11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

A RAPID PREDICTION OF BLAST WAVE PROPERTIES: EMPIRICAL VS. NUMERICAL APPROACH

Piotr W. Sielicki

Poznan University of Technology, Institute of Structural Engineering,
Piotrowo 5 St., 60-965 Poznan, Poland,
piotr.sielicki@put.poznan.pl

Key words: *Explosion, Blast loading, Numerical analysis, Structural safety.*

ABSTRACT

This research contains an overview of some aspects deal with the empirical and numerical predictions of a blast loading. The empirical method bases on the experimental data collected in US standard Unified Facility Criteria. It was prepared by the author an open source code, prepared in Scilab programming language. Basing on this approach any engineer could predict the primary features of explosive loading and take it into account during the design process. However, the main part of the paper includes also the comparison of empirical prediction with the numerical verification. This study is done for TNT spherical charges. All of the numerical consideration were performed using Abaqus Explicit code. The results allow for aware assessing of the basic properties of explosion for equivalent mass of TNT for any kind of condensed, spherical charges. Furthermore, the empirical vs. numerical prediction of blast wave loading were verified.

It is possible to perform an assessment of the structural safety under explosive action. Nevertheless, there are many methods which give wide range of results. They depend strongly on the insight of the designer or researcher and in the fields of interests which are taken into account. In fact, only a few countries introduced explosive loading in official codes e.g. US or Japan. This work presents a rapid assessment method which bases on the US standard in particular. However, the author pay the attention to the credibility and the real factor of safety resulting from this work. It allows to analyse of the structural safety. In fact there are many factors which influence strongly the proper assessment of the blast loading. However, the final course of an overpressure always has the classical form, as presented in Fig. (c). This loading represents pressure changes in only a few microseconds, released during chemical conversion inside the explosive volume. The course of an overpressure in time function in the free air space is shown. Hence, P is overpressure also called the air blast pressure and t is time. The virtual point of measurement is separated from the charge centre with a particular distance called stand-off.

When the process is initiated, following the explosion at the time of arrival t_A , the pressure suddenly increases to a peak value P_{SO} which exceeds the ambient pressure equals

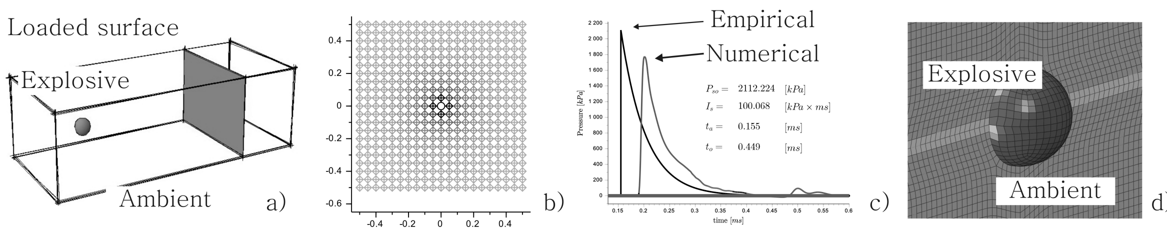

Figure 1: Views of the loading surface: a) Air volume with the virtual plane and explosive, b) Loaded surface, b) Pressure-time relation for selected point on the loaded surface, Empirical vs. FE solution, d) Numerical model (Abaqus CAE) to verify the results.

to P_0. Hence, the pressure decays to P_0 in time t_0, and again reaches P_{SO}^- pressure in order to finally reach again the barometric value, at time t_0^-. The sum of times of over and under pressures is called the time of duration T. The value of P_{SO} is usually referred to as the peak side on overpressure or incident peak overpressure. The knowledge of the instantaneous pressure changes and the duration of the positive phase allows us to calculate the blast impulse of an explosion I_S. It is noticed that the positive phase and its impulse are highly important for the structural strength for any kind of obstacle. In fact the blast resistance of any structure is often presented in P-I space [1].
It is possible to obtain primary properties of explosive loading using tabular data collected in standards. However, the initial question which must be answered deals with the possibility of reflections of the blast wave. It is noticed that the pressure wave could reflect before it reaches the main obstacle. Furthermore, these reflections intensify the pressure, and the final results could be significantly different from the free air explosion. Nevertheless, this work includes two situations, according to the UFC. The first one is the free air explosion. It represents pure theoretical phenomenon. The second one is the hemispherical detonation. It is the typical scenario where the charge is located directly on the ground. It means that pressure generated during detonation reaches the ground. Then, the reflected pressure wave goes through the air and loads the obstacle. Additionally, these both approaches are taken into account in UFC. These data presented in official standard come directly from the explosive actual tests. Moreover, all the values are approximated by simple empirical forms. These outcomes are also introduced in the presented code introduced by the author. It allows for obtaining typical properties of explosive pressure action. The exemplary results are presented in Fig. (b,c).

The presented outcomes are obtained for spherical explosion of 0.2kg of TNT charge placed in 0.4 m stand-off distance. Moreover, the shape of the charge and point of ignition are fixed to be spherical and detonated centrally respectively. The data shows that the loaded area of interests is 1x1 m^2, which is represented by the axes in Fig. (b).

REFERENCES

[1] P.W. Sielicki. Masonry Failure under Unusual Impulse Loading. *Publishing House of Poznan University of Technology*, pp.130, ISBN 978-83-7775-274-6, 2013.