The Debris Collection and Safety Zone Areas

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Abstract. The prediction of hazard zone areas in complex urban space areas of the city infrastructure, regardless of the scale, is an advanced problem. Considering explosion scenarios caused by terrorist incidents or unexpected disaster it is hard to assess the final effect of such loadings on both infrastructure and living organisms. Moreover, the assessment of gas vapors movement through the maze of streets or corridors and its spatial accumulation is also challenging. The paper presents an example scenario of the explosion in the city centre that can be used for crisis management purposes as a hypothetical or real-world case. The primary objective is to calculate blast pressure and debris zone area and to predict the zone of survival in close to real-time manner. In this study authors would like to update the postprocessor code by adding the debris zone calculator. Nevertheless, the data must be obtained during an actual field tests. Because of the actual explosion loading details and the response of the real-size structure are often different than the laboratory or the numerical outcome must be taken into consideration in detail. It also depends strongly on the experiment preparation including the boundaries, weather conditions etc. However, it the composition of mechanical properties of applied concrete as well as concrete reinforcement. It is well known that concrete is brittle in nature. Base on the actual experiment form previous work authors would like to implement the results of the debris range into the real-time computational tool for predicting of hazard zones.

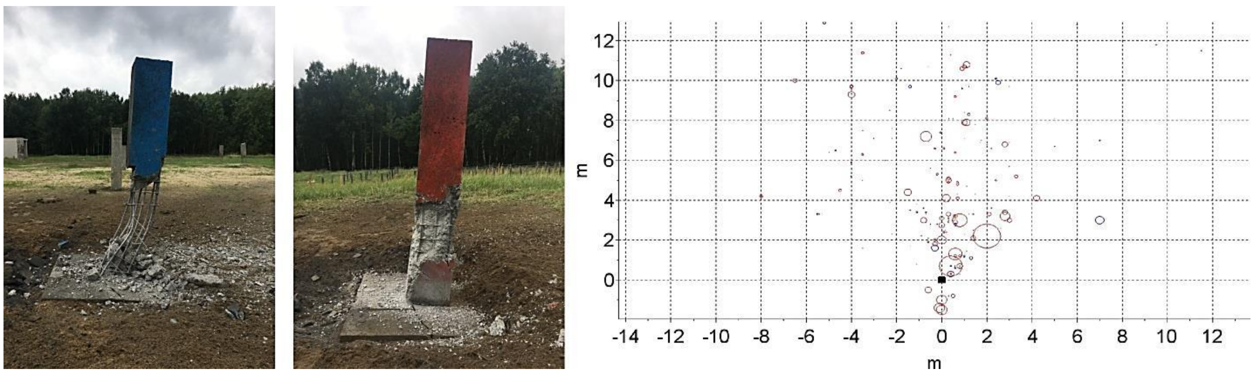
INTRODUCTION

A design of civil engineering structures to protect against the explosion scenario is a challenging task. It depends on the quality of engineer's knowledge as well as the random factors which influence strongly especially if only one experiment was performed. Concrete mixture was designed according to PN-EN 206 standard and experimental procedure for high strength concrete and iteration method of aggregate selection [8]. As components of concrete mixture the cement CEM I 42.5R, water, superplasticizer, and basalt aggregate were applied. The recipe of concrete per cubic meter was as follows: cement 420 kg, water 189 dm3, fine aggregate 0/2 - 709 kg, coarse aggregate fraction 2-8 - 506 kg, fraction 8-16 - 810 kg, superplasticizer - 1% of cement mass and steel end-hooked fibres, with the diameter of 1 mm and length 50 mm, in the amount of 50 kg per concrete cubic meter. The obtained class of concrete in the laboratory test performed according the PN-EN 12390-4 and PN-EN 206 standards equaled C60/75.

The assessment of the structural elements failure under high speed loading demands a series of approach to understand this phenomena in detail. Base on the preliminary lab and bullet dynamic impact tests the authors selected one concrete mixture for a real scale test during an actual loading scenario. The two real size reinforced concrete columns were performed. The authors prepared the actual structures with the dimension 0.3x0.3m and 2m high. As reinforcement the traditional steel rods and randomly distributed short steel fibres were applied. The series tests were conducted with the real field action of the close-in TNT explosion. The final response and detailed fragments distribution were measured.

RESULTS

The actual response of the RC columns after the tests is presented in the Fig.1. The comparison of the results, see Fig.1 (a) and (b), shows that the final response is really different. Both columns were painted by two-colour, i.e., the standard column, Fig.1(a), blue on the sidewalls and red on the front, the reinforced column, Fig.1(b), red colour on the side walls and blue on the front. The steel fibres not only reduced the failure effect as well as prevented the concrete fragmentation. In the Fig.1(c) a debris area is presented. The red circles show the fragment from the standard column, in which the diameter of the circle is the mass of the separate fragment. The blue circles represent the reinforced column response.



(a) (b) (c)

FIGURE 1. Final failure of the RC columns after the loading scenario: (a) the standard RC column, (b) specially prepared RC column with steel fiber, (c) concrete fragment distribution form both tests.

CONCLUSIONS

This study experimentally investigated the fracture response and the behaviour of the real size reinforced concrete column under the close-in explosion of TNT charge. The different concrete mixture types, steel bar reinforcement and steel fibre addon were considered. The crucial outcomes of this research are:

- A contact charge more than 2 kg of TNT was completely destructive for the 0.3x0.3 m column, independently on the mixture and reinforcement type. Concrete was totally removed from the reinforcement.
- The steel stirrups (#8mm) which were closer to the charge than the primary reinforcement (#16mm) were accelerated and cut the primary reinforcement.
- A set of three the same repeat tests, in which the real scale specimens were prepared with a special care, gave three completely different outcomes, considering the debris range and fragments velocity. It was because the steel stirrups were located in the same distance (0.1m), however, differences in the height direction of the column. This difference was about 0.03 m

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