*The object of this study is the processes of perception and redistribution of vertical loads in the structure of a container with a floor made of sandwich panels under operational modes.*

*To ensure the strength of the container, as well as the safety of the cargo transported in it, it is proposed to design a floor based on sandwich panels. It is assumed that each of these panels is made of two metal sheets in a layer between which an energy-absorbing material is placed. Given the presence of energy-absorbing material in the structure of the sandwich panel, the vertical dynamic loads acting on the cargo container during its transportation will be reduced.*

*To substantiate the proposed solution, mathematical modeling of the vertical load on the container during its transportation by a flat wagon was carried out. It is found that the accelerations acting on the container of the improved design are 5.7 % lower than those acting on the container of standard design.*

*The calculation of the strength of the container was carried out under operational schemes of its loads. It has been established that the strength of the container is ensured.*

*A special feature of the results is that the reduction of the load on the container is achieved not by strengthening its structure but by introducing flexible connections into it.*

*The field of practical application of the results is railroad transport. The conditions for the practical use of the findings are the use of energy-absorbing material in the structure of sandwich panels that form the floor of the container.*

*The results of the research will contribute to improving the strength of containers under operating conditions, the safety of the cargo transported in them, as well as increasing the efficiency of the functioning of container transportation*

*Keywords: transport container, container improvement, container load, container strength, container transportation*

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# DETERMINING THE VERTICAL LOAD ON A CONTAINER WITH A FLOOR MADE OF SANDWICH PANELS TRANSPORTED BY A FLAT WAGON

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## 1. Introduction

The development of transport infrastructure is one of the main factors in improving the economic performance of European countries. For a long time, the transport industry has been providing transportation needs of the national economy, as well as people [1, 2]. A significant segment of such transportation is railroad transport [3, 4]. In order to further increase the efficiency of railroad transportation, containers were put into operation. Due to their mobility, it becomes possible to increase the process of loading and unloading of goods from one mode of transport to another.

During operation, the container is exposed to significant dynamic loads. These loads have a different nature and character of origin, as they are inherent in transportation by various modes of transport: rail, sea, road, or air. As a result, both the structure of the container and the cargo transported in it may be damaged. This makes it necessary to carry out unscheduled types of container repairs, and in the case of damage to the cargo – appropriate compensation to the owner. In addition, from the point of view of ensuring the environmentally friendly mobility of container transportation, it is important to minimize cases of damage during operation.

In this regard, there is a need to design solutions that will contribute to reducing the impact of dynamic loads on a cargo container under operational modes. Therefore, the issue of designing new structures of containers with improved technical and operational properties is quite urgent.

## 2. Literature review and problem statement

Improvements in container designs to increase the efficiency of their operation are covered in a considerable number of publications. Thus, in work [5], to reduce the longitudinal load of the container during rail transportation, it was proposed to introduce sandwich panels as components of its structure. This solution is implemented using the example of end walls. To substantiate this improvement, a mathematical modeling of the container load was carried out, the results of which were verified by computer simulation. The expediency of such an improvement has been proven but the authors did not pay attention to the issue of reducing the vertical load of the container under operating conditions.

Similar studies are reported in [6], but the feasibility of introducing sandwich panels to the container structure is considered using the example of the side walls. The authors have built a mathematical model that takes into account the oscillations of the lateral rocking of a flat wagon with containers of an improved design. The results of the calculation proved that the use of sandwich panels as side walls of the container helps reduce its lateral load by 5 % compared to the typical design. At the same time, the work does not propose solutions to reduce the vertical load of the container.

Paper [7] determines the stiffness of the container structure under operational loads. A new geometry of container cladding sheets is proposed. The results of the calculation of the strength of the container, taking into account its improvement, are given. It has been proven that the manufacture of container cladding with a changed configuration of corrugations is expedient. However, the expediency of such an improvement was not considered when the container was subjected to loads that occur during rail transportation.

Work [8], which investigates the structural integrity of a container when it falls from a ship into the sea, is quite interesting. It was established that the strength of the container under constant hydrostatic pressure is not ensured. In this regard, the author team proposed a solution to strengthen the container design. However, the authors did not investigate the expediency of these solutions for rail transportation of containers.

Paper [9] highlights the features of designing a container from a composite material. Such a solution contributes to the reduction of the container's tare and, accordingly, to the increase of the carrying capacity. The results of strength calculations of the proposed design of the container with the most common schemes of its loads in operation are given. It has been proven that the introduction of composite material for the manufacture of the container is expedient. However, this implementation is quite expensive, which restrains the serial production of such containers. In addition, the work does not consider the issues of dynamic loading of the improved design of the container in operation. This may be due to the fact that the author limited himself to some cases of container loads, which, in his opinion, are the most common.

Analysis of the influence of insulating materials on the energy properties of the transport container is covered in work [10]. In this case, the authors found the optimal, from the point of view of energy efficiency, territorial zone of Europe regarding the use of containers. However, the container in this case is considered not as a vehicle but as a building module that has a stationary position. That is, the authors did not pay attention to the issue of using such a container in the transport process.

In order to reduce the dynamic load of the container, in [11] it is proposed to introduce elastic-friction connections into its fittings. This improvement contributes to the partial absorption of kinetic energy that occurs when longitudinal loads are applied to the container. To reduce the volume of the container, it is also proposed to make its components from composite material. The rationale for this implementation is presented. At the same time, the most unfavorable case of container loading is considered – a shunting collision of a flat wagon. It was established that the strength of the container under the applied load mode is ensured. Along with this, the authors did not consider the possibility of reducing the vertical load of the container.

A similar solution was proposed in [12] but it was implemented using the example of a Flat Rack container. The results of the mathematical modeling and computer simulation established that the introduction of dissipative connections into the fittings helps reduce the load of the container by 15 % compared to a typical design. However, again, no attention was paid to the issue of reducing the vertical load of the container in this work.

Features of the design of the container for transportation of fruit and vegetable products are covered in paper [13]. The impact of various options for the execution of containers on the quality characteristics of fruit transportation has been studied. It was established that the most rational is the use of containers made of plastic material. However, solutions to reduce the load of the container during its transportation were not considered by the authors. This can be explained by the peculiarities of the operation of such containers and the type of cargo transported in them as the container was designed specifically for the transportation of a certain type of fruit and vegetable produce.

Analysis of the strength of the floor of a large-tonnage container when moving through a tunnel with an S-shaped configuration is considered in paper [14]. In this case, several options for loading the container with cargo were considered. Based on the research, recommendations are given regarding the safety of transportation of large-tonnage containers through this type of tunnel. However, the authors did not propose solutions for improving the design of the container to reduce its load.

In order to improve the technical and economic indicators of containers, it is also advisable to use the newest materials with improved characteristics in their designs. For example, work [15] highlights the features of optimal design of composite shell sandwich structures with cellular filler. Minimization of the mass of the structure is taken into account as an objective function. The results of the research proved the effectiveness of the proposed approach. However, the authors did not investigate the possibility of its application in the design of the container structure.

Work [16] highlights the features of optimizing the design parameters of the fairing of a launch vehicle. The proposed methodology is implemented on the example of a complex approach of integral design of aggregates of the considered class of equipment. This approach allows simultaneous optimization of the deep level in each compartment of the thickness of the heat-shielding coating, the reinforcement scheme, and the structure of the load-bearing skins, etc. The application of this approach would be interesting when designing a universal container. However, no such studies have been conducted.

In [17], the design features of a railroad car body made of extruded aluminum panels are considered. In this case, the authors applied structural optimization. The proposed technical solutions are confirmed by complex calculations on the strength of the car body. But the authors did not pay attention to the question of applying the proposed methodology in the design of containers as the most common means of transport in international traffic.

Work [18], which highlights the results of determining the expediency of using magnesium alloys in the load-bearing structures of vehicles, in particular cars, has a similar drawback. This solution will contribute to reducing the tare of cars compared to the designs of their prototypes. Regarding the container, this solution would also be appropriate to consider, but the authors did not conduct such studies.

Our review of the literature [5–18] reveals that the issue of improving containers is relevant. However, sufficient attention was not paid specifically to the reduction of the vertical load of the container during rail transportation. In this regard, there is a need to conduct relevant research in the specified area.

## 3. The aim and objectives of the study

The purpose of our study is to determine the vertical load on a container with a floor made of sandwich panels when transported by a flat wagon. This will make it possible to improve the strength of its structure, as well as the safety of transported goods, and, accordingly, will contribute to the reduction of costs for their maintenance in operation.

In order to achieve the specified goal of the study, the following tasks were set:

– to perform a mathematical modeling of the vertical load on a container placed on a flat wagon;

– to determine the strength of the container under operating modes of loading.

## 4. The study materials and methods

The object of our research is the processes of perception and redistribution of vertical loads in the structure of a container with a floor made of sandwich panels under operational modes.

The main hypothesis of this study assumes that the use of a floor made of sandwich panels in the design of the container will contribute to the improvement of its strength under the conditions of operational modes and the safety of the transported cargo.

To ensure the strength of the container, as well as the safety of the cargo transported in it, it is proposed to design a floor from sandwich panels. It is assumed that each of these panels will be made of two metal sheets in a layer between which an energy-absorbing material is placed (Fig. 1). Due to the presence of energy-absorbing material in the structure of the sandwich panel, the vertical dynamic loads acting on the cargo container during its transportation will be reduced.

Sandwich panels will be placed on the frame of the container, which is formed by a set of transverse beams (Fig. 2).

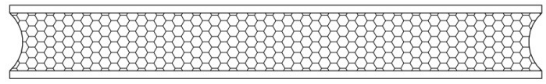


Fig. 1. Sandwich panel cross-section

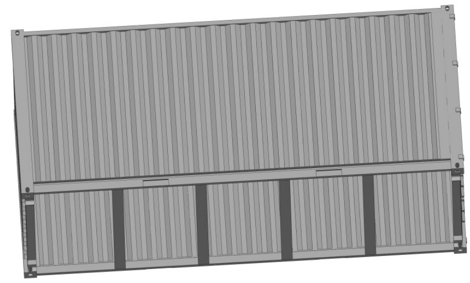


Fig. 2. Container size 1 CC

Appropriate studies were conducted to substantiate the proposed solution. At the initial stage, the thickness of the sheets that make up the sandwich panel was determined. To this end, the Bubnov-Galyorkin method was applied, which is used to determine the thickness of the plates. That is, the floor sheet is considered in the form of a plate, which has a length of $l$=2.34 m and a width of $b$=1.18 m. These geometric parameters are determined based on the geometric characteristics of the container of standard size 1 CC. Then, under the action of a uniformly distributed load $P_v$ on the sheets and the known characteristics of the material of their manufacture, the thickness can be determined from the formula:

$$\delta = \sqrt{\frac{P_v \cdot \frac{96}{\pi^4} \cdot \left(l^2 + \mu \cdot b^2\right) \cdot b^2 \cdot l^2}{\sigma \cdot \left(b^2 + l^2\right)^2}}, \quad (1)$$

where $P_v$ is the load acting on the plate; μ is Poisson's ratio; σ is the permissible stress for the sheet material.

In the case of manufacturing sheets from low-alloy steel of the 09G2S brand, their thickness will be about 6 mm, provided strength is ensured.

To determine the strength of a container with a floor made of sandwich panels when vertical loads are perceived, a calculation was carried out using the finite element method [19, 20]. This method is implemented in SolidWorks Simulation (France) [21, 22] and is used due to the fact that it is one of the most common in the calculation of vehicles, including railroads. Since the main load that will be absorbed by the sandwich panel is vertical dynamic, mathematical modeling was carried out to determine it. The case of vertical loading of the container is taken into account, provided it is transported by flat wagon 13-7024.

It is taken into account that the calculation scheme consists of four bodies: the supporting structure of a flat wagon with four containers, two bogies of the 18-100 model, and the cargo placed in the containers. That is, the calculation scheme has four degrees of freedom in the vertical plane. It is assumed that the containers have the same load using the full load capacity. They were considered as attached masses relative to the frame of the flat wagon.

The track has elastic-dissipative characteristics [23]. Track reactions are proportional to both its deformations and the speed of these deformations.

The system of differential equations was solved in Mathcad (USA) [24, 25] using the Runge-Kutt stepwise iteration method [26, 27]. This method is quite widely used in solving problems of the dynamics of cars, which is due to its advantages compared to other computational methods. For example, the calculation algorithms of the method are homogeneous, and the integration step changes according to the need for the accuracy of the calculations. The initial conditions for solving the mathematical model are set close to zero [28, 29].

At the next stage of the research, a direct calculation of the strength of the container with a floor made of sandwich panels was carried out. The spatial model of the container was created based on its drawing album in the SolidWorks software package (Fig. 3). Aluminum foam is used as an energy-absorbing material forming a sandwich panel.

The container was secured using corner fittings. In this case, the connection "hard pinching" was used. This type of connection is used due to the fact that the fitting stops limit the horizontal movement of the container fittings. In this case, it is assumed that the force of friction between the horizontal surfaces of fittings and fitting stops is greater than the dynamic load acting on the container.

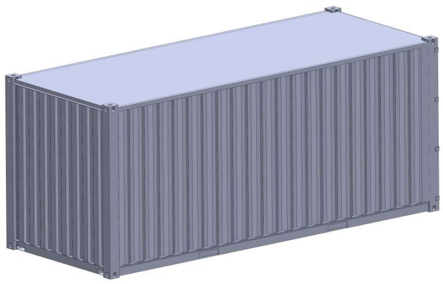


Fig. 3. Spatial container model

The finite element model was built using tetrahedra. The optimal number of finite elements of the model is determined graph-analytically [30]. In this case, the number of model elements was 201,800 with a maximum size of 100 mm and a minimum size of 20 mm. The model is formed by 62175 nodes. The construction material is 09G2S steel, which is used to create railroad vehicles. Allowable stresses for this steel are taken into account on the basis of DSTU 7598:2014. Freight cars. General requirements for calculations and design of new and modernized cars of 1520 mm gauge (non-self-propelled). Foreign analog of this standard: "EN 12663-2. Railroad applications – structural requirements of railroad vehicle bodies – Part 2: Freight cars".

## 5. Results of detecting the vertical load on a container with a floor made of sandwich panels when transported by a flat wagon

### 5. 1. Mathematical modeling of the vertical load on a container placed on a flat wagon

To determine the vertical load on a container with a floor made of sandwich panels, mathematical modeling was carried out.

The calculation diagram of a flat wagon loaded with containers is shown in Fig. 4.

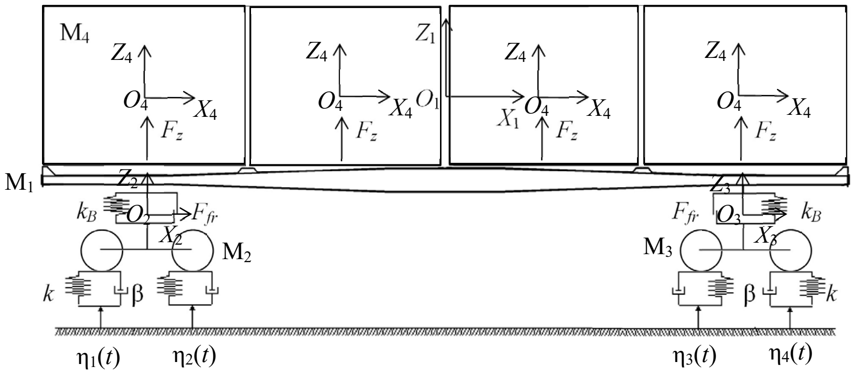



Fig. 4. Calculation diagram of a flat wagon loaded with standard size 1CC containers

In this case, the mathematical model takes the following form:

$$\begin{cases} M_1\cdot\ddot{q}_1 + C_{1,1}\cdot q_1 + C_{1,2}\cdot q_2 + C_{1,3}\cdot q_3 = \\ = -F_{fr}\cdot\left(\operatorname{sign}\left(\dot{\delta}_1\right)+\operatorname{sign}\left(\dot{\delta}_2\right)\right)-F_z, \\ M_2\cdot\ddot{q}_2 + C_{2,1}\cdot q_1 + C_{2,2}\cdot q_2 + B_{2,2}\cdot\dot{q}_2 = \\ = F_{fr}\cdot\operatorname{sign}\left(\dot{\delta}_1\right)+k\left(\eta_1+\eta_2\right)+\beta\left(\dot{\eta}_1+\dot{\eta}_2\right), \\ M_3\cdot\ddot{q}_3 + C_{3,1}\cdot q_1 + C_{3,3}\cdot q_3 + B_{3,3}\cdot\dot{q}_3 = \\ = F_{fr}\cdot\operatorname{sign}\left(\dot{\delta}_2\right)+k\left(\eta_3+\eta_4\right)+\beta\left(\dot{\eta}_3+\dot{\eta}_4\right), \\ M_4\cdot\ddot{q}_4 = F_z - M_4\cdot g, \end{cases} \quad (2)$$

where $M_1$ – mass of the supporting structure of the flat wagon with containers; $M_2$, $M_3$ – mass, respectively, of the first and second bogie; $M_4$ – weight of the cargo in the container; $C_{ij}$ – elasticity characteristics of the oscillating system elements, which are determined by the stiffness coefficients of the springs of the spring suspension $k_B$; $k$ – track stiffness; $B_{ij}$ – dissipative coefficients; β – damping coefficient; $F_{fr}$ – force of friction in the spring set of the bogie; $\delta_i$ – deformations of elastic elements of spring suspension; $\eta_i$ – track unevenness; $F_z$ – vertical force acting on the cargo in the container.

In this case, $q_i$~$Z_i$.

The unevenness of the track was described by the following function [23]:

$$\eta(t)=\frac{h}{2}(1-\cos\omega t), \quad (3)$$

where $h$ is the height of the unevenness; ω is the frequency of oscillations.

Accelerations acting on the supporting structure of the flat wagon with containers were calculated in arrays $ddq_{j,i}$:

$$ddq_{j,1}=\frac{-F_{fr}\cdot\left(\operatorname{sign}\left(\dot{\delta}_1\right)+\operatorname{sign}\left(\dot{\delta}_2\right)\right)-F_z-C_{1,1}\cdot y_1-C_{1,2}\cdot y_2-C_{1,3}\cdot y_3}{M_1}, \quad (4)$$

$$ddq_{j,2}=\frac{F_{fr}\cdot\operatorname{sign}\left(\dot{\delta}_1\right)+k\left(\eta_1+\eta_2\right)+\beta\left(\dot{\eta}_1+\dot{\eta}_2\right)-C_{2,1}\cdot y_1-C_{2,2}\cdot y_2-B_{2,2}\cdot\dot{y}_2}{M_2}, \quad (5)$$

$$ddq_{j,3}=\frac{F_{fr}\cdot\operatorname{sign}\left(\dot{\delta}_2\right)+k\left(\eta_3+\eta_4\right)+\beta\left(\dot{\eta}_3+\dot{\eta}_4\right)-C_{3,1}\cdot y_1-C_{3,3}\cdot y_3-B_{3,3}\cdot\dot{y}_3}{M_3}, \quad (6)$$

$$ddq_{j,4}=\frac{F_z-M_4\cdot g}{M_4}, \quad (7)$$

where $y_1$=$q_1$, $y_2$=$q_2$, $y_3$=$q_3$.

Based on the calculations, the accelerations acting on the supporting structure of the flat wagon with containers were obtained (Fig. 5).

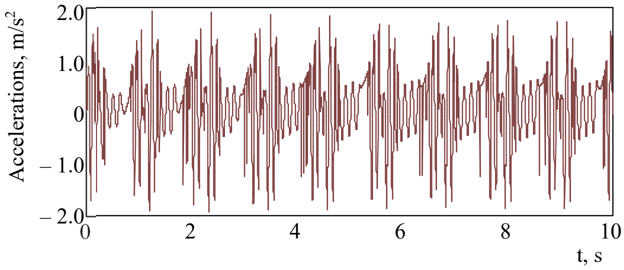



Fig. 5. Accelerations acting on the supporting structure of a flat wagon with containers

Therefore, the accelerations acting on the container are about 2 m/s$^2$. The obtained acceleration value is 5.7 % lower than that acting on a container of a typical design.

**5. 2. Determining the strength of container under operating modes of loading**

The determined value of the acceleration is taken into account when calculating the strength of the container. When drawing up the calculation scheme, it is taken into account that the model is loaded with its natural weight, as well as the weight of the cargo (Fig. 6).

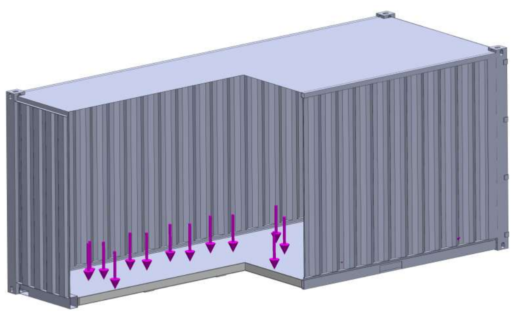


Fig. 6. Design diagram of the container

The finite-element model of the container is shown in Fig. 7.

Fig. 7. Finite element model of a container

The results of our calculations established that the maximum stresses in the container occur in its side walls (Fig. 8) and amount to 118.4 MPa (Fig. 9), which is less than permissible for this grade of steel. Allowable stresses are taken equal to 210 MPa.

The maximum displacements occur in the lower sheet of the sandwich panel, placed behind the center of the floor and amount to 1.13 mm (Fig. 10, 11). Determination of displacement values along the length of the container floor was carried out using the probing function in SolidWorks Simulation.

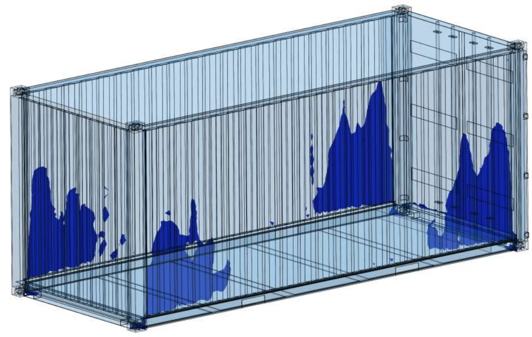
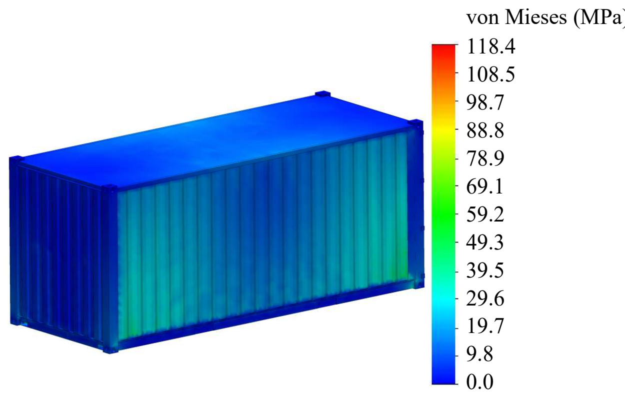


Fig. 8. Most loaded container areas

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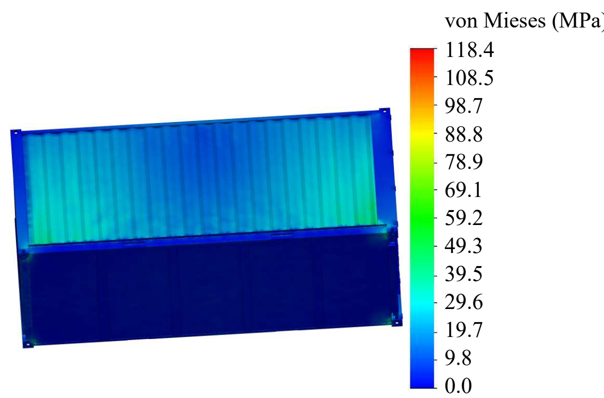
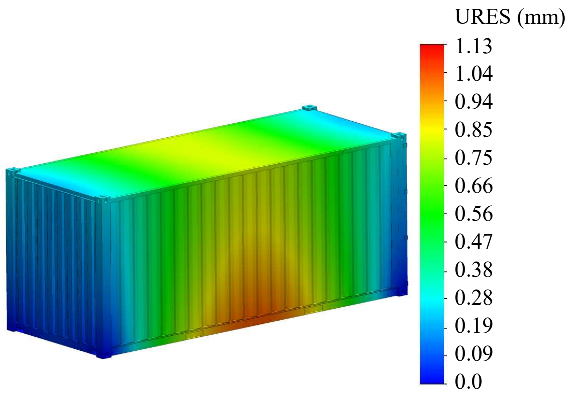



*b*

Fig. 9. Stressed state of the container: *a* – side view; *b* – bottom view

Also, as part of the study, a test was conducted on the strength of the container floor. Such tests are carried out to check the ability of the container floor to withstand the effect of a concentrated dynamic load, which occurs during loading and unloading operations using forklifts or other devices inside the container. The test is carried out using test equipment (bogie) that is equipped with elastic massive tires, with a load of 36.3 kN on each of the two wheels of the bogie or loader. The loading scheme of the container floor when the test equipment is moved relative to it is shown in Fig. 12. It is taken into account that the wheels of the equipment are placed behind the center of the floor.

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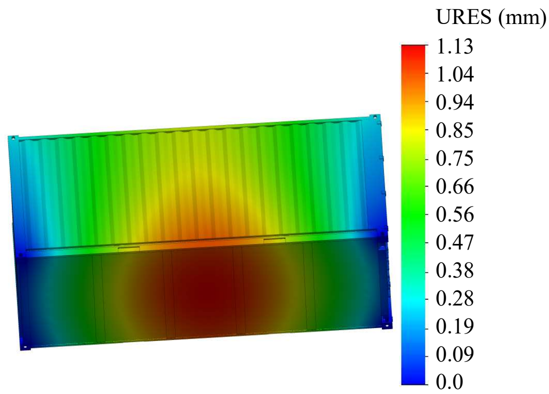



*b*

Fig. 10. Movement in the container nodes: *a* — side view; *b* — bottom view

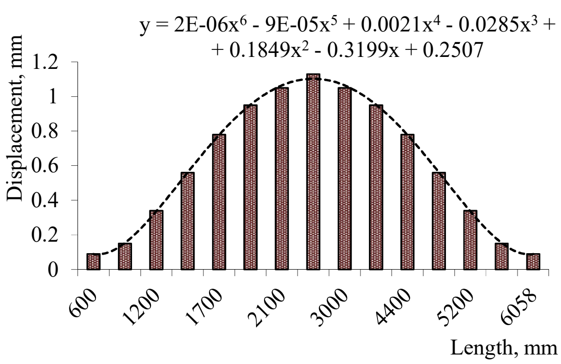



Fig. 11. Distribution of maximum displacements over the lower sheets of the container floor

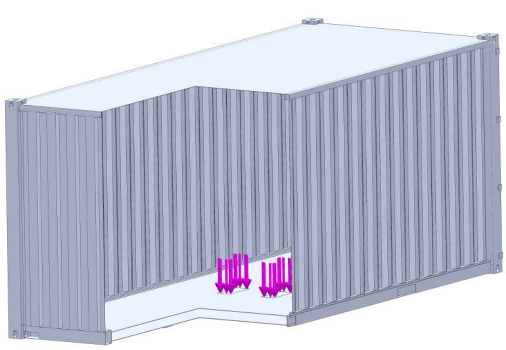
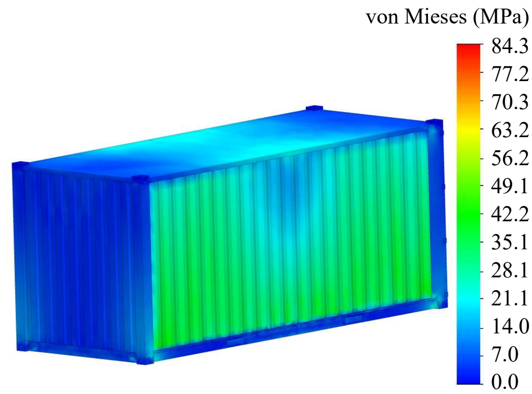


Fig. 12. Container floor loading diagram when moving loading and unloading equipment on the floor

The container is secured using corner fittings. Taking this into account, the maximum stresses occur in the zone of interaction of the upper sheet of the central sandwich panel with the longitudinal beam and amount to 84.3 MPa (Fig. 13), which is much lower than permissible.

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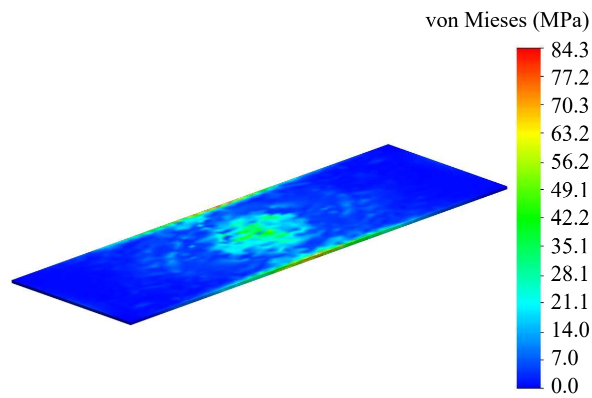


*b*

Fig. 13. Stressed state of the container when moving loading and unloading equipment on the floor: *a* — the container as a whole; *b* — floor

The maximum displacements take place in the middle sandwich panel, which forms the floor of the container, and are less than 1 mm (Fig. 14, 15).

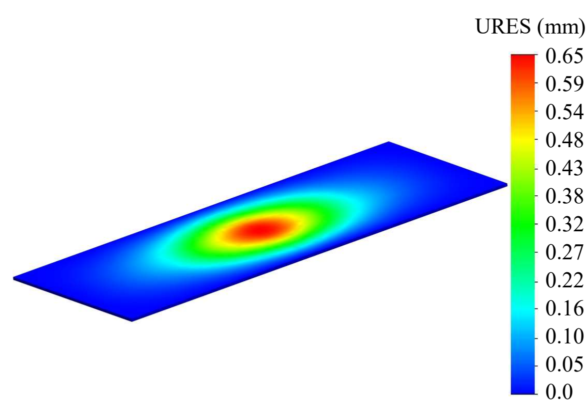


Fig. 14. Movement in the floor of the container when it is loaded by loading and unloading equipment

This distribution of displacement fields is explained by the scheme of fixing sandwich panels and their loading.

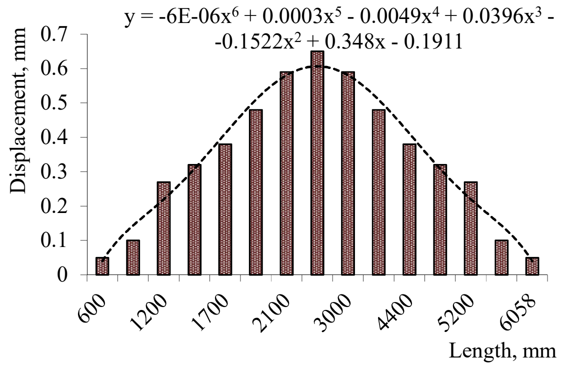


Fig. 15. Distribution of maximum displacements over the lower sheets of the container floor

Therefore, the strength of the container floor under the applied load mode is also ensured.

## 6. Discussion of results of determining the load on a container with a floor made of sandwich panels when transported by a flat wagon

To improve the strength of the container by reducing the vertical load, it is proposed to make its floor from sandwich panels (Fig. 1). Reducing the load of the container is achieved due to the presence of energy-absorbing material in the sandwich panels. In order to justify the proposed solution, mathematical modeling of the vertical load of the container placed on the flat wagon was carried out (Fig. 4). The results of our calculations established that the acceleration acting on the container is about 2 m/s$^2$ (Fig. 5). This acceleration is 5.7 % lower than that acting on a container of typical design.

The strength of the container was calculated taking into account the obtained acceleration value. It was established that the maximum stresses in the container occur in its side walls (Fig. 8). The value of these stresses was 118.4 MPa (Fig. 9), which is significantly less than the permissible. In this case, the maximum displacements occur in the lower sheet of the sandwich panel and are equal to 1.13 mm (Fig. 10, 11).

As part of the study, the strength of the container floor was also determined under the condition of its loading from loading and unloading equipment. With the loading scheme of the container, the maximum stresses in its structure were 84.3 MPa (Fig. 13). They arise in the zone of interaction of the upper sheet of the central sandwich panel with the longitudinal beam. These stresses do not exceed the permissible ones. Therefore, the strength of the container is maintained.

The maximum movements were recorded in the middle part of the sandwich panel, which is located behind the center of the floor (Fig. 14, 15). In this case, these movements are quite insignificant and amounted to less than 1 mm.

The proposed improvement of containers can be implemented not only at the stage of their manufacture but also at the stage of modernization.

It is important to say that this study has certain advantages in comparison with known ones. So, for example, in contrast to works [5, 6], this study proposed solutions aimed at reducing the vertical load on the container under operational conditions. In comparison with the results of studies reported in [7, 14], the proposed improvement of the container helps reduce its load during railroad transportation, which is one of the most used containers in transportation. This work has the same advantage in comparison with [8]. In contrast to the results of work [9], we determined the strength of the container taking into account the dynamic loads determined by mathematical modeling. In comparison with [10], not the stationary load of the container was considered but the dynamic one, under the condition of its transportation by railroad. In contrast to works [11, 12], we have proposed solutions aimed at reducing the vertical load on the container as the most frequent scheme of loading its structure at operation during railroad transportation. The advantage of this study in comparison with the results of [13] is that the proposed improvement helps reduce the load on the container and the safety of the cargo transported in it. In contrast to works [15–18], the solutions proposed in this study are aimed at reducing the load of the container as the most common means of transport in international traffic.

The main limitation of our study is that we have considered the container as an attached mass relative to the frame of the flat wagon. That is, it is taken into account that the container is rigidly fixed to the frame.

The main drawback of this research is that only the fluctuations of the bouncing of the car are taken into account during the mathematical modeling of the container load. That is, at this stage, the influence of galloping fluctuations on the load of the container structure was not considered.

However, it must be noted that this shortcoming can be eliminated at a later stage of the development of this study. In addition, it is planned to determine the load capacity of the proposed container design during transportation and other types of vehicles. This is important because a container is an intermodal transport unit and is transported by almost all modes of transport.

The results of our research will contribute to improving the strength of containers under operating conditions, the safety of the cargo transported in them, as well as increasing the efficiency of the functioning of container transportation.

## 7. Conclusions

1. Mathematical modeling of the vertical load on the container placed on the flat wagon was carried out. In this case, it is assumed that the containers have the same load using the full carrying capacity. It was established that the accelerations acting on the container are about 2 m/s$^2$. The obtained acceleration value is 5.7 % lower than that acting on a container of a typical design.

2. The strength of the container under operational load modes was determined. It was found that when the container receives vertical loads, the maximum stresses occur in its side walls and amount to 118.4 MPa, which is significantly less than the permissible ones. The maximum displacements occur in the lower sheet of the sandwich panel and amount to 1.13 mm.

When loading the floor of the container by loading and unloading equipment, the maximum stresses in its structure amounted to 84.3 MPa, which is also significantly less than the permissible values. These stresses arise in the zone of interaction of the upper sheet of the central sandwich panel with the longitudinal beam.

The maximum displacements were recorded in the middle part of the sandwich panel, which is located behind the center of the floor and amounted to less than 1 mm.

**Conflicts of interest**

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study, as well as the results reported in this paper.

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**Data availability**

All data are available, either in numerical or graphical form, in the main text of the manuscript.

**Use of artificial intelligence**

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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