TESTING OF PROTECTIVE COVERS FOR SPECIAL VEHICLES

Piotr Rybak

Military University of Technology
Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 6839752, fax: +48 22 6837370
e-mail: p.rybak@wme.wat.edu.pl

Wacław Borkowski

Military University of Technology
Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 6839531, fax: +48 22 6837370
e-mail: w.borkowski@wme.wat.edu.pl

Bogusław Michałowski

Military University of Technology
Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 6837346, fax: +48 22 6837370
e-mail: b.michalowski@wme.wat.edu.pl

Zdzisław Hryciów

Military University of Technology
Kaliskiego Street 2, 00-908 Warsaw, Poland
tel.: +48 22 6837269, fax: +48 22 6837370
e-mail: z.hryciow@wme.wat.edu.pl

Abstract

In the paper were presented threats happen to special and transportation vehicles while task performing within the confines of peace forcing and keeping missions on world areas threatened by conflicts and that could be areas of unit future actions. Based on available materials and authors results of numerical and experimental tests, effects of various explosive charges action on special vehicles were presented. Such explosive charges could be used during fighting in urban and mountainous areas as well as other with limited area. Were presented directions of research and development leading to increase protection level for people, inside special and transportation vehicle, against combat agents characteristic for peace keeping and stabilization missions that could be used also while warfare.

In the paper were presented numerical model of protection structure, which were worked out on the basis of the Finite Element Method. There are presented some results of experimental and modelling tests of after blast shock wave action on armoured shell and prepared protection structures for special and transportation vehicles. The maximum deformations of research objects and stress in construction were put. The comparisons of results for numerical and experimental researches were introduced. Protecting structure was loaded by shock wave pressure generated by hypothetical unconventional explosive charge (improvise explosive device or non-contact mine). In the paper were also made effort to point at possibility and necessity to choose the most effective parameters of structure for protected part of combat vehicle against potential threats.

***Keywords**: combat vehicle, transportation vehicle, explosive charge, modelling, protective structure*

1. Introduction

Polish membership in NATO cause responsibility to take part in various projects that have military, stabilization and pacific nature. Specially participation in stabilization and peace keeping mission cause permanent danger to be strike by unpredictable combat means. Mentioned means threatening special vehicles, people inside them as well as installed equipment. Special tasks while mission could be carried out in various regions of the world, politically unstable and overcome by conflicts that were shown on Fig. 1.

Analysis of accessible materials and results of authors investigation, carried out for several years, show how various paralysing means strike structure of special vehicles. Such means could be placed in urban area, mountains or other with limited space (dip canyons and ravines), but also near roads between countries. That create need to continue research works as well as development works steering to find structures and materials well protecting people as well as minimising paralysing effects of vehicles operated in zones threatened by explosion, structures characterised by low weight and high efficiency of protection.

Currently for production of bullet resistant armour are used various materials. Basic types of materials are:

- polythene fibre with ultrahigh molecular weight (produced by: AlliedSignal Spectra and DSM Dyneema) that are ultra light synthetic fibre characterised by high durability as well as humidity, chemical agent, ultraviolent radiation, cutting and abrasion resistant,
- aramide fibre (e.g. DuPont Kevlar, Akzo Twaron) are well known with high durability. Both aramide and polythene fibre are used for weave of ballistic materials. Modern materials weave by Spectra fibre give good ballistic protection as well as protection against deformation of vehicles covered inside sheet metal,
- composites shield technology (AlliedSignal) not weave composites materials are word trademark of advanced armour systems. Excel trademarks at production of soft personal armour are among other things composites Spectra Shield Plus, Spectra Shield and Spectra Flex.

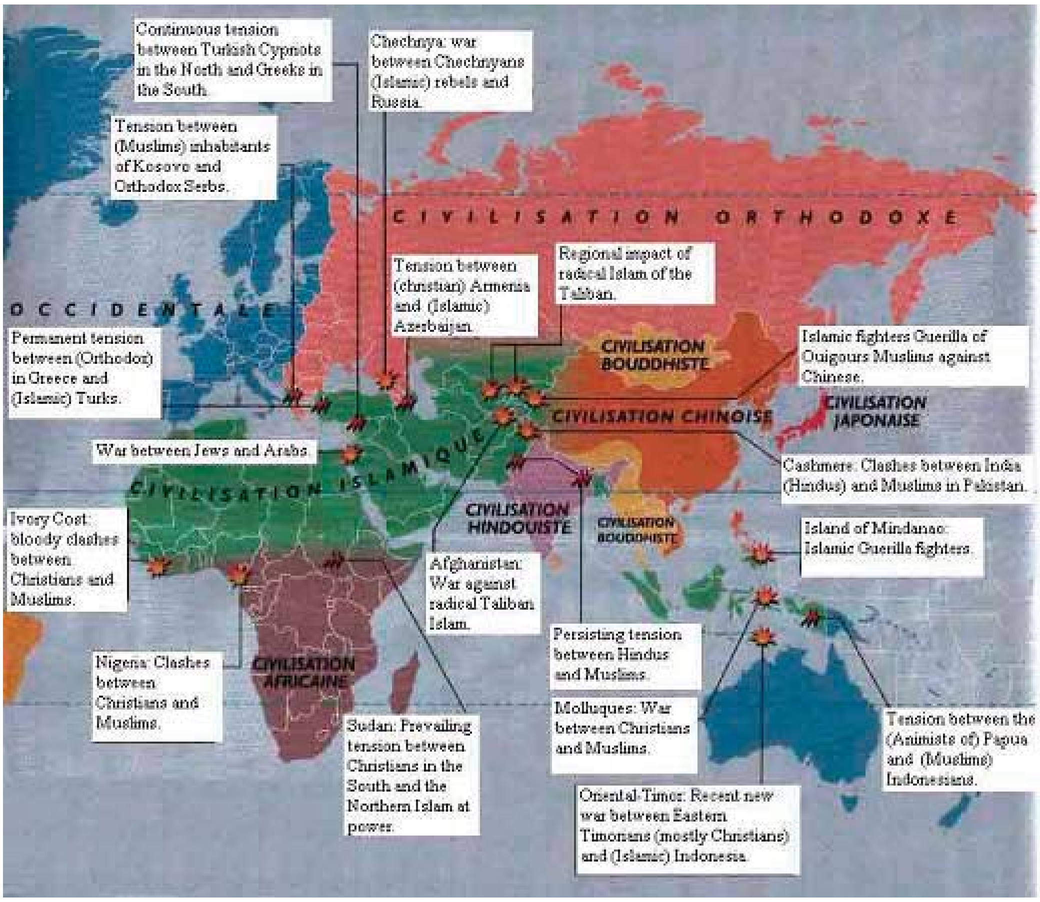

Fig. 1. Regions of the world and reason of unrests

Manufacturing hard bullet resistant armours are used following materials:

- ceramics – hard flint baked in very high temperatures perfectly disperse bullets' energy. They disadvantage is decrease of durability after repeated hitting – they crushing and cracking. They characterize with the considerable mass.
- the duralumin – light alloy resistant to shocks and tear – a little worse with relation to steel and ceramics, however considerably smaller mass,
- titan – light metal, high durability, complicated technology of production, material very expensive and seldom applied.

The research and the obtainment of the good armour, resistant against bullets is a complicated process but with one unknown. Given are the kind and parameters of the bullet, and the unknown material or composite with definite bullet resistance.

A more complicated investigative process is the research of the protection against paralysing factors in the form of mines as well as improvised explosive devices (IED). In this case the process include the description of two unknowns, first – the kind and parameters of the paralysing agent and second – the efficient protection against paralysing factors of mines and IED. A main paralysing factor this type of devices is the pressure of the after explosive shock wave which the value depends on the row of factors (e.g. the mass of the bursting charge, the distance from the barrier, the place of the location etc.).

The formation of the hit resistance and the efficiency of protective structures on charges are realized by authors in the interdisciplinary team for many years now, both in model investigations as and experimental. Within the framework of realized undertakings one performed the protective structure with the small mass and one worked out her numeric model.

The analysis of solutions of the additional protection of vehicles used in grounds threatened evidences the general usage of elements of the modular type.

With the example can be the firm Ceradyne which developed the production of ad on armour also for military vehicles with modules FlexKit (composite material) with the small mass and thicknesses – see Fig. 2. The system is flexible and answers the needs the present army on the battle-field. It make possible quickly and effectively to adapt chosen areas of the vehicle to the required level of the protection.

The additional armour of the car HMMWV of the firm O′Gara-Hess & Eisenhardt is provided as the complete ballistic protection of the vehicle embracing the section of the crew – see Fig. 3. It is leaning for materials composite and ceramic, provide the high protection of people inside the vehicle. The armour is effective against the fire from the small arms, as well as against explosions of mines under tires and before the fire from the light armour-piercing weapon. It provides also the general protection against the airburst and fragments of bullets.

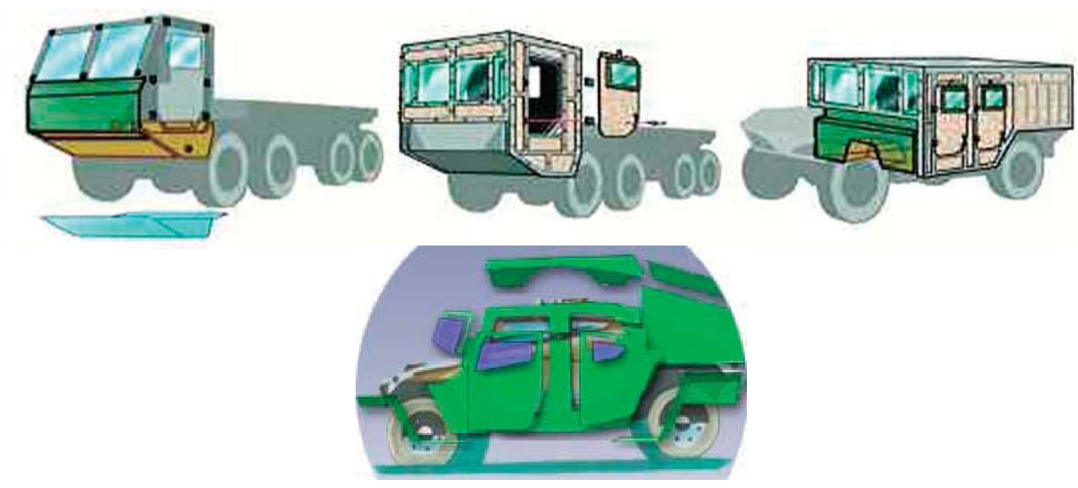

Fig. 2. Modular armour FlexKit [2]

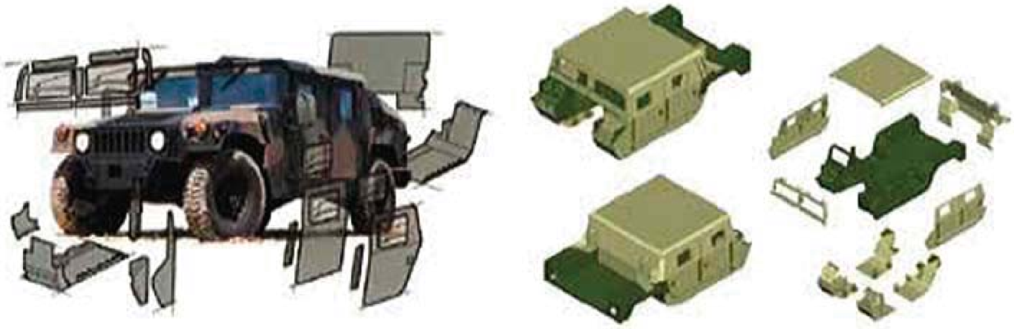

Fig. 3. Composite – the ceramic armour HMMWV of the firm O'Gara [3]

Presented examples of ballistic protections protect mostly against bullets with limited calibre, do not give the full protection against the shock wave of the explosion of mines and IED. The Fig. 4 presents examples of increasing of the level of the protection of vehicles by soldiers taking part in presently leading stabilization-missions.

Fig. 4. Examples of the armour of vehicles by soldiers

2. The model of the object of research

The analysis of the construction of practical solutions of additional protections, make possible to work out the original protective structure with the complicated construction made from light materials, which represents the Fig. 5. With the main aim which was accepted at the construction was the obtainment of the protective structure of assuring the sufficient degree of the deformation, connected with the absorption of the energy of the shock that can protect the construction of the vehicle against the direct loud as a result of the explosion.

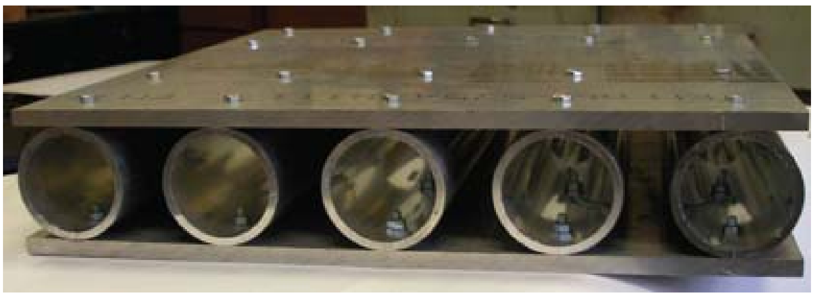

Fig. 5. The protective structure

Based on the performed protective structure one worked out its numeric model, basing on the Finite Element Method (FEM) – see Fig. 6.

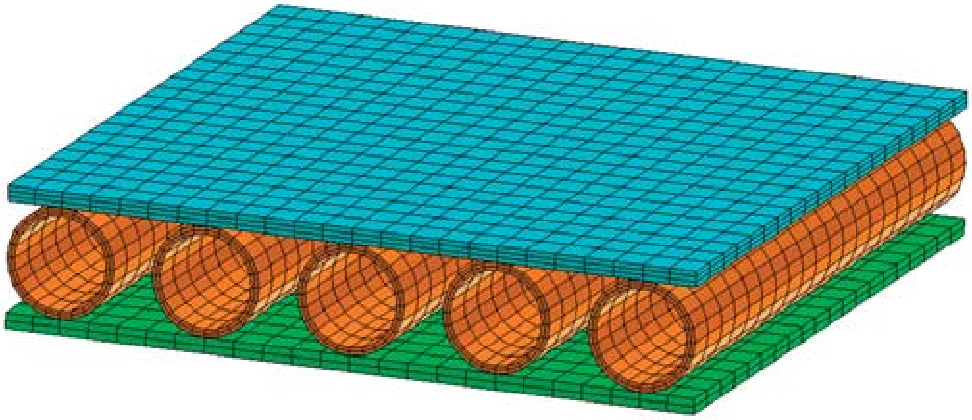

Fig. 6. The FEM model of the protective structure

The numeric model was initially experimentally verified. One carried out researches consisting of the estimation of the level of the deformation of the external plate and pipe elements under the shock load made by freely coming down ball, with given height, made from hard material with the limited mass and dimensions. In Fig. 7 were shown the effect of the shock of the ball for the surface of the considered structure.

To similar research of the load were carried out one the numeric model of the structure. The effect of calculations one presented on Fig. 8, 9 and 10. In Fig. 8 were presented the deformation of the protective structure in the area of the shock of the ball, in Fig. 9 the stress distribution in her elements, and in Fig. 10 the diagram time versus force in the area of the shock of the ball. The area of the shock of the ball in numeric research is exactly the same like the place of the shock of the ball no the real object.

Fig. 7. The effect of the shock on the elements of the structure

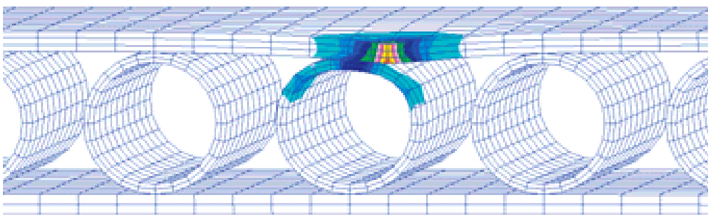

Fig. 8. Deformations of the model under given charge

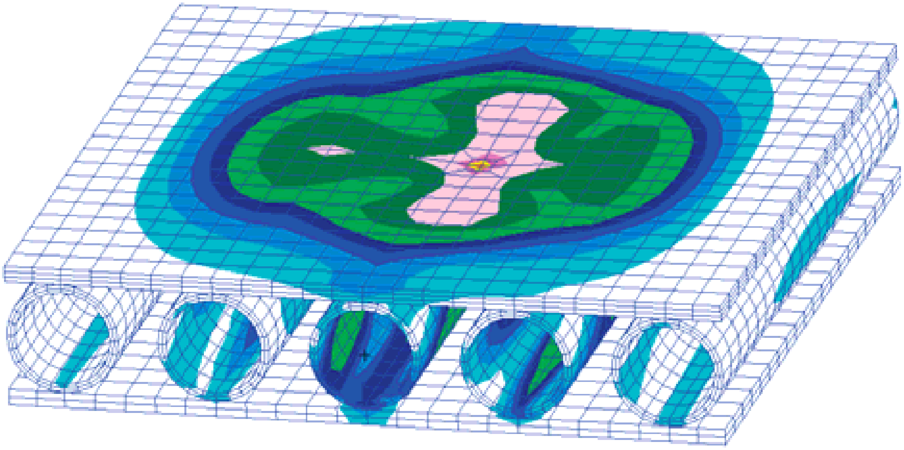

Fig. 9. Distribution of tensions in the protective structure

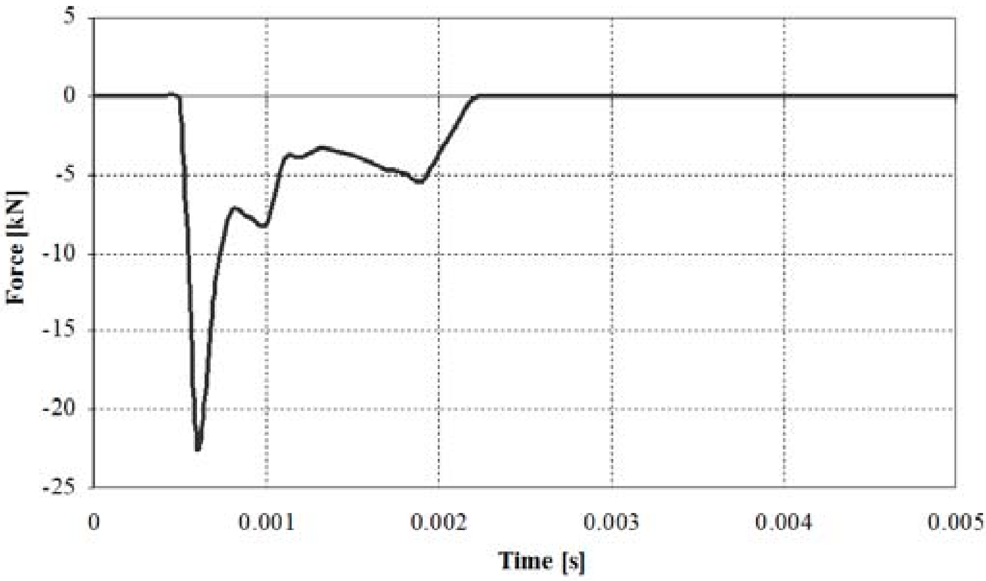

Fig. 10. The diagram time versus force in the plate of the external structure in the area of the shock

The comparison of results obtained from the experiment and calculations shows that the model well reflects the real object, both with reference to deformations as and forces and can be used for further research connected with the selection of parameters of materials and geometry of the structure.

3. The model of charges

For the case of the load by mine or the improvised explosive device – IED, the problem was formulated as follows: the shock wave generated in the any point of the space, propagates in the gas and effects met on her own way the object (the barrier which is in this case the protective structure). The detailed description of the model of the load is given in [1]. On Fig. 11 were presented the exemplary characteristic of the pressure at the front of the shock wave for the short distance from the epicentre of the explosion generated by the not contact-character charge with the given mass.

The model of the load takes into account the propagation of the wave of the pressure during, the weakness of the pressure behind the front of the wave, the position the epicentre of the explosion in relation to analysed construction. The model was verified experimentally, by laboratory research and of range. One obtained the good similarities of results.

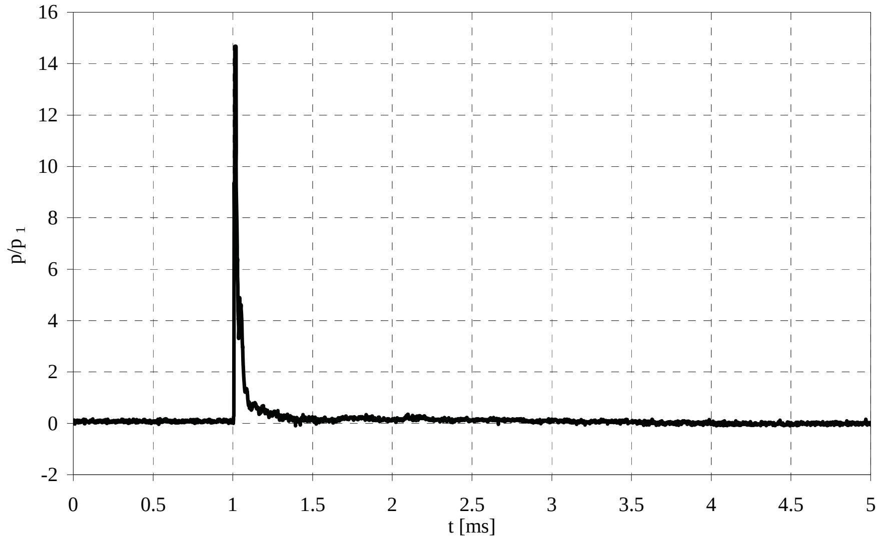

Fig. 11. The example of characteristic, pressure versus time, of the shock wave

4. Model investigations

To numeric research one used worked out, original model of generating of the load - the propagation of the after explosive shock wave and the model of the module of the protective structure. The model of the structure one loaded by the pressure at the front of the shock wave generated with the unconventional charge (with the improvised explosive device – IED or with the not contact mine).

On the job one presented some from calculations, influences of the post explosive shock wave generated with the explosion of the hypothetical mined charge on the protective structure. In Fig. 12 were presented the character of the deformation of elements of the protective structure for the moment of reaching of maximum values, for given bursting charge.

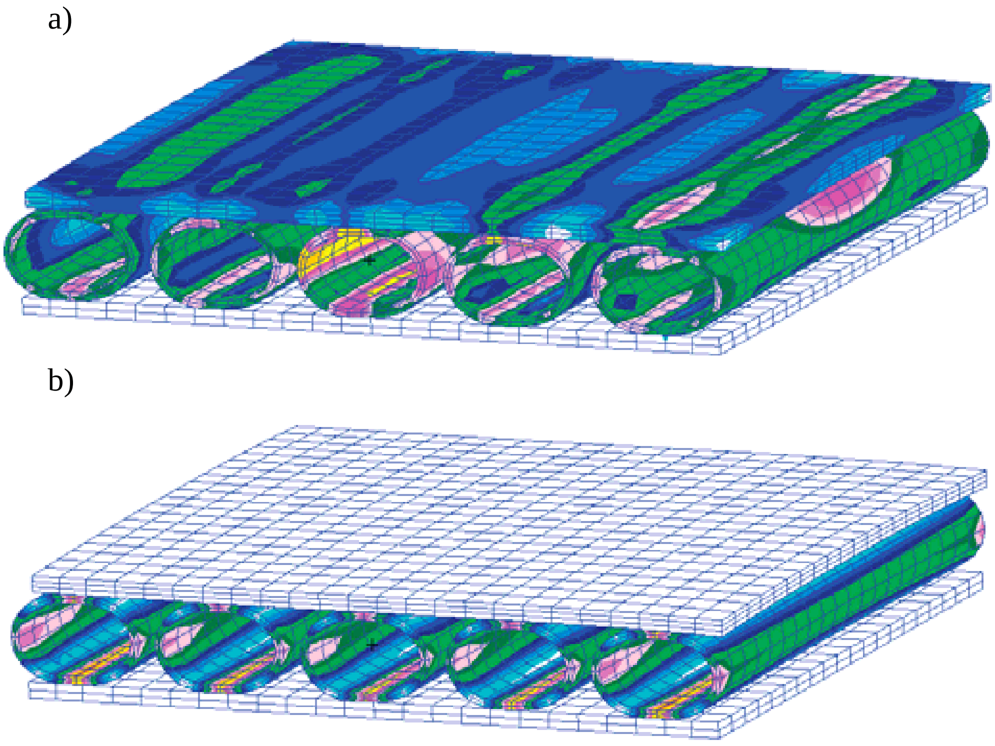

Fig. 12. Deformations of the protective structure under the influence of the activity of the explosion of the explosive charge: a) in phase activities of the loads, b) after the passage of the loads

4. Final results

Presented results of preliminary experimental researches as well as model tests are promising and encourage to further research over the obtainment of the optimum- protective structure not only against mines and improvised explosive devices but also against other paralyzing means.

Worked out structure as well the model makes possible the multi variants formation depending on the application. Characteristic parameters of protective structures one can choose properly for protected area of the hull or the chassis.

Additional protective layers can be installed also inside the min of transportation or also elements of his permanent equipment can be made from protective material – Fig. 13 and 14.

Fig. 13. The example of elements of the protection fastened inside the vehicle [4]

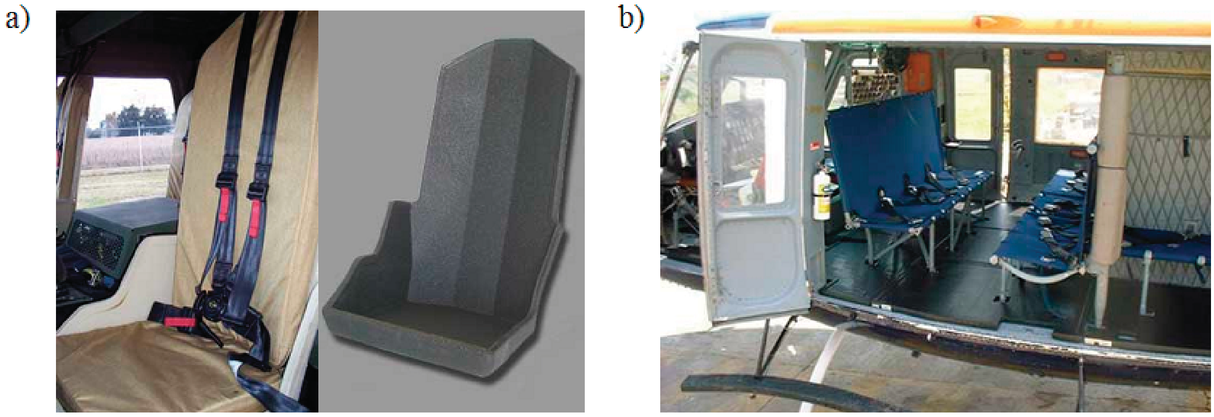

Fig. 14. a) Seats of HMMWV made from nylon and aramid, b) the floor of the helicopter Black Hawk stuffed with the layer of Floor LVF Kit [5]

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