ANALYSIS OF STRUCTURAL ELEMENTS UNDER CLOSE-IN BLAST LOADS – A DISCUSSION OF BLAST ANALYSIS METHODS FOR ENGINEERING APPLICATIONS

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Abstract:
Recent and historical terrorist activities such as Oklahoma City bombing in 1995, Brussels airport and Maalbeek metro station bombing in 2016, Manchester Arena bombing in 2017 and Easter bombing attack in Colombo, Sri Lanka in 2019 have demonstrated that targeted attacks can have devastating consequences and pose a significant threat to public safety and economic development. Due to the intentional nature of IED attacks it is unlikely the risk can ever be entirely eliminated. Therefore, the incorporation of physical mitigation methods to reduce vulnerability is often utilised to minimize the extent of the consequences as far as reasonably practicable. Typically, within building design this is achieved through blast hardening of structural elements.

Enhancing structural elements to withstand blast loading requires a thorough understanding of the dynamic response modes and element damage to determine residual load bearing capacities. Several analysis methodologies are commonly adopted within industry to achieve this; varying from Single Degree of Freedom (SDoF), Multi Degree of Freedom (MDoF), and High-Fidelity Physics based Finite Element Modelling (FEM). SDoF analysis is a simplified methodology for assessing dynamic systems where loads are uniform. Typically, these are far field blast scenarios, with a metric scaled distance exceeding 1. For close in blast scenarios, metric scaled distance less than 1, MDoF and FEM are commonly utilised to capture local phenomenon associated with localised material failure and fluid-structure interaction, where applicable.

Guidance on the appropriate analysis methodologies, particularly near the cross-over between simple and complex problems, is not well defined in standards and literature. With the development of methodologies to consider fluid-structure interactions, namely Arbitrary Lagrangian-Eulerian (ALE), the most appropriate methodology for any given problem has become even less defined. This paper aims to explore the requirements, limitations, and engineering effort for each methodology, to develop guidelines for the analysis of structural elements under close-in blast.