

Dalibor Coufal<sup>1</sup>

## THE ANSYS WORKBENCH AND ANSYS AUTODYN SOFTWARE AND THEIR SCOPE FOR MODELING BLAST WAVE EFFECTS TO THE MILITARY BASE

### Abstract

*Nowadays, the highest priority of all Allied armies is to participate in ensuring the foreign military missions. The military troops are daily used in various locations around the world to eliminate the terrorist threat. In this case they face often to the danger of death. The activities of soldiers in foreign countries are significantly influenced by the role of military bases. The system of internal base conception must be able to provide accommodation and protection of troops against external threats. The article deals about the use of ANSYS Workbench and ANSYS AUTODYN software and its utilize for modeling the effects of explosions to the important parts of military base. This program as a preventive measure can be effectively used in the designing of the most important parts of the military bases.*

**Keywords:** ANSYS Workbench, ANSYS AUTODYN, blast wave, military base, protection

### 1. INTRODUCTION

In the present time the main task of Allied armies consists in ensuring the foreign military missions. Whether is the principle of the mission in the service of the Provincial Reconstruction Team in Afghanistan's Logar province, or the Battlegroup operating under various missions in whole the world, there is one similarity in the question of security. All the soldiers are daily under the pressure of possible death.

With the foreign military service the need of accommodation and safety of military units is solved. This matter of fact is realized with military bases, which are located in different areas and specific climatic conditions in the world. The soldiers, being on duty a lot of months, require protection and facility through the military bases. For this reason the main attention is dedicated to the military bases protection, which is associated with positive effect on morale, psychological and mental health of the soldiers.

Terrorist attacks aimed to the military bases bring one of the biggest life-threatening dangers for military foreign units. According to the experience, the attacks are mostly maintained by the explosives-filled cars which are coming to the base [2]. For this reason the main attention is focused to the protection of base entrance.

To avoid the massive casualties, where the suicide bomber kills a lot of soldiers by a rammed van, it is important to propose the entry parts. It is also necessary to know, how will be the explosive blast wave spreading in this space.

---

<sup>1</sup> National Defense University, Brno, [dalibor.coufal@unob.cz](mailto:dalibor.coufal@unob.cz)

For detecting the effects of blast waves is advantageous to use software from ANSYS Inc. For this reason, the article is focused on using software such as ANSYS Workbench platform, and ANSYS AUTODYN, as a software which is supplied as an integral part of the ANSYS Workbench environment.



Fig. 1. Aftermath of Truck Bomb attack on US Military Base in Wardak, Afghanistan, 10<sup>th</sup> September 2011 [1]

## 2. THE ANSYS SOFTWARE OVERVIEW

### 2.1 ANSYS Workbench

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multi-physics analyses with drag-and-drop simplicity.

With bi-directional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation Driven Product Development. [2]

Typical tasks you can perform in Workbench are:

- Creating models using DesignModeler or importing models from a variety of CAD systems.
- Generating a numerical mesh suitable for a variety of FE and CFD methods using Meshing or Advanced Meshing
- Performing implicit finite element analyses using Simulation for structural, thermal, and electromagnetic simulations.
- Performing explicit transient nonlinear dynamics simulations of solids, fluids, gases, and their interaction using ANSYS AUTODYN
- Optimizing designs using DesignXplorer or DesignXplorer VT, and implementing a chosen design back into the original model [3]

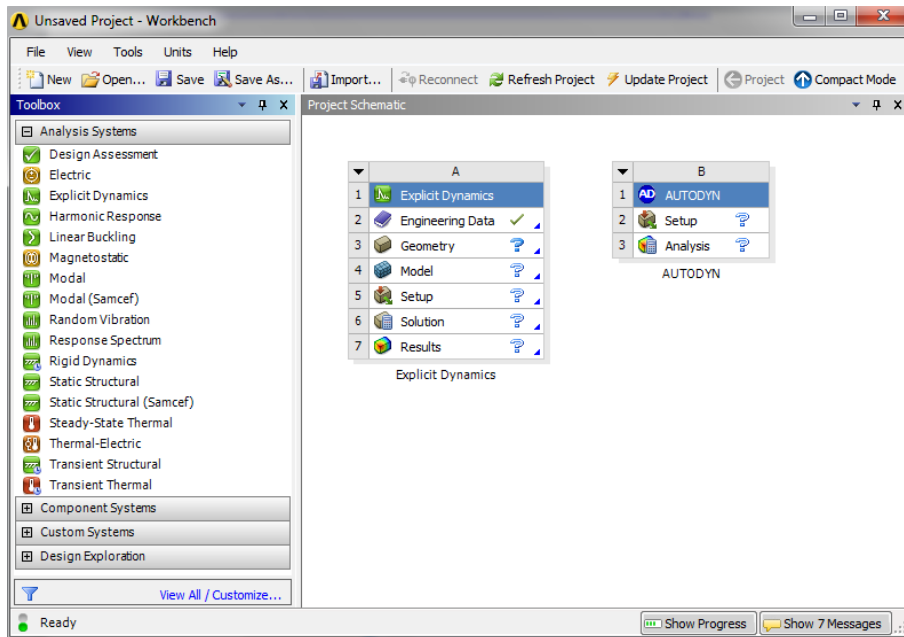


Fig.2. Main screen of ANSYS Workbench platform<sup>2</sup>

## 2.2 Ansys Autodyn

ANSYS AUTODYN is an explicit analysis tool for modeling nonlinear dynamics of solids, fluids, gas, and their interaction.

With a fully integrated, easy to use graphical interface allowing set up, running, and post processing of problems, ANSYS AUTODYN offers:

- Finite elements (FE) solvers for computational structural dynamics;
- Finite volume solvers for fast transient Computational Fluid Dynamics (CFD);
- Mesh-free particle solvers for high velocities, large deformation, and fragmentation (Smoothed-particle hydrodynamic - SPH);
- Multi-solver coupling for multi-physics solutions including coupling between FE, CFD and SPH;
- A wide suite of materials models incorporating constitutive response and coupled thermodynamics;
- Serial and parallel computation on shared and distributed memory systems. [4]

ANSYS AUTODYN has been used in a vast array of projects and nonlinear phenomena. It is also possible to use it effectively for building protection measures and insurance risk assessment for blast effects in military bases.

---

<sup>2</sup> Property of the author.

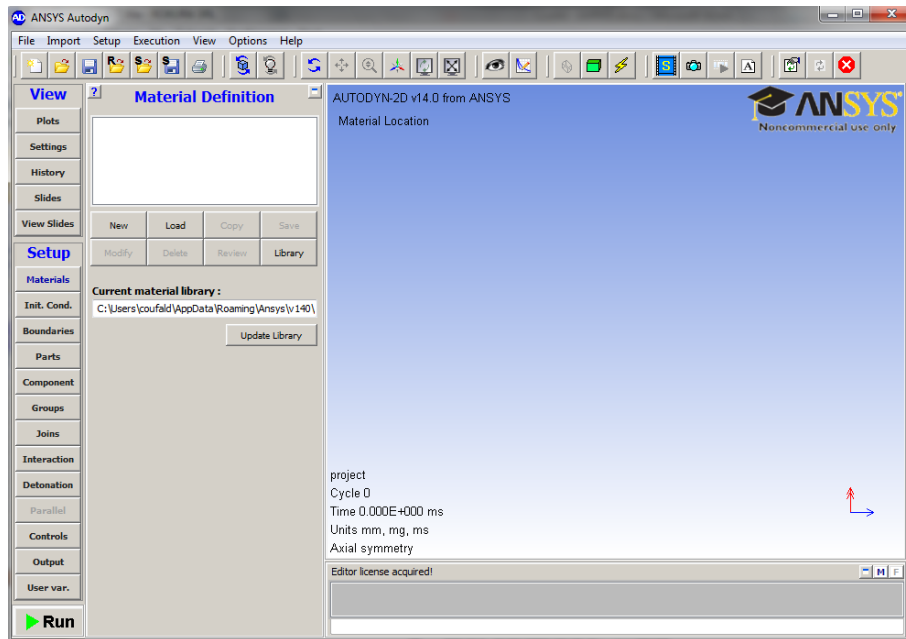


Fig. 3. Main screen of ANSYS AUTODYN<sup>3</sup>

### 3. THE PREPARATION OF INDIVIDUAL COMPONENTS TO THE CALCULATION

#### 3.1 The model of military base

Before any calculation it is necessary to make a 3D model of base or specific part, where the blast wave will be realized. There are more options how to do that. It is possible to use ANSYS DesignModeler, or any CAD system because of ANSYS Workbench platform compatibility. From this point of view there is no problem to import such models created in Autodesk Inventor or AutoCAD. For calculations, all the models must be done in 1:1 scale.

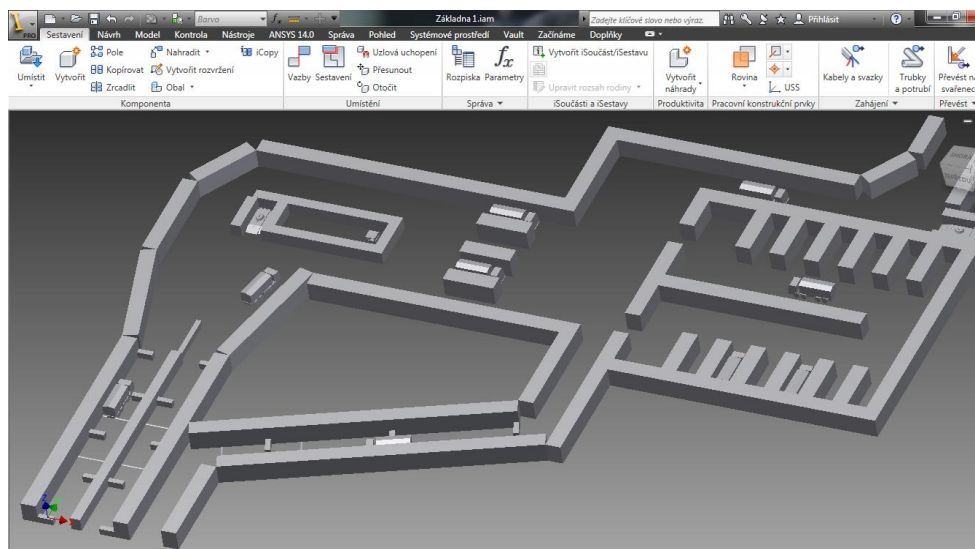


Fig. 4. The model of military base created in Autodesk Inventor Professional 2012<sup>4</sup>

<sup>3</sup> Property of the author.

<sup>4</sup> Property of the author.

### 3.2 Creating the 2D Spherical Blast

After the model creation it is possible to initiate a new project for spherical blast in 2D dimension. This process is realized with the ANSYS AUTODYN program. At first it is needed to choose the model name of the 2D calculation, set symmetry and units.

As the next step it is necessary to load material data from library like an Air and TNT. Next step is to generate an Euler part – wedge, where is possible to define minimum and maximum radius and the number of cells. It is recommended to use grade zoning because of prevent to energy error. It is needed to spread the element size – small elements put close to the explosion and enlarge them with increasing distance. The blast wave is bigger with increasing distance from epicenter, so the error energy is not expanding with bigger elements.

Next part is to fill Euler mesh with the Air material. In the same way, the Euler mesh is filled with TNT in the shape of ellipse with radius x and y which are the same as the radius of the explosive. Finally, it is necessary to form the I Boundary line as Flow-out condition. This will determine no reflection of spreading blast wave. The last step is to set in Controls menu the number of cycles and time after which the calculation will be performed. After the calculation is necessary to save .fil file format which will be later used for the calculation in ANSYS Workbench.

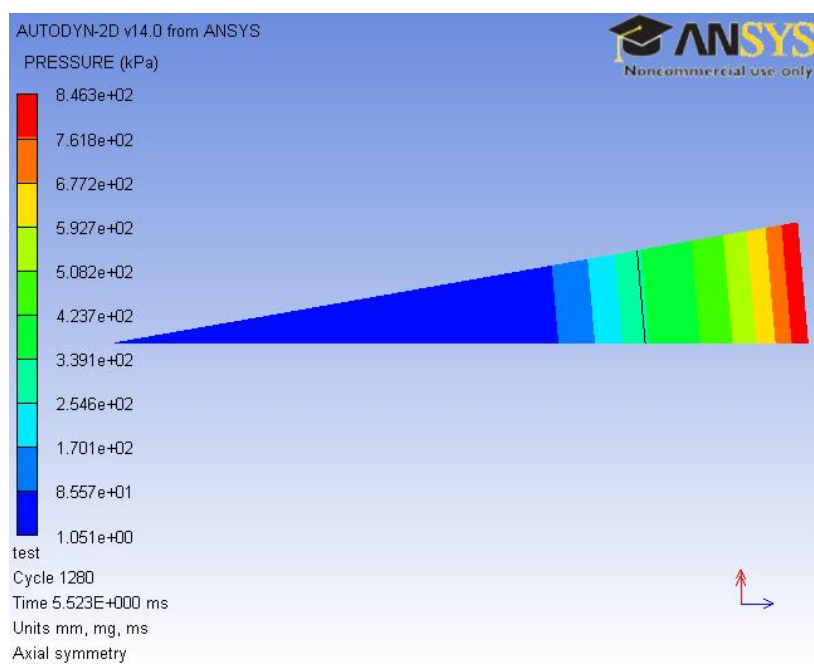


Fig. 5. The 2D model of 1000 kg TNT explosion<sup>5</sup>

### 3.3 Creating new project in ANSYS Workbench

After launching the icon of ANSYS Workbench it is possible to see Toolbox full of offers. In the case of Urban Blast project it is necessary to create an ANSYS Explicit Dynamics Analysis. After this step, the environment (created military base in .agdb or compatible CAD format) is imported from database by the choice Geometry.

The Model choice enables to set all selected model parts to rigid and to generate mesh. Mesh generation is one of the most critical aspects of engineering simulation. Too many cells may result in long solver runs, and too few may lead to inaccurate results [5]. For the purpose

<sup>5</sup> Property of the author.

of the blast wave simulation is sufficient to generate an automatic mesh. With these procedures it is required to insert a Velocity boundary condition, for all components to 0 mm/s. Together with this step must be inserted Standard Earth Gravity.

Now the model is ready to be transferred to AUTODYN. The easiest way is to enable Setup – Transfer Data To New – AUTODYN. After double clicking on the AUTODYN setup will open the model within AUTODYN.

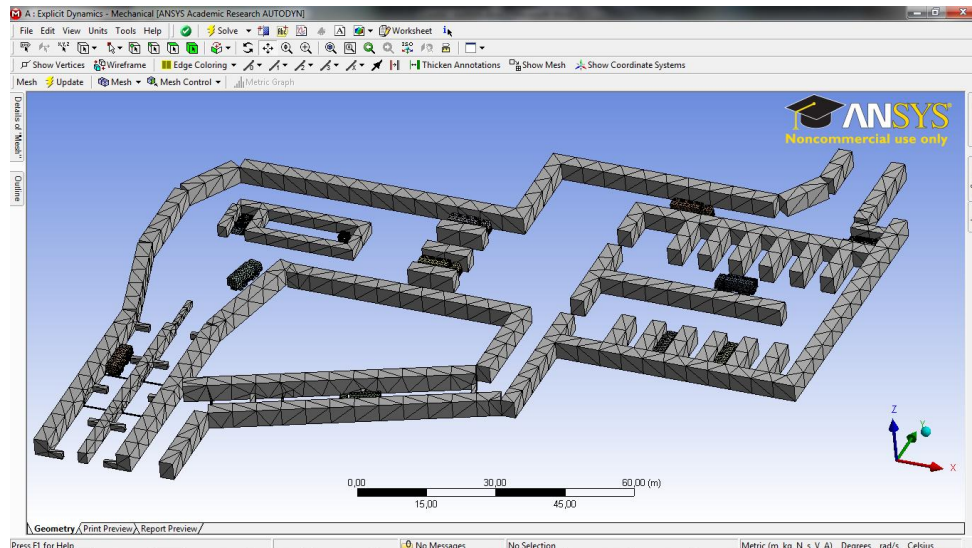


Fig. 6. The 3D model mesh done in ANSYS Workbench<sup>6</sup>

#### 4. PERFORMING THE CALCULATION IN ANSYS AUTODYN

The ANSYS AUTODYN part is supposed to realize the final calculation and the simulation of the blast wave [6]. It starts with loading Air and TNT from the AUTODYN material Library. Next step is to create new Initial Condition which includes material Air. It is necessary to input Initial Density  $0.001225 \text{ g.cm}^{-3}$  and Internal Energy  $2.066 \cdot 10^5 \text{ Jkg}^{-1}$ .

After that, an Euler 3D multi-material part needs to be created. Here is to input the origin, size, and number of cells in all three dimensions, and to fill it with previous Initial Condition. Next is to remap the solution of a 2D simulation of a detonation. It is done by reading data file with .fil format, which was created by 2D spherical blast calculation.

It is also necessary to input origin of 2D explosion, select all materials to remap and choose the symmetry axis direction (usually Z axis). The last point consists in debugging the interactions between each component by switching on the Euler-Lagrange Coupling choice. The calculation time and the number of cycles shall be changed to appropriate values in Controls option, and the result file can be specified in Output choice. Also the boundaries should be set. It is recommended to input new boundary – flow\_out – to prevent the Air reflection caused by the rigid walls. The calculation is started by the button Run.

During the calculation there is an information window, where is to see number of cycles, time of calculation, and individual time steps. During the calculation there can be some reasons why the process stopped. This can be solved mostly with changing Wrapup Criteria (cycle limit, time limit or energy fraction) or Timestep Option (in the case of the Error: Time step too small). For the need of illustration there is also choice to make an animation. In the Output offer it is possible to save result files defined by number of cycles or time and later to collect them with appropriate frame delay.

<sup>6</sup> Property of the author.

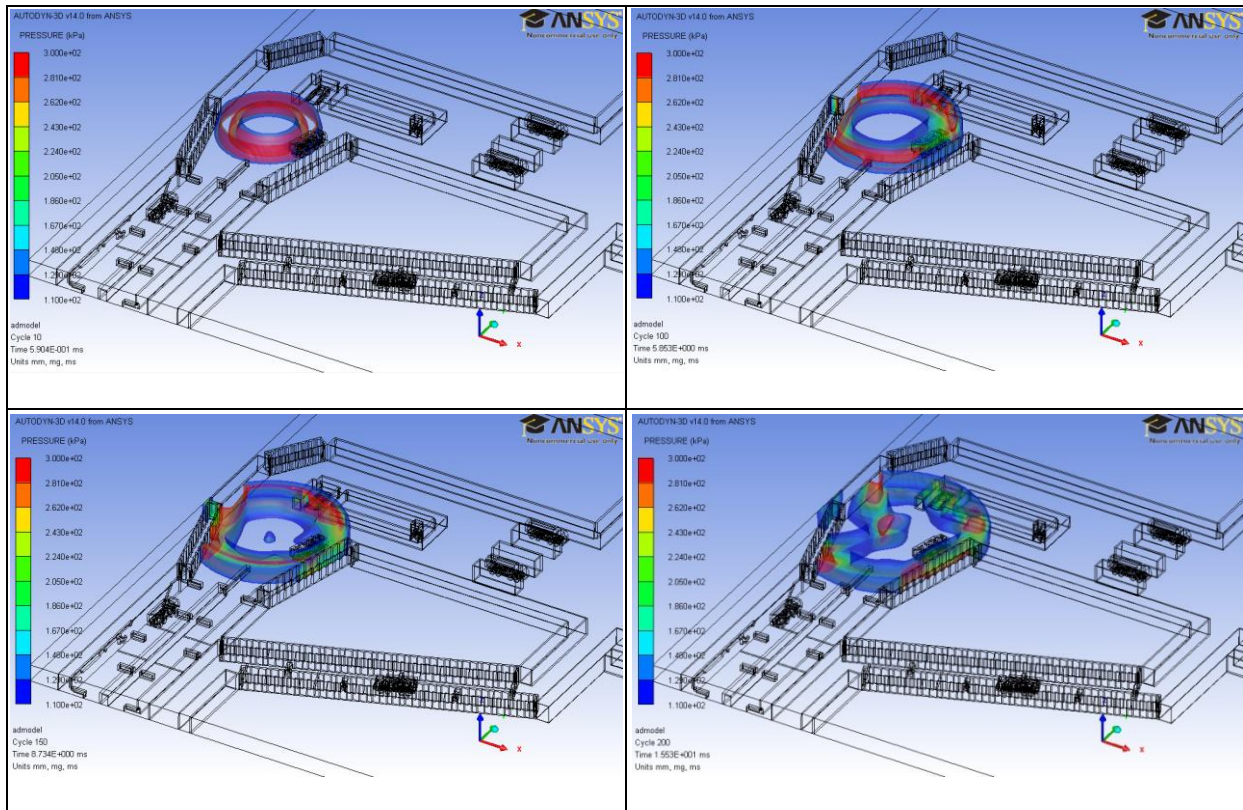


Fig 7. The spreading of 1000 kg TNT blast wave<sup>7</sup>

Type of car	Range of blast wave with lethal effect [m]	Minimum distance for evacuation [m]	Area threatened by flying fragments [m]
Maximum weight of explosion [kg]			
Hatchback car	30	460	550
230			
Combi car	40	550	850
460			
VAN	60	850	1200
1800			
Nákl. Auto	100	1200	2000
4500			
Cisterna	140	2000	2200
13700			
TIR	190	2200	2200
27300			

Tab. 1. Risks associated with the detonation of specific quantity of explosives placed in particular type of vehicle [7]

<sup>7</sup> Property of the author.

## 5. CONCLUSION

In the present time the terrorism is currently one of the most widely threats of the 21<sup>st</sup> century. Its strength consists in the way of fighting which is realized by terrorists. In most cases these attacks are led by conventional weapons with taking the advantage of surprise.

This situation may change radically when the terrorists get weapons of mass destruction like nuclear or biological bombs. The impact of such terrorist act connected with that kind of device can be completely devastating, currently hard to imagine.

It is important to understand that the loss of human lives and material is not primarily threat to the troops serving in foreign missions. The most significant fact is permanent threat resulting from the principle of terrorism – to feel every time in the danger of death. This is a most powerful effect that attacks on basic human needs such as safety and security. For these reasons the military bases have to be secured in the best possible way.

The article is aimed to familiarize the reader with the possibilities of ANSYS Autodyn program. With the knowledge of spreading the blast wave it is easier to design the main parts of military base like entrance, headquarter, ammunition depot etc. It is necessary to understand that all the soldiers are serving in hostile conditions for several months. For this reason the defense of military bases should be one of the highest priorities of every army.

## BIBLIOGRAPHY

1. Pakconnects. SHAH, Asif. *Pakconnects* [online]. 2011-09-12 [cit. 2012-03-21]. Dostupné z: <http://pakconnects.blogspot.com/2011/09/aftermath-of-truck-bomb-attack-on-us.html>
2. ANSYS. *ANSYS Workbench Platform* [online]. 2012. vyd. [cit. 2012-06-07]. Dostupné z: <http://www.ansys.com/Products/Workflow+Technology/ANSYS+Workbench+Platform>
3. Renssealer Polytechnic Institute (RPI) - Renssealer Hartford. *AUTODYN - New features* [online]. 2012. vyd. [cit. 2012-06-07]. Dostupné z: <http://www.ewp.rpi.edu/hartford/~ernesto/F2010/EP1/Materials4Students/Danyluk/autodyn-new-features.pdf>
4. ANSYS Customer portal. *ANSYS AUTODYN in Workbench* [online]. 2012. vyd. [cit. 2012-06-07]. Dostupné z: [http://www1.ansys.com/customer/content/documentation/120/wb\\_adyn.pdf](http://www1.ansys.com/customer/content/documentation/120/wb_adyn.pdf)
5. MAŇAS, Pavel; KROUPA, Lubomír. Simulation within Force Protection Engineering. In: *Proceedings of the International Conference on Military Technologies 2011, ICMT'11*. Brno: University of Defence, 2011, p. 209-216. ISBN 978-80-7231-787-5.
6. KROUPA, Lubomír; MAŇAS, Pavel. Blast threat to structures. In: *Sborník 4. ergonomické konference*. Brno: Univerzita obrany, Fakulta ekonomiky a managementu, 2010. ISBN 978-80-7231-756-1.
7. JANÍČEK, Miroslav. *Pyrotechnická ochrana před terorismem*. Vyškov: Educa Consulting, 2002, 158 s., [16] s. barev. obr. příl. ISBN 80-902-0896-7.