CUMULATIVE DAMAGE IN LAYERED TARGETS

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In recent years there has been an increased interest in the concept of employing multiple precision penetrating weapons as a means for achieving enhanced hard target kill. This enhanced kill capability is achieved through the mechanism of cumulative damage where the damage generated by each weapon in a sequence of two or more weapons accumulates in progressively deeper and deeper target layers leading to defeat of targets that are invulnerable to single-weapon attacks. Development of prediction models and mission planning tools to support employment of this technique requires an understanding of how damage is generated in layered targets, how damage progresses through the target layers with each succeeding weapon, and how penetration and detonation are affected by damaged materials.

The mechanisms involved in the cumulative damage process are inherently complex. The complexity in the problem arises because of the different damage modes that may occur, the dependence of detonation energy partitioning on the specific damage modes, varying levels and distribution of damage for each mode, finite asymmetric damage fields, and limitations on weapon accuracy. The problem can be simplified considerably by addressing only those damage modes that produce significant softening of the target over large areas and neglecting those modes that produce insignificant softening, regardless of area. For instance, a penetration hole through a burster slab is a fully damaged region of the slab; however, impact of a succeeding weapon in that region is a highly improbable event because of the small area. On the other hand, a surface spall may cover a relatively large area resulting in high probability of impact by succeeding weapons in that area but the influence on penetration is relatively insignificant. Neither of these cases contributes significantly to the cumulative damage process.

In this paper we review the various detonation conditions and resulting damage modes that may arise in a typical layered target; and introduce a conceptual model for describing energy coupling pathways and how these pathways drive the evolution of complex damage. We discuss results of two test events that demonstrate important damage modes, provide estimates of the levels of enhancement for penetration and detonation effects in concrete with pre-existing damage based on analysis of test results, and propose an approach to a mathematical model of cumulative damage.