INVESTIGATIONS OF COMPOSITE ENERGY ABSORBING ELEMENTS

Tadeusz Niezgoda

Military University of Technology, Faculty of Mechanics,
Department of Mechanics & Applied Computer Science
Kaliskiego 2, 00-908 Warszawa, POLAND
tel.+ 48 22 683 94 61
e-mail: t.niezgoda@wme.wat.edu.pl

Wiesław Barnat

tel.: +48 22 683 78 30
e-mail: w.barnat@wme.wat.edu.pl

Andrzej Kiczko

tel.+ 48 22 683 72 21
e-mail: a.kiczko@wme.wat.edu.pl

Abstract

In this work the problem connected with an improvement of the road safety through implementation of additional elements absorbing the hitting energy is taken into consideration. The experimental results of a basic absorbing element of the glass epoxy composite are presented. The results of these tests will serve for the construction of a reliable numerical model of a panel of protective elements. The coincidence between the experimental and numerical results is also proved, showing that introduced approach to the modelling of the process of the progressive destruction and the energy absorption by composite elements is not only properly assumed but is very promising for the future. Efforts which lead to increase the amount of absorbed energy need actions directed to improving absorbing energy properties of used elements. Therefore, the received results will serve as guidelines for elaboration the methodology of the research structures of that type and also could be used in further research works within the scope of increasing the road security. In the article it is also proved that there is the necessity to conduct the series of comparative experiments and also tests verifying numerical studies at loading speeds which can be compared with ones in reality e.g. crash test or shock wave of an explosion. The validated, in such way, method of numerical simulations enables the limitation of costly and long-lasting research of real objects.

Keywords: *impact test, FEM simulation, passive safety, composite structure, energy absorbing materials*

1. Introduction

The basic role of the protective panels is to dissipate the hitting energy coming from a collision or explosion. Striving to a cost reduction by changing the weight of energy absorbing elements or increasing safety go on because of using energy dissipating elements, by a destruction of structure elements.

From [2 - 5] the essentials clues, concerning the modification of existing constructional solutions by using additional composite energy absorbing elements, are supplied. This can immensely improve the efficiency of kinetic energy absorption of such structures.

Nowadays composites are used more frequently for a production of responsible, strongly loaded constructional elements. This quite automatically increased a demand for computational methods with the aid of which the prediction of a behaviour of composite structures in the exploitation conditions is quite efficient.

The received results from the approach which is sometimes called the classical theory of composites (leading the composite material to the orthotropic layer) are not sufficient anymore [2]. The great quantity of works testify for it. Within the period of last 20 years the different attempts of elaboration of methods which described and predict the behaviour of composite material in more detail appeared. One of the problems, stimulating this research, is a modelling of composites' behaviour, subjected to percussive loading, with putting pressure on the description of properties of energy absorbing materials [1].

2. Investigation stand

The static tests were carried out on 8802 Instron machine, impact tests were carried out on the High Velocity Dynatup Impact System, 9250HV Model, made in Instron. The device was in configuration enabling getting values of hitting energy to 940 J at the crosshead speed equal to 8.9 m/s or maximal crosshead speed at the moment of hitting, 16,5 m/s at the energy 640 J. The device allows measurement, registration and illustration of the beater speed, the force acting on the sample, absorbed energy, the deformation of a sample just immediately after the test and in time function or in function of each mentioned quantities.

3. Tests

Samples for tests are in shape of pipes made of the epoxy composite, of epoxy resin E 53 Epidian strengthen by glass fibres in the shape of mat. The glass mate was manually filtrated. In the article the results of samples with the inner diameter of ø40 mm and the height equal to h = 50 mm are presented. In Fig. 1 the process of the destruction of the sleeve with the wall thickness 2 mm and the mass equal to 20.72 g is presented, the upper plate moves down linearly with the speed of 10 mm/min, compressive force diagram (Fig. 2). In the beginning of the diagram the distinct jump of the force value is seen, which is caused by the lack of an initiator (bevelling at the edges of the sleeve).

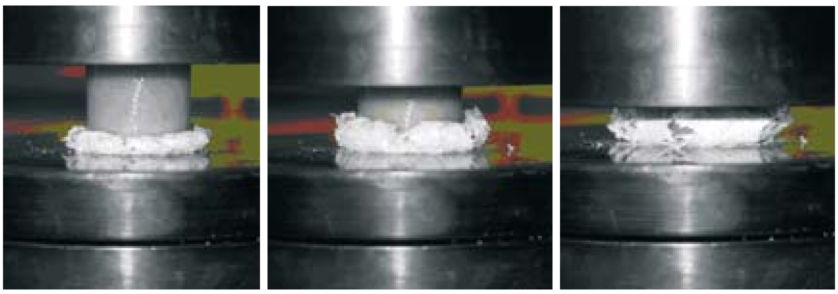

Fig. 1. Failure mode of the composite sleeve

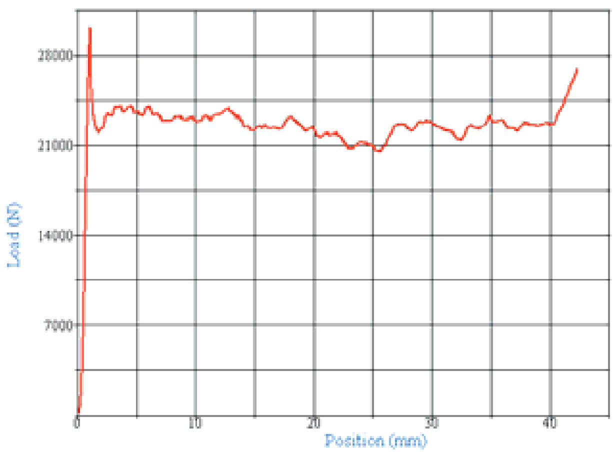

Fig. 2. Experimentally obtained compressive force diagram for the composite sleeve

Then the diagram has a constant character as a result of a progressive way of damaging a composite element. Such character of the progression of a destruction force is caused by appearing the delamination of the sleeve (so called brush).

As a result of the experiment it was stated that the average force of progressive destruction equals to 23 kN. After taking into account the road which the plates of the strength machine are to cover, the work of progressive destruction was estimated as 805 J. The relative absorption of energy of the damaged part of the composite sleeve equals to 38,85 kJ/kg.

The similar sleeve, with the thickness of the wall of 1.5 mm and with the mass 13.3 g with the initiator of destruction in the form of bevelling under the angle 45º from the upper edge, was tested at the investigation stand for percussive tests (Fig 3). Tests were carried out at the crosshead speed of the machine Dynatup 9250 HV equal to 8.4 m/s.

Fig. 3.Composite sleeve after and post impact test

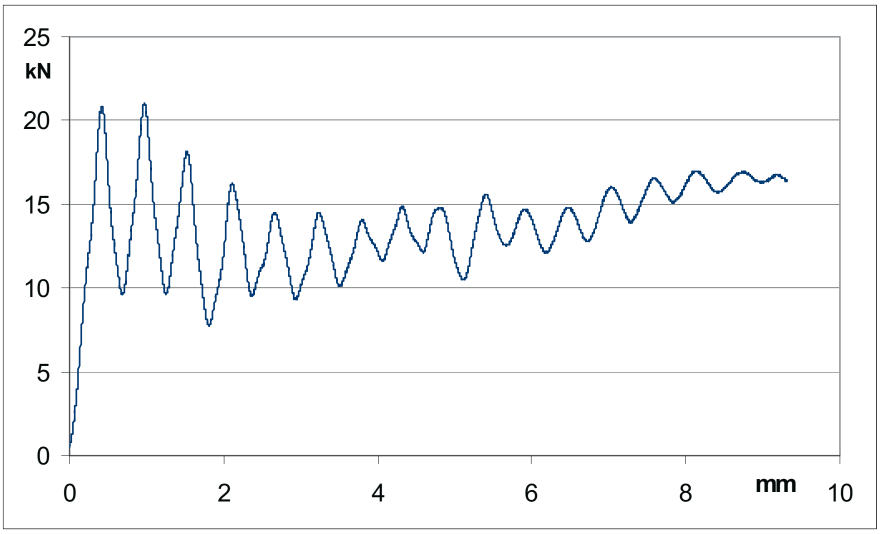

Fig. 4. Experimentally obtained in the impact test compressive force diagram for the composite sleeve

The diagram of the force transmitted by the sleeve in the percussive test in the function of displacement is presented in Fig. 4. The relative absorption energy determined in the percussive test is equal to 38.3 kJ/kg. No essential difference in the work of the progressive destruction in a static test and the percussive test was noticed.

4. Numerical simulation

The above example was tested also numerically with the use DYTRAN software. In the similar way as in the experiment (Fig. 1) the composite element was numerically pressed by stiff elements of plates. The numerical computations resulted in the diagram of the force of progressive destruction in dependence on displacement (Fig. 5).

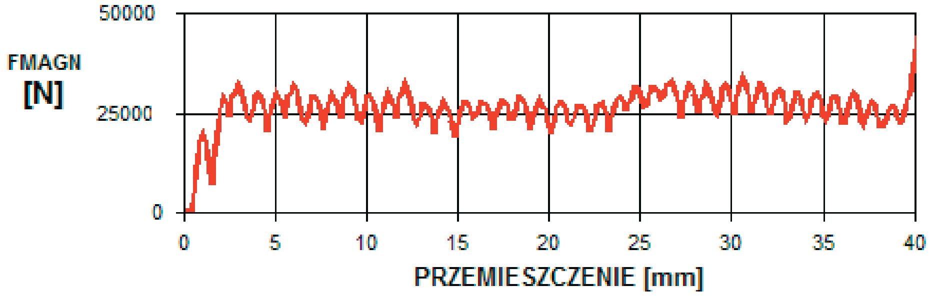

Fig. 5. Numerically obtained compressive force diagram for the composite sleeve

The numerical diagram, as the experimental diagram, has the stable character. The numerical model of the composite sleeve is subjected to deformation, the same deformation as the one stated in the case of an experiment. The way of the deformation of the composite sleeve is presented in Fig. 6.

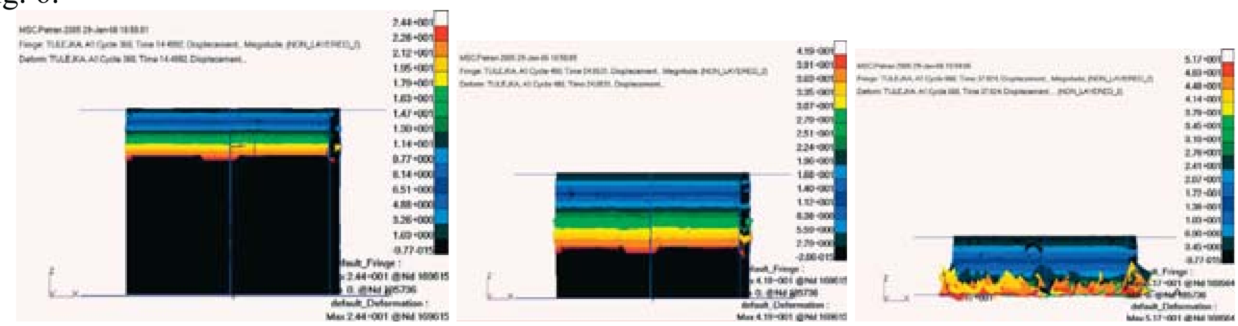

Fig. 6. Deformation mode of the composite sleeve numerical model

Numerical results are in accordance with the results of the experiment. The numerically received relative energy of absorption is about 40 kJ/kg. Such coincidence of results proves that this approach to the modelling of the process of the progressive destruction and as well the energy absorption by composite elements is good.

5. Conclusions

The basic condition of carrying out the simulation of the processes of the percussive destruction is to conduct tests in the conditions as similar as possible to real conditions.

It is also required to conduct the series of comparative experiments and also tests verifying numerical studies at loading speeds which can be compared with ones in reality e.g. crash test or shock wave of an explosion. The validated, in such way, method of numerical simulations enables the limitation of costly and long-lasting research of real objects.

The received results will serve as guidelines for elaboration the methodology of the research structures of that type and also could be used in further research works within the scope of increasing the road security.

The next stage of the research is to be a consideration of the modification of existing constructions in order to increase their energy absorbing properties by using the elements with changed profiles and new structures which are able to absorb greater quantity of energy.

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