Progress Report on U.S. Research in Fire Risk, Hazard, and Evacuation

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Since the last UJNR meeting in mid-1988, considerable progress has been made in the U.S. in the areas of fire risk, hazard, and evacuation.

1. PROGRESS

In August 1989, the National Institute of Standards and Technology's Center for Fire Research (CFR) officially released its Hazard I computer model and analysis method for fire hazard analysis. Following several years of development and a year-long, formal beta test, Hazard I is now considered ready for application to real decisions in specified areas. CFR recommends that Hazard I be used only in analyses of single-family dwellings or other properties having similar sizes and layouts.

The elements of Hazard I were described to the UJNR in previous meetings. It includes four principal models: (1) a model of the growth and spread of fire effects, given a user-specified fire, (2) a model of the activation of detectors, (3) a deterministic model of the evacuation behavior of occupants, and (4) a model of the cumulative impact of fire effects on occupants, based on their exposure.

Two simpler fire hazard models were used by Harold E. Nelson to assist in the investigation and reconstruction of the 1988 fire at the First Interstate Bank Building in Los Angeles, California.(1) Mr. Nelson used the Available Safe Egress Time (or ASET) model of fire development and the Detector Activation (or DETACT-QS) model of detector activation. This analysis was the latest in a still small but growing number of real applications of computer fire models published in wide-circulation magazines to reach a larger audience than fire researchers.

Hazard I also serves as the central core of a fire risk assessment model developed by researchers at CFR, Benjamin/Clarke Associates, and the National Fire Protection Association (NFPA), under the sponsorship of the National Fire Protection Research Foundation (NFPRF). The second phase of this four-year, three-phase project was completed this month, and the prototype version of the general model is now complete. The next and last phase will address the preparation of a user's manual. Dr. Frederic Clarke will describe the model later in this session.

Hazard I and the new fire risk assessment model also served as the occasion for a new evacuation model developed by Rita Fahy of NFPA in 1989. EXIT89 is designed to combine the essential deterministic behavioral elements of Hazard I's EXITT model with modeling of the queueing and delays that occur in common exit paths of larger buildings. A presentation on EXIT89 also will be given later in this session.

In a joint U.S./Japan collaboration in the fire risk area, Dr. Ai Sekizawa of the Fire Research Institute and Dr. John Hall of NFPA developed a general

conceptual framework to describe the growing number of fire risk models in Japan and the U.S. This paper will be presented later in this session.

Under a grant from CFR, Mark Brandyberry and Professor George Apostolakis of the University of California at Los Angeles developed a set of concepts and models to use in translating laboratory tests and other physical measurements of the properties and relationships of potential heat and fuel sources into probabilities of fire ignition for fire risk analysis.(2) The example scenario used by the authors involves ignition of upholstered furniture by a portable or space heating device. Bayesian statistical techniques are used to allow experimental evidence to adjust a user-specified estimated distribution for the probability of ignition.

Dr. G. Ramachandran of the United Kingdom published in a U.S. fire research journal an overview of probabilistic models that can be applied to fire risk evaluation.(3) These models include (a) a model of ignition probability as proportional to a power of floor area, (b) a similar model of total area damaged by fire, (c) a model of area damaged by fire as an exponential function of burning time, (d) a model of financial loss as a log normal distribution, (e) logit-based models of the probability that loss in a particular fire will exceed a specified large value, and (f) Markov process models for state-transition models of fire development.

Three authors from Washington University in St. Louis, Missouri published an analysis using the event-tree format called decision analysis to assess the impact of laws requiring smoke detectors.(4) This topic had earlier been the subject of an analysis by Offensend and others through CFR.(5)

It should be clear from this review that most of the progress of the past year and a half has revolved around the CFR Hazard I project. This includes the fire risk assessment model built on Hazard I as a base, the Brandyberry and Apostolakis work to support Hazard I, and the Fahy model to extend Hazard I. Other work involves either application or synthesis of older, less comprehensive models. The latter work represents progress in the use of fire risk, hazard, and evacuation models, while the Hazard I-related work remains the principal force behind development of new models and methods for fire risk, hazard, and evacuation in the U.S.

2. REFERENCES

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2. Mark D. Brandyberry and George E. Apostolakis, "Fire Risk Analysis Methodology: Initiating Events", NIST-GCR-89-562, prepared for the National Institute of Standards and Technology under NIST Grant No. 60NANB6D0649, Gaithersburg, Maryland: NIST-CFR, March 1989.

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4. David D. Jensen, Alice E. Tome, and William P. Darby, "Applying Decision Analysis to Determine the Effect of Smoke Detector Laws on Fire Loss in the United States", Risk Analysis, Volume 9, Number 1, March 1989, pp. 79-89.

5. Susan Godby Helzer, Benjamin Buchbinder, and Fred L. Offensend, Decision Analysis of Strategies for Reducing Upholstered Furniture Fire Loss, NBS Technical Note 1101, Gaithersburg, Maryland: National Bureau of Standards, June 1979.