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PROJECT OF A PLATFORM-CONTAINER FOR INTERMODAL TRANSPORT

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Abstract

The object of research is a cheap, easy-to-build basic module and multi-platform sets, obtained by combining basic modules with dimensions corresponding to typical railway containers: 10' (with a length of up to 3m), 20' (length of up to 6m), 30' (length of up to 9m). Such structures can be used to support the intermodal rail-road transport of wooden and metal logs. Such a structure with various longitudinal dimensions ensures high mobility resulting from the modular structure and the possibility of selecting transport configurations as well as the use of various forms of loading / unloading, including: typical crane operations, the use of forklifts or hook winches. The use of a platform-container will eliminate the need to repeat the operation of individual loading or unloading of each unit of the transported load (e.g. a single block of wood, a bundle of bars, as a metal log, a single pipe, etc.) during each reloading operation (from the place of logging, production, storage, etc.). A single basic module of the platform has the dimensions of a 10' railway container.

Keywords: metal and wood logs, rail and road transport, single platform-container

1 Introduction

Currently, various types of methods are used to facilitate the performance of loading and unloading operations and to support transport at different stages of log delivery. The available publications provide information on various solutions dedicated mainly to the road transport of logs (e.g. the "Euroflat" kit and other) [1]. However, they are characterised by a narrow specialisation and a variety of individual solutions dedicated in various versions, depending on the specific loading and unloading requirements and the specification of the logs intended for transport. Currently available solutions are mostly container structures [2] or a type of a fixed-length platform [1], designed and equipped mainly for one type of loading and unloading, most often of the hook type, for appropriately adapted vehicles [2, 3], including tractors and trucks. There are also solutions available on the market for loading and unloading operations as well as for transporting logs on roads in unimpeded terrain and on public roads. There are also various solutions for loading and unloading logs at railway stations/terminals [2-5]. The used methods are i.a. overhead crane loading and crane loading [2, 3] using typical rope slings and many others (e.g. with the use of various types of forklift trucks). Unfortunately, there is currently no universal system on the market for the organisation of comprehensive long-distance transport of logs. As a result, timber transport is the proverbial "bottleneck" for the forestry industry, which is a significant problem not only in Poland, but also in other European countries (e.g. in the Scandinavian countries [6]).

2 The object of research

The object of research regarding this project is a cheap and easy to build basic 10' (length of up to 3 m) module of a platform-container [7]. It can be used as a single platform or multi-platforms obtained by combining basic modules with dimensions corresponding to typical railway containers: 20' (length of up to 6 m) and 30' (length of up to 9 m). Individual modules and sets can be used to support railway and road transport of wooden and metal logs, including pipes, products transported on pallets and loose materials. The use of such a structure will eliminate the need for multiple repetitions of individual loading and unloading operations for each unit of the transported load (e.g. a single block of wood, a bundle of bars as a metal log, a single pipe, etc.) during each reloading (from the place of logging, production, storage, etc.). The supporting set with the log load can be repeatedly reloaded (using four different types of loading and unloading techniques most commonly used in the transport of logs) from delivery vans to various types of railway wagons and vice versa without the need to empty the set. It is possible to move a platform, e.g. with a load of logs, using different means of close transport without the need to empty the set from the load. For this purpose, the following solutions can be used: typical rope slings and lifting with a self-propelled or stationary crane, overhead crane etc., forklifts, various types of forklift devices and standard hook lifting. The structure of the proposed platform-container for intermodal transport includes original solutions protected by national and European patent application [7].

3 Construction of a single platform-container module

A single platform-container module supporting the transport of logs has the dimensions of a 10' (length of up to 3m) railway container. Such a platform has a modular structure. It can be assembled in various configurations depending on the intended use. The complete module – a single platform consists of a steel frame, a rotating end carriage placed vertically at one end of the frame or two end carriages at both ends and a set of removable stanchions with ties surrounding the load.

The main part of the platform module is the welded frame. Its two longer sides, to which the rope lifting slings were welded using e.g. mobile cranes, are equipped with lower skids constituting the support/base of the frame, together with container holders for mounting the set on the platform of wagons and road trucks, and upper handrails with built-in stanchion slots. They are locked in the frame slots with removable, loosely fitted bolts. A separate platform-container frame without stanchions is shown in Figure 1.

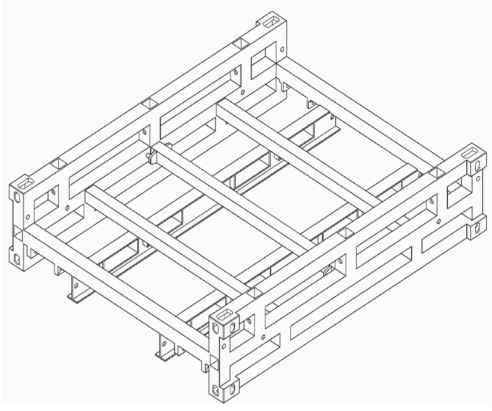

Figure 1 Frame of the platform-container without stanchions, with two rails of a standard hook lifting mechanism visible under the floor ribbing

A folding end carriage can be placed in the front and rear part of the frame, securing the longitudinal movement of the transported log load. The end carriage is the second main component of the modular platform-container. It is made in the form of a plate with stiffeners and a handle for the hook lifting of the load module. The end carriage is mounted to the longer sides of the frame using two lower bolts and two upper bolts on both sides of the frame and two struts also fixed by removable bolts to the frame railing and in the upper part of the end carriage, respectively. Additionally, in the lower part of the stiffeners, each end carriage is equipped with comb brackets, connecting the end carriage's middle reinforcements with longitudinal rails by screws, mounted on the bottom of the frame with the standard roller mechanism of the device for the hook lifting of the platform with the load.
The end carriage of the platform-container in the folded configuration and placed vertically at one end of the structure is shown in Figure 2. The complete single platform-container module in the configuration with two end carriages mounted vertically in the working position at both ends of the frame is shown in Figure 3.

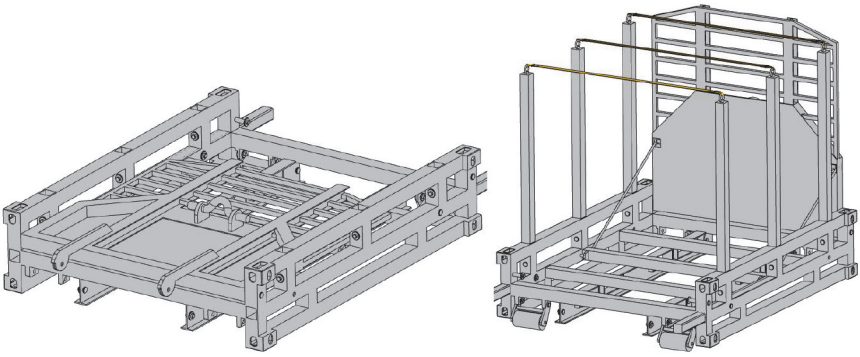

Figure 2 End carriage mounted on the platform frame in the folded configuration and placed vertically – for one-sided securing of the load with stanchions

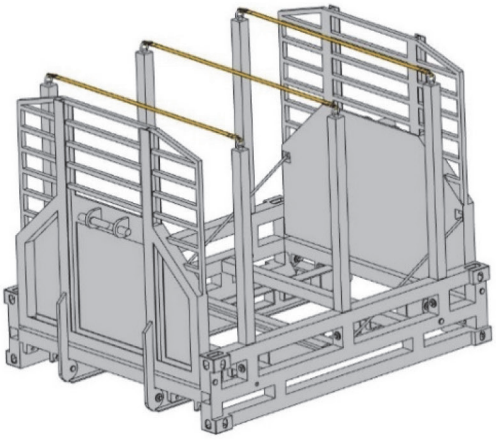

Figure 3 Complete single platform-container module in the configuration with two end carriages mounted vertically and fixed with lateral braces and comb bottom joints

In a single platform-container module, each end carriage is mounted to the platform's frame using side braces and special comb joints installed in the lower part of the end carriage wall. The purpose of this joint is to fix the end carriage to the rails of the standard hook lifting mechanism, attached to the bottom of the module frame. The end carriage is a movable component or it can be folded to the transport position so that empty modules, transported to the place of loading or during storage e.g. in warehouses or at terminals, take up the smallest possible space. Figure 4 shows the sets of six frames with double end carriages in the folded position for transport or storage of empty container modules. Figure 5 shows the complete single platform module in the configuration prepared for transport with the load of wooden logs.

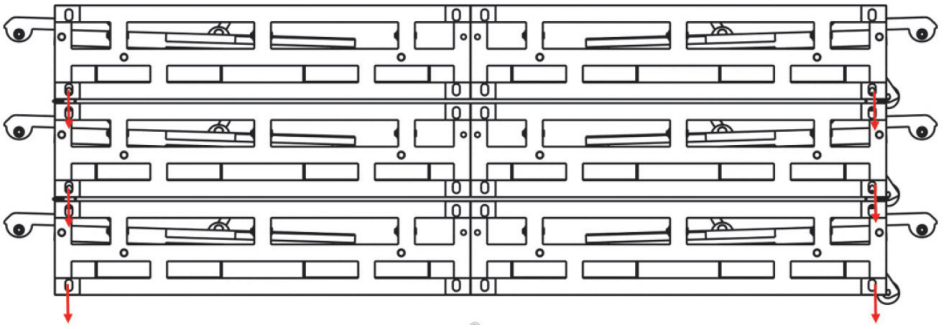

Figure 4 Sets of six frames with double end carriages in the folded position for transport or storage of empty modules

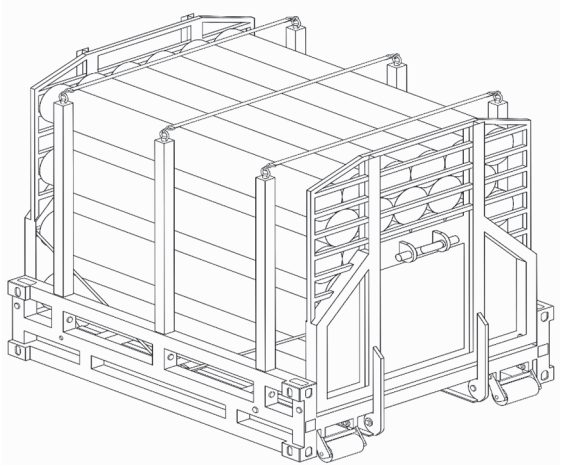

Figure 5 Single platform module in the configuration with two end carriages, stanchions and the load of wooden logs

Additionally, a single platform module can be equipped with removable metal or composite side walls and a roller shutter folding roof. Such a structure will enable the protection of loads, such as e.g. steel in coils or paper, against precipitation. A demonstrative view of the platform-container with side walls and unfolded roof is shown in Figure 6.

Figure 6 View of the platform-container with side walls and unfolded roof

The basic module of the platform-container with such a structure and intended use corresponds to the initial version of the structure protected in Poland and abroad by patent applications. This concept requires thorough strength tests and formulating answers to a number of design questions, so that, on the basis of the collected results and data describing the strength of such a device in specific applications, a structural design of a single module of the 10' (length of up to 3 m) platform-container can be developed.

4 Structural design of a single platform module – selected problems

Due to the modular structure of a single 10' (length of up to 3 m) platform solution, the expected high mobility of the structure of the platform for the transport of logs resulting from the possibility of its free configuration depending on the intended use, the range of goods to be transported and, at the same time, the possibility of folding the platform for stoppage/waiting and transport without load, the patent concept of the platform solution provides for numerous bolt and screw joints. Bolt joints are used to attach removable stanchions cooperating with the frame slots. Screw joints are designed to fix the lower part of the end carriage with the rails of the standard solution of the hook lifting mechanism mounted on the bottom of the frame. All these connections, due to the type of their loads, their variability depending on different operational variants and applications, require particularly precise verification of strength, especially in the initial phase of tests. Therefore, this project provides for the performance of simulation tests using analytical and numerical methods of the complete structure of a single platform-container as well as detailed tests, including also separate bench models of connections essential for this type of construction for the above-mentioned reasons.

4.1 Initial technical assumptions

The following initial technical assumptions for the designed single platform-container module were adopted:

- strength criterion – structure safety factor n = 3;
- construction material: weldable steel S355; R_{dop} = 120 MPa for n = 3;
- tare weight of the complete set of a single platform-container module $m_{max} \leq 2500$ kg;
- log load/log weight of up to Q_{max} = 100 kN;

- maximum loads due to operational variants/cases of taking a load from the ground amounting to P_{max} = 100 kN;
- 1st kinematic criterion of structure safety – for operational load variants of lifting the platform using a rope sling (lifting devices, overhead cranes, etc.) and fork loading $W_{max} \leq 2$ mm;
- 2nd kinematic criterion of structure safety – for operational load variants of lifting the platform with a hook mechanism $W_{max} \leq 5$ mm (the biggest deformations of the end carriage and frame elements).

4.2 Methodology of construction works

The direct scientific goal of the discussed project will be the development of the concept for a single module of a 10' (length of up to 3m) platform-container that will meet the adopted design assumptions. For this purpose, the following research methodology was implemented:

a) Stage of initial works
   – Preparing 3D documentation based on the patent concept and simplified geometric, analytical and numerical models;
   – Performing multi-variant numerical tests of the strength of the platform-container;
   – Preparing the initial design of the structure after considering the modification of the patent concept of the platform-container;
   – Preparing 3D documentation of the platform-container according to the completed patent concept.

b) Stage of detailed works
   – Developing the bench design and selected prototype connections of the mobile components of the platform-container for quasi-static testing;
   – Preparing the elements of a separate prototype joint for mounting the end carriage with the platform frame and selected elements of the bench for conducting preliminary strength tests of the above-mentioned joint in terms of loads determined on the basis of numerical simulations;
   – Building benches for laboratory tests of separate joints;
   – Performing bench tests of the strength of the most loaded connections of the platform-container used according to the above-mentioned preliminary structural design;
   – Developing numerical models, verified on the basis of the results of experimental tests;
   – Conducting multi-variant advanced numerical analyses and developing structural corrections in the preliminary design of the platform-container, taking into consideration the necessary EU-RP standards;
   – Preparing the final construction and working documentation for the construction of prototype structures of the platform-container structure.

c) Stage of implementation works
   – Building prototype structures of platform-containers;
   – Conducting qualification tests of various versions of the platform-container.

5 Conclusions

The following design and functional features of the proposed solution for a single platform-container module supporting the transport of logs, which are unique and currently have no counterpart in any domestic and foreign device of this type, should be emphasised:

- modular structure with high rigidity and strength,
- basic module consisting of a small number of components,
- possibility to use various methods of loading logs,
- possibility to use various typical wheeled road vehicles in road transport,
- possibility to use various types of wagons in railway transport,
- possibility to disassemble the elements of the module, which reduces the storage space and enables easy transport,
- possibility to change the configuration of the platform-container depending on the user's requirements and easy assembly/disassembly of module components,
- possibility to use it for temporary/ad hoc storage of logs in difficult terrain.

As a result of the implementation of the project in accordance with the platform-container test methodology presented above, prototype variants of the structure will be built and the necessary qualification tests will be conducted, preparing for the implementation of the proposed platform-structure.
At the moment, there are pending construction works at the stage of developing detailed design solutions, including the joints of the target module of the basic platform-container, and obtaining national and European patent protection.

Acknowledgements

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