Impact Simulation of Extreme Wind Generated Missiles on Radioactive Waste Storage Facilities

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Abstract

The structural design of temporary storage facilities for radioactive waste generally requires the fulfillment of highly severe performance criteria if compared to conventional buildings. International standards include rules and guidelines to account for design scenarios due to the natural environment, like earthquakes, extreme winds (tornadoes) and floodings, or to human intervention, like explosions and impacts. Among these, one of the most demanding external events to consider is the impact of extreme wind generated missiles. In particular, the whole building envelope has to ensure an adequate protection level, including the entrance doors, whose height and width are generally large enough to allow the transit of material handling and transportation systems, therefore representing potential weak points for external objects intrusion. In this context, the present work focuses on the study of the behavior of a double leaf steel door subject to the impact of extreme wind generated missiles. In the common design practice basically two different kinds of impact are considered: the first involves quasi-rigid small objects with limited mass and high translational velocity, this is called hard impact; the latter involves massive objects with smaller velocity and larger contact areas, we call this soft impact.
The numerical simulation is carried out by making use of COMSOL Multiphysics® Structural Mechanics and Nonlinear Structural Materials Modules (version 4.3b). Contact, which is the main source of numerical complexity, is here modeled both in a simplified way, even though effective, by imposing the non-penetration constraint in average terms, and by approximating the distribution of contact pressure over the impact area. Moreover, the nonlinear material behavior modeling allows one to obtain a realistic prediction of the energy dissipation capabilities of the structure. Both step by step static and dynamic transient analyses are performed, comparing the results with those obtained by using more simplified literature approaches, and with explicit contact force time histories provided by norms and guidelines.
The results obtained in this study give evidence that COMSOL Multiphysics® is a useful tool also for the numerical dynamic simulation and performance assessment with reference to impact problems, which represent an extremely important issue in the field of nuclear related structures design.