ABSTRACT

Nakano, Victor M. Ph.D., Purdue University, May 2008. A Design Assessment System to Protect Buildings from Internal Chemical and Biological Threats. Major Professor: Dulcy M. Abraham.

Recent world events involving chemical and biological (CB) attacks within critical infrastructure have highlighted a potential threat to buildings and their occupants. The March 1995 release of sarin gas in a Tokyo subway and the September 2001 mailing of letters containing anthrax spores have demonstrated the viability of using CB agents as weapons on critical infrastructure. These two attacks resulted in 17 deaths with an additional 5000 people being exposed. As a result, protection of buildings from CB threats has become an important design consideration. A design assessment system has been developed to provide decision makers with the ability to compare multiple building designs for protection against an internal CB release. This assessment system includes modeling and simulation of CB contaminant dispersion, a quantitative method to calculate protection levels, and analyses using econometric statistical and multiple objective optimization models for design selection. This thesis describes the design assessment system phases, and includes computational details for multizone modeling and exposure assessment based on median CB lethal concentrations. Multiple design options are considered which include: dilution ventilation, exhaust systems, separate air handling units, high level chemical and particulate filtration, building segmentation, and the use of a CB sensor system. Two-factor random effects and ordered probability model (with random effects) statistical models are estimated. Weighted sum, multiple objective optimization models are developed for design selection. A hospital emergency room is used as an illustrative example since it has a modern air handling system and building complexity.

The research framework and modeling described in this study can be used to assess CB protection on existing buildings or to evaluate protection alternatives in future buildings during the design concept phase. The results can assist decision makers with building planning and future capital investments. Additionally, the methodology can be applied to perform vulnerability assessments of existing buildings to determine ingress and egress routes in the event of a CB attack.