Chapter X
Quickly Channeling Crowd Population in Emergency:
An Emergency Evacuation Command System

INTRODUCTION

Evacuation remains one of the main public protection strategies in response to a man-made or natural incident when people are at risk. In most cases when an evacuation is required, it indicates the presence of danger and urgency. By instinct, people affected act to escape from the danger; thus, two typical phenomena often occur during an evacuation: competitive behavior and herding behavior (Festinger, 1954).

If people perceive a threat and are trapped at an incident site, they try to get out as soon as possible. Usually, they look for exit signs or evacuation routes that can lead them to a safer place and proceed to the nearest one. For people near the exit or route entrance, moving toward the exit or entering the evacuation route may be the only likely escape choice. Thus, two forms of competitive behavior may exist simultaneously: the effort to pass through the exit (or enter the route) as quickly as possible, and the effort among those at risk to run toward the exits. Such behavior may cause congestion at the exits or entrance points, even to the point that people may crush one another. The India stampede event on January 26, 2005, is just such a tragedy. According to media reports (BBC, 2005; CNN, 2005), a screaming crowd fled down narrow walkways chaotically when fires broke out, causing many people to be crushed and resulting in 250 deaths.

Another well-known phenomenon in emergencies is herding behavior. When faced with uncertainty or lacking sufficient information about the situation, people tend to follow others. In an emergency situation, people trapped at the incident site may not know the location of evacuation routes or which route will lead them to a safer place. If everybody else moves toward certain directions, individuals may not undertake detailed decision making but rather just follow the others. Thus, a mass of people moving toward the exits in the same directions form. Unconsciously, the people involved create a new emergent norm that guides their behavior. Herding behavior sometimes can facilitate safe evacuations, *when the people at risk form an orderly movement to avoid a stampede. However, if those in the rear push forward, injuries from falling and crushing likely will occur.*

In other cases, people receive injuries because of the behaviors of the crowd during the evacuation rather than the actual cause of the emergency. Because evacuation is a form of collective behavior, reducing the occurrence of crowd stampeding, and congestion represents a major issue for those who must organize an effective evacuation. In addition, factors such as the number of available evacuation routes and the capacity of each route affect a successful evacuation. In this chapter, we present a model of evacuation that helps both evacuees and evacuation commanders achieve a quick and safe evacuation plan, should an emergency situation occur. We implement the model as a computerized emergency evacuation command system (EECS).

The EECS guidance system adopts everyday methods of direction, such as traffic signs guiding traffic flow, directional markers pointing people to the right store inside a huge mall, or descriptive signs helping patrons find a specific aisle in a grocery store. The system also takes dual roles. First, it informs all people at risk about the location of the nearby evacuation routes, the condition of each route, and where to leave safely without congestion. On the basis of this information, people in the affected area can make quick decisions to follow the least congested route and escape from the affected area safely.

Second, it helps evacuation commanders determine (1) the time required to evacuate people at risk safely; (2) the routes to use for the evacuation (inbound or outbound traffic), according to their geographic characteristics; (3) the capacity of each evacuation route, given its constraints; and (4) the number of people or rescue materials that should be assigned to each route to avoid overload and congestion. Depending on the characteristics of the incident site, the proposed model can generate an evacuation strategy that allows for safe evacuations of a big crowd in the least time and without congestion. By simulating human movement, the system also can display this information graphically, updated within very short time periods to reflect the current situation of each route.

Because evacuation may be necessary in any place—a high-rise building, a social gathering place (e.g., sport field, lecture hall, subway station, shopping mall), a city, or a region—and because the characteristics of evacuation sites determine human walking behavior, we consider three types of cases. First, an evacuation may occur in a place in which stairways are not used as evacuation routes, such that people may crowd in a non-compartment open area, with single or multiple routes leading away from the affected site. Second, an evacuation may happen underground, such as in a subway station. In this case, people must go up to the ground level using stairways. Third, an evacuation could happen in a high-rise building, for which stairways are the primary evacuation routes. We model human moving behavior and discuss how to generate a strategy that can quickly channel the crowd safely during an emergency in each case.

In the remainder of this chapter, we briefly review existing research on evacuation, and discuss some of its important factors. We next discuss evacuations in three cases: non–high-rise site, one-story building, and high-rise site. In each case, we consider the geographic characteristics of the evacuation site and model people's moving behavior using models that calculate the minimum time required for safe and complete evacuation. To help evacuation commanders organize a quick and successful evacuation during an emergency, we present our computerized emergency evacuation command system (EECS), which indicates the evacuation routes from the affected area, displays alternative routes, and manages congested rotes. To verify the proposed evacuating method, we conduct a simulation in which we compare EECS with two benchmark cases:, random self-evacuation and herding behavior.

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