4.3 Available Data and Input Into Models

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Abstract

There is a need for better data to improve our knowledge of human behavior in fire. This data can be used in the development and refinement of evacuation models and in the use of such models. Once collected, human behavior data must be published in peer-reviewed journals and conference proceedings. A central repository should be created to store the data in a format that enhances its use by researchers, fire safety engineers and the regulatory community. The data collection itself must be adequately funded. We need a coordinated effort to collect this sort of information, rather than ad hoc projects when major incidents occurs. Valuable time can be lost in the pursuit and processing of funding. One important method for collecting this data is post-incident surveys and interviews. Although there are some disadvantages to this technique, it provides valuable insight into actions and behaviors in real-life emergencies.

Introduction

Evacuation models are key tools for the evaluation of engineered designs. Fire growth models can predict the spread of smoke and other toxic products throughout a structure. Evacuation models can predict the location of people as they exit the structure. Used together in the evaluation of a design, these models can provide some indication of the risk that occupants might face under a modeled scenario.

Evacuation models vary in complexity, but all rely on data, either in their development (i.e., they are calculation methods based on observations) or as input. The models may simply provide estimates of evacuation times, or they may be intended to more fully simulate occupant behavior, including decisions.

Brief Overview of Evacuation Models

There are different types of evacuation models. There are simple straightforward calculation methods for estimates of evacuation times. These equations or simple computer models may be based on observed movement from drills and experiments.

The next level of complexity is network flow models that handle large numbers of people. These models are useful for benchmarking designs, but they cannot be used to predict what any one person might experience, since they treat the occupants like water in a pipe rather than as individuals.

Behavioral simulation models are the most complex, treating more of the variables related to both movement and behavior. Their added complexity requires tremendous amounts of data for their development, if the assumptions they contain regarding behavior are to be based on reality

rather then expediency. Their users also need a fuller understanding of the components of human behavior in fire in order to choose appropriately among available options.

Types of Data Needed for Models

Data can be used to develop the equations or algorithms in models or to serve as input to the models. Data is also needed to test the validity of the models.

All evacuation models require data on the characteristics of occupants, their actions during evacuation, delays that may occur, and travel speeds for different types of occupants. Data is needed on, for example:

- delay times, i.e., the time that elapses between when people are first alerted to an incident and when they begin to leave, including the time they may take to prepare for evacuation;
- walking speeds on different types of surfaces, up and down stairs, under different degrees of crowdedness, and for people with a range of physical abilities;
- occupant characteristic, including age, gender, degree of training, familiarity, etc., to account for differences in actions and reactions among the different types of people for different types of occupancies;
- the variety of specific actions people may engage in during evacuation, since these will impact the time people take to leave the building;
- effects of obstructions in travel paths, which can cause delays or block egress; and
- exit choice decisions, which determine travel paths and affect travel times.

Sources of Data

The appropriate methods for collecting the needed data vary, and each collection method has its advantages and disadvantages.

Videotaped observations of actual evacuations are ideal, since they show exactly what different people did, and the elapsed time can be calculated directly from the tape. They will show how long it takes people to react to cues, to seek information and/or prepare to evacuate, and will record their movement (including queueing, walking speed, flows through doorways, in corridors or on stairs, precedence behavior at merges, etc.) The characteristics of their individuals, including any mobility impairments, can be determined from the tape, or can be obtained later in interviews. However, videotapes are rarely available for actual fire incidents, so what is obtained is information that, though valuable, is not directly applicable to decisions and movement of people under actual stressful conditions. Regardless of its limitations, extensive and valuable work in this area has been undertaken in recent years in mid- and high-rise apartment and office buildings. [Proulx et al 1994, 1995a, 1996]

Laboratory experiments have been done to test the effects of smoke on decision-making and travel speed. [Jin 1997, Kubota 2001] Because of ethical issues and increasing restrictions and outright bans on the use of human subjects, however, researchers rarely undertake such experiments.

Post-incident surveys and interviews can be used to obtain information from survivors of actual fires. This method has been used for a great many years (Bryan 1977 and 1983, Woods 1990, Best 1977, Proulx et al 1995b, Fahy and Proulx 1996). A methodology for conducting post-fire interviews is detailed in (Keating and Loftus 1984). Although these methods will give real-life evidence, there are disadvantages. Recollections and descriptions will be subjective. The elapsed times are not recorded objectively, and the reported times may be distorted. Details can be lost as time passes after an incident, making timeliness of data collection an important issue. Recollections of a group of people may converge over time as they share their stories and meld details.

Research Needs

In order to better understand human behavior in fire, to enhance the effectiveness and completeness of evacuation models, and to provide better information for the users of evacuations model, additional study is needed in a range of areas.

The areas of study involve the need for more data on all the time components of behavior, particularly those that are not a simple matter of speed and distance; data on the variability of those time components; and data or models on the factors driving behavior choices and the variability in time to perform certain actions. Some of the more specific areas are listed and described here:

- effects on counterflows in stairs: what do we know about the impact of firefighters going upstairs while occupants evacuate or of rescuers (e.g., in hospitals or nursing homes) returning for more people?
- movement capabilities of a wide cross-section of society: how much do we know about variations in movement capability by age or by walking impairment?
- evacuation of disabled people: how are wheelchair users expected to evacuate and how long with that take; how might their evacuation impact the overall evacuation flow?
- differences in response to a range of cues: do people respond differently to different types of alarms or different fire cues?
- waking effectiveness of a range of cues: what would be the most effective method or design to awaken people and alert them to a fire?
- delay times before beginning evacuation: what is the effect of being alone, being with others, the types and number of cues, the type of occupancy, a person's experience with false alarms?
- flows on different types of stairway configurations: what do we know about the use of space on stairs, flows on spiral stairs, the effect of the geometry of stairs?
- behaviors: who decides to stay and who decides to go; what is the basis for exit choice; how can we predict stopping and turning back behaviors; who queues and who doesn't; do we know how to predict an individual's need for rest during long evacuations?
- effects of training of staff and/or occupants: how can we begin to quantify the impact of training of staff or occupants on reducing delay times and/or improving travel times?
- perception of risk: what factors impact perception of risk and how does risk perception impact judgment?

- toxic effects: at what levels do toxic products affect decision making, movement speeds and survival and how do those effects vary among people?
- interaction between people -- how do the presence of social groups impact evacuation delays and movement?
- elevator use: assuming they were safe to use, how would they be used effectively for evacuation, and would they be used by everyone or only by those with mobility impairments?
- alarms: can building occupants recognize alarms and how audible are they throughout a building, given ranges in ambient noise and light levels?

Education and Training

Research in human behavior is a discipline that could benefit greatly from improved partnerships with researchers in the behavioral sciences. (Horasan and Saunders, 2001) Differences in approach to research between physical and social sciences must be bridged so that the best information can be identified and applied to the fire problem.

Once data is collected, it must be put in the hands of the people who can use and apply it. Two international symposia were held in recent years which have helped to focus attention on this research field, which has been an essential first step and the proceedings from the symposia are valuable resources (ISHBF 1998, 2001). However, there were few practitioners in the field of fire safety engineering present at either symposium. They need a place to find the current state of knowledge in human behavior so that they can effectively and appropriately apply available evacuation models. Model developers need access to the data so that they can use it as the basis for assumptions and calculations. Building and fire regulators need the data so that they can better understand and evaluate the analyses of engineered designs. In the overall field of fire safety sciences, researchers studying the physics and chemistry of fire need to appreciate the role of human factors in the use of products, the maintenance of systems, the response to real-world fires, and their vulnerability to fire's effects. This all points to the need for a cross-disciplinary approach to the study of human behavior in fire.

Barriers to Improved Collection and Use of Data

We lack a central repository for research on human behavior in fire. A central storage system for data would require that efforts begin to standardize the collection or reporting of collected data so that retrieval would be simplified. A first attempt to consolidate some of the available movement and delay time data has been proposed, but that was only a very preliminary first step (Fahy and Proulx, 2001).

There are several barriers that exist today that limit our ability to create such a clearinghouse. Much of the data collected over the past few decades was never published, and so, cannot be used. Any data collection project must be published in peer-reviewed literature.

A standard reporting mechanism would allow data from various sources to be compared, without unduly constraining the approaches researchers choose to use. For example, every data set should include a description of the occupancy, the capabilities of the occupants, their number,

the fire safety systems present, the effectiveness of those systems and any other information that supplies a context for the data. This would enable researchers to identify the similarities between data sets and allow comparisons or aggregations where appropriate. Aggregated data should be reported in terms of distributions that will capture the range of observations, rather than just summary statistical measures.

And finally, data must be shared. This is difficult when the research is funded by an entity that will claim a propriety right to the data. Government-funded research, however, should be disseminated as widely as possible, so that all can benefit.

Conclusion

Human behavior in fire is clearly an area that would benefit from increased research efforts. If only one aspect of the research had to be given top priority, it should be the timely collection of post-fire incident data. The U.S. Fire Administration of the Federal Emergency Management Agency contracts for the investigation of significant fires. The incidents to be investigated are agreed upon by the contractor and contract officer, with the cooperation of the responding fire department. Very little delay occurs after notification of the fire and the dispatch of the investigation team.

A similar program for the collection of survey or interview data could be instituted. This would reduce the delays that now occur while proposals seeking funding are developed and reviewed. General agreement on approach (which can vary from incident to incident) can be reached beforehand. A schedule for completion of reports and planning for their dissemination would also be agreed. Every incident needs a methodology tailored to that incident, and that unavoidable customization step takes long enough. Coordination with USFA may be necessary, since an on-scene incident investigation, including information on the fire, the geometry of the structure, the presence and performance of fire protection systems, etc., bear on the actions of the occupants in attempting evacuation.

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