Research Project: Nano particle reinforced composites for critical infrastructure protection
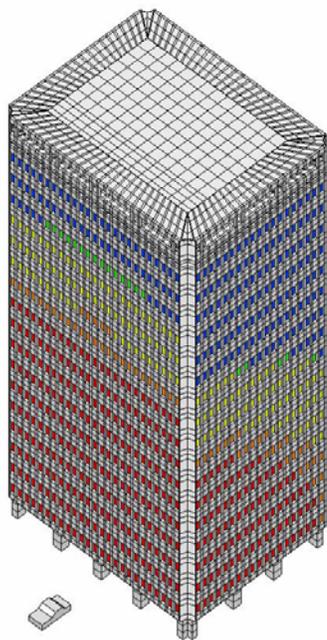
Research Topic: Building blast modeling and evacuation simulation

Problem

With the increasing terrorist threat, the vulnerability of public buildings, such as governmental offices and sport arenas, subjected to explosives, needs to be assessed. The assessment should include not only the physical damage of the building and the instant blast casualty, but also the subsequent evacuation and survivability. The assessment can be used to design stand-off distance for vehicle assess to mitigate the impact, the structure retrofitting strategies for better protection, and improved evacuation route and procedure to minimize casualty..
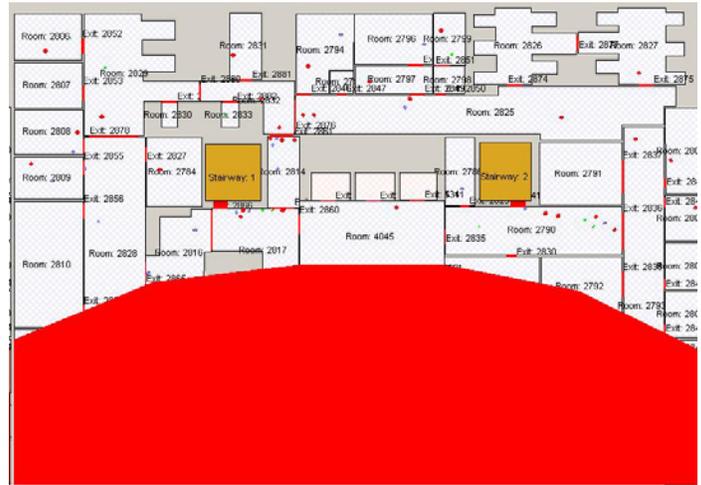
Approach

Computer modeling is used to simulate blast damage caused by a car bomb and the personnel evacuation. *E-Sim* (Evacuation Simulation) is proprietary software developed by ARA (Applied Research Associates, Inc.). It has the following capabilities: (1) model the movement of agents (humans) during normal or emergency situations; (2) serve as an assessment/diagnostic tool to determine optimal ingress/egress solutions for facilities, (3) examine where bottlenecks or problems exist, (4) evaluate and develop emergency plans, (5) aid in the design of ingress-egress or shelter-in-place for new facilities and major renovations, and (6) assist in training and planning simulations.

Blast damage of a floor. The red zone shows heavy damage. Agents in this zone are assumed to have perished. The small red dots indicated individual agents.

pedestrian dynamics. Agents can interact and exchange information when they run into each other.

Findings

The work is in progress. The evacuation scenario of an undamaged building has been established as a baseline for comparison purposes. Blast simulations have been conducted to the unretrofitted building to examine the physical damage, the evacuation time, and the casualty.
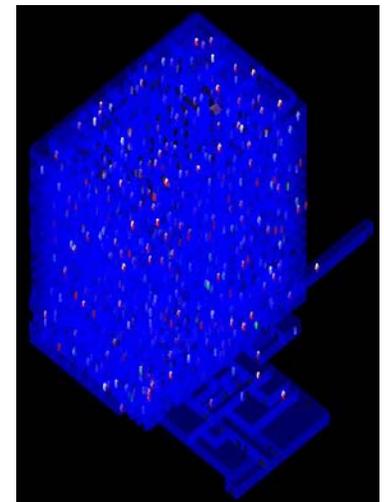
Work is underway to examine the various countermeasure scenarios such as extending the defense barrier to allow larger stand-off distances, retrofitting the building using conventional materials and structures, and protecting selected part of the building using the new generation of nano-particle reinforced materials.

Three-dimensional animation of evacuation. Each bright dot represents an agent moving through the building.

An undisclosed public building located in the State of Mississippi is selected for simulation. The floor plan and the rudimentary structural information are gathered from the responsible agency and from site visit. The location and size of the bomb threat is determined from the actual barrier location and the research team's experience. Two-dimensional blast simulation is conducted to determine the damage of individual floors. A number of agents (people) are deployed on each floor, each with cognitive capability and different

Building damaged by a car bomb, based on simulation. Red zone shows heavy damage.

Impact

The established modeling procedure can be used to assess the vulnerability of critical infrastructure subject to blast. The simulation capability allows the planner to design and select the most cost-effective defense strategies.

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