The Impact of Forming Processes on Road Barrier Strength

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Abstract. This paper presents a numerical study of a road barrier subjected to a bus crash test. The authors focus on the proper description of a barrier material model which parameters are verified according to a simulated forming process. The barrier model is divided into three zones, each of which have material properties characterized by different constants. Deformation of the barrier under impact is evaluated according to European regulations (EN 1317). In comparison to the performed bus crash test, the crash test parameters obtained in the numerical simulation (static working width and normalized working width) gave more accurate results when the improved material model was utilized.

INTRODUCTION

Levels of vehicle containment can be defined, based on the European EN 1317 standard [1]. Barrier verification is carried out based on an experimental test on a specially prepared track. However, such experiments are relatively expensive and, due to the large amount of debris and the short period of the actual impact, they cannot give much insight into the crash process. Numerical simulations, on the other hand, allow not only verification of the usefulness of the protector, but also improvement of its geometry in order to provide better absorption capacity [2]. Typically, numerical simulations consider a steel material to be completely homogenous, neglecting the fact that it has experienced an intensive deformation process [9]. In this work, the authors suggest that utilizing a numerical approach in order to verify material properties and their influence on the crash process is a good option. The aim of this paper is to provide a modelling concept which reconciles both simplicity and proper description of the barrier material.

DETERMINATION OF BARRIER STRENGTH BASED ON FORMING PROCESS SIMULATION

The material deforms significantly during the forming process, thus changing the properties of the structure [3]. In barrier manufacture, this process induces plastic deformation of almost all the material that is subjected to press forming. Such deformation causes an increase in yield stress due to the hardening of the steel. Simulation of the forming process is essential to verify the level of this stress. To this end, a typical commercially-produced KTC 015 bridge barrier [4] was chosen. The barrier consisted of an A-type guardrail, absorbers and connected posts mounted to the base with chemical anchors. The guardrail segments (4320 mm length) were connected to each other by bolts.

To verify material parameters after the manufacturing process, a complete analysis of the forming process was carried out. A steel plate was connected to a support in exactly the same way as during experimental forming. The plate was placed between two stamps, one of which was fixed while the other pressed the plate at a constant quasi-static speed. A finite element model was built from three- and four-node shell elements. A remeshing procedure was used in order to avoid the problem of distorted elements. The highest stress value is around 500 MPa, which is more than twice that of the original yield of steel (240 MPa).

RESULTS

The KTC 015 barrier was tested both experimentally and numerically according to the TB51 standard [4], which specifies an impact speed of 70 km/h when a bus hits a barrier at an angle of 20°. The bus model was compatible with standard [4] and contained over 500 beams, 55,000 shells and 3,000 solid elements. The model was slightly modified to provide efficient calculations. The tire model using the airbag option was utilized. Initial angular velocity of the wheels and linear velocity of the bus at the start time were declared. The sophisticated suspension design was simplified using one-dimensional elements and a new material model specific to the description of linear elastic beams. Appropriate stiffness and damping were defined. The influence of the modifications was minimized during crash simulation due to the introduction of dynamic relaxation before the bus was crashed into the barrier.

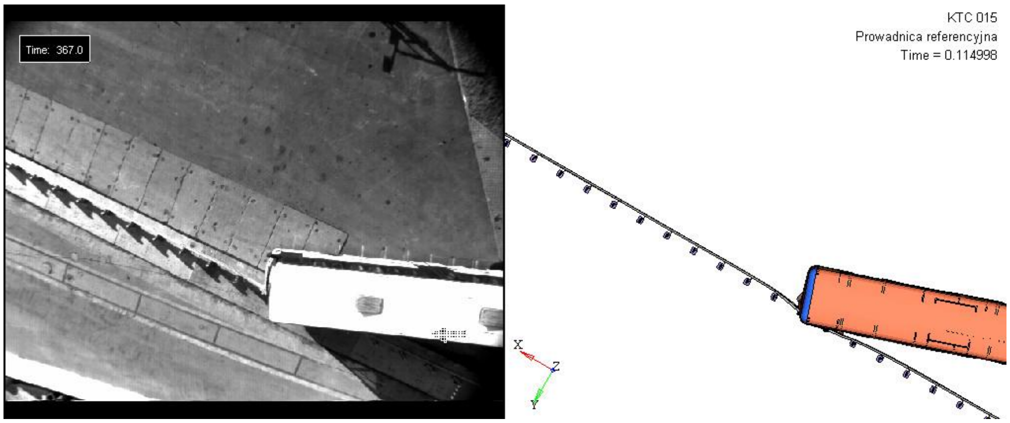

FIGURE 2. Deformation of a bus and a barrier in the experimental test and numerical simulation

CONCLUSIONS

The obtained results prove that defining a proper road barrier model requires the manufacturing process to be taken into account. Intensive plastic deformation induces a significant increase in yield stress. Such a phenomenon takes place only in the area where the highest strain is observed during the forming process. The barrier model was divided into three zones, each of which had material properties characterized by different constants. In such a way, both a low complexity model and a good description of the modified barrier behavior was achieved.

The general behavior of the barrier and the bus during the crash test is similar, regardless of the type of modelling. However, closer observation of the barrier shape after impact leads to important conclusions. The model of the barrier guardrail built of homogenous material was much flatter than the one in the improved model. A comparison with the experimental results proves that the new simulation method better describes barrier deformation. In addition, deformation of the barrier under impact was evaluated according to European regulations (EN 1317). Both the static working width and normalized working width gave more accurate results if the modified material model was utilized, compared to the real bus crash test.

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