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NUMERICAL ANALYSIS OF STRESS AND STRAIN STATE OF STRUCTURAL ELEMENTS OF CONTAINER TERMINAL

NUMERIČKA ANALIZA STANJA NAPONA I DEFORMACIJE KONSTRUKCIONIH ELEMENATA KONTEJNERSKOG TERMINALA

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- container terminal
- equivalent stress
- finite element

Ključne reči
- kontejnerski terminal
- ekvivalentni napon
- konačni element

Abstract

The results of the research regarding the stress and strain state in structural elements of the container terminal are presented in this paper. The container terminal is used for the electrical energy supply and control system of conveyor belts in the exploitation of mining basin 'Kolubara'. Stress analysis of the structural elements has been done with loading containers where one container with electrical equipment weighs 28 tons. The container terminal is in the process of production.

Izvod

Rezultati istraživanja stanja napona i deformacija strukturnih elemenata kontejnerskog terminala su predstavljeni u radu. Kontejnerski terminal služi za snabdevanje električnom energijom i upravljanje sistemom transportnih traka u eksploataciji u rudarskom basenu „Kolubara“. Analiza stanja napona i deformacija strukturnih elemenata je urađena pri utovaru kontejnera iz razloga što je jedan kontejner sa elektroopremom težak 28 tona. Kontejnerski terminal je u procesu proizvodnje.

INTRODUCTION

In the mining basin ''Kolubara' there is a need for containers that are supposed to contain more recent technology equipment. For this purpose, the research has been conducted as presented in this paper. The calculation is done for such a container. Firstly, the technical documentation has been made, and the strength of structure during loading is calculated, and finally, the results of research are presented.

In this paper, the observed structure is considered as a problem that belongs to the theory of thin-walled structures. The theory of thin-walled structures has been developed in the recent decades. This problem has been investigated by C.F. Kollbrunner, N. Hajdin, and S. Timoshenko, /1-4/. In recent years, problems of strength of thin-walled structures have been researched by W. Abramowicz and N. Anđelić, /5-7/. By applying the Finite Element Method, numerical calculation of structural strength is facilitated in greater detail, which a group of authors has researched, /8-11/.

SUBJECT TO BE CONSIDERED

The container terminal is a whole that is formed by two containers whose width is 3200 and 2900 mm and the length is 13000 mm, Fig. 1. Transport and manipulation of containers can be done only separately, by each container separately, Fig. 2, but not as a contingent of two containers. Containers are connected with bolts M20, the quality of 8.8.

After connecting two containers, the joint location is covered with a special plate that is fastened with bolts. At the area of joining container roofs is a plate of special material resistant to all weather conditions. Containers are equipped with doors that have anti-panic lock whose purpose is to provide a safe exit from the interior of the container when the door is locked.

Production technology is such that containers are mostly made of bended metal sheets (plates), so as to form a thin-walled structure. For example, pillars and belts are made of sheets 8 mm thick. In order to consider the thin-walled structure, the condition is given as, /3, 6, 7/:

$$\frac{t}{a}, \frac{t}{b} \leq \frac{1}{10} \qquad (1)$$

where: t is the wall thickness; a and b are cross-sectional dimensions.

Figure 1. Container terminal.

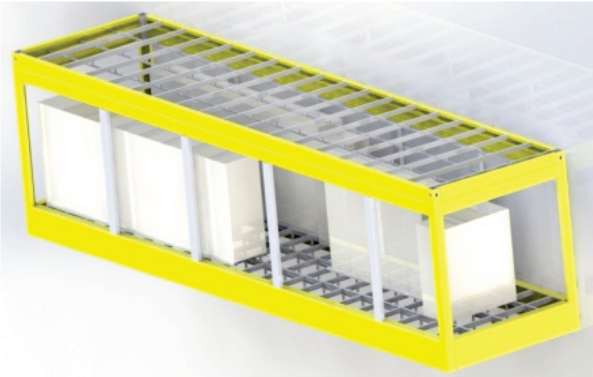

Figure 2. One half of the container terminal.

LOAD CONTAINER

It is envisaged that the loads are like concentrated forces. These forces act on the floor of the container. Therefore, the stress analysis for the whole structure during loading has been performed. The effect of the normal stress is larger compared to other stress components, so stress calculation is reduced to check the normal stresses.

Stress analyses have included standard calculations of material resistance (calculations of floor elements, welded joint shear, eccentric tensioning of pillars, buckling belts). Positions of elements that carry the structure are shown in Fig. 3.

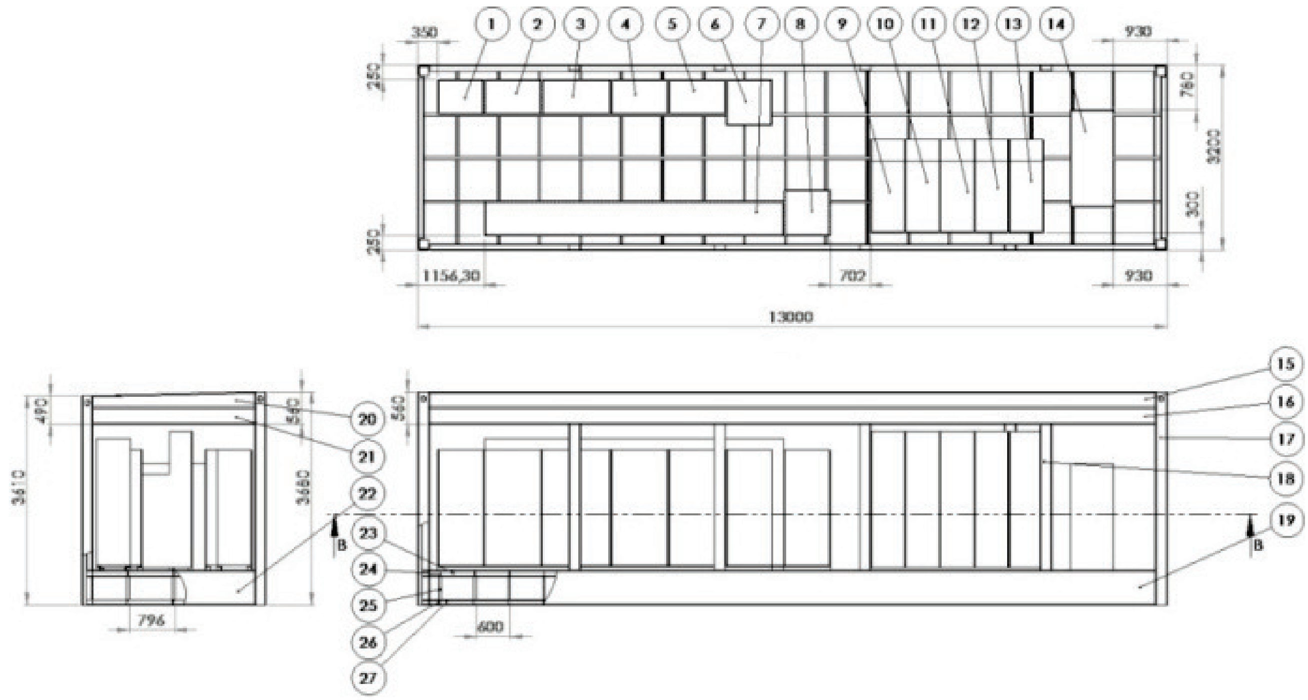

Figure 3. Positions of elements that cross the floor of a loaded container and their weight.

Weights of elements are given in Table 1.

Table 1. Sizes and weight of equipment that supports the container floor.

Position	Name	Dimensions (mm)	Weight (kg)
1	Locker	800 × 600 × 2000	300
2	Locker	1000 × 600 × 2000	250
3	Locker	1200 × 600 × 2000	400
4	Locker	1000 × 600 × 2000	350
5	Locker	1000 × 600 × 2000	350
6	Locker	800 × 800 × 2000	600
7	Locker	5200 × 600 × 2200	3500
8	Locker	800 × 800 × 2000	250
9	Locker	600 × 1625 × 2350	800
10	Locker	600 × 1625 × 2350	800
11	Locker	600 × 1625 × 2350	800
12	Locker	600 × 1625 × 2350	800
13	Locker	600 × 1625 × 2350	800
14	Trafo	750 × 1850 × 1670	2000

MATERIALS AND METHOD

Calculations are made using finite element method, /8/. Material properties used for simulations are shown in Table 2 below, /12/.

Table 2. Mechanical properties of steel S235.

Young's modulus of elasticity (Pa)	Poisson's ratio	Yield stress (Pa)	Allowable stress (Pa)
$2.1 \cdot 10^{11}$	0.3	$235 \cdot 10^{6}$	$160 \cdot 10^{6}$

Numerical simulations, /9/, have been performed using ABAQUS software. Used units are (m), (N) and (kg).

In Figure 4, the load and boundary conditions are shown, /9/. Beam elements have been used (beam model), /14, 15/. The loads include the weight of the container.

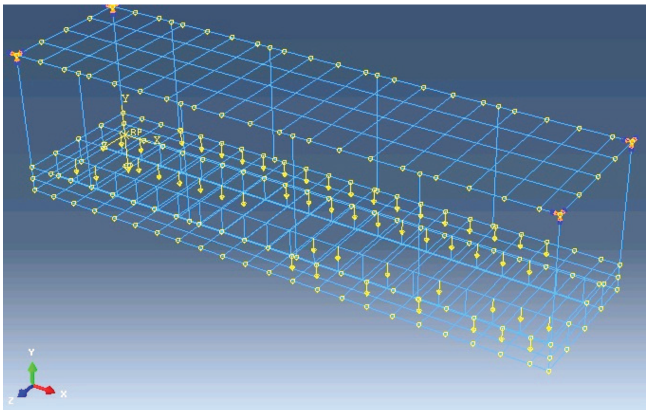

Figure 4. Loading and boundary conditions.

RESULTS AND DISCUSSION

Figure 5 shows the distribution of equivalent stress according to Hencky-Mises, in Pa.

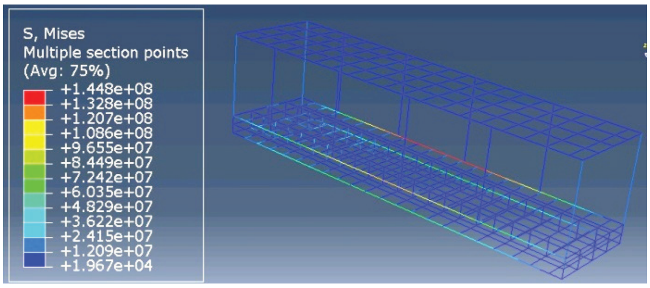

Figure 5. Equivalent stress according to Hencky-Mises, in Pa.

The distribution of normal stresses in (Pa) is shown in Fig. 6.

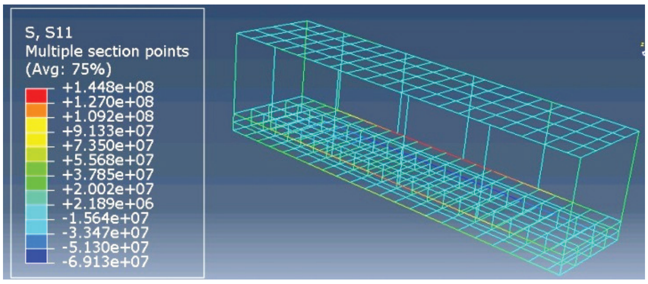

Figure 6. Normal stresses σ_{11} in Pa.

Distribution of shear stresses in Pa is shown in Fig. 7.

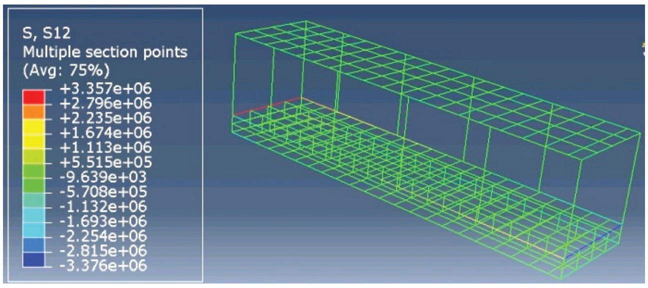

Figure 7. Shear stresses τ_{12} in Pa.

The container terminal in the manufacturing process is shown in Figs. 8 and 9.

Figure 8. Container in the manufacturing process.

Figure 9. Container in the manufacturing process.

CONCLUSIONS

In this paper, the authors have presented the stress analysis of a 1300 × 3200 terminal container structural elements. Moreover, normal and shear stresses in the upper belt of the floor have a maximal value, and are within the allowed limits for the given material, Figs. 5-7. Container transport can be done only by a qualified person with the appropriate equipment and devices for transport. During loading and unloading of containers, the cables must be placed at an angle of 60° relative to the horizontal surface, and no one should stand in the zone of the container within a radius of 15 m. All equipment for manipulation (crane, chains, cables, hooks, etc.) should have the appropriate capacity and possess a valid document, proving that it has been tested. The containers have been successfully transported and are operating in the mining basin 'Kolubara', Fig. 10.

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Figure 10. Container terminal.

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