EXPERIMENTAL-NUMERICAL ANALYSIS OF STEEL – FOAM ENERGY - ABSORBING PANELS FOR ROAD BARRIERS MODERNIZATION

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Abstract

The works on steel – foam e nergy–absorbing structures for the road barrier W-beam guardrail were carried out because of the necessity of increasing the passive s afety of road barriers [1-5]. A road barrier guardrail is made of steel sections. These types of sections are c haracterized by good strain properties, although their energy–absorbing abilities and pos sibilities for "softer" vehicle impact energy are unsatisfactory. In order to increase energy – absorption on the road barrier guardrail additional tin–foam sections were used. Experimental tests on the modified road barrier guardrail were carried out on a testing mac hine INSTRON at the Facul ty of Mechanics and A pplied Informatics of the Military Academy of Technology. Tw o meters long W-beam guar drail was investigated in a three point bending test, perpendicularly and under the angle of 20º. As a res ult of the experiment al research diagrams of dependence of bending force on displacement were obtained. On the basis of aforementioned diagrams the energy that was absorbed by i ndividual road barrier elements: tin coating, foam insert and steel guardrail, was e stimated. Obtained results of the experi mental research were also compared with the results of the numerical si mulation of the finite elements method in LS-DYNA system.

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

1. Experimental research of additional protection panels with foamed polyurethane filling

At the test stand, in the first version (traverse angle of incidence 90 Fig. 1 and 2) a three point bending test of the road barrier guardrail with additional protection panel was carried out.

Fig. 1. Examination stand for the three point bending test at the traverse angle of incidence 90° - with a protection panel

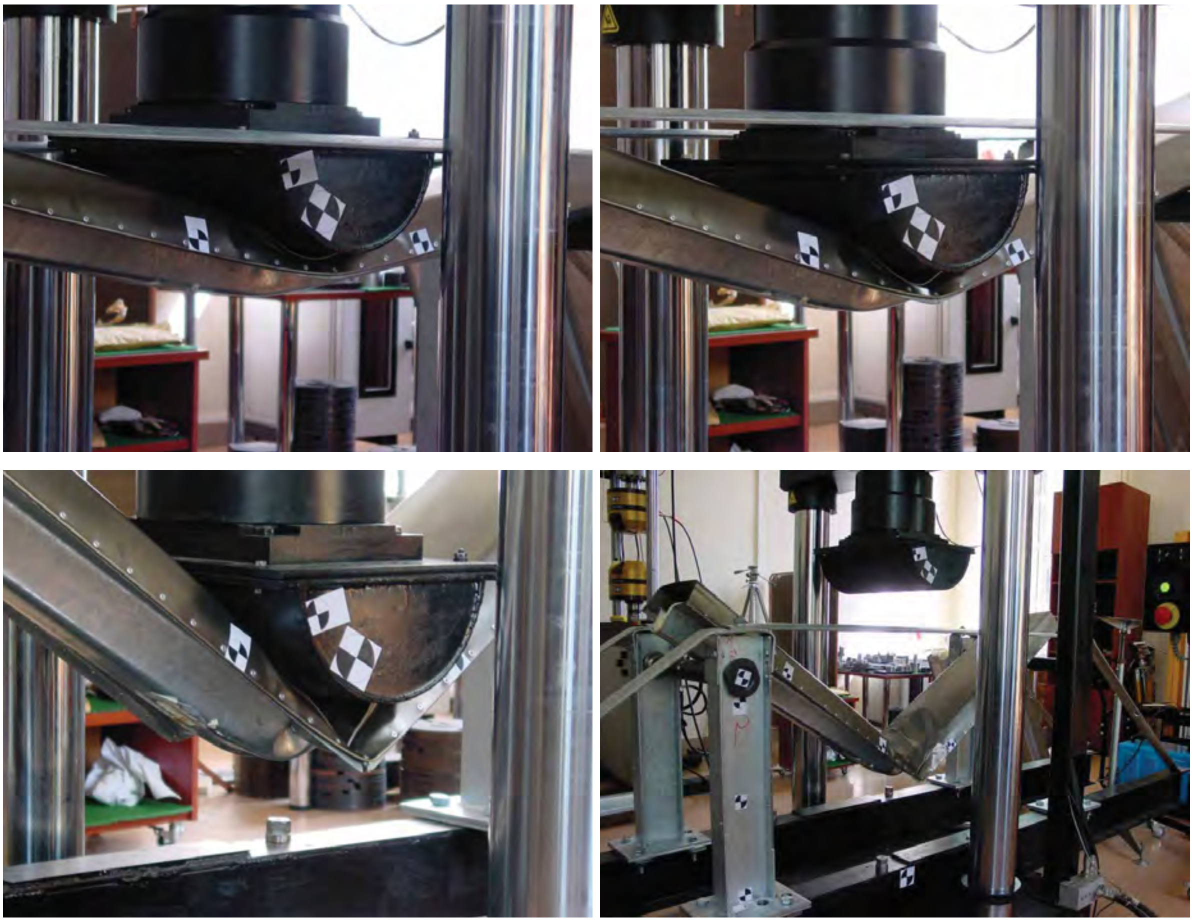

Fig. 2. Panel bending test run

For comparative purposes the protection panels were made, filled with polyurethane foam system EKOPRODUR BF5032 that by hardening doesn't require air access. Two bending tests were carried out with aforementioned panels. It was found out, that the two component polyurethane system for making the rigid foam hardened in its whole volume. In Fig. 3 panels with the filling, mentioned above, are shown after a carried out bending test.

At the test stand, in the load version II (traverse angle of incidence 20°), the bending test of the road barrier belt guide poles with additional protection panel was carried out. In Fig. 4 the bending test run is shown.

Fig. 3. Protection panel after a carried out test according to the I load variant

2. Numerical test of additional protection panels with polyurethane foam filling

Research stands was modelled for the bending test of guide poles 2000 mm long at the traverse angles of incidence within the range of 90 and 20°. The belt and the coating in all cases were modelled using the finite elements of the shell type. For belt and steel coating modelling

Piecewise_Linear_Plasticity material was used. Material data was acquired from strength tests. Thickness of a belt was 3 mm, protective panel coating thickness was 0.5 mm and the thickness of overlap in the coating (near rivets) was 1 mm. Polyurethane foam was modelled with elements of a solid type using Honeycomb type material. Material data was acquired from strength tests. The coating was connected with the belt by constraints of a weld type. Friction, with the factor equal to 0.2, between panel elements, panels and supports was taken into consideration.

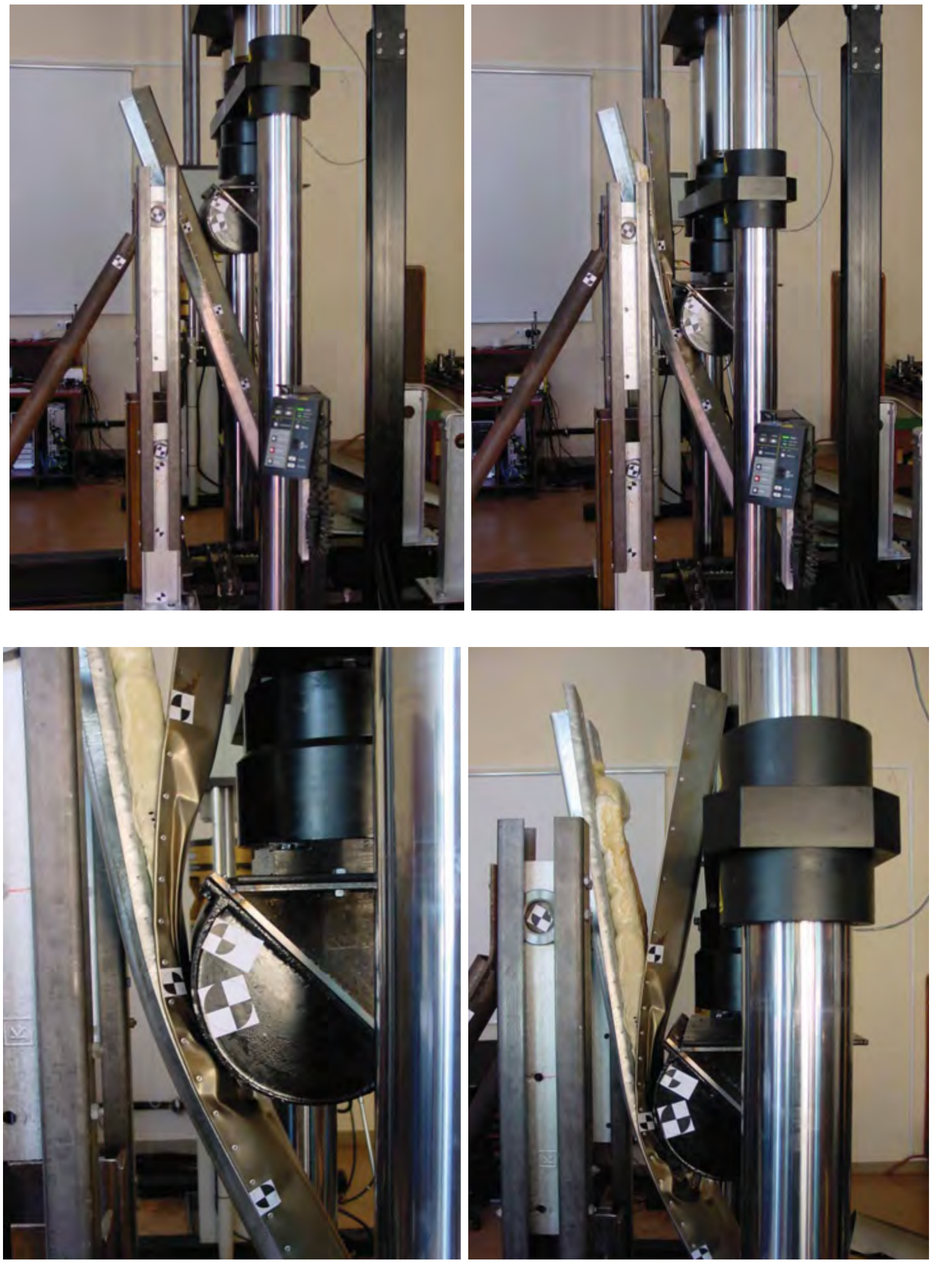

Fig. 4. Protective panel bending test run

Models underwent bending tests by putting them under load with a not deformable stamp moving with the constant speed. Calculations were performed in LS-DYNA program.

Figure 5 shows a numerical model of the road barrier belt guide poles with a protection panel on the stand for tests at the traverse angle of incidence equal to 90°. Deformation of a model during the numerical simulation was presented in Fig. 6. The manner of a model's deformation is similar to the deformation manner of the real construction. Both bending of a panel, in the real construction and in the numerical model, took place in the place of applying a stamp. In both cases a portion of rivets was destroyed in the vicinity of the load application. The dependence force - displacement obtained in experimental tests and numerical simulation are presented in Fig. 7. Maximal force was observed by the panel's deflection for about 65 mm. Its value is 25 kN. In Fig. 8. a diagram of absorbed energy by the belt in the traverse displacement function was presented.

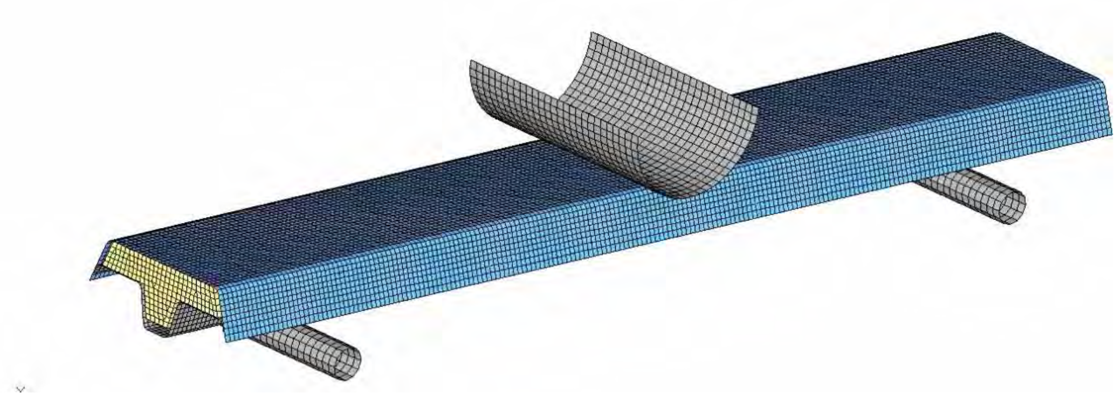

Fig. 5. Numerical model road barrier belt guide poles with a protection panel on the work stand for tests at the traverse angle of incidence 90°

Fig. 6. Numerical simulation of the protection panel bending test on the test stand at the traverse angle of incidence 90°. Figures show numerical deformation of the model by the traverse displacement in succession: 0; 200 and 450 mm

Numerical model's deformation of the road belt guide poles with a protection panel on the stand for test at the traverse angle of incidence 20° during the numerical simulation was presented in Fig. 9. The manner of deformation is similar to the deformation manner of a real construction. Both, in the real construction and in the numerical model, the panel bending took place in the stamp application place. In both cases a portion of rivets was destroyed in the vicinity of the load application place. The dependences force - displacement obtained in the experimental tests and the numerical simulation are shown in Fig. 10. In Fig. 11 the diagram of an absorbed energy by the belt in the function of traverse displacement was presented.

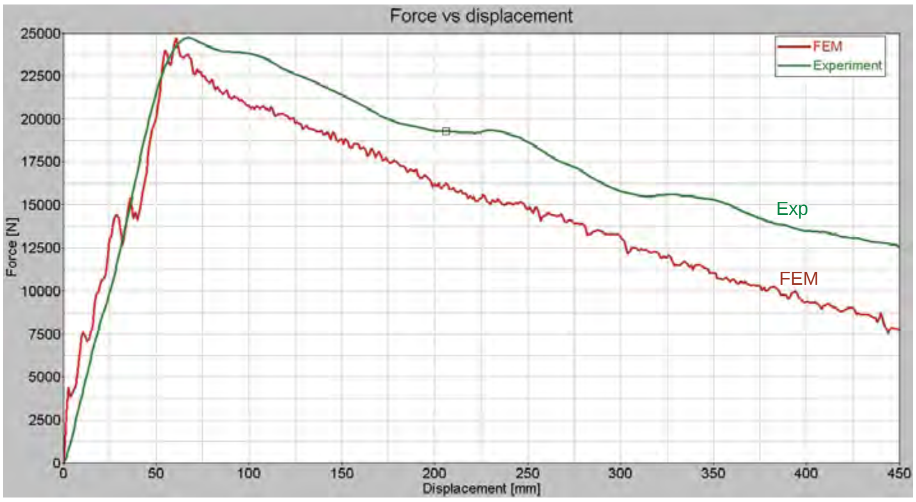

Fig. 7. Comparison of the load forc e – dis placement of th e traverse curves i n the guide poles with the pr otection panel bending process by the traverse angle of incidence 90°

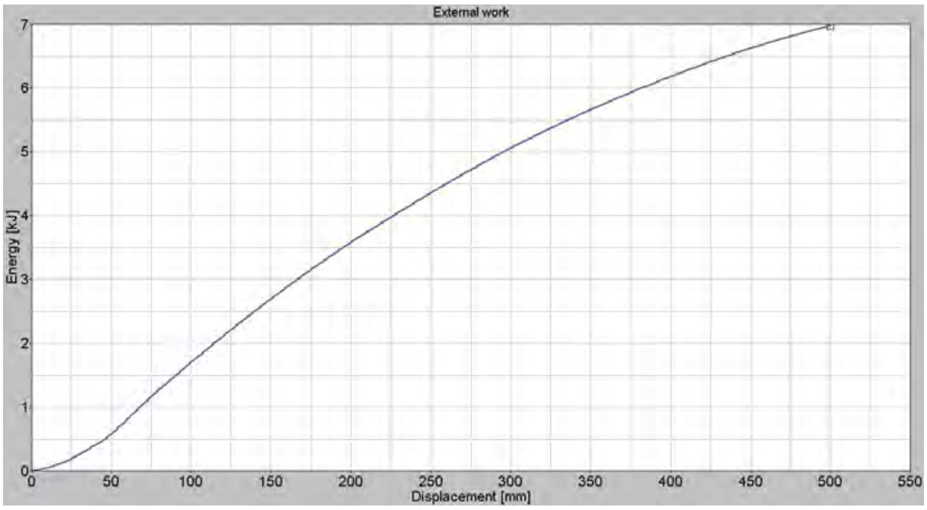

Fig. 8. Absorbed energy by the belt diagram [J] in the traverse displacement function

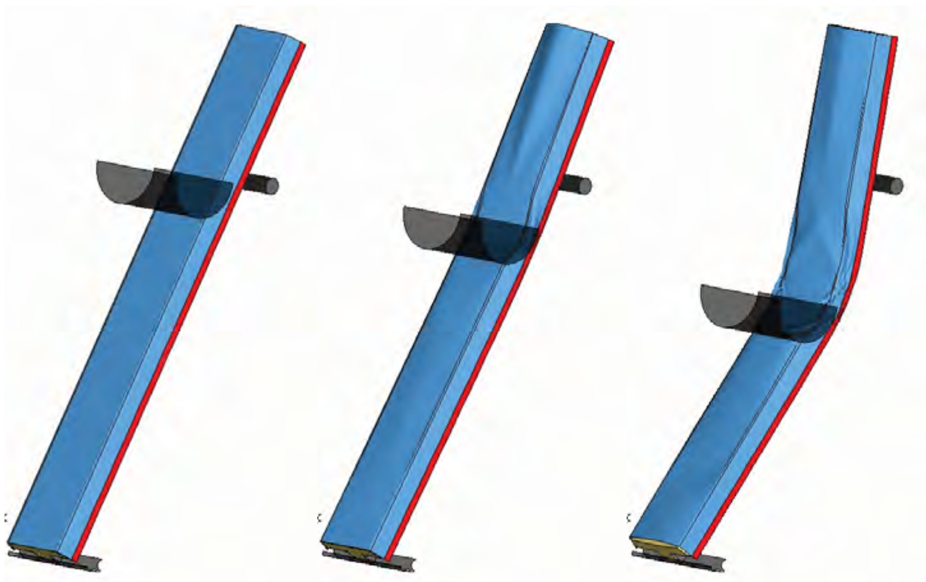

Fig. 9. Numerical simulation of a pr otection panel bending test at the traverse angle of incidence 20°. Figures show numerical model of deformation by the traverse displacement in succession: 0, 200 and 450 mm

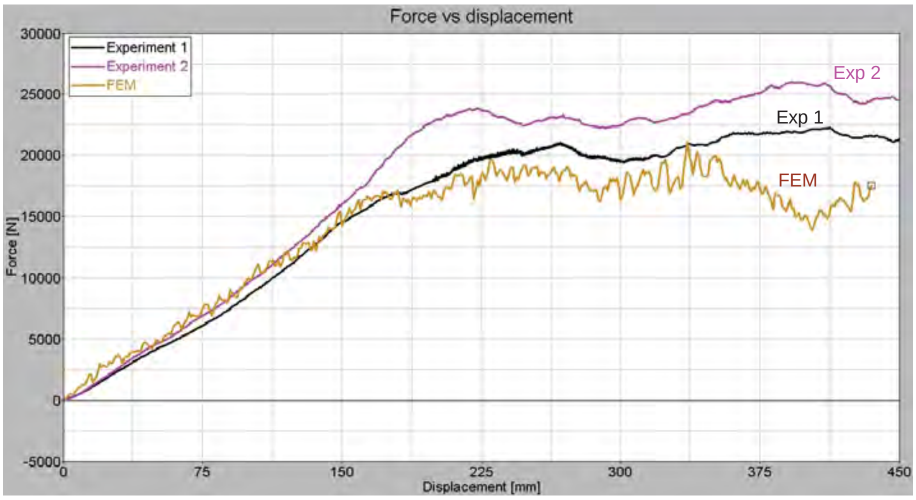

Fig. 10. Comparison of the load force – displacement of the traverse curves in the guide poles with the bending process of the protection panel at the traverse angle of incidence 20°

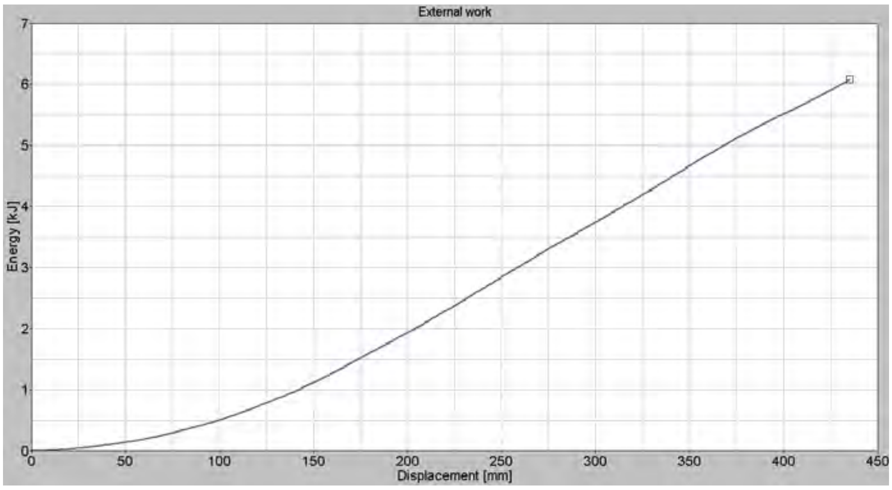

Fig. 11. Absorbed energy by the belt diagram [kJ] in the function of the traverse displacement

3. Conclusions

In this work, validation results of the system of energy – consuming panels were presented. For the analysis of two load variants – incidence under the angle 90° and 20° were adopted. A big force can be observed in the function of the traverse displacement and also in the function of deformation of individual panels' elements. The results show that on the basis of numerical calculations, the amount of absorbed energy by individual elements and the correctness of the numerical models can be inferred.

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