THE INFLUENCE OF FORMING PROCESS ON ROAD BARRIER STRENGTH

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1. Introduction

Road barriers are becoming more and more popular as a mean to minimize a risk of vehicle collision with a roadside tree or oncoming traffic. The most common barriers are made built from either concrete or steel [1] which are still popular due to their simplicity and a low production cost. Certain levels of vehicle containment can be defined based on the European EN 1317 standard [2]. Barriers verification is carried out on the basis of experimental test, however, such experiments are relatively expensive. Numerical simulations allow not only verification of protector usefulness but also improvement of its geometry based on different kinds of tests. Most road steel protectors are manufactured using a forming process. However, this factor is not included in nowadays literature. Typically, numerical simulations consider steal material to be fully homogenous neglecting the fact that it experienced an intensive deformation process. In this paper, an approach which reconciles both computational efficiency and proper material description is suggested.

2. Determination of barrier strength basing on forming process simulation

A typical bridge barrier KTC 015 produced commercially [3] was chosen. A complete analysis of a forming process was carried out. In order to solve the problem in an efficient way, a computer simulation method was chosen. The Finite Element Method (FEM) implemented in the LS-DYNA commercial code was used with an implicit (central difference) time integration algorithm. The initial shape of the processed material and further steps of the forming process are presented in Fig. 2a-b. In Fig. 2d, reduced stress in the final stage of the forming process is presented shown. The highest value of tress is around 500 MPa, which is more than twice as much as the one describing original yield steel (240 MPa).

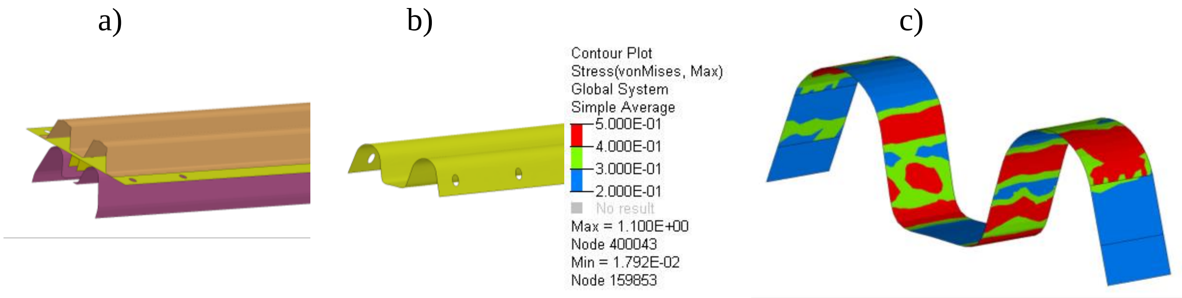

Fig.2. Simulation of a forming process: a) initial shape of the plate and stamps, b) plate in the final stage, c) reduced stress in the final stage

3. Verification of a modeling methodology basing on experimental test

KTC 015 barrier was tested both experimentally and numerically according to TB51 norm [2]. During the impact test, a bus hits a barrier with an initial speed 70 km/h at an angle 20˚. The bus model was compatible with norm [2] and was obtained from [4]. Two simulation tests were conducted. In the first one, a homogenous material model for the barrier was utilized. In the second approach, three material models were used in order to take into account an influence of a manufacturing process. Each material model was characterized by different yield stress.

Deformations originated during a crush test, captured in particular moments of time, are presented in Fig.4. General behavior is similar for both simulations including different material models. Because of that fact, only simulation with homogenous material is presented below.

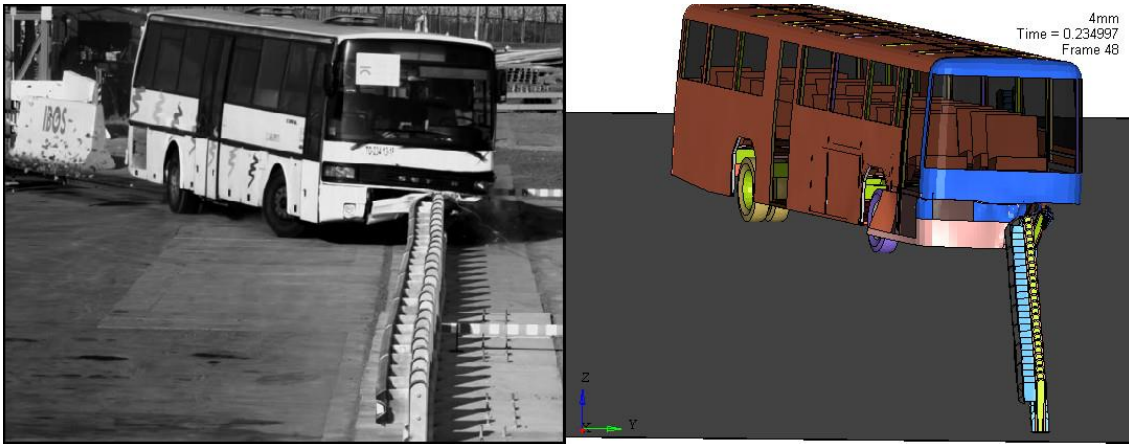

Fig.4. Deformation of bus and barrier in the experimental test and numerical simulation

The crush test results are evaluated according to standard described in [2]. Parameters presented in Tab.1 prove that an improved model of a barrier gives better results. Both a static working width and a normalized working width give more accurate results in comparison with the performed bus crush test.

Parameter	Experiment	Simulation	
		Homogenous model	Triple model
Static working width [mm]	860	870	860
Normalized working width W_n [mm]	1000	903	970

Table 1. Crush test parameters including experimental and numerical results with different material models.

4. Conclusions

The obtained results prove that defining a proper model of a road barrier requires taking into account a manufacturing process. Intensive plastic deformation induces a significant increase in yield stress. Such a phenomenon takes place only in an area where the highest strain is observed during a forming process. Evaluation of the barrier under impact according to European regulations (EN 1317) shows clearly that an improved model better describes its mechanical behavior. Both a static working width and a normalized working width give more accurate results in comparison with the performed bus crush test.

6. References

[1] Y. Itoh, C. Liu, R. Kusama (2006). Dynamic simulation of collisions of heavy high-speed trucks with concrete barriers, Chaos Soliton. Fract., 34, 1239-1244.
[2] EN 1317-1:2010. Road restraint systems – Part 1: Terminology and general criteria for test methods.
[3] http://www.ktcpolska.eu/en/ktc_015.html
[4] http://www.ncac.gwu.edu/vml/models.html.