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ANALYSIS OF THE INTERACTION BETWEEN A PASSENGER TRAIN WITH PASSIVE SAFETY SYSTEM AND A LARGE ROAD VEHICLE IN A COLLISION

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At present, a topical problem for the Ukrainian railway transport is the development of high-speed passenger rail vehicles with passive safety systems (PSSs) to provide safety in emergency collisions. Since 2016, the Ukrainian State Standard DSTU EN 15227:2015 (EN 15227:2008) has been in force in Ukraine. The standard is equivalent to the European Standard EN 15227, according to which PSSs are mandatory for all passenger railway vehicles under development. According to the EN 15227, PSSs shall protect the passengers and the train crew and provide vehicle load-bearing element safety in normative collision scenarios. The Standard EN 15227 specifies reference trains, four collision scenarios, and criteria for assessing the compliance of the designs of PSS-equipped vehicles with the specified normative requirements. This paper considers scenario 3, which characterizes an impact between a passenger train and a large road vehicle of 15 t (for example, a heavy lorry) at a grade crossing at a speed of 110 km/h. The large road vehicle considered in this scenario is a large-size deformable obstacle (LSDO) with given dimensions standing freely at a grade crossing. When designing PSS-equipped railway vehicles, one has to analyze the collision dynamics by scenario 3 using mathematical simulation and to assess the computed average longitudinal accelerations and plastic deformations in the load-bearing elements of the vehicles under consideration by the criteria of the Standard EN 15227. In doing so, particular attention must be paid to the adequacy of simulation of the train–obstacle interaction. In this paper, a locomotive-hauled passenger train is considered. The aim of this work is to determine the force characteristic of an impact between an LSDO and a PSS-equipped locomotive at a grade crossing. To achieve this aim, the nonlinear dynamic contact problem of an impact between a LSDO and the front part of a locomotive was considered. The LSDO was a structure made up of three fragments (a casing, a core part, and a lower part) having different materials. The parameters of the structure were determined according to the Standard EN 15227 from the solution of the problem of an impact between the LSDO and a rigid ball of 50 t. The driver's cabin was the cab developed by MDS Research-and-Development Manufacturing Enterprise for the EP20 electric locomotive with PSS elements integrated thereinto. The frame of the driver's cab has a reinforced front wall, a collapse zone, and a safety zone to save the locomotive crew. Two energy-absorbing devices (EADs) are installed in the end part of the locomotive body frame level with the automatic coupler. The paper presents new finite-element models of the plastic deformation of LSDO, EAD, and cab frame elements in a collision by Scenario 3. As a result of this study, the contact force acting between the LSDO and the locomotive front part was obtained as a function of the longitudinal displacement of the LSDO center of mass in a collision. The proposed approach and methodology and the mathematical models developed may be used in the design of home PSS-equipped passenger locomotives.

Keywords: *passenger train, collision at a grade crossing, large-size deformable obstacle, passive safety system, nonlinear dynamic contact problem, finite-element simulation.*

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