NUMERICAL STANDARD TESTS OF RAILWAY CARRIAGE PLATFORM

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Abstract

The object of the paper is to build a numerical model of a railway wagon and perform statics calculation. The examined railway wagon is designed to transport interchangeable containers in ACTS (Abroll Container Transport System). The essential matter of such reloading is placing the container on a special rotating platform, which enables horizontal reloading of the load on the truck. The carriage is equipped with a flat frame cooperating with two bogies and three mobile platforms rotated in respect to central knots in order to simplify the process of loading and unloading of the interchangeable containers. A numerical model was verified and validated by experimental and numerical tests. Particular attention was paid to the support model in a contact place of the frame-carriage and bogies. The paper presents the results of static calculations prepared in accordance with relevant standards for this type of construction. The numerical model was loaded according to the requirements of PN-EN12663 standard specified for the F-I vehicle and BN-77/3532-40 standard. The finite element method was used for numerical analysis. A discreet FEM model was developed with the aid of MSC Patran pre-processor, while MSC Nastran code was applied for simulations. The results of calculations are presented by displacement and stress characteristic. Strength of construction was determined based on results.

Keywords: *ACTS intermodal wagon, standard strength test of the structure, FEM, numerical analysis*

1. Introduction

In intermodal transportation systems, convenient and effective loading systems play a significant role. [6, 7]. Nowadays, railroad combined transport constitutes an alternative for car transport. It is based mostly on the principle of horizontal loading (ACTS system). ACTS system [1] is created by three fundamental elements: a carriage equipped with rotating platforms, a truck with suitable load capacity, interchangeable containers.

The paper presents the results of static analysis prepared in accordance with relevant standards for this type of construction. There were presented the numerical models of an exemplary rail carriage operating in ACTS system – Fig. 1. The carriage is equipped with a flat frame cooperating with two bogies and three mobile platforms rotated in respect to central junctions (Fig. 1) in order to simplify the process of loading and unloading of the interchangeable containers. After loading the containers, the loading platforms are blocked for the time of transportation between stations.

Fig. 1. Exemplary carriage platform for intermodal transportation in ACTS system [1]

A numerical model was verified and validated by experimental and numerical standard tests. Particular attention was paid to the support model in a contact place of the frame-carriage and bogies. The numerical model was loaded according to the requirements of PN-EN12663 [8] standard specified for the F-I vehicle and a standard BN-77/3532-40 standard. The finite element method was used for numerical analysis.

2. Numerical FE models

An FE model of the frame-loading platforms system of the carriage was carried out with MSC Patran code [2]. At the first stage of works, the model of the carriage frame was built. The frame was modelled with the use of the 1D and 2D shell-beam elements (Fig. 2).

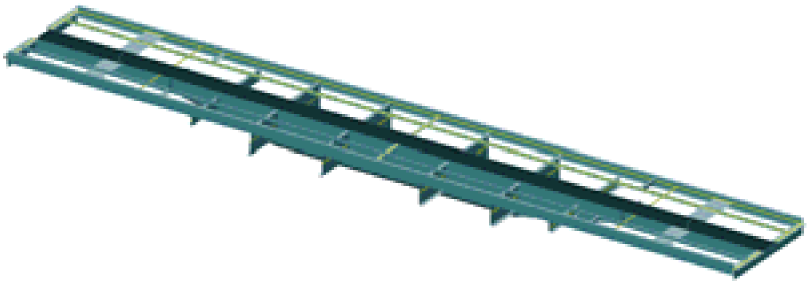

Fig. 2. Carriage frame FE model

At the next stage of works, FE models of carriage rotating platforms were developed. The platforms were modelled with the use of 1D elements. The accurately prepared models of rotating platforms were integrated with the model of the carriage frame. The complete model of the system is composed of of the main frame and three platforms adequatly arranged on the frame main plate, as it is shown in Fig. 3.

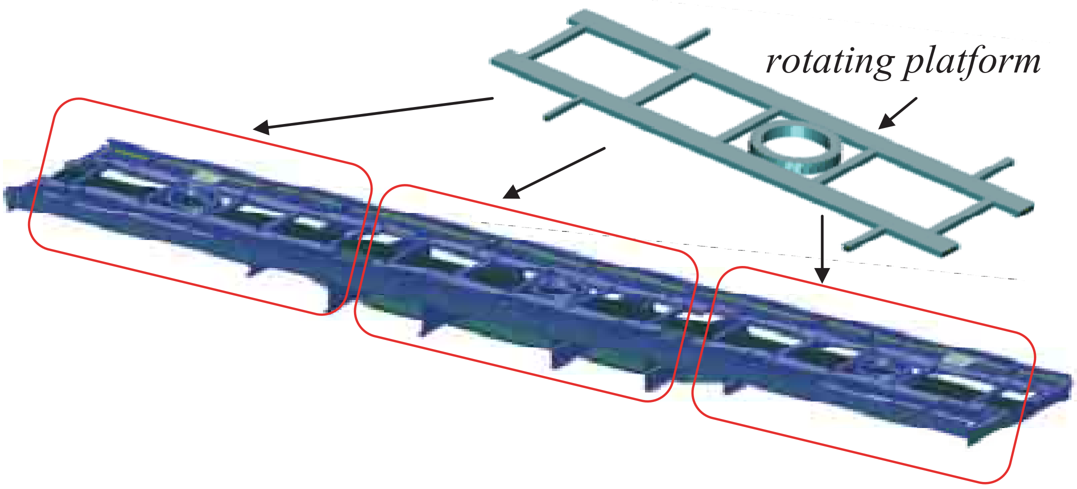

Fig. 3. Full model of the carriage platform: frame with three rotating platforms

The joints between the subassemblies and the contact conditions were defined with the use of MPC elements [3, 5]. The parameters of cross sections corresponding to the real ones were ascribed to all the elements of the model. The model of material was defined as steel with standard strength parameters for constructional steel. There was assumed a material linear-elastic model with the following parameters:
– Young modulus $E = 2\cdot10^{11}$ Pa;
– Poisson ratio $\nu = 0.3$;
– Density $\rho = 7.8\cdot10^{3}$ kg/m^3.

3. Numerical analysis of the static loading test

At this stage of research, the conditions of the loading test carried out on the real carriage were numerically modelled. There were considered two options of loading. First of them assumed that the model was only influenced by the deadweight of the frame-loading platforms system equal to 195 kN. The other variant of loading assumed that the all-up weight of a completed carriage with the load on three platforms equal to 710 kN. This is the loading option corresponding to the weight, which was used at the extreme measurement of carriage deflection (carriage deadweight along with the weight of three containers loaded with the fine coal). The external loading from the containers with the load was modelled in the form of constant loading put on the elements of crossbar of the three rotating platform (Fig. 4).

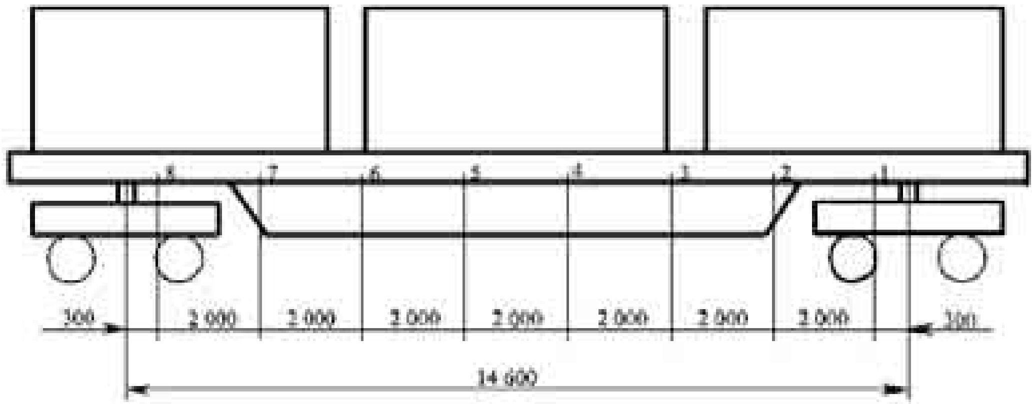

Fig. 4. Loading in the model of rotating platform (view on the rotating platform and carriage frame)

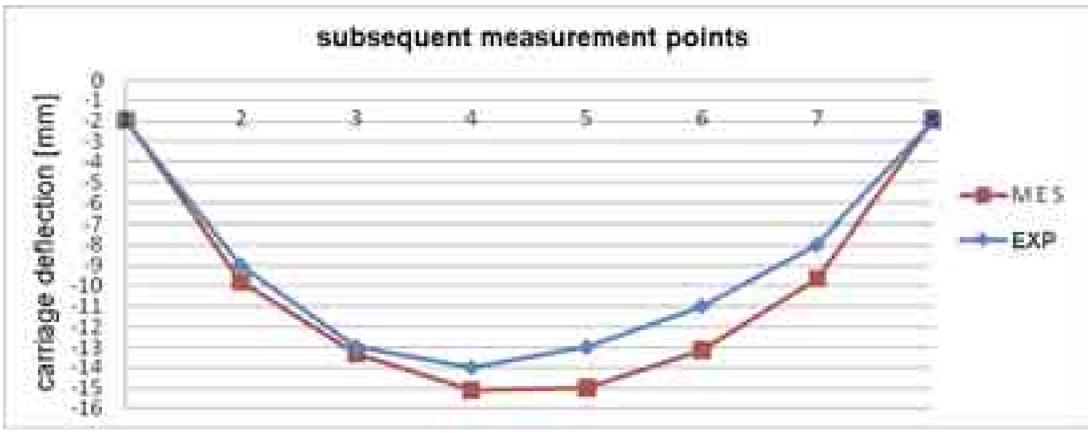

Fig. 5. Carriage deflection at the subsequent measurement points

It was verified that the maximum value of the relative deflection for the examined platform equal to 14mm. The deflection determined in such a manner will be used for comparison with the results of numerical analyses and for the evaluation of the accuracy of the applied numerical models (Fig. 5). The value of relative deflection for the numerical model is equal to 15.1mm. The maximum stresses reduced according to H-M-H hypothesis [4] determined in the second option of the test equal to 168MPa.

4. Numerical standard tests of railway platform

The wagon construction was developed so that it meets the requirements included in PN-EN12663 standard determined for an F-I vehicle (extreme and exploitation cases and superposition) and in BN-77/3532-40 standard (additional cases). According to these standards, the following load dimensions of the wagon were determined (Fig. 6-9).

Fig. 6. Variant A: compression of the wagon in the axis of buffers with force of 2MN

Fig. 7. Variant B: compression of the wagon with force of o.4 MN applied diagonally on the level of buffers

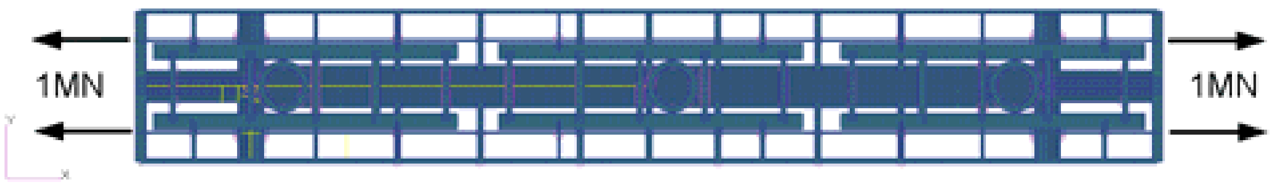

Fig. 8. Variant C: tension of the wagon in the axis of couplers with the force of 1 MN

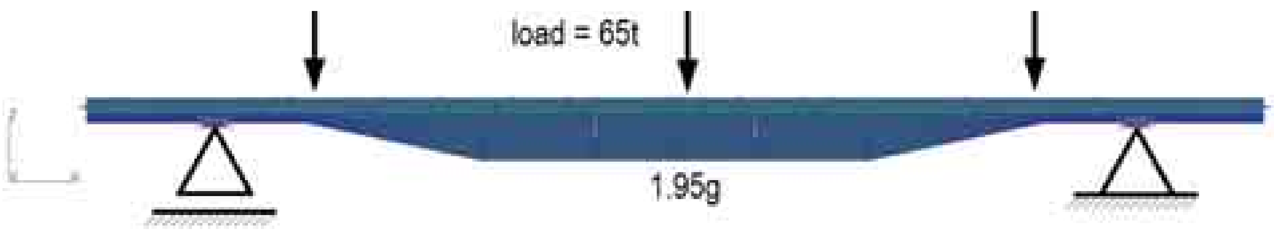

Fig. 9. Variant D: maximum service load subjected to acceleration of 1.95g

The paper presents the results of static calculations prepared according to above-mentioned standards. The following values of maximum stresses according to strain hypothesis H-M-H were obtained for individual cases (Fig. 10, 11):

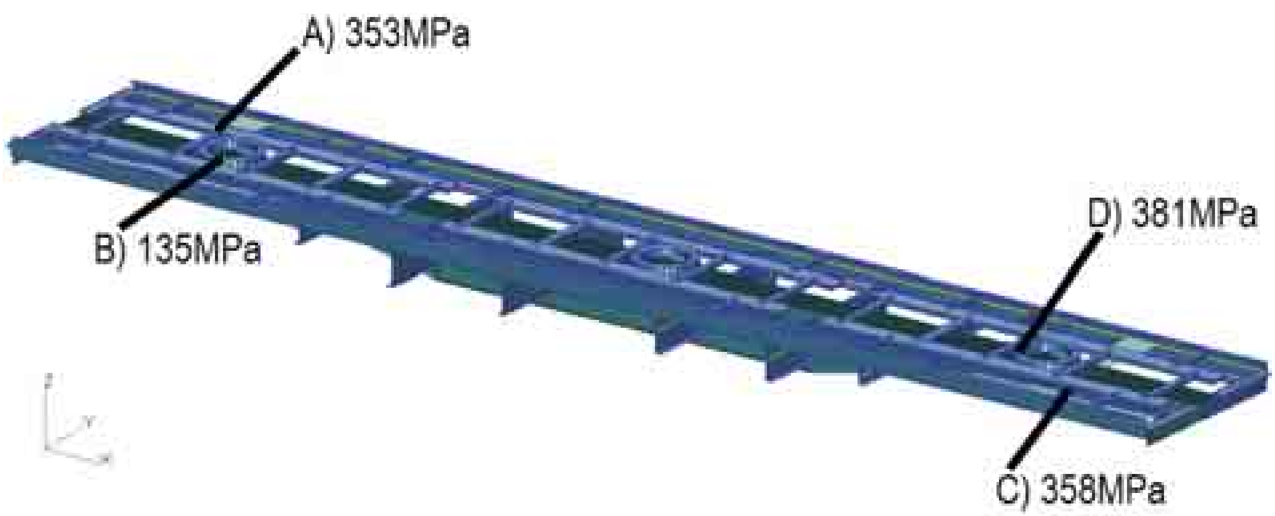

Fig. 10. Comparison of results; H-M-H stresses for the individual models of frame wagon in different case of the applied standard loads

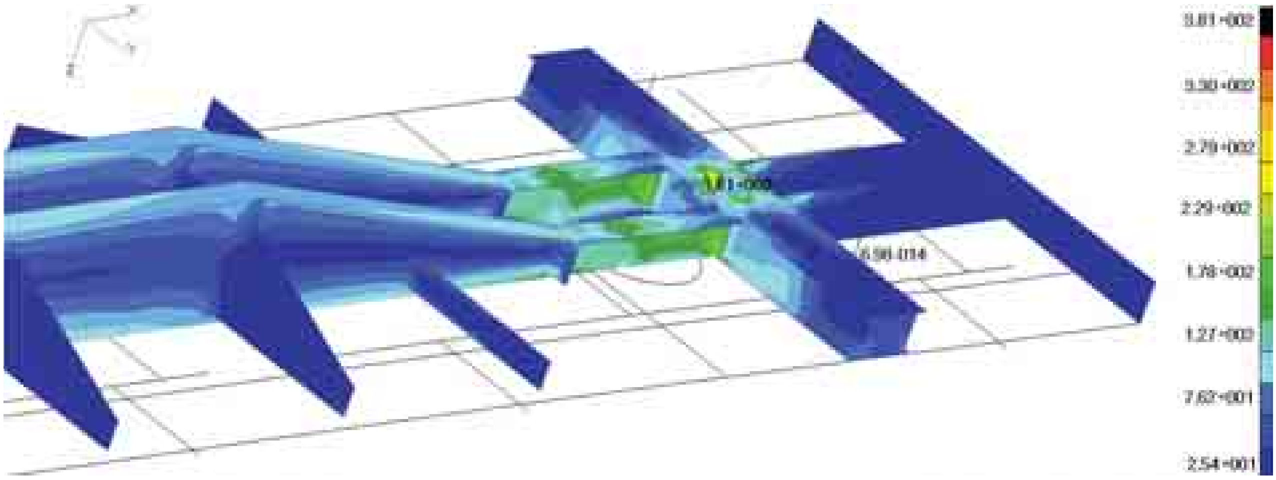

Fig. 11. Reduced H-M-H stresses of the variant D, view from the bottom of the model

4. Conclusions

The paper presents the selected elements of the research methodology of the frame-carriage loading platforms system for specific transports. There was discussed the structure of the numerical FE models of the system and the selected results of static analysis. The models were verified with the use of the results of an experimental measurement of the decline of the real rail carriage platform. The value of the frame deflection obtain from the numerical simulation of the static test corresponds to an experimental value (the maximum difference equals to approximately 8%). On the basis of the verified analysis, it can be concluded that the developed model is correct and can be used to further strength research.

The greatest stress concentrations occurred in the places of wagon swivel pin location. The yield stress of the material; S355 steel (Re=400 MPa), was not exceeded in any of the standard loads variants. The significant convergence of the verifying test and satisfying results of standard tests allow an unequivocal statement that the wagon presented in the article can be applied to combined transport ACTS. The developed methodology of the tests of such constructions allows it to be implemented both at the stage of the design and for the tests of already exploited or renovated constructions.

Acknowledgements

Paper financed by National Centre for Research and Development –PBR R10 0023 06/2009.

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