Assessment of Damage and Protective Capacity of Buildings Exposed to Weapon Effects

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Abstract — FOI has for many years conducted experiments and developed models for assessment of damage and protective capacity of buildings exposed to weapon effects. The main tools used for these types of assessments are large scale, empirical based evaluations and more detailed finite element analyses. In this paper we present the tools that have been developed and the ongoing work at FOI in this area.

Keywords—Protective capacity of buildings, Simulations

I. INTRODUCTION

It is often of vital interest to have knowledge and tools to assess damage to buildings and injury to people in case of attacks with conventional weapons and IED (Improvised Explosive Devices). The ability to perform assessments can also be used for analysis and development of possible countermeasures for accident scenarios involving explosive events. FOI has for many years conducted experiments and developed models for this type of assessment. In this poster we present two different tools that are being used at FOI for these types of assessments, covering two different levels of detail, accuracy and ability to make large scale assessments. The VEBE tool allows for fast, large scale assessments on a city level. However, the finite element method is used in cases where a more detailed assessment of how buildings, walls and individual sections respond to blast waves and fragments is required.

II. DAMAGE ASSESSMENT TOOL - VEBE

The VEBE model ("verkan i bebyggelse")[1] was developed by FOI to simulate and calculate the extent of damage from attacks with conventional weapons against an urban area, and it can also be used to assess the extent of damage from IEDs. The simulation is performed on a digital map of buildings, underground supply systems, shelters and humans. Every building is classified individually according to a construction type scheme. Sample output from the model is explosion damage to buildings and injuries to people. In addition, simulated fire occurrence and fire spread and effects on buildings and people are simulated. Simulations can be performed either in a single round with the ability to follow the progress of damage with time or alternatively the simulation can be performed repeatedly a number of rounds with random outcomes presented statistically. The calculation sub-modules in VEBE are mainly empirically based and generalized to a limited set of building types and predefined damage levels in order to quickly provide an overview of the extent of damage. However they cannot simulate in detail the load with respect to exact geometry, neither can they in detail simulate the combined effects of blast and fragments.

III. FINITE ELEMENT ANALYSIS (FEA)

When using finite element methods the accuracy of the result and the size of the model go hand in hand with the computational time. Thus, a big challenge is to describe the behavior of reinforced concrete, as well as the loading it is subjected to, in an accurate enough but efficient manner allowing for investigations concerning large structures to be performed in a reasonable time scale. As a first step the possibility of modeling the reinforcement as a "smear out" part of the concrete was investigated using a simple concrete slab as a model structure. Also, a simplified empirically based tool was used to calculate the blast wave loading of the structure. The models were validated using experiments conducted at FOI, including a four-point bending-test under quasistatic conditions, and dynamic tests using TNT as explosive material [2].

IV. DISCUSSION

Both approaches presented are important when assessing the potential damage of an explosive device. The approach using FEA can give a more detailed and reliable results for smaller structures, and provide input to the VEBE tool. The VEBE tool, in contrast, provides a very fast and large scale picture of the effect of explosions in urban areas. Developing these two tools, especially FEA, is an ongoing research area at FOI.