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Determination of the force characteristic of head car's passive safety system – large road vehicle interaction in a collision

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One of the priorities of the National Economic Strategy of Ukraine for the Period up to 2030 is the development of the transport sector, in particular railway vehicle renewal, the introduction of high-speed railway passenger transport, and railway traffic safety improvement. The home motor-car trains must be renewed in compliance with new home standards harmonized with European ones, among which one should mention the Ukrainian State Standard DSTU EN 15227, which specifies the passive safety of a passenger train in its emergency collisions with different obstacles. New car designs must provide not only effective up-to-date braking systems to prevent emergency collisions, but also passive safety systems with energy-absorbing devices. The main purpose of these devices is to reduce the longitudinal forces in the intercar connections and the car accelerations to an acceptable level for the three collision scenarios specified in the DSTU EN 15227. The Department of Statistical Dynamics and Multidimensional Mechanical Systems Dynamics, Institute of Technical Mechanics of the National Academy of Sciences of Ukraine and the State Space Agency of Ukraine, developed a passive protection concept for home high-speed passenger trains in emergency collisions by the DSTU EN 15227 scenarios, proposals on the passive protection of a motor-car train head car, and honeycomb designs of lower- and upper-level energy-absorbing devices (EAD 1 and UL EAD, respectively), which are integrated into the head car front part and serve to damp the major part of the impact energy in front collisions with obstacles. This paper considers DSTU EN 15227 Scenario 3: a collision of a reference motor-car train at a speed of 110 km/h at a railway crossing with a large 15 t road vehicle, which is simulated as a large-size deformable obstacle (LSDO). The aim of the paper is to determine the force characteristic of the interaction of energy-absorbing devices mounted on the head car front part with a large road vehicle in a collision to assess the compliance of the proposed passive protection with the normative requirements. Finite-element models were constructed to analyze the plastic deformation of the elements of the EAD 1 – LSDO, UL EAD – LSDO, and EAD 1 – UL EAD –LSDO systems in a collision with account for geometric and physical nonlinearities, steel dynamic hardening as a function of the impact speed, and varying contact interaction between the elements of the systems considered. The studies conducted made it possible to determine the force characteristics of energy-absorbing device – obstacle interaction and the total characteristic of the contact force between two lower-level devices and two upper-level ones as a function of the obstacle center of mass displacement in a collision. The proposed mathematical models and the calculated force characteristics may be used in the study of the dynamics of a reference motor-car train – large road vehicle collision with the aim to assess the compliance of the passive protection of the home head car under design with the DSTU EN 15227 requirements.

Keywords: *motor-car train, traffic safety, emergency collision, head car, passive safety system, energy-absorbing devices, large vehicle.*

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