NUMERICAL RESEARCH ON THE SPECIAL CONTAINER OF INCREASED TECHNICAL AND DESIGN REQUIREMENTS

Piotr Rybak, Wacław Borkowski, Zdzisław Hryciów
Bogusław Michałowski, Andrzej Wiśniewski, Józef Wysocki

Military University of Technology
Institute of Motor Vehicles and Transportation
Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 6897752, fax: +48 22 6837370
e-mail: prybak@wat.edu.pl

Abstract

This paper presents issues related to the process of designing a 30-feet container to be used as a mobile laboratory for collecting the environmental samples and identification of biological threats. Tactical and technical assumptions for the container, taking into account the requirements of the transport and movement of the army at long distances and in the difficult areas by means of transport characterized by increased traction properties, made the starting point. A possible way of relocation on the land roads using commonly available and military means of transport, possibilities of loading and unloading using the autonomic system and automatic levelling system are described. It describes the process of creating the MES model of the supporting structure and assumptions taken for that purpose. The basic assumption included invariability of shape, geometry and dimensions of a container compared to containers recognized in the world as the standard ones. Some results of numerical calculations carried out at two stages are presented. At the first stage, the issues on the own values were solved. Frequencies of own vibrations and associated forms of vibrations were identified. At the second stage, forced container vibrations were analysed. Resistance calculations were performed for the supporting structure of the container in the aspect of evaluation of the strain condition of the whole structure, as well as its components for assumed load variants. A variability of resistance calculations takes into account such cases as the influence of the under-container trailer riding on the uneven ground, loading and unloading a container from a trailer using autonomous system, diversity of loads on the supports resulting from the change of the ground density under the supports. A preliminary analysis of container transport possibilities and transport unit traction properties have been also carried out.

Keywords: *numerical research, dynamical loads, simulation*

1. Introduction

Scope of executed tasks, their complexity and range made the basis for modification of transport technologies also in the armed forces resulting in increased mobility of chosen military components and their autonomy. These tasks require increased ability to relocate the equipment, materials and technical equipment to chosen locations as soon as possible. One of the most important tasks that armed forces have to face is to reduce the effects of the use of weapons of mass destruction. It is possible by quickly reaching the area of use, detection and identification of pollution type and possibly quick response. A special container used as a mobile laboratory for collecting the environmental samples and identification of biological, chemical and other threats makes the subject of this paper.

Due to expected operation conditions, the container has to meet, among others, the following requirements:

– to be characterized by a proper mechanical resistance during transport on the roads and unpaved paths, during reloading and operation on various grounds,
– to possess proper tightness and be equipped with devices protecting the interior against pollution factor penetration,

- provide protection against the influence of weather conditions as temperature, water, moisture, dust etc. during storage, transport and reloading,
- provide maximum functionality and work comfort in the laboratory rooms at assumed internal dimensions,
- be equipped with autonomous loading and unloading system,
- should not limit the driving abilities of the transport unit.

2. Research subject

Out of the whole range of standardized containers, a container modelled on a 30-feet container, as far as geometry and dimensions are concerned was chosen for a mobile laboratory. The main factor of such choice was a compromise between obtaining the biggest possible space for specialist equipment and preserving the highest terrain crossing ability. The laboratory container has to be characterized with a structure much different from the standard one in order to meet imposed requirements. Therefore we call it a special container. The MES model of the container was developed in the LS-DYNA system using rigid and deformable elements. Fig. 1 presents a general outline of the container, while Fig. 2 shows the model of its supporting structure.

a) *b)*

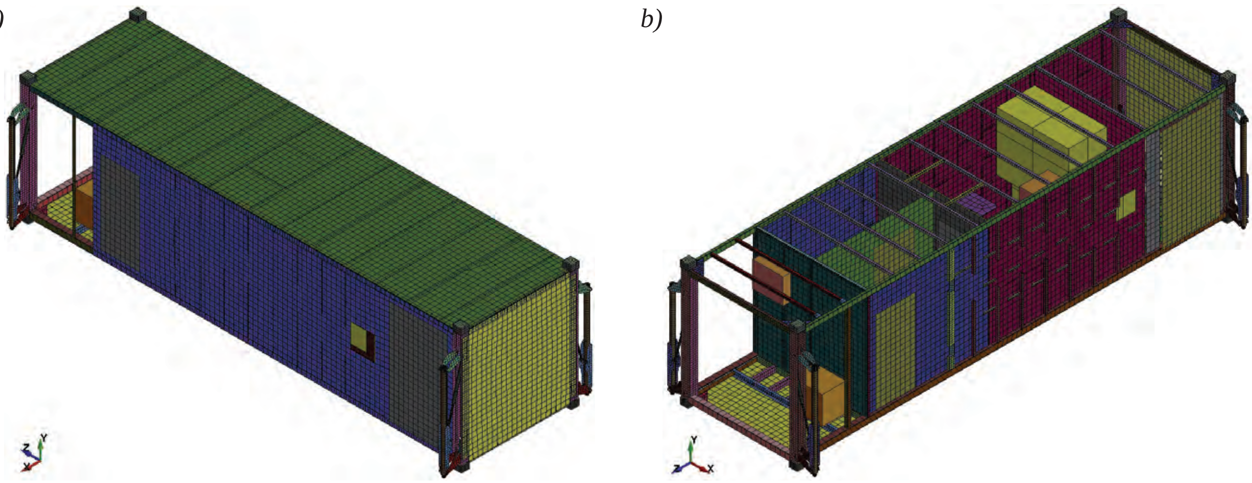

Fig. 1. Special container draft

a) *b)*

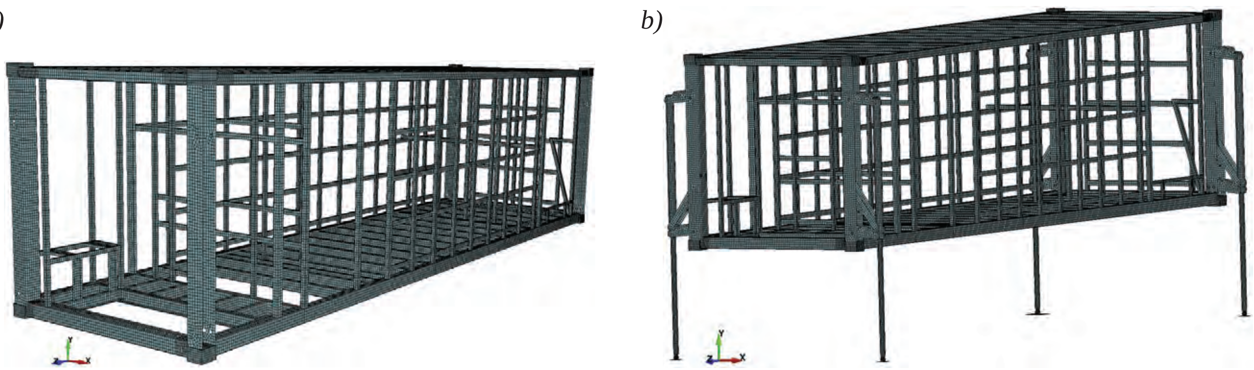

Fig. 2. Model of the supporting structure of the special container (a), and the structure with unfolded loading and unloading system (b)

3. Model tests

The model tests of the container supporting structure were executed at two stages. At the first stage own vibrations were considered. At the second stage, forced vibrations for assumed load variants were analysed.

3.1. Own vibrations

A generalized issue on own values was solved for a developed container model. Basic frequencies of own vibrations were calculated for a container supported by the fixing mounts and a container supported by the actuators of the autonomous loading and unloading system, as shown in Tab. 1. Associated forms of vibrations were also defined for both supporting options. The first two forms of vibrations for the support by the fixing mounts are presented in Fig. 3a and b, while the forms of vibrations for the case of the actuator support are shown in Fig. 3c and d.

Tab. 1. Frequencies of own vibrations of the container structure

Frequency number	Frequency of own vibrations, *f* [Hz]	
	container supported by mounts	container supported by actuators
1.	6.35	1.57
2.	8.42	1.66
3.	9.70	2.21
4.	12.02	7.85
5.	15.32	8.51
6.	15.82	9.31
7.	16.82	10.06
8.	18.86	15.54
9.	19.50	15.72
10.	21.13	18.45

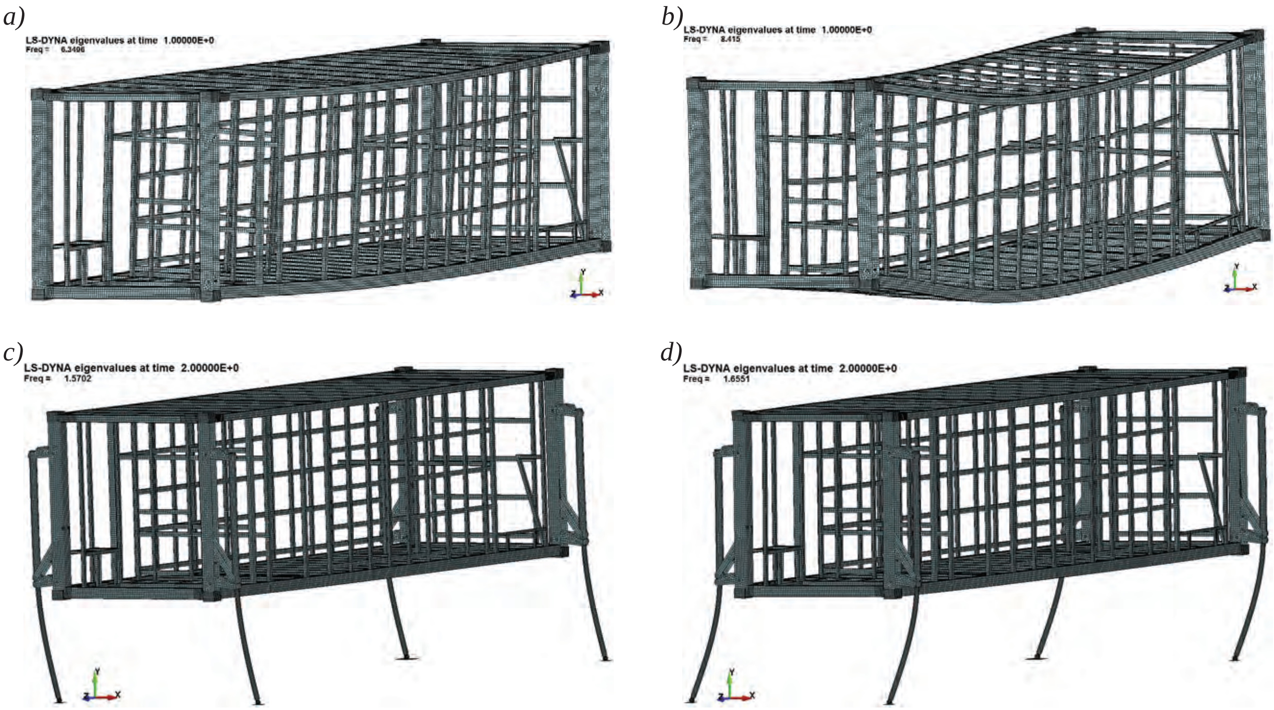

Fig. 3. Selected forms of own vibrations of the container structure at various support configurations: a) for frequency f_1 = 6.35 Hz support by mounts, b) for frequency f_2 = 8.42 Hz support by mounts, c) for frequency f_1 = 1.57 Hz support by actuators, d) for frequency f_2 = 1.66 Hz support by actuators

For a container supported by the mounts, the first four own frequencies were identified as the main vibrations of the fundamental supporting structure of the container. While the other associated, vibrations represent the forms of complex vibrations of the structure components. A significant fact is that basic frequencies of own vibrations do not match the frequencies of own vibrations of the ground and the transport trailer. Regarding the structure unfolded on the supports, three first frequencies of own vibrations result from vibrations of the flexible supports. The following four ones represent the main vibrations of the supporting structure including intermediate support connectors, while the other ones refer to the complex vibrations.

3.2. Resistance tests on the container supporting structure

The tests were performed in order to evaluate the strain of the container supporting structure at the stage of design and manufacture process. Calculations were performed for assumed load variants, resulting from expected the most unfavourable incidents during its operation. Calculation variants include such cases as the influence of the under-container trailer riding on uneven terrain, container loading and unloading from the trailer by means of an autonomous system, load differentiation on the supports resulting from the ground density change under the supports. Some results are presented in following figures. Fig. 4 shows deformations in the structure, while Fig. 5 presents distribution of stresses reduced at increased load of one actuator support.

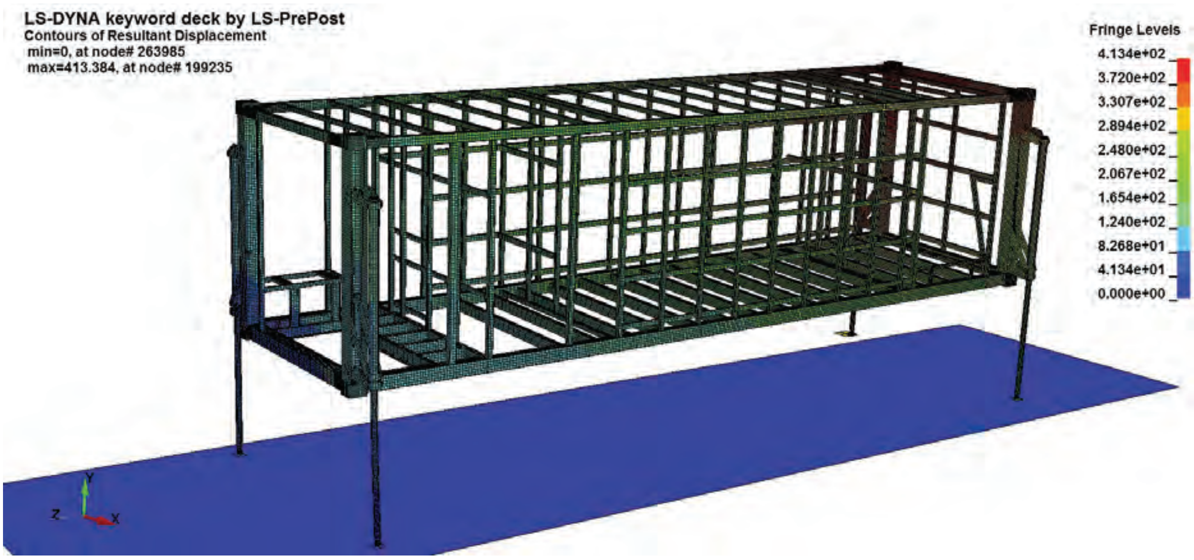

Fig. 4. Resultant deformations of the container supporting structure at increased load of one support

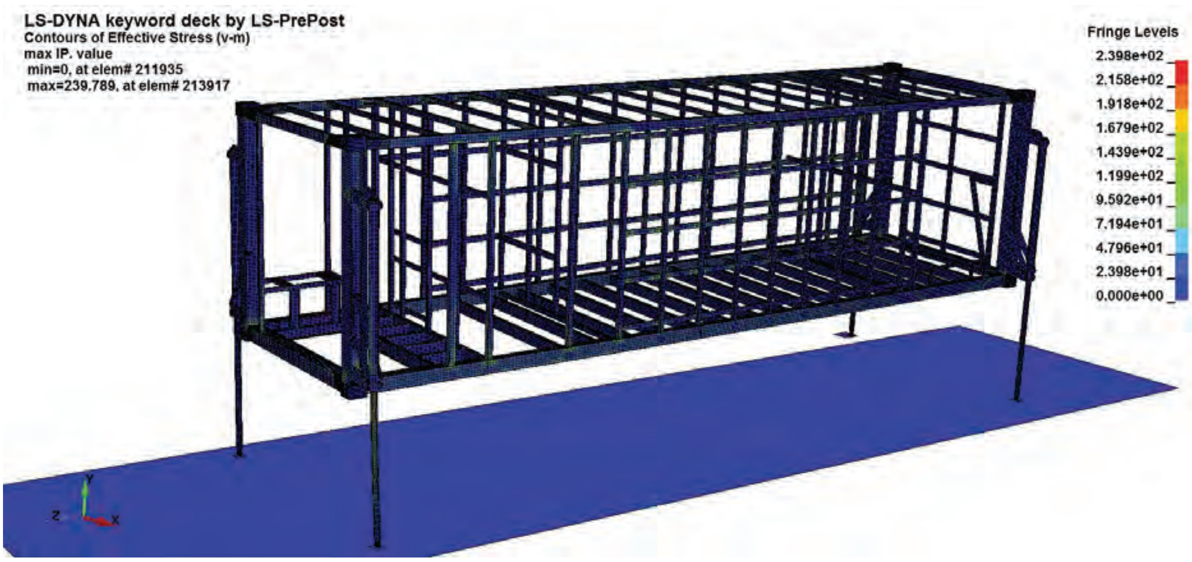

Fig. 5. Reduced stresses of the container supporting structure at increased load of one support

4. Transport abilities of the mobile laboratory transport unit

Mobile container laboratory for collection of the environmental samples and environmental threat identification is designed for, among others, a road transport by means of various tractors and various available under-container trailers. Expected transport unit configurations are presented on the following figures. Fig. 6. presents a transport unit consisting of a saddle tractor with an armoured cabin and a classic trailer by Wielton (Fig. 6a) or a trailer with increased traction abilities by Auto-Hit sp. z o.o. (Fig. 6b). Fig. 7 presents the aforementioned trailers in a configuration with a common wheeled tractor.

a)

b)

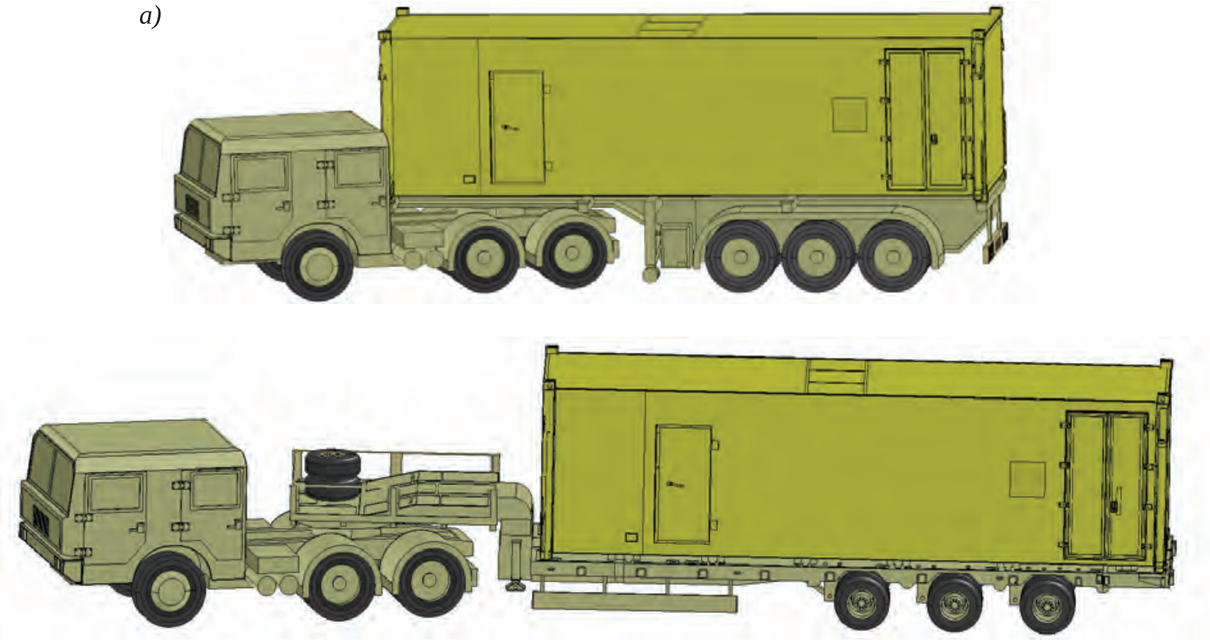

Fig. 6. A transport unit with a military saddle tractor: a) classic trailer by ZREMB, b) increased mobility trailer by Auto-Hit sp. z o.o.

a)

b)

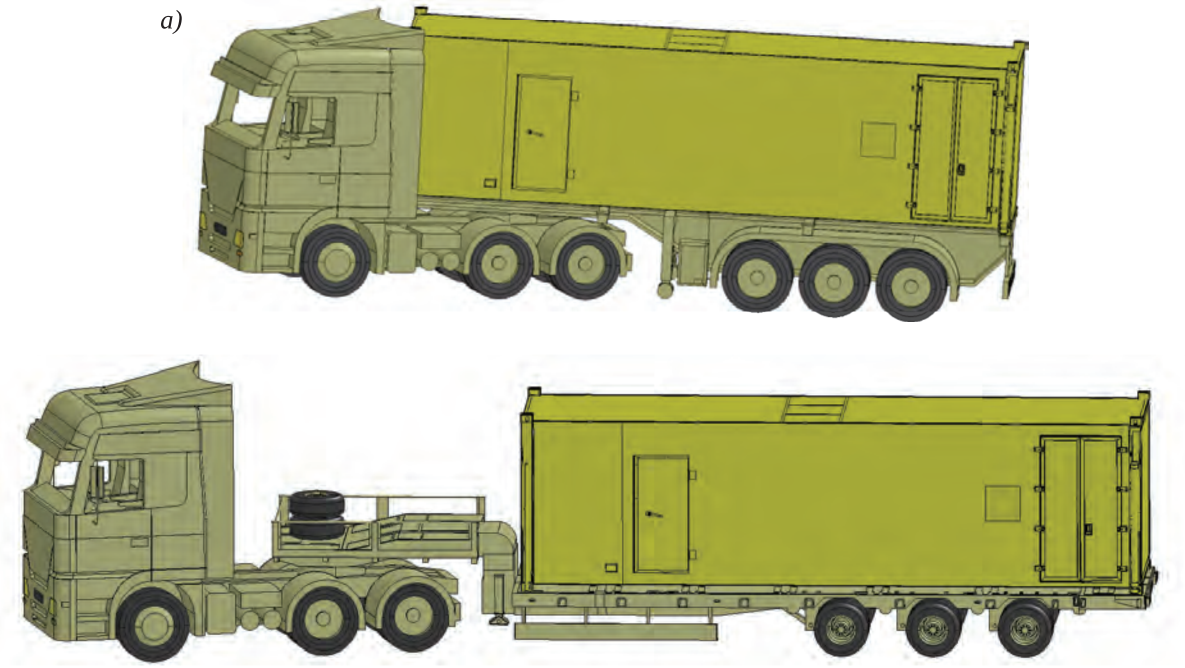

Fig. 7. Transport unit with a civilian saddle tractor: a) classic trailer modelled on a trailer ZREMB, b) increased mobility trailer modelled on a trailer by Auto-Hit Sp. z o. o.

The results of the initial calculations of traction characteristics of presented units are promising and a careful analysis and modifications will allow for meeting difficult operation requirements.

4. Summary

Obtained resistance calculation results allow for a positive evaluation of the supporting structure. They indicate a correct selection of shapes, geometry and configuration of components as well as materials used for building a model. However, an experimental verification, to be carried out at the next stage, is required for a full evaluation.

Acknowledgements

Scientific work financed from resources for science in years 2011–2014 as research project.

References

[1] Mitschke, M., *Dynamika samochodu*, WKiŁ, Warszawa 1977.

[2] Borkowski, W., Rybak, P., Hryciów, Z., Michałowski, B., *Wpływ stanu technicznego zawieszenia na obciążenia dynamiczne pojazdu specjalnego*, Teka Komisji Motoryzacji, Zeszyt Nr 33/34, Kraków 2008.

[3] Generalna dyrekcja dróg publicznych, *Rowy*, Ogólne specyfikacje techniczne, Warszawa 1998.

[4] Borkowski, W., Michałowski, B., Rybak, P., Wiśniewski, A., *Analiza obciążeń dynamicznych transportera opancerzonego przy pokonywaniu przeszkód terenowych*, XII Konferencja Naukowo-Techniczna Techniki Komputerowe w Inżynierii, Słok k/Bełchatowa 2011.

[5] Rybak, P., Borkowski, W., Hryciów, Z., Wysocki, J., Michałowski, B., *Badanie obciążeń dynamicznych pojazdów mechanicznych w aspekcie bezpieczeństwa oraz komfortu jazdy*. Systems Journal of Transdisciplinary Systems Science, Vol. 16, No. 1, 2012.