INVESTIGATION OF ROAD BARRIERS ON THEIR ABILITIES TO ABSORB ENERGY OF HITTING

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Abstract

In the article the results of tests and numerical computations of road infrastructure elements-protective barriers are presented. On the base of carried out tests (in laboratory conditions) the forms of deformations of each of elements and their assemblies, components of road protective barriers, were described. The determination of stiffness of each type of barriers, at the moment of their destruction, enabled to elaborate the methodology of the construction of numerical models and numerical simulations of the process of the barrier destruction. The absorption of energy of three subassemblies of road barriers, consisting of the W-beam guard rail section of 0.7 m, a post and SP01, SP05 and SP09 mounting hardware, was experimentally determined. From the comparison the experimental results with the numerical simulation ones it is seen that proposed numerical models with a good accuracy present the behaviour of the real elements of barriers. Investigations enabled to estimate the distribution of absorbed energy of each constructional elements of barriers at the moment of their destruction. Further step in the investigation is to be an attempt to modify the construction, paying special attention to increasing its ability to absorb energy of collision. On this base the protective road barrier system can be enriched with elements absorbing energy. Great energy absorbing abilities have elements which are subjected to progressive destruction e.g. by plastic deformation or delamination of elements produced from relatively cheap fiberglass reinforced plastic composites. The elaborated methodology of numerical simulation with the use of LS-DYNA software enables the essential shortening of the test period of worked out solutions.

Keywords: *numerical simulations, validation, road transport, road barriers, passive safety*

1. Introduction

Many factors influence on the transport security, e.g. acting with deliberation, drivers' abilities, a vehicle's technical condition and road infrastructure. If one of these factors fails and the uncontrolled movement of the vehicle occurs then the most important task is to be fulfilled by the road barriers energy absorbing elements. The Department of Mechanics & Applied Computer

Science of the Military University of Technology carries out the most advanced numerical simulations connected with percussive influences on constructions putting the special emphasis on protective structures which are to ensure safety of people and devices [1 - 3]. The agreement on access to VII Outline Programme on „SST-2007-4.1.6: Intelligent Road Restraint System (RRS)” was declared by the Department of Mechanics & Applied Computer Science of the Military University of Technology.

Experimental studies are indispensable in the process of verification and validation of elaborated numerical models. The correlation between an experiment and a numerical simulation is the essential factor which influences on the correctness and efficiency of computations.

2. Experiment

The absorption of energy of three subassemblies of road barriers, consisting of the guard rail section of 0.7 m, a post and SP01, SP05 and SP09 mounting hardware, was experimentally determined (see Figs. 1 - 3).

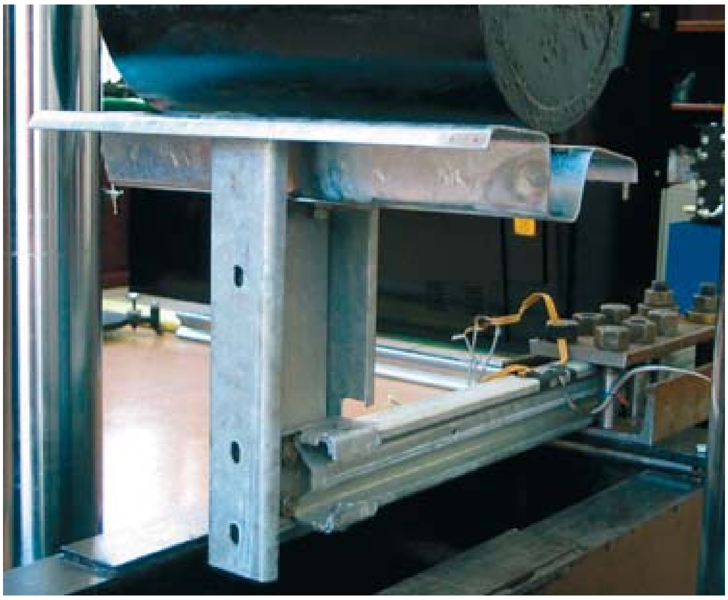

Fig. 1. Subassemblies of SP01 road barrier

Fig. 2. Subassemblies of SP05 road barrier

The post which was under investigation was inserted into a clamping ring, attached to the stand bed. The loading force was transferred through the half-cylinder of 273 mm diameter. The centre of the cylinder was at the height of a bolt connecting a post with a belt (in a distance of 575 mm from the attachment).

During the test deformations of chosen posts were registered by strain gages in order to compare the reaction of a real post with its numerical model. The energy absorbed by guard rail as a result of squeezing it between stiff plates was also determined.

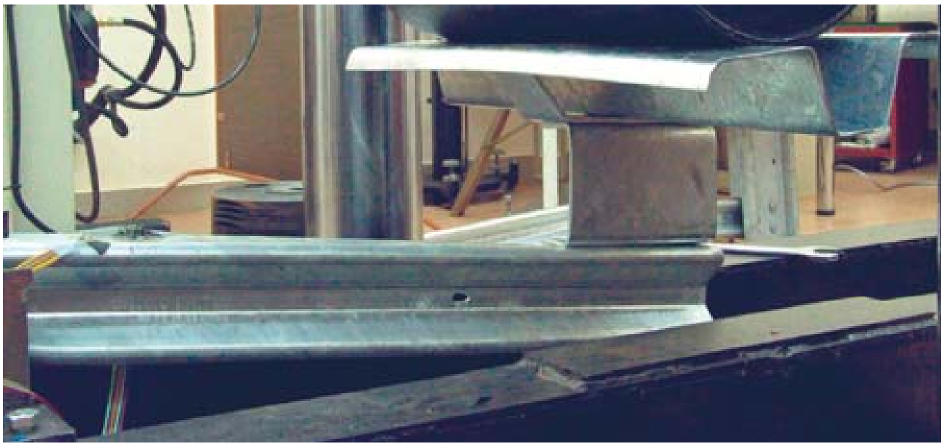

Fig. 3. Subassemblies of SP09 road barrier

2. Experimental results

As a result of the experiment curves: displacement-force, displacement-deformation, and displacement-absorbed energy were determined. The model diagrams are presented in Figs. 4 - 6.

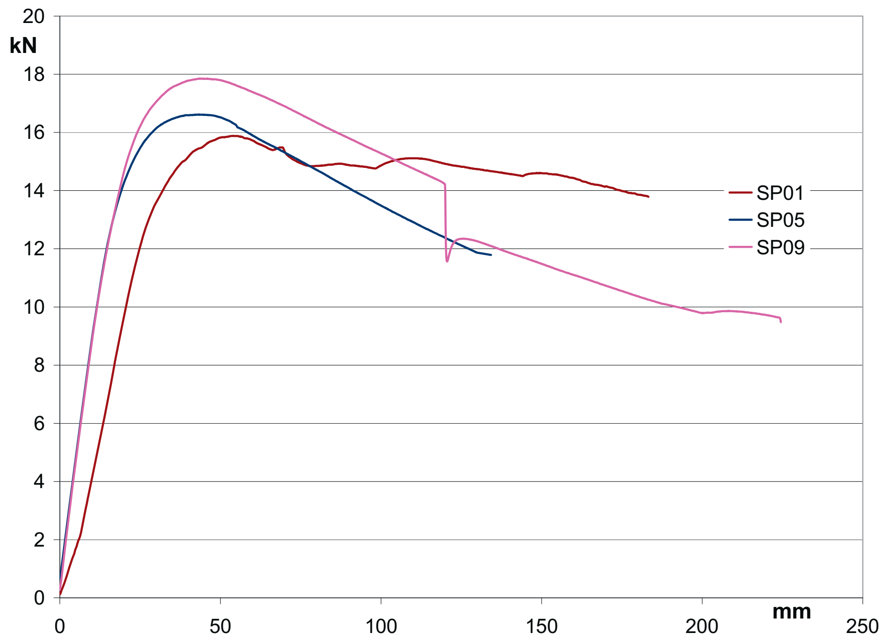

Fig. 4. Experimental curve: displacement-force for SP01, SP05 and SP09 road barriers

On the experimental curve: displacement-force for SP01, SP05 and SP09 road barriers, the apparent greater strength of the SP09 barrier is seen, which arises from the manner of loading in the strength machine, the spacer (blockout) limits possibility of „free" revolution of the end of the post after breaking the screw, joining the spacer with the guard rail, which occurs at the deflection 120 mm, the diagram force-displacement superimposes itself on the curve outlined for the variant without the spacer - SP05. The spacer was not subjected to any major plastic deformations at the period of tests, so it can be assumed, with small degree of negligence, that it didn't absorb the deformation energy.

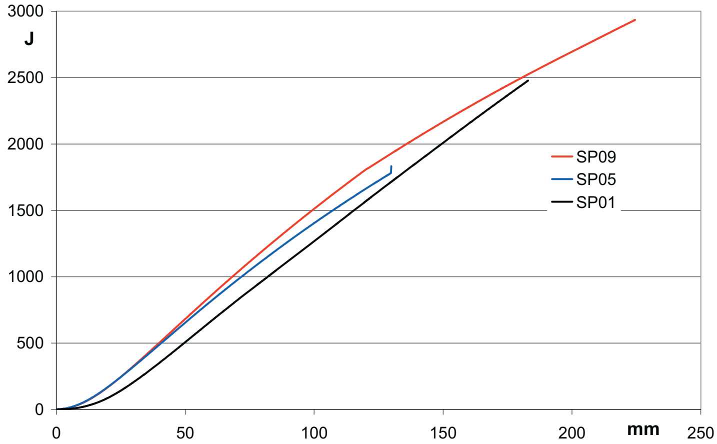

Fig. 5. Experimental curve: displacement- absorbed energy for SP01, SP05 and SP09 road barriers

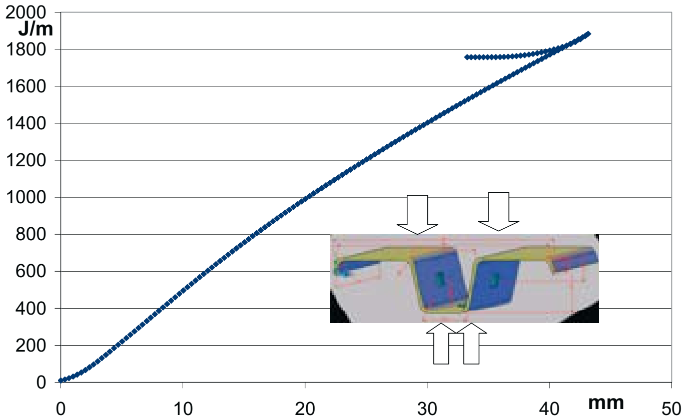

Fig. 6. The energy absorbed by guard rail (W-beam) as a result of squeezing it between stiff plates

The mechanism of destroying the SP01 outrigger support is different, the view of it is shown in Fig. 7. The fastening knots of outrigger to the post, as well as to the W-beam, are subjected to the plastic deformation. In the beginning the support is more fragile, the absorption of the energy of a striking vehicle undergoes on the longer road, so at smaller delays.

Fig. 7. Subassemblies of SP01 road barrier after test

Plastic deformations of the guard rail appear at the force about 60 kN/m, in the presented tests the guard rail is elastically deformed.

3. Numerical simulation

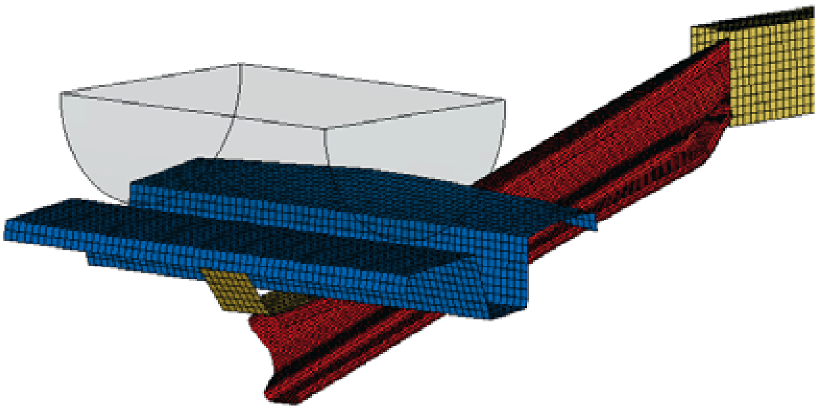

Fig. 8. Deformation of the numerical model of the SP-05 road barrier

The results are to be used in numerical methods, for example LS DYNA, to simulate collisions of highway vehicles with roadside safety structures. In the article the results of tests on rigidity for the SP-05 road barrier, loaded with non-deformable stamp, moving with a constant speed, are presented (Fig. 8.). For making a numerical model of a post, a bracket and guard rail the elements of shell type were used. A numerical simulation of the test was carried out for a displacement of a traverse of 0.25 m.

The maximal force appeared at the deflection equal to 65 mm. The character of the post deformation is presented in Fig. 8. The similarity of deformations of a real barrier and its numerical model is visible. As in the experimental test also in the numerical model the bending of the post at the fixing took place. In both cases the barrier behaved in the same way. The great compatibility of the experimental results with the numerical ones proves the correctness of the numerical modeling of the problem (Fig. 9).

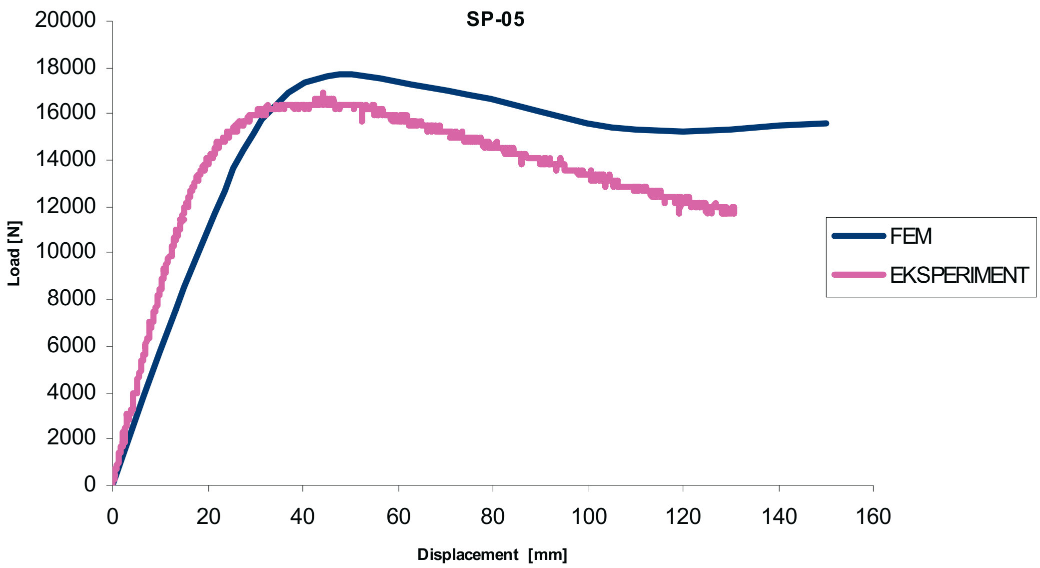

Fig. 9. Comparison of diagrams achieved numerically and experimentally for the SP-05 road barier

4. Conclusions

The method of the numerical simulations, based on experimental tests of elementary cases enables shortening the costly and long lasting investigation of real objects. The received results will serve as guidelines for the elaboration of the methodology of a numerical simulation of the structures of that type and will be used in the further tests within the scope of increasing road safety.

References

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