Mitigation of UNDEX Bubble-Jetting Effects on Structures[1]

James L. O'Daniel and Stephen P. Rowell, US Army Engineer Research and Development Center, Vicksburg, MS.
Gregory S. Harris and Roger Z. Ilamni, Naval Surface Warfare Center, Indian Head Division, Indian Head, MD.
Georges Chahine, DYNAFLOW, INC., Jessup, MD.

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Underwater explosions result in multiple loading regimes, including the formation of a shock wave and the expansion and collapse of a bubble generated within the water by the detonation. When the bubble is near a vertical structure, it can collapse and form a high-speed water jet that can strike the structure. Previous work has shown that this bubble jetting can result in significant late-time localized loading when compared to the initial shock loading. This paper presents results from an investigation into multiple concepts to mitigate the loading due to bubble jetting. A series of small-scale experiments was performed with an experimental setup designed to inflict both shock and bubble jet loads onto an unmitigated structure and then onto that same structure with a mitigation system in place between the structure and the explosion. Both flexible and rigid structures were examined, as structure response affects the bubble behavior. Although there was an issue with the scaling of the bubble, since the relative importance of inertial and gravity forces was not conserved, the data captured were used to validate numerical codes for this particular behavior. Simulations were then done on full-scale scenarios. Mitigation systems examined included bubble screens, air gaps of various configurations, water jets (i.e., fast-moving water), and several semi-solid systems that allowed water flow through a system of solid non-responding constructs. High-speed underwater video was captured to accompany the pressure and acceleration information gathered. Supporting high-fidelity numerical simulations scoped out the initial charge characteristics and were evaluated against experimental bubble behavior and structural response.

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