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Experimental studies of glued Aluminum-glass joints

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Abstract. Glued steel-glass or aluminum-glass joints are to be found, among other things, in vehicles (cars, buses, trains, trams) as windscreen assembly pieces for the supporting structure. For the purposes of the experiments, samples were made in which the top beam was made of the AW-2017A aluminum alloy and the bottom beam was made of thermally reinforced soda-lime glass whereas the glued joints were made of one-component polyurethane glue Körapur 175. The tests were performed under four-point bending conditions at monotonic incremental bending moment values on the Instron 5965 durability machine. The experimental study of the durability of glued joints under four-point bending conditions with the monotonic incremental bending moment allows to determine the values of stresses, whose value is related to initiation of damage of the tested joint.

1. Introduction

At the initial stages of constructing the construction of the machine components are carried out on samples. Their shape and dimensions are based on norms, examples of which are develop [2, 5, 6]. The results of the tests performed on standard samples are presented in [11]. There are also many examples of research conducted using non-standard samples [3, 14] from a wide range of scientific disciplines. Glued steel-glass or aluminum-glass joints are to be found, among other things, in vehicles (cars, buses, trains, trams) as windscreen assembly pieces for the supporting structure. This application requires the combination of high durability properties to be maintained for the intended service life so as to ensure a high level of safety for vehicle users. Conducting experiments of this type of connections, in terms of their sturdiness and durability, allows to select their geometrical features so that they can meet the normative and utility requirements. In the paper [9] the results of investigations of glued aluminum-glass joints with static and creep loading were presented. Obtained results allow determining the minimum life of the connectors. The tests were performed on samples of the original shape corresponding to the construction of the structural element.

The paper [1] describes the study of glue joints in which nanoparticle glue was used. The use of nanoparticles has been associated with the ability to diagnose damaged joints. In the study, overlapping samples were used. In the work [4] the defectability and static strength of adhesive joints, produced using five different types of dispersion methods, were carried out on the basis of examinations of overlapping samples. In the article [8], adhesion tests in glass supporting structures are presented in relation to the effect of different substrates (glass, structural steel and stainless steel, aluminum alloy) and surface preparation (sanding of the glass surface). The original test samples consisted of a glass rectangle adhered to a cuboid with glass, steel and aluminum alloy.

This paper is to present a method of assessing the damage of the glued aluminum-glass joint under conditions of a monotonically increasing bending moment [3].

2. Method

A new type of specimens, being the subject of the patent application in Poland fig 1. [10], was used in the studies. The sample consists of two beams: top one (longer) made of structural material such as steel, aluminum alloy, and bottom one (shorter) that is part of the glass, which be tempered, layered or

traditional glass. The top beam may have any cross-section, e.g. rectangular, square, c-shaped, etc., which is characterized by different values of the moment of inertia. The bottom beam, meanwhile, is made of rectangular glass. Tensometric sensors are mounted to the both beams in order to determine the deformations of the individual beams under load.

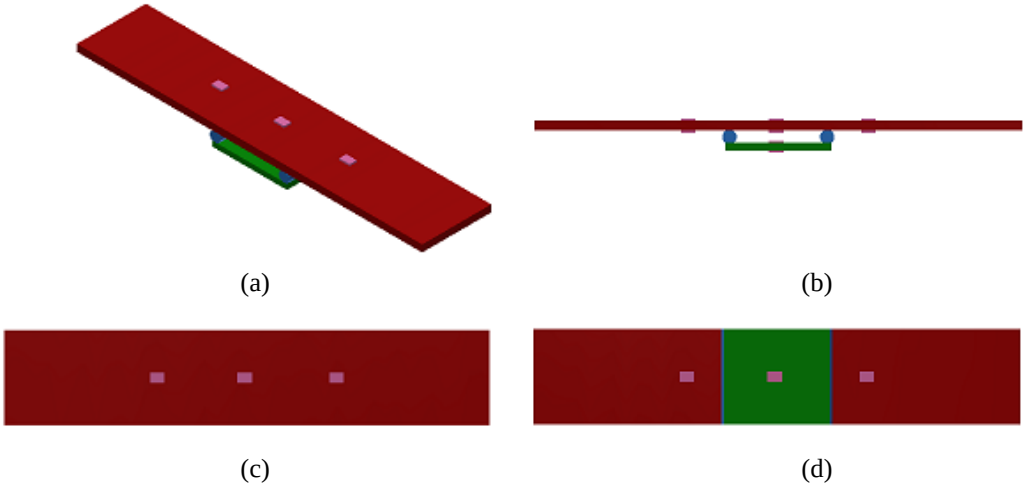


Figure 1. General construction of an innovative test specimen for glued joints: a - axonometric view, b - side view, c - top view, d - bottom view

For the purposes of the experiments, samples were made in which the top beam was made of the AW-2017A aluminum alloy (AlCu4MgSi alloy mark according to the PN-EN 573-3: 2010), and the bottom beam was made of thermally reinforced [12], whereas the glued joints were made of one-component polyurethane glue Körapur 175 [13]. The geometrical dimensions of the test sample are shown in Figure 2 and the physical form of the sample object is shown in Figure 3. The selected mechanical properties of the AW-2017A aluminum alloy are shown in Table 1, while the properties of sodium glass are presented in Table 2.

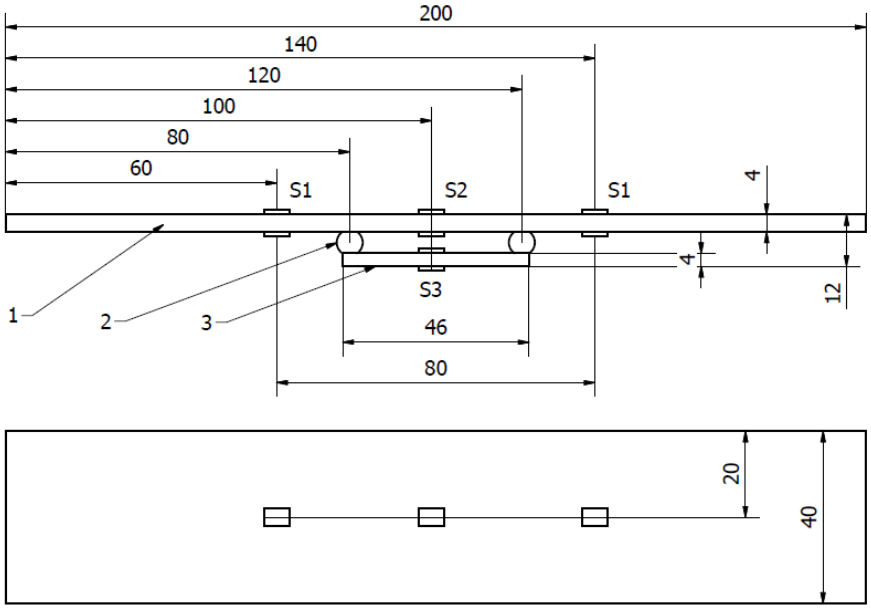
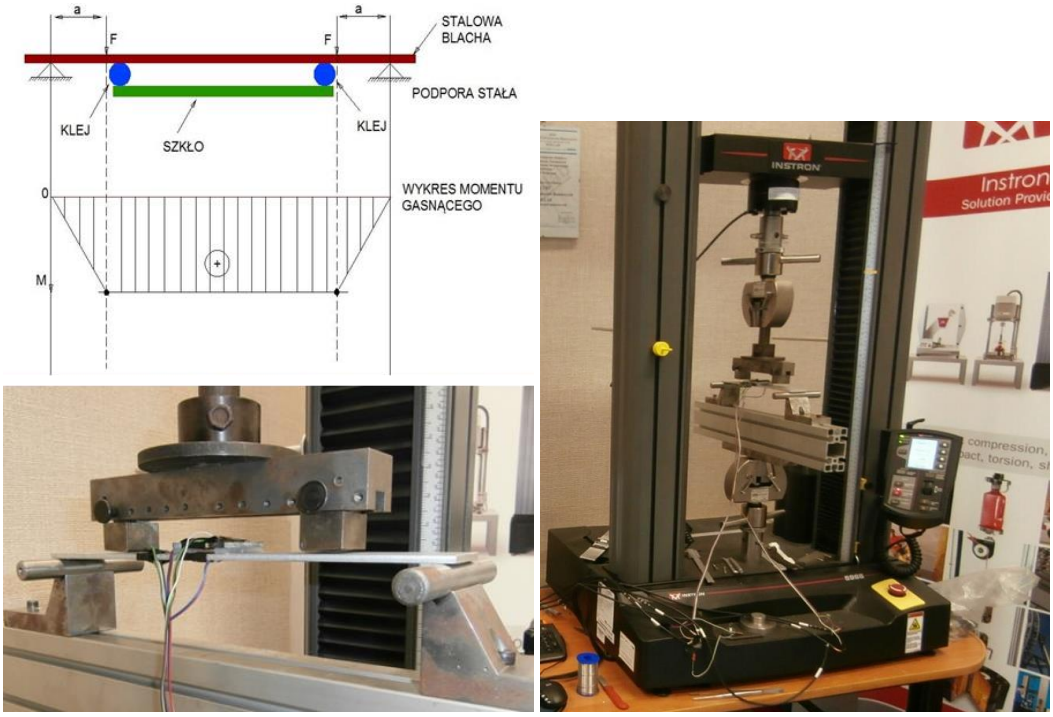


Figure 2. Geometric dimensions of the sample used in strength tests

(a) (b)

(c)

Figure 3. Physical form of research object



(a) (b)

Figure 4. Method of loading sample (a) and construction of test stand (b)

Table 1. Mechanical properties of the AW-2017A aluminium alloy [7]

	$R_{p0,2}$	R_m	E	A_5	Z
	MPa	MPa	MPa	%	%
Mean value	320	470	73077	16,1	23,0
Standard deviation	1,3	4,5	1304	0,8	0,8

Table 2. Mechanical properties of thermally reinforced soda-lime glass [12]

	R_c	R_g	E	G	
	MPa	MPa	MPa	MPa	-
Data by manufacturer	39	83	72000	30000	0,23

The tests were performed under four-point bending conditions at monotonic incremental bending moment values on the Instron 5965 durability machine. The sample allows bending tests to be performed at bending loads while maintaining a constant bending moment in the glued joint area. Figure 4a shows the method of loading the sample during testing, while Figure 4b presents the test bench.

3. Result and Discussion

The experimental studies of glued joints under monotonically increasing bending moment values allowed to determine the stress values in the top beam made of aluminum alloy and the bottom beam made of thermally reinforced soda lime glass. Figure 5 shows the course of stress changes in the individual components of the sample: S1 - Stress in the top beam beyond the place of the glued joints, S2 - Stress in the upper bar between the glued joints, S3 - Stress in the bottom beam between the glued joints. The intersection of the stress lines in the top beam marked S1 and S2 was assumed to be the criterion for identifying the initiation of damage to the glued joint. Combining the top beam with the bottom beam using two glued joints causes the top beam to become more rigid in the middle section.

Then the stress value (S1) in the top beam beyond the bottom beam fixing point is higher than the stress value (S2) between the glued joints. This is the case until the joints carry the load from the top beam to the bottom beam. In the event of initiation of damage to the glued joint, the load value transmitted by the bottom beam decreases. This results in increased stress (S2) in the top beam between the glued joints. Therefore, the stress value corresponding to the point of intersection of the stress waveform curve for S1 and S2 can be considered the limit stress value that the glued joint is able to transfer. For samples where the thickness of the adhesive layer was 3 mm, the glued joint damage occurred at a stress range of 20 MPa to 38 MPa.

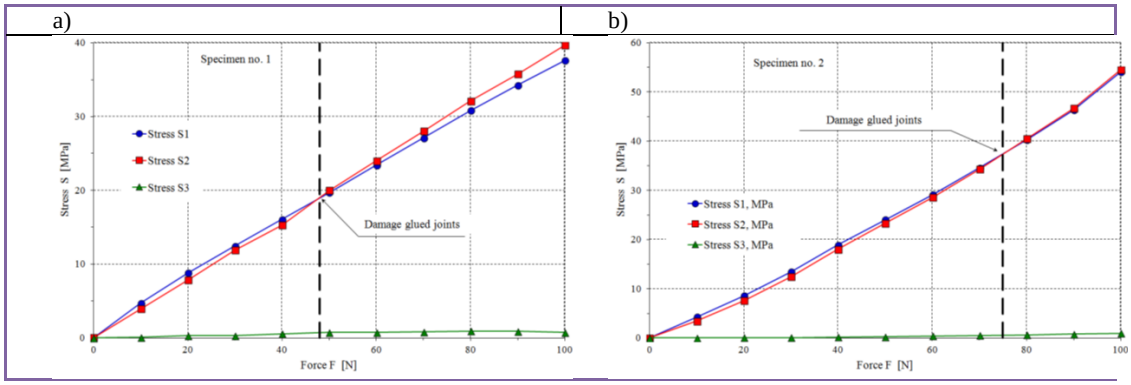


Figure 5. Sample results of glued joint tests: a – specimen no.1, b – specimen no.2

4. Conclusion

The new type of specimen has been developed to allow for the testing of glued joints of different structural rigidity, with special emphasis on the steel-glass, aluminum-glass, steel-aluminum and similar connections. The experimental study of the durability of glued joints under four-point bending conditions with the monotonic incremental bending moment allows to determine the values of stresses, whose value is related to initiation of damage of the tested joint. Obtained results are difficult to relate to the results of other authors because of many factors affecting the properties of the joints and the way the samples are prepared. In the next work of our team will be presented results of studies of adhesive joints implemented with the use of normative samples and new samples. Preliminary investigations indicate the suitability of a new type of specimen to evaluate the durability of the glued joints of machine components. In order to confirm their usefulness, a broader program of research will be carried out including: various combinations of materials, thickness of adhesive layer.

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