Simulating Westchase Hilton Hotel Fire: An Application for the Calibration of Computer Simulation BGRAF.

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ABSTRACT:

BGRAF is a graphics computer simulation based on a CAD system developed at the Un. of Michigan, Arch. and Planning Research Lab. to simulate the egress behavior of people in fires. The model aims at studying the influence of environmental factors such as architectural differentiation, visual access & plan configuration on the decision process of route selection in fires. It also aims at investigating the behavior response patterns of people in fire situations. A preliminary report on this model can be found in the proceedings of the National Institute of Building Sciences, Building Technology and Conference, March '85.The current study further elaborates the model, and applies it to an actual fire incident, West Chase Hilton Hotel fire, as reported by the National Fire Protection Association report. The role of different model parameters, the influence of people characteristics and chance parameters, and the infulence of information flow during the event are investigated and reported. A number of computer output is also included.

L'INCENDIE A L'HOTEL WESTCHASE HILTON : SIMULATION

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MOTS-CLES

Ordinateur, Simulation, Incendie, Comportement Humain, Incendie d'hotel

BGRAF est une simulation par ordinateur graphique qui a ete elabore a l'Universite du Michigan au Laboratoire de recherches en architecture afin de simular le comportement des gens qui cherchent a sortir des incendies. Elle fait appel a la banque de donnees fournie au moyen d'un programme producteur d'esquisses qui a ete developpe au Laboratoire. Le modele vise a etudier l'influence sur le choix des voies de sortie des facteurs environmentaux tels que la visibilite et le plan des lieux et a examiner les schema ou "patterns" des reponses humaines face aux incendies. Un rapport preliminaire sur ce modele se trouve dans les actes du NIBS, Building Science and Safety Technology , March' 85. L'etude procede a une elaboration plus poussee du modele et a son application au cas d'un incendie reel-- celui de l'hotel Hilton West Chase-- tel qu'il a ete rapporte par l'Association Nationale pour la Protection Contre les Incendies. Ont ete examines et rapportes le role des divers parametres du modele sur les l'influence des caracteristiques des personnes, et les parametres dus au hasard.

INTRODUCTION

Fire safety researchers are increasingly emphasizing the role of human factors during fires (Canter,1980). As a consequence of this, several models have been developed to represent human behavior in fires. While some of these are conceptual in nature, some have been operationalized as working computer models (Chalmet,L.G., Francis,R.L., & Saunders, P.B., 1982; Cooper, 1982; Stahl,1979; Ozel, 1985), where the behavioral component largely varies from one to another. While the first two are mainly concerned with evacuation times and available safe egress time in fires, the latter two incorporate human factors to a greater degree. Stahl's computer model has been a very important step in providing a sound basis and in setting an example of how behavioral simulations can help to clarify conceptual issues to greater detail.More recent efforts by Levine (1985) and MacLennan (1985) also accept human behavior as an integral part of their conceptual structure,although MacLennan's is yet to be implemented as a computer model (NIBS '85 Conference Proceedings, p.97).

This paper attempts to summarize the results obtained by simulating an actual fire incident, the West Chase Hilton Hotel fire, by using the emergency egress model BGRAF developed at the Un. of Michigan, Architecture Research Lab. based on a CAD system developed in the lab. BGRAF besides employing advanced graphics for modeling, also incorporates environmental factors that effect way-finding and spatial orientation into its conceptual structure. (See NIBS '85 Conference Proceedings, p.91 for more on the structure of BGRAF).

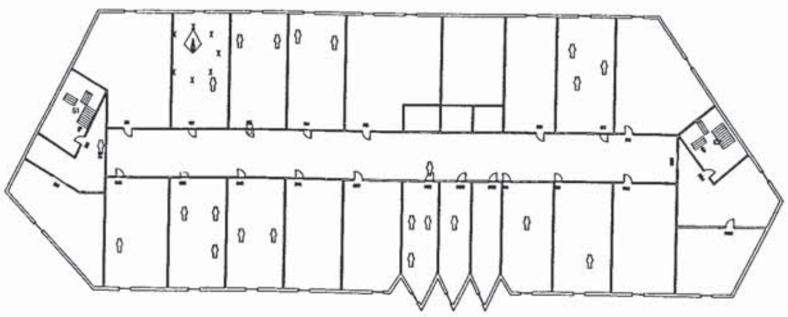

Fig. 1. West Chase Hilton Hotel, Computer Simulation Output.

WEST CHASE HILTON HOTEL FIRE, MARCH '82

The National Fire Protection Association (NFPA) report on West Chase Hilton Hotel fire was taken as a basis in simulating the 1982 fire incident in this Houston,Texas hotel, which resulted in the death of 12 hotel guests and serious injury to three others. All of the fatalities were occupants of the fourth floor, the floo of origin. The fire, which was reported at 2:25 a.m., occurred in a guest room, Room 404 (Fig.1) located at the fourth floor of the hotel's 13-story high rise tower. Table 1. summarizes the time frame of the event. At 2:20 a.m. room 404 occupant returns to discover the fire and to find his roommate unconscious in the room. As he takes his friend out, he leaves the room door only partially closed. This contributes greatly to the spread of fire and smoke into the corridor. No early warning was reported by means of alarms or smoke detectors.

(Table 1.): Time Line of Significant Events

2:00 a.m.	- Odor of smoke noticed - 10th floor
2:10 a.m.	- Light smoke noticed - Room 804 Phone call to operator, Automatic alarm is sounding at control panel.
2:20 a.m.	- Room 404 occupants return, Smoke in fourth floor corridor, Discover fire in Room 404.
2:25 a.m.	- Telephone alarm to Houston Fire Department.
2:31 a.m.	- District chief on scene. Fire showing from fourth-floor window(full room involvement had occurred before 2:31 a.m.).
2:38 a.m.	- First water applied to fire in room 404.
2:41 a.m.	- Fire knocked down.

(NFPA report on West Chase Hilton Hotel fire,p.21)

Actions taken by people: Due to lack of early warning by fire alarms or smoke detectors, a great majority of guests, most of which were asleep at the time of the fire, became aware of the fire rather late, finding that smoke and heat conditions in the corridor precluded escape. Many of the occupants indicated that they were awakened by the loud noises in the other rooms of fourth floor, which were due to efforts of some occupants to break windows and to call for help. Many reported investigating the corridor for the source of the disruption.Except for one occupant who was found in the corridor, all of the casualties were found in their rooms, behind closed doors. Only two survivors, other than the occupants of room 404, successfully used the corridor to escape. Two others were rescued by fire fighters from the corridor.

Many of the guests were only familiar with the elevators, and some were confused about the location of stairways, mistakingly trying to open a storage room door next to the stairs. The only people who seemed to be familiar with the stairs were the occupants of the room of fire origin, since one of them had used the staircase to go upstairs to his room, when he found the elevators inoperable.

SIMULATING THE FIRE INCIDENT

Assigning of values to model parameters was done by dividing the process into several sections. First, the fire spread scenario was considered and the time of first phone call to the operator (2:10 A.M.) was taken as the starting point of the simulated event. This was mainly due to the behavior component of the model, since there was no human action reported prior to this. Another decision made at this point was to restrict the simulation to the fourth floor, which is the fire floor, since most of the critical activity have occurred on this floor. On the other hand, the end of the simulation was set at the time of fire extinquishment, i.e. at 2:41 a.m. (31st min. in the simulation).

Other critical events were the spread of smoke to several remote rooms and the ventilation of one single room at fire floor due to the breaking of windows in that room. Since smoke was able to spread into rooms 407 and 408 behind closed doors,in the model the spread of smoke into these rooms was scheduled to start at 2:22 am., i.e. at the 12th minute of the simulation. This scheduling was essential, since local smoke spread in the simulation is programmed not to go through closed doors. But due to the intensity of smoke, it was able to migrate into these rooms relatively early in the course of the fire event. Smoke spread to rooms 411,412 413 and 415 was also scheduled, a few minutes later, at the 14th minute of the simulation (at 2:24 a.m.). The occupants of room 423 were able to break windows with a chair and get help. This room was scheduled to be ventilated at the 21 st minute of the event (2:31 a.m.). Another subevent, the arrival of the fire department was scheduled to happen also at the 21st minute of the simulation (2:31 a.m.). The effect of this was mainly on the amount of environmental cues available to the occupants, in some cases effecting the sleep status of the occupants, in other cases causing goal changes, such as deciding not to exit, but to go to windows for help.

The fire had started as a smoldering fire, caused by the ignition of upholstery during cigarette smoking. Initially, the model was only allowing a steady fire and smoke spread rate. After detailed consideration of the nature of the fire in West Chase Hilton Hotel, it was decided that the fire spread rate should vary in time as the simulation proceeds in order to be able to represent different types of fires. Within this context, the critical intervals of fire propagation were found by calibrating the model parameters. Doubling of spread every 8 minutes starting at 2ft. per min. was found to best represent this particular fire and gave results closest to the actual incident.

One other major factor, critical in representing the fire spread was the beginning time frame of the simulation. Obviously the exact time when the fire itself has started was very hard to estimate. The first account seems to have come from a 10th floor occupant at around 2:00 a.m., but the smell of smoke was not considered serious enough to be reported. Next critical point in time is at 2:10 a.m., when an 8th floor occupant reported considerable smoke to hotel desk and left her room. Setting the first time frame at a particular point in time effected spread rate and the interval at which this spread rate changed. Fire and smoke spread model needs to be further tested by using data from other fire events; from other fire spread models; and by using other starting points in time for this particular fire event. Currently there are plans to implement other times such as 2:00 a.m. and 1:50 a.m.instead of 2:10 a.m. as the starting point and studying the effect of this on fire spread rate and critical intervals of spread.

Since there are no accounts of human action until 2:10 a.m., setting the beginning of simulation to any other time implies that structure of the simulation should enable fire spread and human action to start at different time frames. The model already has a feature incorporated into its structure called "delay of response", which is related to factors such as alarms, sleep status, arrival of fire department, noise, smoke and fire. This enables different starting points for fire spread and human action.

Occupant characteristics: Although the occupants represented in the simulation were all hotel guests, two different groups were identified due to different sleep status and different occupant location in the building. Familiarity levels of both groups were assumed to be the same, and was reflected to the model as a higher preference level for the corridor.

Group I. Those occupants who were initially in the fire room were clustered into one group. There were only two people in this group. The occupant, who returned to the room to find his friend semi-conscious, was obviously given an initial status of awake, and the other one asleep. Since the fire was already in the room,the goal to "investigate" was given a low probability (.20) of occurence (mainly due to the search efforts of the incoming occupant to find his friend). "Egress" was given the highest probability (.80) and the walking speed was assumed to be normal (60ft./min.).

Group II. All other occupants at the fire floor were placed into second group. While they have higher probability of investigation (.40), egress probability was set at 60% . For this group, an alternate strategy was also defined for "egress" goal, which meant an alternative set of actions. These actions were comprised of "turn back","go to window" and "stay in place" actions. All of these actions were already defined in the action library of the model. Since most of these occupants found themselves in smoke upon awakening by noises from other rooms, the walking speed for this group was accepted to be reduced by smoke (30ft./min). The actions of this group has influenced how the factor "noise" was handled in the model. A factor called "probability of waking up due to noise" was introduced. Since at this point, there was not sufficient data to assign a tested value to this probability, 50% was accepted as a reflection of this lack of data. Twenty occupants were placed in group II., and their initial locations were given by using the data provided in the NFPA report.

RESULTS

Model parameters were determined by using the data provided by the NFPA report, although in some cases the best estimate method had to be used. Some of the parameters were readjusted after making several runs with the initial values. The probabilities assigned to different goals were found to be quite realistic and no major adjustments were needed.

Due to the special nature of the actual event (night time), factors effecting sleep were found to be extremely important. The most unexpected effect was created by the noise factor and by human interaction which invoked the waking up of all occupants of a room, if only one was awake in that room. By the end of 31 minutes of simulation, a great majority of occupants were awakened, while this did not necessarily meant action, since many had by that time exceeded their smoke tolerances and were incapacitated.

The probabilities of opening and closing of doors by occupants were found to be very important in effecting smoke and fire spread. After several runs, it became evident that the initial 50% probability of closing an open door should be decreased, since it was not producing the actual actions of occupants and was interfering with the fire spread portion of the simulation. After testing several probabilities, 30% was found to produce similar action patterns to the actual event. This is an example of how calibration of model parameters can generate information, which should eventually be field tested and verified.

In general, very few occupants ever left their rooms and attempted to exit, successfully replicating the actual fire incident. Besides impairment due to smoke, the smoke level in the corridor also contributed to this lack of egress attempt, since the decision process of opening a door and entering an adjacent space was also based on the level of smoke in the other room. If it was beyond the tolerance level of the occupant, he did not enter the room. This feature played an important role in restricting entry to the corridor.

Overall the simulation of an actual fire incident helped to understand the structure of human behavior. Probably due to the nature of this particular fire, information flow and delay of response were found to be the most critical factors in determining actions of occupants. The goal structure, which is an important part of the simulation, did not effect human action as much as it was expected, since people were either asleep or inacapacitated due to smoke, and were not active during the event. Currently day time fire incidents are being simulated. The comparison between night time and day time fires will hopefully reveal the effect of information flow vs.the effect of goal structure and thus actions of people. The building configuration in this particular building was not a major factor on human behavior, since most of the human action was restricted within the bounds of each guest room.

The ambiguity as to when exactly an actual fire ignition has occurred became critical when an actual fire incidence was simulated. This factor will not be as important in simulating hypothetical fire events, since fire ignition can be assumed to occur at any point in time.

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