ANALYSIS AND VALIDATION OF A PSEUDO UNDERGROUND STORAGE STRUCTURE DESIGN

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ABSTRACT

Current explosives safety quantity-distances (ESQDs) from conventional earth covered magazines (ECMs) impose strict limits on the planning, construction and use of ECMs in areas with high density population, infrastructure development, or limited land availability in military installations. DSTA and NAVFAC EXWC collaborated in the design of a Pseudo Underground Storage Structure (PUGSS) to reduce encumbered land. The PUGSS consists of a series of storage cells separated by blast resistant walls (BRWs). The PUGSS roof consists of heavily reinforced concrete slab with soil cover. Based on the Department of Defense (DoD) Unified Facilities Criteria (UFC) 3-340-01 and 3-340-02, the BRWs are designed to mitigate blast pressure which may cause acceptor ammunitions and explosives to detonate.

DSTA and NAVFAC EXWC conducted an explosives test of a half-scale single storage cell of the PUGSS, as shown in Figure 1 and Figure 2. The test validated that: (a) the BRW design prevents propagation of detonation to other storage cells in the PUGSS, and (b) the BRWs and the roof slab with earth cover will mitigate exterior overpressure and debris hazards. The test article had a loading density 9.23 kg/m^3. The acceptor panel of the BRW with a smallest scaled stand-off distance of 0.153 m/kg$^{1/3}$, has experienced a peak support rotation of 8.2 degrees. The roof slab with a scaled thickness of 0.083 m/kg$^{1/3}$ sustained a permanent displacement of 0.97 m with no indication of rupture or breach.

DSTA and NAVFAC EXWC analyzed the load environment and the response of the BRWs using single-degree-of-freedom (SDOF) method accounting compression membrane effects and redundancy in the load path. Due to deviations from the UFC design criteria, additional numerical simulations were completed using SHAMRC (Second-order Hydrodynamic Automatic Mesh Refinement Code), BlastX and LS-DYNA. The numerical simulations with the full SHAMRC and BlastX pressure loads showed a similar structural behavior observed in the test.

By including the design features of the PUGSS, underground magazine (UGM) explosives safety siting criteria may be applied to the full-scale PUGSS. The maximum credible event (MCE) for the PUGSS shall be a small-fraction of the storage capacity.