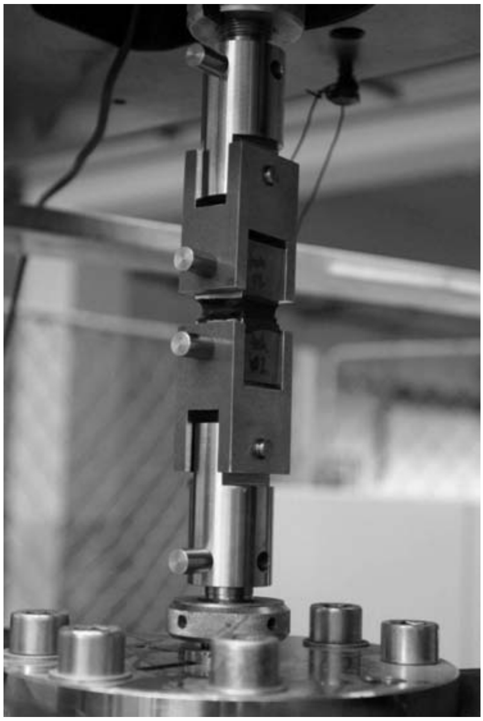

Fig. 2. Setup of tension test of adhesive

2.2. Structural detail of girder bracket

Specimen with structural detail of adhesive joint of the girder bracket and the roof was designed. Loading of these specimens was made by means of designed fixture simulated state of loading on real construction. Specimen with the fixture can be seen in Fig. 3. Specimens ware tested on universal testing machine Heckert FPZ100/1. Producer of the roof used obtained results for comparing different production processes and different designs of the girder bracket. Profile of the girder bracket used on final production roof has Ω shape.

2.3. Testing on full scale specimen

Full size stand was designed to prove the fatigue life properties of adhesive joints. Standard [2] specifies level of loading and number of cycles without failure. On the tram roof are carried a number of containers with different weights and dimension of the fixture. With regard to the space possibilities of our laboratory it was decided, that half of the tram roof was used for testing. The biggest and most heavy container was chosen for mounting on the roof. Loading in driving direction was chose for durability test. Hydraulic actuator IST PL40N was used for loading. Force was applied by means of loading frame and also mass of ballast was used to achieve weight of original container. Standard [2] prescribes loading in driving direction on level ±0.2 g. Experiment was carried out at a frequency 7 Hz and was applied 10^7 cycles without failure. After fatigue life experiment was applied force to obtain residual strength of adhesive joints. Maximal force of the actuator PL40N was applied without visible failure. Deflection sensor was installed in several locations on the surface of the roof and displacements ware measured during static loading. Measurement units HBM Spider8 ware used for data acquisition. Experiment was performed under normal temperature and humidity conditions.

Fig. 3. Tensile testing of girder bracket

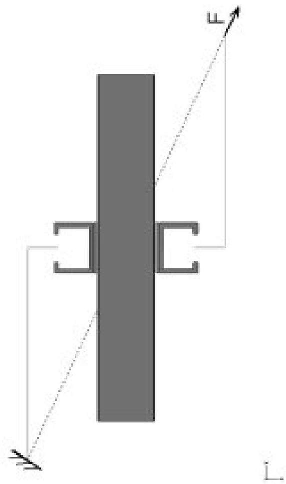

Fig. 4. FE model of structural detail

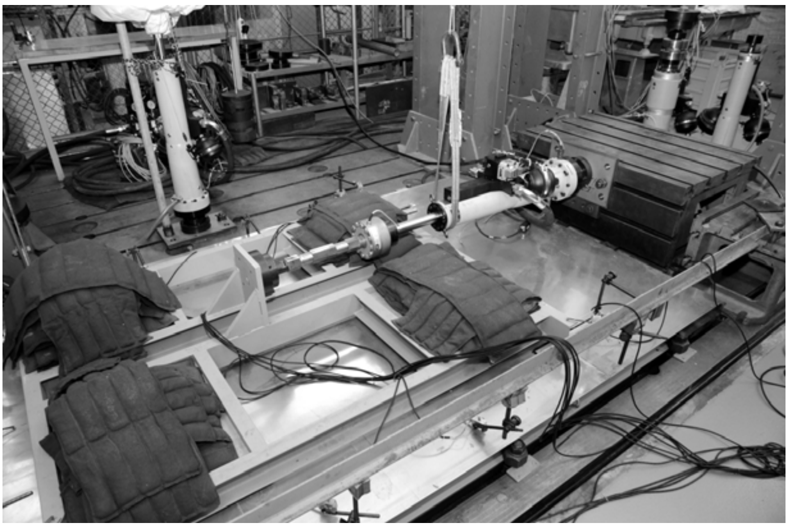

Fig. 5. Setup of full scale experiment of fatigue life of adhesive joints

3. Computational part

Numerical simulations of tensile and shear tests were made by means of FEM software ABAQUS. The adhesive layers ware modelled by cohesive elements. Results from experimental testing ware used for setting elements properties. The FE model of structural detail was modelled by these tuned elements. The girder bracket and sandwich faces ware modelled by continuum shell elements, core was modelled by structural elements.

FE computation was used to choose the most loaded container for full scale experiment. Global model of tram cabin was loaded accordance with tram manufacturer. Results from global model ware compared with results from the model corresponding to full-scale experiment. Stress and strain analysis of adhesive joints ware made.

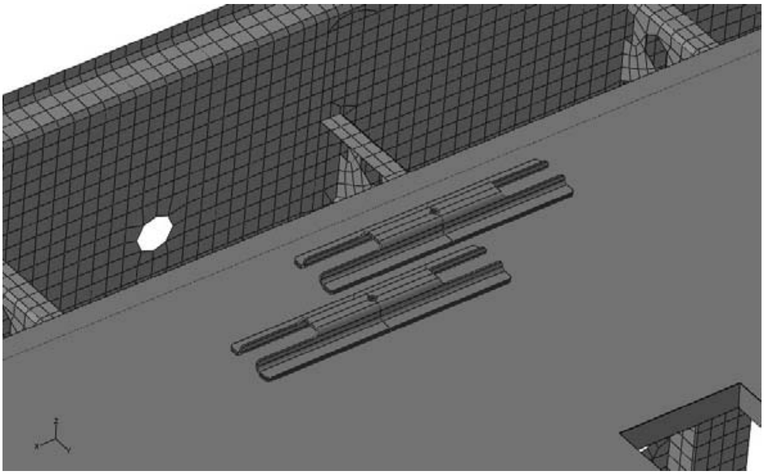

Fig. 6. Detail of global FE model

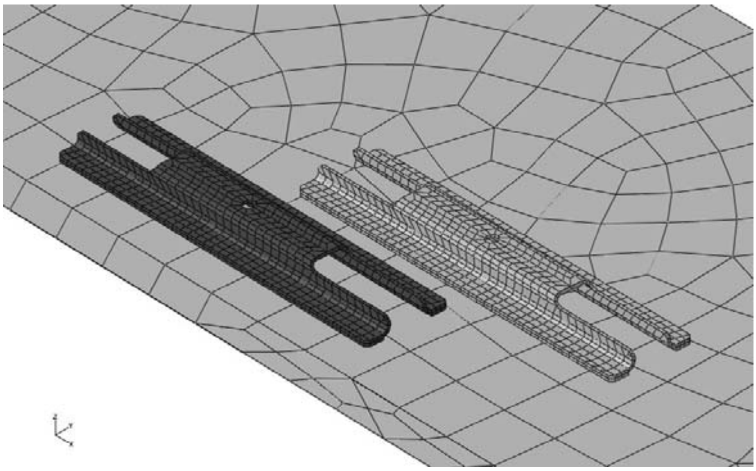

Fig. 7. Detail of FE model of full scale experiment

4. Conclusion

This article describes the work undertaken during the assessment of the adhesive joints on the roof of the tram. Adhesive material properties ware determined and ware used in FE simulation. It was carried out full scale experiment on the selected container and adhesive joints durability was proven according to standard ČSN EN 12633 [2].

Acknowledgments

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References

[1] ČSN EN 14 65 Stanovení smykové pevnosti v tahu tuhých adherendů na přeplátovaných tělesech.

[2] ČSN EN 12633-1 Železniční aplikace – Pevnostní požadavky na konstrukci skříní kolejových vozidel – Část 1: Lokomotivy a vozidla osobní dopravy (a aleternativní metoda pro nákladní vozy) 2010