



CETRA²⁰¹²

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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University of Zagreb
Faculty of Civil Engineering
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IDEA AND TESTS OF THE RAILWAY WAGON WITH A ROTATABLE PLATFORM FOR INTERMODAL TRANSPORT

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Abstract

In recent years, combined systems based on vertical or horizontal handling have been implemented into European railway transport. In vertical and horizontal systems, loading and unloading require special terminals. Vehicles, using their own engines, are driven on and off platforms through a ramp at the last carriage (horizontal system). A railway wagon with a rotatable low and flat loading floor for bimodal transporting will be presented in this paper. Such a structure can be used for transporting various types of vehicles, for example, tractors, trucks, trailers, semitrailers, cargo containers. The railway wagon allows quick and convenient loading/unloading of vehicles and containers (without cranes), no platform infrastructure is required, instead of hardened, flat, surface; no need for hubs, terminals or special logistics; each wagon can be operated separately. It is possible to transport vehicles of 4m height and 36 tons mass on a GB1 gauge. The railway wagon comprises a body having end portions mounted on the standard two-axis bogies and a middle portion recessed with respect to the end portions along recess walls, a loading floor horizontally rotatable above the body. The loading floor is rotated by a pair of linear actuators, connected pivotally at each longitudinal side of the body to the longitudinal side edge of the body and to the middle of the corresponding longitudinal side edge of the loading floor. By dint of supporting the loading floor on guides and stabilizing it with locking pins, the wagon keeps a stable and rigid configuration during the transport. The loading floor is further supported on the rollers. The wagon may further comprise stabilizers mounted under the end portions of the body and configured to support the body on rails in the loading configuration.

Keywords: Intermodal transport, railway wagon with a rotatable platform for transport of semitrailers, numerical FE analysis

1 Introduction

Application of a set of special railway wagons for combined transport [3] benefits in the following areas: reducing of trucks transit time, reducing traffic on the roads reducing harmfulness of the influence on natural environment and many others. There hasn't been implemented a system to combined transport in our country so far. In European railway transport in recent years, there have been implemented combined systems based on horizontal or vertical reloading or others systems. These systems require developed reloading terminals equipped with, for example, vertical reloading devices of accurate load capacity or other expensive and complicated devices enabling loading and unloading activities.

The latest solution, developed in Europe in recent years, is the system of transportation of TIR type trucks by railway developed by French company MODA LOHR [5]. This system requires an extended infrastructure, especially, railway platforms as well as proper maintenance of the

platform devices, particularly in winter conditions. Figure 1 presents new intermodal systems developed by above mentioned French company and MEGASWING wagon built by Swedish company Kockums Industrier [6]. MEGASWING wagon is equipped with a low-loader rotating platform, which is rotated in respect to an asymmetrically located rotating junction, placed at the rear part of the wagon over its 'over-bogie' part. The other end of the moving platform, shifted outside the outline of the wagon, is equipped with a special running mechanism cooperating with overhanging arms stabilized by hydraulic supports on the surface of the reloading railway platform ramp.



Figure 1 Wagons for trucks semitrailers transportation developed by French company MODA LOHR and MEGASWING developed by Swedish company Kockums Industrier [5, 6].

The wagon with a rotatable platform for combined transport, proposed by Military University of Technology (MUT), enables easy and fast autonomic loading followed by transport and autonomic unloading of TIR type trucks without the need of investment into development of additional infrastructure. Fundamental assumptions, the essence of a constructional solution of the wagon with a low-loader rotatable platform for combined transport were described in the paper. A technology demonstrator and selected results of simulation tests of such a wagon were also presented.

2 Idea of a special railway wagon with a rotatable platform for intermodal transport

A railway wagon with a rotatable, low and flat loading floor was presented in the paper. Such a structure can be used for transporting various types of vehicles, for example, tractors, trucks, trailers, semitrailers, cargo containers. The railway wagon allows quick and convenient loading and unloading of vehicles and containers (no cranes needed), self loading and unloading; no platform infrastructure is required, instead of hardened, flat, surface; no need for hubs, terminals or special logistics; each wagon can be operated separately. The developed methodology of examination of such a wagon structure enables its implementation both at the stage of the design and during tests on already exploited or renovated constructions.

2.1 Initial constructional assumptions

The concept of a new type wagon–platform in the below described tests meets the following initial constructional assumptions:

- outer dimensions of a wagon–platform result from DB1 gauge and dimensions of a basic semitrailer of 36 t weight, which was assumed for constructional works,

- platform is supported by two typical biaxial railway bogies,
- frame–support is equipped with over–bogie parts and a lowered bottom plate for building–up the moving body of the wagon,
- rotatable part of the wagon–platform enables an independent entry of the set of tractor/ towing vehicle and semitrailer from the one side and exit from the other side (the arterial body of the wagon),
- motion of the rotatable part is developed by two horizontal hydraulic actuators located in tailboards of the wagon body. The motion is implemented in respect to the central junction connected to the wagon frame–support on the lowered bottom of the frame,
- rotating junction is not subjected to extensive loads, either during transit or during loading/ unloading,
- during loading, in order to stabilize the platform, a bottom plate of the wagon frame will be supported on the heads of rails on the additional hydraulically controlled supports,
- during transport, the tailboards of the rotating part will be connected to the over–bogie part with the locks operating as the pin joints with two shear planes. The locks will be also hydraulically controlled,
- at the ends of the rotating part of the wagon body, there will be located rolls enabling its moving on the railway platform and simultaneously constituting a support of the rotating platform in the process of loading/unloading.

2.2 Structure of a new type wagon–platform

The innovative system of TIR type trucks railway transport proposed by MUT is schematically presented in Figure 2.

The proposed wagon for combined transport is built of a rotatable platform (3) – Fig. 4, which is rotated in respect to a rotating junction (4) placed in the central part of the floor plate of the wagon chassis (9) with the use of two hydraulic actuators (5 and 6) fixed in the platform tailboard and leading tracks mounted to over–bogie parts of the wagon chassis (7).

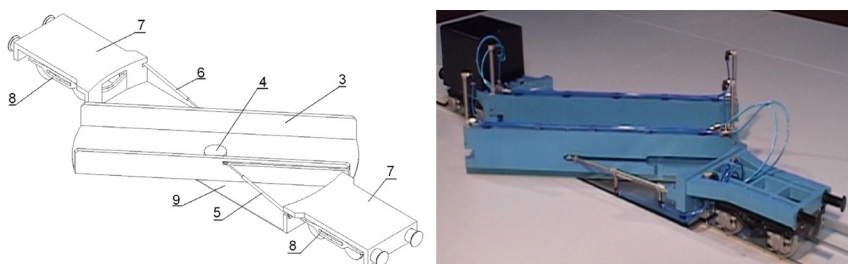


Figure 2 Scheme and 1:14 scale model of the special railway wagon with a rotatable platform for transport of TIR–type semitrailers.

The wagon is also equipped with an openwork over–bogie carrying structure (7) located over the carriageable bogies (8) at the both ends of the chassis. The wagon chassis is equipped with supporters used for stiffening the construction during loading and unloading. The moving platform of the wagon is equipped with a group of special retaining tools, so called rolls, installed in the area of its ends, constituting its additional support during the rotation and enabling the free rotation of the platform in respect to the bottom plate of the wagon as well as in respect to the railway platform plate during loading and unloading. During these operations, there are also applied additional supports of the plate of the wagon chassis (9) resting on the heads of the rails. In the transport position, the rotating platform of the wagon for combined transport is firmly mounted on the over–bogie part with the use of special buckles with locking pivots (Figure 3).

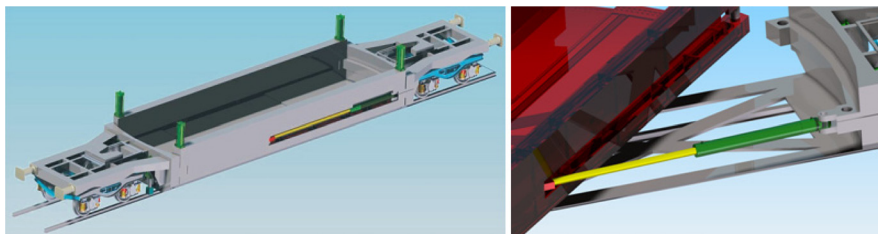


Figure 3 Geometrical model of the special railway wagon with a rotatable platform – view of four vertical pin joint type locks and a part of the wagon structure prepared for loading and unloading operations.

The standard carriageable bogies, selected on the base of producers catalogues for combined transport, are applied in the proposed wagon. Dependently on the applied bogies, the wagon can be used also in broad-gauge traction.

Applying of the special locks connecting the rotating part of the body–platform with over-bogie parts of the frame–support of the wagon is of significant importance for accurate working of such a solution. Figure 3 schematically presents pin joint type locks with a hydraulic drive. Such locks inactivate the rotatable platform of the wagon body in the transportation position and assure accurate stiffness of such a system.

Figure 4 presents selected views from the animation explaining the procedure of preparing, loading and unloading of a semitrailer of a truck with a rotatable platform of the body.

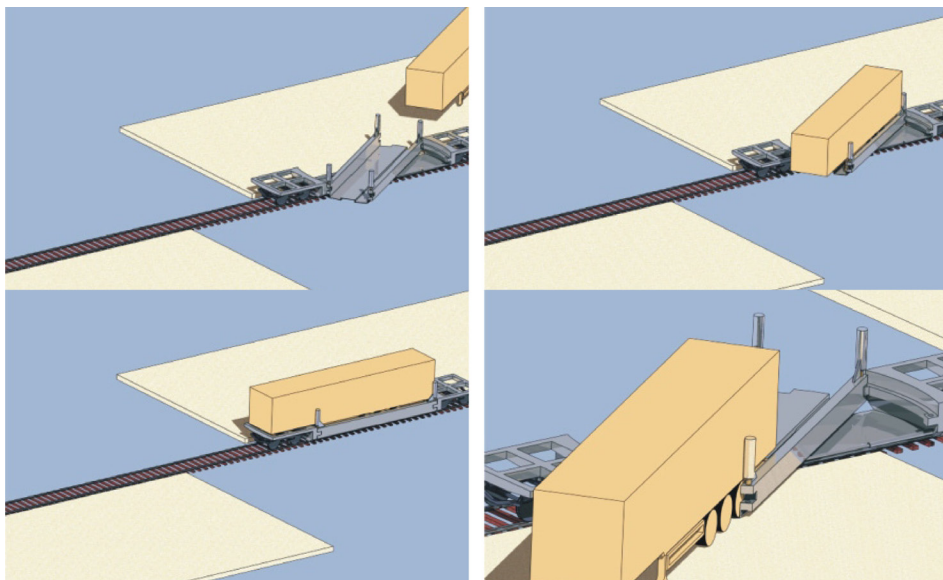


Figure 4 Selected animations of loading and unloading operations for the wagon with a rotatable platform.

2.3 Main features of the special railway wagon with a rotatable platform

In relation to presently utilized construction of such a type, the presented wagon's advantages are as follows;

- applying of repeatable wagons—platforms with an automatic rotating body for fast, safe and easy loading and unloading of trucks,
- constructional dimensions of the wagon with the load in the form of a semitrailer up to 4 m meet GB1 gauge, with the special consideration to 130 mm height over the rail head,
- applying of repeatable reloading railway platforms in the form of a system of repeatable segments for quick, easy and safe loading and unloading of trucks without additional crane devices,
- relatively simple and cheap infrastructure of the proposed system,
- enabling of cheap, ecological and safe transport of truck tractors with a semitrailer with a total length of 17,
- low exploitation costs of such a system.

3 Numerical tests

The object of the presented paper is selected problems of numerical analysis of strength of a constructional solution for a wagon with a rotating platform subjected to the influence of standard loads. The calculations were carried out on the basis of PN-EN 12663 standard [1]. There were discussed the selected results of numerical tests of constructional subsystems obtained in the considered version of the wagon for combined transports.

3.1 FE model of the special railway wagon

Taking into consideration the character of the designed wagon, it was assumed that correct mapping of the construction is possible only when all the subsystems are simultaneously subjected to the analysis considering boundary conditions resulting from their cooperation. Due to the nonlinear character of the mapped cooperation of wagon subsystems, including contact phenomena, MSC.Marc [4] software was selected for calculations.

The model of the presented constructional version of the wagon with a rotating platform consists of 93000 nodes and 83000 elements. Figure 5 presents an FE model with all essential constructional subsystems of the wagon considered.

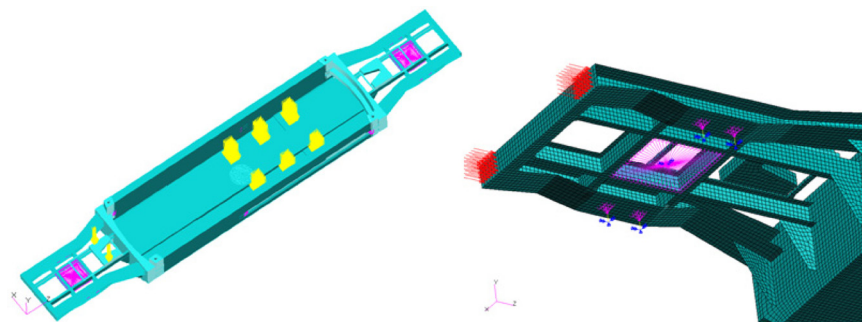


Figure 5 Wagon FE model – general view and model of boundary conditions (constraints and loads).

In a numerical model, there was applied a contact algorithm for both mapping the cooperation of particular subsystems of the wagon and connecting the layer elements with solid elements. For this purpose, a 'Glue' type contact was applied [2, 4]. The same type of contact

('glue' type) was defined between a pivot and a rotating platform and between a pivot and a frame and a chassis of the wagon.

It should be noted that such connection of different kinds of elements does not allow exact calculation of stresses in the area of connecting. In such a case, the only way to exactly determine stresses is a global–local analysis [2], i.e., constructing individual detailed models of connections and their analysis taking into consideration the results obtained from a global model of a complete structure.

3.2 Numerical results

Discrete FE models of the wagon with a rotating platform, discussed above, were applied and numerical analyses were carried out with the use of a finite element method (FEM). The interaction of the load was defined as sets of concentrated forces acting in the regions of pressure of the semitrailers wheels. Basic values of forces and an application region were assumed on the basis of the triplexial semitrailers with a maximum load of the total mass of 36 tons. In some variants of the loading, inertial forces were also acting on the platform. For the particular cases of loading, the values of forces were scaled according to standard requirements [1]. The following cases of numerical analysis are developed:

- variant I – the case of compression the wagon in the axis of buffers with force 2MN,
- variant II – the case of loading with own mass and mass of load increased by coefficient equal to 1.95,
- variant III – the case of loading with both own and load masses at simultaneous compression with 2MN force in the axis of bumpers,
- variant IV – the case of loading with both own and load masses in the unloading position.

Figure 6 presents the selected results in the form of maps of displacements and reduced stresses HMM corresponding to the case of numerical tests defined according to a standard [2].

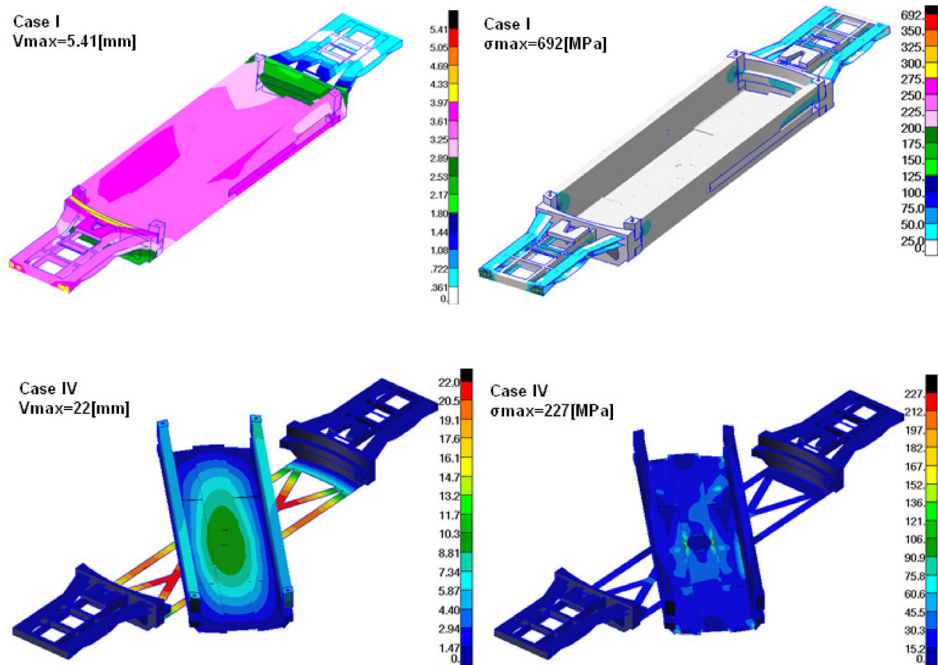


Figure 6 Case I and IV – selected results in the form of maps of displacements and reduced HMM stresses.

4 Summary

The results of analysis carried out in variant I show that the pivots locks of buckles connecting a rotating platform with the wagon frame (over-bogie parts of the wagon chassis) are the most strained region in the model. The maximum of stresses occur locally at the places necessary model simplifications were possible to influence accumulation of stresses. It mainly concerns small areas of mounting of the tailboard buckles with the support and parts of pivotal locks. In variant IV, there was examined the strength in the wagon configuration occurring after unlocking of pivotal buckles between the tailboards of a rotating platform and an over-bogie part of the wagon frame as well as after rotating the platform to the loading/unloading position. In this case of loading, there were applied additional boundary conditions considering the fact of the rotating platform leaning against the railway platform (through the rolls mounted under the utmost edges of the platform) and acting of additional supports founded hydraulically onto the rails under the wagon support during the loading – unloading operations. On the basis of the carried out examinations, it can be concluded that the highest values of contact stresses occur in the slight areas of mounting of the buckles connecting the tailboards of the moving platform with the over-bogie part of the wagon support. Unfortunately, these concentrations occur in the areas where very accurate geometry mapping and considering even slight constructional details is required. It results in a significant increase of dimensions of discrete models and extension of calculation duration time.

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Presented constructional solution is protected by European patent application – EP 10461528

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