20th International Conference
ENGINEERING MECHANICS 2014
Svratka, Czech Republic, 12 – 15 May 2014

EXPERIMENTAL EVALUATION OF THE EFFECTS OF A CONCRETE BARRIER TO PRESSURE WAVE PROPAGATION

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Abstract: *This paper presents the results of an experimental program focused on measuring the parameters of the blast wave resulting from explosive detonation and possibilities of influencing propagation of this blast wave in order to minimize risk of injury of people near the explosion. Multiple arrangements of solid blast barriers are proposed and experimentally evaluated. The results obtained from the experiments are presented and explained. Thanks to the use of TNT charge, the experimental results can be directly compared to data derived from other blasts without barriers. That presents a valid basis for determination of the overall barrier effectiveness in reducing overpressure at the front of the blast wave.*

Keywords: Blast Wave, Experiment, Barrier.

1. Introduction

Due to rise of the threat of terrorist attack, the research in the field of blast loading of structures and their interiors has gained considerable attention in the recent years. Buildings such as railway stations, airports or embassies ought to be designed to ensure as much safety of the users as possible. The structure shall not collapse due to any of the considerable design situations. Furthermore, measures shall be taken to reduce the severity of the explosion, i.e. the magnitude of the pressure wave coming from epicentre of the explosion and the amount of potentially harmful flying debris.

An experimental program was proposed in order to determine ways to influence propagation of the blast wave by a system of concrete blast barriers.

2. Experimental Program

The experimental program was performed by the Institute of Energetic Materials, Faculty of Chemical Technology, University of Pardubice, Czech Republic. Prior to the experiment itself, a numeric study was conducted to predict the behaviour of the pressure wave in interaction with solid barrier and multiple arrangements of blast barriers which were designed. The pure TNT charge was used as an explosive. That means the results obtained could be easily compared with experimental data from other authors. Pachman et al. (2013) and Foglar and Kovář (2013) conducted series of experiments with varying yield and standoff distance from the explosive charge.

2.1. Scaling

Given typical dimensions of public building and predicted maximal weight of an explosive charge to be carried by a single person, it was decided to conduct experiments in reduced scale 1:*n*. Widely used scaling laws (Henrych, 1973) state:

$$A_{real.} = A_{model} \cdot n \qquad (1)$$

$$W_{real.} = W_{model} \cdot n^3 \qquad (2)$$

where *n* is a scaling factor, *A* is any parameter of length and *W* is weight of the explosive.

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2.2. Barrier arrangement

Multiple arrangements of barriers were evaluated numerically using FEM analysis software LS-DYNA prior to the experiment. Some arrangements were chosen for the experiment (Fig. 1). Thanks to reduced scale of the experiment easily obtainable RC precast walls were used to model solid barriers (Fig. 2). This solution was cheaper than custom made concrete panels. Use of precast walls also allowed easier handling and repositioning.

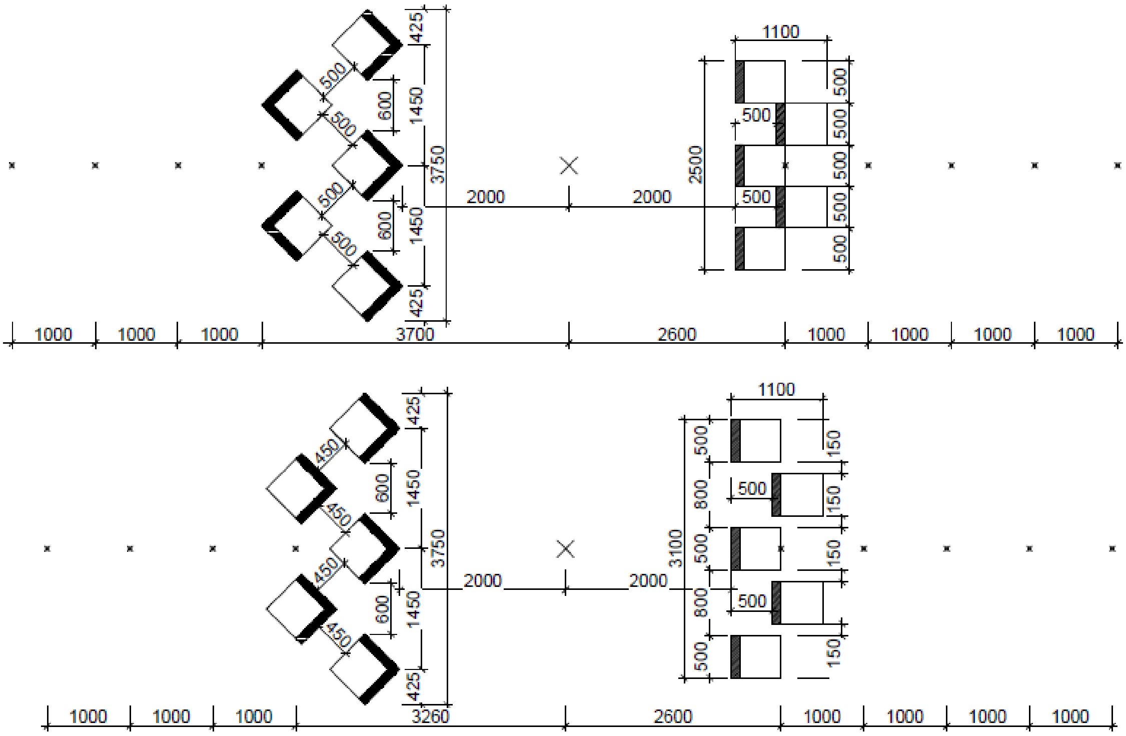

Fig. 1: Tested Arrangements of Concrete Barriers: 1A (top left), 1B (top right), 1D (bottom left), 1E (bottom right). Dimensions in mm.

Fig. 2: Barrier Layout 1A and 1B set up on site.

One additional arrangement was considered (1C). Five precast walls were positioned in line and were equipped with custom made steel console pointing at 45 degree angle towards the explosive. This arrangement was added to the original set because the numerical study predicted greater effectiveness of angled shape than basic rectangular shape used in arrangements 1A, 1B, 1D and 1E.

2.3. Data collection and results

During the experiments, the pressure sensors were used to measure the peak overpressure at the front of passing pressure wave. For each arrangement, the sensors were placed in multiple distances with step of 1000 mm as shown in Fig. 1. Each experimental arrangement was repeated at least twice.

The obtained results are summarized in Fig. 3 and Fig. 4. The figures show comparison of the measured peak overpressure on the front of passing blast wave for each considered arrangement and for situation without any barrier. Rectangular barriers (Fig. 3) do not appear to have any significant effect on the value of peak overpressure. On the other hand, the angled barrier (Fig. 4) has proven that there is a possibility of influencing the propagation of the pressure wave with rigid barriers.

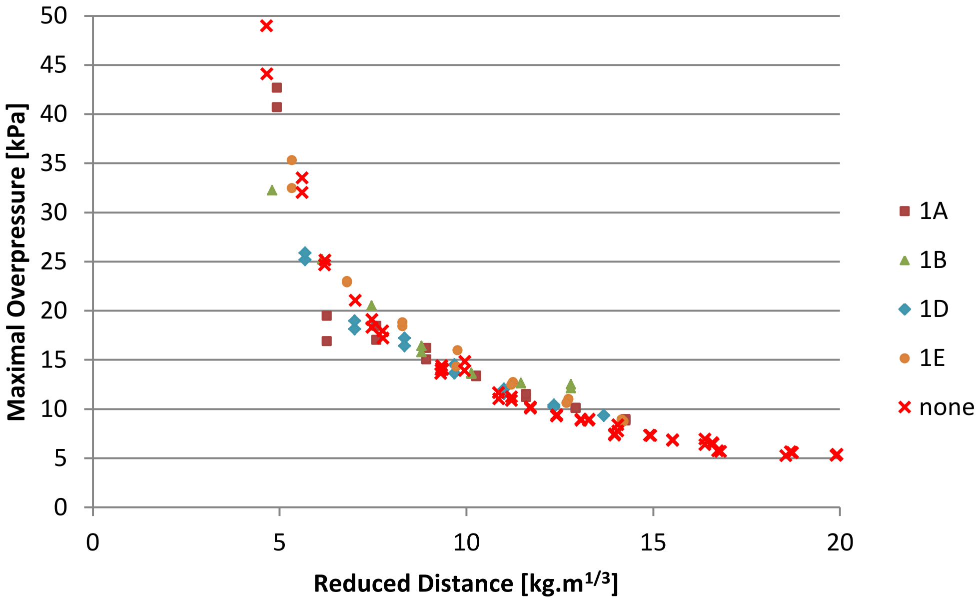

Fig. 3: Comparison of the measured peak overpressure behind barriers type 1A, 1B, 1D and 1E with experiment without barriers (Pachman et al., 2013).

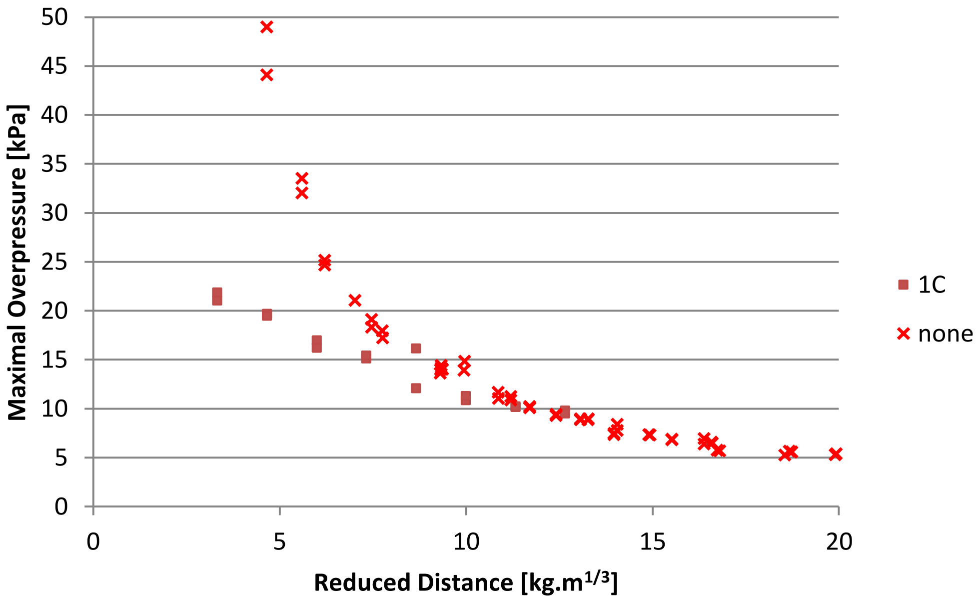

Fig. 4: Comparison of measured peak overpressure behind barrier type 1C with experiment without barriers (Pachman et al., 2013).

3. Conclusions

Although experiments were executed as planned, the results failed to prove predicted effectiveness of solid rectangular barriers. However the angled design of barrier type 1C showed some optimistic results and will most likely determine direction of further research in field of barrier arrangement optimization.

The results also indicate that even if barrier type 1C has some effect on lowering the peak overpressure, the effect is limited to the area directly behind the barrier. In greater distance the effect diminishes rapidly and pressure wave resumes its original strength. That leads to the assumption, that the very effective reduction of the peak overpressure in greater area is not achievable with rigid barriers. The main benefit of such barriers would be the absorption of potentially harmful flying debris carried by the blast wind.

Experimental data will be subsequently used for calibration of numerical FEM models used to predict pressure wave propagation. If satisfactory agreement between experiment and numerical model would be achieved, the need for expensive experiments would be reduced. Computer modelling of experiments presented in this paper can be found in Hájek & Foglar (2014).

Acknowledgements

The support of the Ministry of the Interior of the Czech Republic project no. VG20132015114 and the Czech Republic Grant Agency project no. 13-30441S is kindly acknowledged.

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