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Static and Fatigue Testing Sandwich Segment of the Bus Roof

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Abstract: Problem of lightweight and safe the bus roof is solved by MIT CR: FR-TI4/349 project. Several variants of sandwich roof was tested on samples in the previous period. Some problems with the technology appeared in the production of the entire roof. Methyl methacrylate adhesive was tested with respect to the declared adhesive ability for arbitrary surfaces. Sandwich specimens using methyl methacrylate adhesive were made and loaded by 4PB. The results were compared with the strength of sandwich samples made using PU adhesive. Several specimens were subjected to cyclic loading in order to get approximate fatigue life of tested variants.

Keywords: Sandwich Bus Roof; 4PB Test; Fatigue Test; Methyl Methacrylate Adhesive.

1 Introduction

Sandwich specimen with PVC foam and galvanised steel sheet faces was tested in previous period [3]. With regard to the results of previous tests were manufactured bus roofs with a selected combination of faces and cores. Adhesive failures appeared on some produced roofs. Manufacturer of methyl methacrylate adhesives presents a wide variety of surfaces with the declaration of strength, so it was proceeded to test the methyl methacrylate adhesives for this product. Shear tests of adhesive joint were carried out. The combination of adhesive and PVC foam was tested with the core shear tests according ASTM standard. Flexural rigidity and strength of the sandwich samples was obtained using 4PB test. Numerical simulation of static 4PB test was made by means FEM software. Samples structural nodes were cyclically loaded and was intended tentative fatigue resistance.

2 Experimental Analysis

2.1 Adhesive

Shear strength is the most important characteristic of the bonded joint. To verify the bonding technology were manufactured samples to obtain shear resistance of methyl methacrylate adhesive. Samples were loaded according to standard ČSN EN 1465 [1]. The average shear strength obtained from this test fit the middle of the range of values reported by the adhesive manufacturer. Tested samples can be seen in Fig. 1 and test record can be seen in Fig. 2.

2.2 Sandwich Shear Properties

The shear properties of a combination of methyl met hacrylate adhesive and PVC foam were tested with respect to standard ASTM C273 [2]. Test results were compared with experiments carried out on samples of the same core material, but using a polyurethane adhesive. PVC foam density was 55 kg/m^3. Strength of the samples with methyl methacrylate adhesives was about 30 percent higher, but the evaluation the shear modulus was about 10 percent less as compared to samples with PU adhesive. Tested sample can be seen in Fig. 3 and dependence record of force versus displacement can be seen in Fig. 4.

Fig. 1: Adhesive joint specimen during shear test.

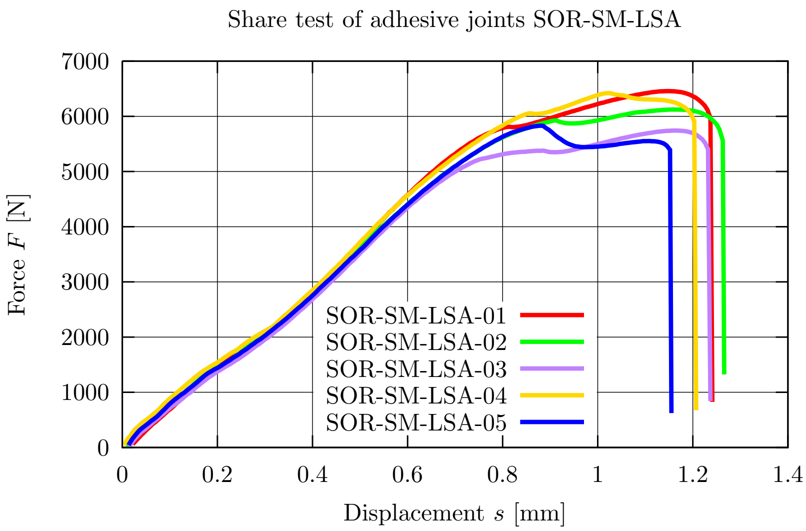

Fig. 2: Diagram of shear tests of adhesive joints.

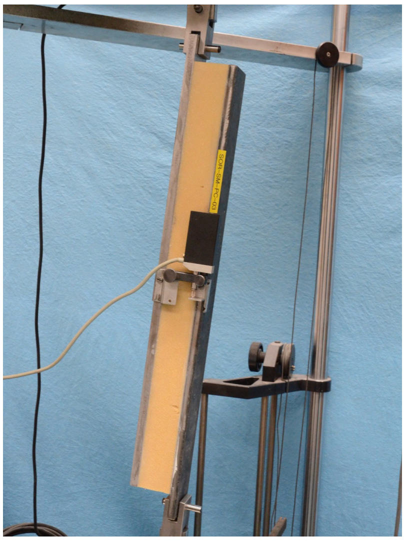

Fig. 3: Test of shear properties of core.

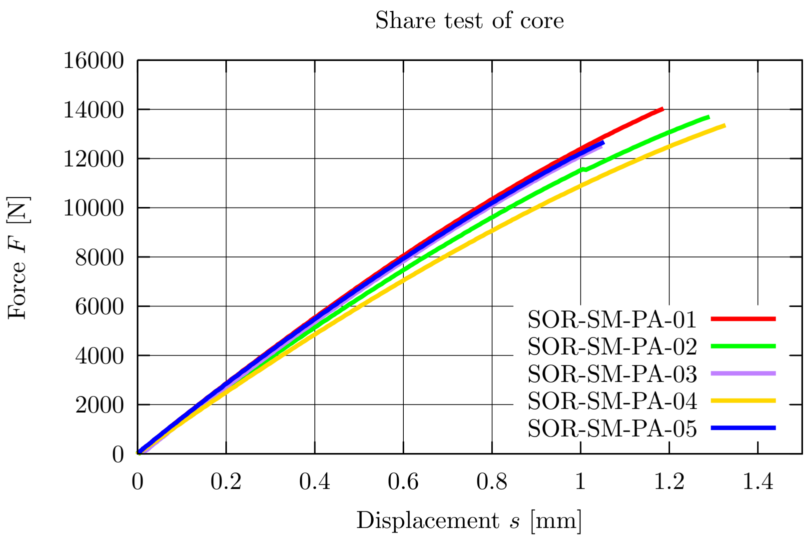

Fig. 4: Diagram of force versus displacement.

2.3 Static Bending Tests of Sandwiches

Sandwich with a core of PVC foam and face made of stainless steel or aluminium alloy sheets were interesting for manufacturers of busses. As in previous tests [3] were made samples with continuous core (Sample Foam A) and samples with core interrupted by structure node (Sample Str. Node A) and four point bending (4PB) test was applied to samples.

Other four types of samples were manufactured. Sample Foam C and was made with stainless steel faces. Sample Foam D was made with the upper face from stainless steel and the bottom of an aluminium alloy. Samples Str. Node C and D were prepared similarly. Density of core was same – 55 kg/mm^3. Strength of sandwich samples with MMA adhesive and stainless steel faces is about 30 percent lower in comparison to samples Foam A [3] and samples Structure nodes D (stainless steel and aluminium alloy sheets face, MMA adhesive) have a strength of about 20 percentages lower compared with the sample Str. Node A (PU adhesive, varnished galvanised sheet), moreover, the standard deviation was larger compared to samples produced with PVC adhesive see Fig. 5.

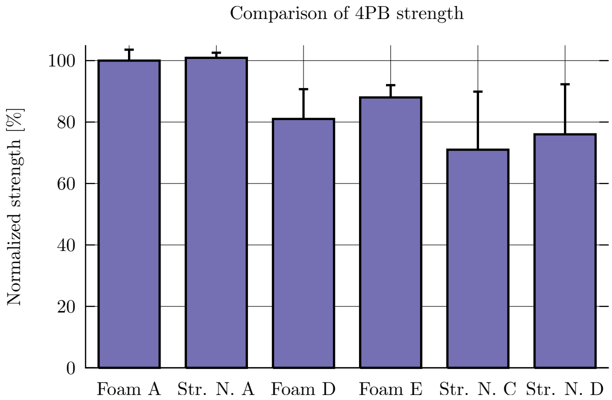

Fig. 5: Comparison of strength with standard deviation.

Fig. 6: Comparison of typical test result for various kind of specimen normalised to strength of sample Foam A.

2.4 Fatigue Bending Test of Sandwich

Samples Str. Node A and Str. Node D were cyclically loaded by four points bending see Fig, 7. The test was carried out by a hydraulic actuator and finished after achieving sample fault. Five specimens of each group were tested. The results of tests are plotted in the Fig. 8. Relative maximum load (the maximum load to the ultimate strength of the sample Str. Node A) is plotted on the vertical axis. Cyclic loading was constant force amplitude when the cycle loading ratio was equal 0.1.

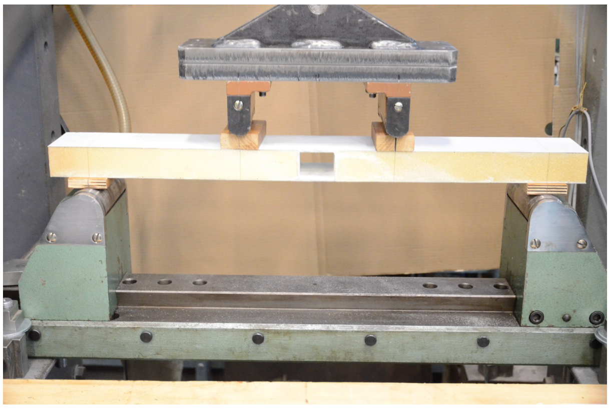

Fig. 7: Specimen Str. Node A in stand for cyclic 4PB test.

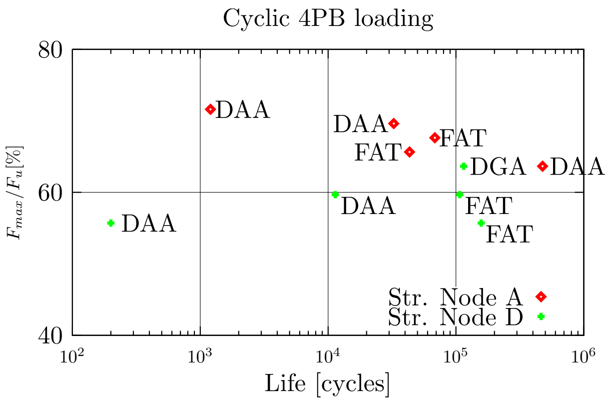

Fig. 8: Results of cyclic loading.

Failures of the samples were two main types, with respect to the ASTM standard D393 [5] are marked FAT (Filament fracture, At load bar, Top facing) see Fig. 10 and DAA (skin to core Delamination, At load bar, core-facing bond) see Fig. 9. The main problem was the question of fixation of the sample in one position during the cyclic test.

3 Numerical Simulation

Static bending tests sandwiches were numerically simulated by FEM. Model sandwich roof will be used for calculations of behaviour of the bus body using FEM software ABAQUS. The PVC foam was modelled as an isotropic material with linear 8 node elements and adhesive joint between the core and the faces was modelled

Fig. 9: Failure type DAA

Fig. 10: Failure type FAT

using cohesive elements.

4 Conclusion

Sandwiches were subjected to static loading, which were numerically simulated. The results were compared with data obtained from previous research. Based on the static and cyclic bending test, it was shown that application of a methacrylate adhesive using a stainless steel coatings does not give better results compared with sandwich specimens with polyurethane adhesive and galvanised sheets.

Acknowledgement

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