TOPOLOGY-BASED MODEL FOR COMBINED EFFECTS OF AIR-BLAST AND PRIMARY FRAGMENTS

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During an explosive event, damage is caused by a combination of air-blast overpressures and fragmentation effects. Although it is widely accepted that fragmentation effects cause considerable damage to structural and non-structural building elements, damage caused by fragments is often overlooked due to the perceived complexity and ambiguity of current fragment mitigation design guidelines. Furthermore, when analysis is performed for air-blast overpressures and fragmentation effects, these two analysis procedures are performed separately, which can be time consuming and lead to conflicting results. This paper introduces a topology-based framework for assessing the combined effects of air-blast and fragmentation loading. Rather than examining the effects separately, the proposed framework borrows methods developed in the mathematical field of Topology to understand the geometric relationship between the quantifiable effects of both loading scenarios.

The proposed framework uses the fixed relationship between a building's geometry and potential threat locations, to quantify damage caused by a variety of threat scenarios. Combining loads due to air-blast overpressures and fragmentation is suitable for this procedure because both loading scenarios originate from the same location. Primary fragments are assumed to radiate outward from the same charge that generates air-blast overpressures. The relationship between a point on a building's surface and the threat location is quantified by a Threat Intensity Measure (TIM). The TIM represents all the information about the expected exposure of the surface to concentrations of air-blast and fragmentation loading. For example, the TIM for air-blast loading is pressure and impulse, while the TIM for fragment loading is the momentum of each fragment. The TIMs for both loading scenarios are sorted to produce a surface area damage profile. Once the damage profile for each loading is established, topological methods are used to understand the relationship between TIMs at varying damage levels. At equivalent damage levels, the TIMs resulting from both threat scenarios are topologically equivalent. Consequently, the designer can choose to design for the threat scenario that results in the most advantageous design. The chosen design will result in the expected damage prediction independently of which threat scenario is considered.