A NUMERICAL STUDY OF THE SYNERGISTIC EFFECT ON BLAST-RESISTANT DESIGN

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A computer test-bed is being established for the first-principle simulation of multi-scale structural failure under blast loads. Since the structural failure due to explosion involves plasticity, damage, localization, thermal softening, phase transition and fragmentation, accurate constitutive models are not yet available for building materials. Also, a robust spatial discretization method is a necessity for large-scale simulation of multi-physical phenomena involved in blast responses without invoking fixed mesh connectivity. With the development of the Material Point Method (MPM), which is an extension from computational fluid dynamics (CFD) to computational structural dynamics (CSD), a model-based simulation is performed here on the synergistic effect of blast wave and fragmentation on the dynamic structural failure response.

The transition from continuous to discontinuous failure modes plays an important role in the dynamic structural failure responses. As shown in the recent publications [1-4], the evolution of localized failure, which characterizes the transition from continuous to discontinuous failure, could be simulated via the transition among elliptic, parabolic and hyperbolic governing differential equations. Sample simulations have demonstrated the potential of the MPM in simulating the multi-physics involved in failure evolution. As can be found in the open literature [5, 6, among others], however, the synergistic effect of blast wave and fragmentation on dynamic structural failure has been usually simulated via an uncoupled approach or a "coupled" approach with an interface between CFD codes and CSD codes. As a result, numerical results are very sensitive to the choices of different time steps and meshes for different physical phenomena. Hence, a coupled approach in a single computational domain seems to be necessary if objective results are needed.

In this presentation, a numerical procedure with the use of the MPM is demonstrated through model-based simulation of several interacting physical phenomena in a single computational domain, such as case bomb expansion and fragmentation, blast wave expansion through the broken case, flight of the fragments, and blast and fragment impact on the target. As a result, the synergistic effect on blast-resistant design could be explored through this numerical study.

References

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