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EXPERIMENTAL AND PRELIMINARY NUMERICAL DYNAMIC ANALYSIS OF EFFECT OF SAMPLE GEOMETRY ON IMPACT STRENGTH OF ADHESIVE JOINTS

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ABSTRACT

The research, described in this article, relates to one of the aspects of methodology of block bonded joints. The authors tested experimentally the influence on the test findings of slight, practically unnoticeable variations in the geometry of the samples, which consequently result in changing the load conditions. The experimental studies were completed with preliminary dynamic numerical calculations of the test cases. The experimental testing was conducted with an impact dropping tool, designed to examine adhesive joints. The maximum energy of the pendulum used in the investigation equaled 15 J. In order to determine the impact loading of the examined joints, we used a dependency according to which the energy used to detach the upper element of the sample in this test, i.e. the energy lost by the pendulum, is a measure of impact strength of the adhesive joint. The sample elements were made with steel S235. In order to bond the samples, the authors used Epidian 57 epoxide resin with Z1 hardener. The models for numerical computations were prepared on the basis of samples used in experimental studies. The prepared models, taking into account the initial and boundary conditions, were subjected to dynamic numerical calculations by means of the finite element method with the use of the Explicit Dynamics module in the ANSYS programme. The numerical calculations were made to compare the compliance of the results of the experimental and analytical investigations as well as the assessment of the impact of the size of boundary conditions, which were subjected to parametrization, upon the values of occurring stresses during the conducted impact loading simulations.

Keywords: adhesive joint, impact loading, pendulum hammer, numerical calculations.

INTRODUCTION

Adhesive bonds, in the currently designed and used constructions structures, apart from static and fatigue loads, may also be exposed to impact loading. An example of this type construction is modern cars in which many elements are manufactured using adhesive bonding technology. In order to properly design and ensure crashworthiness of glued structures, there are investigations conducted as well as estimations of impact strength of the used joints. The techniques using dropping hammers are the most commonly used methods for low speeds of impact loading. Normative methodology described in PN-ISO 9653 is a variation of such an examination, using an impact hammer which has been modified to conduct research into adhesive joints. This test method is difficult to repeat due to the need to keep very precise behaviour parameters of the samples as well as the test conditions (Adams, 1996).

In the investigation, we analyzed the effect of the distance between the bottom edge of the impactor and the adhesive joint upon impact loading, recorded in the tests. For the sake of safety of the test device, the smallest distance between the impactor and the joint in question equalled 0.4 mm, whereas the largest one was equal to 1.6 mm. We also investigated the effect of geometry irregularities of the sample, in which there occurred a small angular rotation of the sample elements against each other, upon the impact loading of the adhesive joint. When putting the samples together, the upper element in each sample was rotated at an angle of 0.5-4º ± 0.5º.

The experimental testing was completed with a preliminary numerical investigation, whose primary aim was to verify the correctness of the developed sample models and other parameters adopted for the implementation of the calculations. In the computations we took into account linear properties of an isotropic polymer material, while the characteristics of the metal elements were adopted from the software material database ANSYS, for constructional steel. The variable parameter of the conducted calculations was the distance between the edge of the impactor and the surface of the bonded joint or the angle of rotation of the glued cuboid metal element in relation to the reference axis which is perpendicular to the metal piece.

RESULTS AND CONCLUSIONS

Both the results of experimental testing and numerical analysis findings indicate a very significant impact of even a slight angle of rotation of the sample pieces against each other upon the obtained results of impact loading of the examined joints. Such a phenomenon stems from changing the load conditions (in relation to properly glued samples) and causes a significant increase in the max principal stress in the adhesive joint, which is confirmed by numerical calculations. As a result of changes in the height of applying the load, the recorded impact loading of the examined joints was also changed. The highest impact loading was characterized by adhesive joints, in which the impact loading was applied closest to the joint.

The numerical calculations showed uneven stress distribution in the joints of the block samples which were dynamically impact loaded. The values of max principal stress occur at the edge, where the impactor strikes, and von Mises stress on the opposite side. Even slight twisting of a glued element has the effect of overlapping stresses on the loaded corner. The results of the numerical investigations proved inconsistent with the results of the investigation. Significant discrepancies in the results of experimental and analytical testing indicate that in further research there is a need to increase the computation time and analyze components of the stress tensor in order to determine which stresses mostly affect the value of impact loading of the examined adhesive joints.

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