ABSTRACT

Title of Thesis: A STUDY ON TOTAL EVACUATION VERSUS SELECT EVACUATION FOR HIGH-RISE OFFICE BUILDINGS

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Over the past hundred years, high-rise office buildings have been evacuated primarily due to fire incidents and terrorism attacks. Due to these incidents, there has been attention given on how to evacuate high-rise buildings more efficiently.

Therefore, this thesis focuses on evaluating the evacuation strategies of high-rise office buildings, with particular attention directed to how these strategies are affected by a building's size and occupant density. It discusses and demonstrates the issue of evacuation time as it relates to high-rise office buildings through the use of an evacuation model, EXIT89, and reviews the resulting times established by the model for each total and select evacuation strategy.

Overall, this research resulted in identifying that there are differences in the performance of the total and select evacuation strategies, with a greater penalty in the overall evacuation case than in the local case (time to get evacuees out of the affected area).

A STUDY OF TOTAL EVACUATION VERSUS SELECT EVACUATION FOR HIGH-RISE OFFICE BUILDINGS

by

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DEDICATION

My Grandmother, Marina Gilbert

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CHAPTER 1

INTRODUCTION

1.1 DEVELOPMENT OF HIGH-RISE BUILDINGS

High-rise buildings began to appear around the 1880's (O'Hagan, 1977), and the first high-rise office building was constructed in the 1889 reaching a height of 309 feet (Matlins, n.d.). Since then, as this type of structure grew in popularity with the number and size of high-rise buildings or "skyscrapers" as they came to be called (Hall, 2001) increased rapidly. The Empire State Building, completed in 1931 at a height of 1,250 feet (The Skyscraper Musuem, n.d.), held the record for tallest building in the world until 1974, when it was surpassed in height by the Sears Tower at 1,450 feet (Council on Tall Buildings and Urban Habitat, 1997).

In the 1960's and 1970's, the push to build upward was primarily driven by economics, as real estate, especially in major cities, became a premium. By 1973, New York City had 77 buildings greater than 500 feet, including the newly constructed World Trade Center Buildings (National Bureau of Standards [NBS], 1979). As of October 2001, the top ten tallest buildings in the world ranged in height from 1,148 feet to 1,483 feet, according to the list developed by the Council on Tall Buildings and Urban Habitat (2001). The current "Official World's 100 Tallest High-rise Buildings (Office Use)" lists buildings building ranging in height from a low of 762 feet to a maximum of 1,671 feet (Emporis Building Database, 2004).

From the 1880's to the late 20th-century, the labeling of the high-rise buildings were redefined based on their ever increasing gross building areas. The Skyscraper Museum has developed the categories of *Jumbo* and *Super Jumbo* to describe the biggest buildings over this period of history. Between the periods of 1880 and 1900, *Jumbo* and *Super Jumbo* were used to describe gross building areas under 250,000 and 500,000 square feet, respectively (The Skyscraper Museum, n.d.). By the last half of the 20th century, the term *Jumbo* describes a gross building area greater than 2,000,000 square feet, and *Super Jumbo* greater than 4,000,000 square feet (The Skyscraper Museum, n.d.). Since 1950, 31 high-rise buildings around the world contain two-million or more square feet in gross building area (The Skyscraper Museum, n.d.). The highest concentration is in the United States: New York City (14); Chicago (6); Pittsburgh (1); Boston (1); and Detroit (1). The remainders are in Canada (1); China (1); Japan (4) and Kuala Lumpur (2) (The Skyscraper Museum, n.d.).

While high-rise buildings create great efficiencies in the use of real estate by providing housing and/or office space for more people per square foot of land, it is these very efficiencies that create the potential for increased problems in the event of an emergency, by both increasing the consequences of the disaster and increasing the challenges in an evacuation. The evacuation of high-rise buildings, and the effect of density of people in the buildings, is the focus of this research.

1.2 HISTORY OF HIGH-RISE OFFICE BUILDINGS

As mentioned previously, the first high-rise office building, The World Building, opened in New York City in 1890, at a height of 309 feet (Matlins, n.d.). In the early 1900's, high-rise office buildings began to grow dramatically, doubling and tripling in height. By 1931, the Empire State Building in New York City was completed at a height of 1250 feet (The Skyscraper Museum, n.d.).

During the years following World War II, high-rise office buildings were built taller, and could be found in locations across the United States and around the world. The World Trade Center in New York City was completed in 1970 with the official opening on April 4, 1973 (The Skyscraper Museum, n.d.). These twin towers reached heights of 1,368 feet and 1,362 feet (The Skyscraper Museum, n.d.). Just a few years later, the Sears Tower was completed in Chicago, Illinois, reaching a height of 1,450 feet tall (The Skyscraper Museum, n.d.). In April 15, 1996, the Petronas Towers in Kuala Lumpur claimed the crown, being named the tallest two towers in the world by the Council on Tall Buildings and Urban Habitat (n.d.), at a height of 1,483 feet.

One of the factors enabling increasing heights has been the improvements in construction technology. ". . . there has been a gradual evolution in their construction from cast iron and wood to steel frame protected by concrete (O'Hagan, 1977)." An example of one of the first steel frame buildings is the Home Life Insurance Building in New York (O'Hagan, 1977). Within the 21st-century, these materials are being used to construct the even taller high-rise buildings. An example of this is in the Petronas Towers, which consist of steel-reinforced concrete columns and high-strength concrete with curtain walls of glass (The Skyscraper Museum, n.d.).

Along with improvements in exterior construction, interior design and fuel loads within high-rise buildings also changed. Earlier designs included a single stairway, protected on the landings by a metal-covered wooden door and enclosure, unenclosed elevator shafts, and interior standpipes located outside the stair enclosures

(O'Hagan, 1977). This style of design was found in the Triangle Shirtwaist Building, which had a severe fire that killed 143 garment workers. As a result of this fire, the focus of fire protection went from reducing large fires destroying entire cities to a ". . . greater appreciation of and accountability for safety of life (Grant, 1993)." From this focus, two pamphlets were published in 1912 which served as the basis for the development of the Life Safety Code (Grant, 1993)

Due to the development of Life Safety Code, the interior designs of today's buildings include multiple stairways, enclosed vertical shafts, and automatic sprinkler protection with interior stair-access standpipes (National Fire Protection Association [NFPA] 101, 2003). Along with these changes in fire protection, the interior designs now contain "…new materials such as plastics for cladding; new types of construction such as light weight walls, shafts for air conditioning etc (CFPA, 1977) ." In addition, the office walls which used to serve as part of the compartmentation of the building have been replaced by open floor plans containing modular partitions. The offices containing wood desks and metal filing cabinets were located throughout floor plans have been also replaced with modular offices which are constructed from an assortment of products including large quantities of plastics. On the negative side, these innovations have contributed to an increased fuel load, leading to the rapid build-up of heat and the fast spread of fire, and the ductwork provides a potential pathway for smoke (NBS, 1979). Furthermore, these changes have increased the exposure of occupants to toxic and smoke-filled environments which, in turn, make their evacuation in a timely manner extremely difficult.

1.3 CURRENT DEFINITION HIGH-RISE OFFICE BUILDINGS

Before developing the input for evacuation model discussed later in Section 4 of this thesis, it is important to explore the various definitions of high-rise buildings. This allows for the development of baseline hypothetical buildings to be used that are representative of the high-rise community, as well as to note the variations in the definitions used.

Throughout much of the United States, the National Fire Protection Association (NFPA) codes and standards have been accepted as the basic guideline for the design and construction of life safety requirements for buildings. NFPA 101, *The Life Safety Code*, 2003 Edition, Section 3.3.27.7, defines a high-rise building as "a building greater than 23m (75 ft) in height where the building height is measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story." This 75 foot requirement was established based on the effectiveness of exterior fire fighting attack capabilities on evacuations. (Boring, Spence, and Wells, 1981)

In 1975, the Confederation of Fire Protection Association-Europe (CFPA-Europe) collected data on the heights that defined high-rise buildings based on the associated building codes of the eleven attending countries. The defining heights ranged from a building over approximately 72 feet to a building over approximately 164 feet for office buildings (CFPA, 1977)

In 1977, another definition of a high-rise building was offered based on the lack of exterior access to the upper floors for fire fighting (O'Hagan, 1977). This definition referred to the approximate reach of the standard aerial ladder engine, which was 100 feet in height.

Another, less quantitative, definition is provided by the General Services Administration (GSA) which in an international conference on fire safety in high-rise buildings held in 1971 in Warrenton, Virginia, stated that:

> A high-rise building is one in which emergency evacuation is not practical and in which fires must be fought internally because of height. The usual characteristics of such a building are: -It is beyond the reach of the fire brigade's equipment. –It provides potential for significant stack effect. –It requires unreasonable evacuation time (GSA, 1971a)

Table 1-1 summarizes the different definitions used for minimum height of high-rise office buildings. For the basis of this thesis, 75 ft (approximately five stories) will be used to define the minimum height of a high-rise office building.

Table 1-1: Definitions of high-rise office buildings.

Source	Definition for High-Rise Office Buildings
NFPA 101, *Life Safety Code* (NFPA, 2003a)	"A building greater than 23m (75 ft) in height where the building height is measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story."
Confederation of Fire Protection Association-Europe (1977)	"A building with height ranging from a cut-off point of "over 22 meters" [approximately 72 feet] to the highest point of "over 50 meters" [approximately 164 feet] for office buildings."
John O'Hagan (1977)	"A building that lacks viable exterior access to the upper floors for fire fighting [approximately 100 feet]."
General Services Administration (1971a)	". . . A building beyond the reach of the fire brigade's equipment [about 75 feet]; it provides potential for significant stack effect; and it requires unreasonable evacuation time."

By contrast, there are no established maximum height requirements for high-rise office buildings. With the ongoing development and use of high-strength construction materials, new heights are being continually reached. In 2004, the Petronas Towers were surpassed as the highest office building in the world by the Taipei 101 (Taipei Financial Center) in Taipei, Taiwan, which reaches a height of 1,671 feet (Emporis Building Database, n.d.).

1.4 SAFETY CONCERNS OF HIGH-RISE BUILDING EVACUATIONS

There exist many situations that would require the evacuation of a high-rise office building. While fire is certainly the most likely given the historic trends, it is far from the only reason. Indeed, Pauls (1977) noted that "Fire is usually considered the most probable reason for rapid evacuation of all or part of a building; however, other emergency conditions, such as bomb threats, tornadoes, or loss of electric power might lead to evacuation in certain types of buildings." However, as stated, review of data for the past twenty-seven years indicates that the evacuation of high-rise office buildings has been primarily due to fire incidents and terrorism attacks. (National Research Council Canada, 1977)

1.4.1 FIRE

Throughout their existence, high-rise office buildings have had their share of fire incidents. One of the most deadly fires occurred approximately 20 years after the first high-rise office building was constructed. As previously stated, the fire, which occurred in New York City on March 25, 1911, on the eighth floor of the Triangle

Shirtwaist Company, was blamed for 143 fatalities and the estimated evacuation of 600 occupants from the building (Grant, 1993). Four additional fire incidents occurring in high-rise office buildings are First Interstate Bank, One Meridian Plaza, the Los Angeles County Health Building, and the Cook County Administration Building, which are notable for their fatalities, property damage or both.

The First Interstate Bank, located in Los Angeles, CA, experienced a fire on Wednesday, May 4, 1988 after business hours (Klem, 1992). Four of the floors of the 62-story building were completely destroyed, and millions in property damage was incurred. The next major high-rise fire broke out on Saturday, February 23, 1991, in One Meridian Plaza, located in downtown Philadelphia (Klem, 1992). This fire extended over eight of the total 38 floors, from the 22^{nd} to the 29^{th} floor. Three fire fighters died battling this fire. This was followed just over a year later by a fire on the seventh floor of the Los Angeles County Health Building on Saturday, February 15, 1992 (Klem, 1992). Twenty-four fire fighters and one civilian were injured as a result. More recently, a high-rise office fire occurred on October 18, 2003 in the Cook County Administration Building in Chicago ("Chicago Police", 2003). The fire occurred at the close of the business day, killing six people and injuring seven others. These fires occurred during non-peak business hours.

Appendix 1 is a table of extracted listings of the fatal fires in high-rise office buildings taken from the "International Listing of Fatal High-Rise Structure Fires 1911-Present" (Hall, 2001, Appendix A). The listings include date of the fire, building, reported dollar loss, location, number of deaths, floor of origin, and height in stories. This list was last revised by the author, Hall, in October of 2001.

1.4.2 TERRORISM

Within the United States, terrorist attacks have been blamed for three high-rise incidents; the damage to the World Trade Center in 1993, the devastation of the Oklahoma Federal Building in 1995, and the total devastation of the World Trade Center Towers in 2001.

On February 26, 1993, a bomb exploded in a subterranean garage of the World Trade Center in New York City. This explosion resulted in six fatalities, 1,000 injuries and the evacuation of over 100,000 people (Fahy and Proulx, 1995).

In 1995, the Alfred P. Murrah Federal Building in Oklahoma City was destroyed when a bomb was detonated parked on the outside curb of the building. This attack claimed the lives of 167 people and injured 759 people. There were 361 persons in the building (Mallonee, Shariat, Stennies, et al,1996).

To date, the most devastating attack and evacuation event in a high-rise office building occurred on September 11, 2001. This terrorist attack on the World Trade Center Twin Towers in New York City is blamed for 2,830 fatalities (Federal Emergency Management Agency, 2002), and the forced evacuation of an estimated 10,000 to 14,000 occupants in the two towers (Pauls, 2002)

These attacks and the numerous other fire-related fatalities have focused the attention of the popular media and technical experts of many disciplines on ensuring safer high-rise office buildings.

1.5 HIGH-RISE BUILDING CONCERNS

Since the World Trade Center collapse in 2001, there have been questions on whether the exit capacity of the building was sufficient for the amount of occupants in the building. "A change in the New York City building code in 1968 reduced the number of stairs in tall buildings (Dwyer and Flynn, 2005, p. 109)." The authors, Dwyer and Flynn (2005), compared the number of exits provided in the Empire State Building versus the World Trade Center Towers. The Empire State Building has five stairwells from the sixth floor and up and a fire tower (a stairwell with a vestibule that functions as an air lock) for 2.25 million square feet of office space. They estimate about 15,000 occupants. The World Trade Center Towers had three stairwells to all floors for about 4 million square feet of office building. They estimate about 20,000 occupants. Not only is the number of stairs being questioned, the location of the stairs to each other is being questioned since the World Trade Center stairs were located in the center of the building. (Dwyer and Flynn, 2005)

The distance of travel of the occupants as it relates to fatigue is also being questioned. In the first bombing of the World Trade Center, the evacuation of individuals from Tower 1 took up to 4 hours 5 minutes, and from Tower 2 took up to 3 hours 27 minutes (Fahy and Proulx, 1995). The Siu Ming Lo and Barry Will (1997) have authored a paper addressing fatigue in climbing down stairs in high-rise buildings. They suggest an area of refuge be implemented for every 18 floors for individuals to rest during the evacuation of the building.

1.6 HIGH-RISE BUILDING EVACUATION EXPERIENCEES

When the first high-rise office buildings experienced fires in the early 1900s, rescuing large numbers of occupants from the upper floors during an emergency became a new challenge for the fire protection community. First, access to the occupants on the upper floors from the exterior of the building was limited to the reach of the aerial ladder, which was 75 feet (approximately the building's fifth floor). To reach occupants on the upper floors, rescuers had to traverse the stairwells, moving against those people trying to evacuate the building. “Such fire fighting activities must now be largely carried out inside buildings, since most floors in high-rise structures are out of the reach of effective external operations (NBS,1979)."

Second, fire protection systems were not installed in these early high-rise buildings; specifically, automatic sprinkler protection was not provided. Not only were fire fighters tasked with rescuing occupants, they also needed to control the fire to prevent the structure collapsing on them and the escaping occupants. Furthermore, the use of an emergency voice/alarm communication fire alarm system had not yet been developed. Occupants were notified by bells and horns, and were therefore unable to receive specific evacuation instructions (NBS, 1979).

In addition to design and construction issues, the increased height of high-rise buildings had other effects, which concerned the human element. In a study on the human behavior of the occupants evacuating the World Trade Center after the 1993 bombing, a total of 218 out of the 379 surveyed voluntarily left the building. Thirty-five of them attempted to leave, and 126 of them did not leave voluntarily. Of these 126 occupants, some were waiting for further instruction, did not realize that there was a problem, or waiting on better conditions. (Fahy and Proulx, 1995) "Pauls and Proulx have indicated the need in predicting evacuation times to be sure to accurately assess this evacuation time delay relative to the population characteristics as influenced by the occupancy of the building . . . (Bryan, 1998, p. 6)."

Another aspect of the human element is the influence of fatigue in evacuation. Fatigue was characterized in an article published in the Fire Safety Science-Proceedings of the Fifth International Symposium referencing the need for areas of refuge for high-rise buildings. Here, the author states "It has been found that evacuees will normally experience fatigue while traveling in a downwards direction after approaching nearly about 5 minutes…" (Lo and Will, 1997, p. 739) They predict the evacuees will become fatigued after having traveled about 18 stories.

1.7 TYPES OF EVACUATION STRATEGIES

Under Chapter 4 of the *Life Safety Code* (2003a), one of the chief objectives cited is occupant protection. Specifically, it states "a structure shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the time needed to evacuate, relocate, or defend in place." With the increase in height of high-rise buildings, considerable debate has developed concerning which of these three types of evacuation strategies to use. Each is described in the following paragraphs.

1.7.1 TOTAL EVACUATION STRATEGY OF HIGH-RISE BUILDINGS

Total evacuation of a high-rise building includes the complete exiting of all occupants within the building to the outside of the building. From childhood school days onward, fire safety education has instructed occupants to leave burning buildings upon hearing the fire alarm. The current NFPA campaign for children titled "Sparky's ABCs of Fire Safety" includes, "Get out fast when you hear an Alarm because Big fires start small." (NFPA, n.d.) This approach uses the "flight" mode from the instinctive "fight or flight" mechanism.

This instinct has been noted by Woods as "One of the instinctive acts of a person who finds himself in a fire, or any situation over which he does not have mastery, is to run away from the 'hostile environment'." (Marchant, n.d., p. 51) Woods studied 952 fire incidents to arrive at three general types of reactions individuals had to a fire. One of these reactions related to the individuals' concern with evacuating the building by themselves or as part of a group. While this instinct to flee is quite strong, it can be frustrated in high-rise buildings, as the fire may be located several floors above or below the individual's location. (Canter, 1980) Thus, danger is placed on the path of flight given the natural instinct and intuitive good sense of leaving a burning building; it should come as no surprise that, in the early years of high-rise office buildings, occupants were instructed to leave the building upon hearing the fire alarm system.

The question of how much time is required to evacuate a high-rise building has been discussed throughout the literature review. There are several estimates of times based on real evacuations and fire drills performed on high-rise buildings. One article stated "The maximum building height at which evacuation [total] is possible within five minutes via the stairway can be mathematically calculated and is approximately twenty to twenty-five storeys." (CFPA, 1977, p. 26) Pauls uses fire drill information to establish tables on the total evacuation of a hypothetical 15 story building. Currently, the evacuation time for high-rise buildings is estimated based on evacuation models which base their data on various fire drills. However, it is difficult to determine the exact way to give a time because the time is dependent on the building's characteristics and population reactions. (NFPA, 2000)

1.7.2 SELECT EVACUATION STRATEGY OF HIGH-RISE BUILDINGS

In the 1970's, there was a shift in the evacuation procedures for high-rise office buildings from total evacuation to a select evacuation process, in which the occupants of the fire floor and the floors above and below the fire floor relocate to designated safer floors. This shift was as a result of the 1971 conferences sponsored by the Public Building Services (which is now referred to as the GSA), which were held to discuss fire safety design of the Seattle Federal Building, a 36-story, 500-foot structure scheduled to house over 3,000 employees. During the second conference in October of 1971, it was stated "We learned that total evacuation is neither feasible nor necessary since fires can be contained on one floor or a portion of a floor. Total evacuation may result in certain occupants going to areas where there is smoke and exposing themselves to increasing risks (GSA, 1971b, p. 4-3-4-4)." There was a task group developed at the conference addressing personnel movement. The group gave a description of each of the five concepts, the associated evacuation characteristics, and the group's remarks. The five concepts were titled total building movement, partial building evacuation, vertical movement within building, horizontal movement within building, restricted movement, and staged personnel movement. (GSA, 1971b)

The shift from total evacuation to select evacuation was also discussed during the CFPA conference held in 1970. To ensure the ability to accomplish this select evacuation, the conference papers included the following statement: "Basically, taller buildings and high-rise buildings should be designed with structural and technical measures and facilities aimed at safety, so that in the event of fire, only the fire storey and the storeys immediately above and below would need to be evacuated."(CFPA, 1977, p. 26)

Hence, the Seattle Federal Building was the first federal building in the United States being designed with the intent to a select evacuation strategy. Depending on the fire incident, the evacuation of the floors above and below the fire could consist of a range of one to five floors. The instructions for the select evacuation were given through the fire alarm notification system being used by the fire department incident commander or other fire department representative. (GSA, 1971b)

Pauls defines the select [phased] evacuation in the handbook (Proulx, 2002) describes evacuating the fire floor, the floor below and all the floors above the fire floor. The occupants proceed to the outside of the building, and then the rest of the building is evacuated. This is different than the common thought process of select evacuation in that the occupants on the fire floor and one to two floors above and below the fire floor evacuate.

During the same decade, another development in fire alarm system notification provided further ability to perform select evacuations. Before the 1970's, the notification component of the fire alarm system was based on bells and horns. Zoned instructions were not possible through the use of the fire alarm system given the general nature of broadcast. In the late 1970's, the beginning of voice alarm and 'zoned' fire detections systems were developed, along with the development and installation of smoke management systems within high-rise office buildings. These systems were able to exhaust the fire floor, and pressurize the floors above and below to prevent smoke from entering the areas. With these advancements, command center personnel were able to control the evacuation of people in different areas, or floors and control the spread of the smoke into other areas or floors of the building. (Sharry, 1983)

1.7.3 DEFEND IN PLACE STRATEGY IN HIGH-RISE BUILDINGS

The third strategy noted by the *Life Safety Code* (NFPA, 2003a), defend in place, also called "stay-in-place" allows building occupants to remain inside the building until the fire is extinguished. This technique of stay-in-place is used within hospitals, hotels and residential buildings, which have different safeguards in place to accommodate their occupants during a fire incident. In addition, this technique is used for individuals with severe mobility impairments in multistory buildings. Specifically, Section 7.5.4 of the *Life Safety Code* (NFPA, 2003a) requires individuals with severe mobility impairments to have access to means of egress. In multistory buildings, the easiest way to meet this requirement is by providing "areas of refuge". (NFPA, 2003a) The definition area of refuge is an area to be used temporarily during egress as a staging area and which provides a relative safe environment to the occupant while rescue efforts are being considered.

With the passage of the Americans with Disabilities Standards for Accessible Design in 1994 (Code of Federal Regulations, 1994), more and more buildings are now accessible to disabled occupants. The need to protect these individuals in an emergency situation until the fire department is able to rescue them is an issue that is being looked at in the fire safety community. In 1993, Shields and Dunlop (1993) authored a report on the experiences of disabled occupants who had survived a fire or had gone through an evacuation. Three different options being implemented include areas of refuge, safe elevators, and the buddy system. The areas of refuge would fall under the "stay-in-place" strategy because the individual stays there until the fire department rescuers can retrieve them. According to the *Life Safety Code* (NFPA, 2003a, p. 64), “Areas accessible to people with severe mobility impairment, other than existing buildings, shall have not less than two accessible means of egress." This technique is being focused on the disabled occupants not on a large population of the building's occupants to use with the exception of the Japanese. As mentioned previously, they suggest an area of refuge be implemented for every 18 floors for individuals to rest during the evacuation of the building. (Lo and Will, 1997)

The defend in place strategy is also used in the marine industry aboard various types of ships, especially cruise ships. Cruise ships are considered to be floating high-rise buildings due to their size and amount of occupants on board. The evacuation of passengers to the water is only used upon extreme fire incidents, typically, the passengers are kept in areas separated from the incident. These ships are specifically designed with compartmentation in mind to keep the fire incident, keep the other occupants from the fire incident, and while trained fire fighting personnel on board mitigate the fire incident in the affected compartment.

The defend in place strategy does have its detractors, however, Guylene Proulx (2001) states for instance that the open concept floor plans of these office buildings reduce the containment of the fire within a compartment and limit occupant possibilities for "protect-in-place" activities. In addition, since the occupants are alert, dressed and mainly responsible for themselves, they are better prepared to evacuate their area.

1.8 LACK OF RESEARCH

Currently, the nationally recognized standards and codes do not place a limitation on the amount of time necessary to evacuate or relocate occupants from high-rise office buildings. The only reference to the ability to evacuate in a timely manner is indirect, providing economic incentives for timely evacuation by putting more onerous structural requirements on those buildings with poor evacuation capability. Specifically, Section 4.2.2 of the *Life Safety Code* (NFPA, 2003a) requires that "Structural integrity shall be maintained for the time needed to evacuate, relocate, or defend in place occupants who are not intimate with the initial fire development." The structural integrity of buildings is defined through IBC (ICC, 2003) and NFPA 5000 (NFPA, 2003b) for construction. For example, IBC requires that high-rise office buildings have building elements with at least a one-hour fire resistance rating and be fully sprinkler protected.

Along the same lines, performance based designs need to develop safety objectives that ensure sufficient time for occupant evacuation of the building and internal fire fighting rescue efforts prior to its structural collapse. (NFPA, 2000)

1.9 FOCUS OF RESEARCH: TOTAL VERSUS SELECT EVACUATION STRATEGY

This thesis focuses on evaluating the evacuation strategies of high-rise office buildings, with particular attention directed to how these strategies are affected by a building's size and occupant density. It discusses and demonstrates the issue of evacuation time as it relates to high-rise office buildings through the use of an evacuation model, EXIT89, and reviews the resulting times established by the model for each total and select evacuation. The approach will consider building size and density of occupants as they relate to total versus select evacuation strategies in order to propose which would be more suitable for each of the hypothetical building combinations reviewed.

The simulation model will be based on a representative, yet hypothetical, high-rise office building. Increases in square footage and height of the proposed layout of the building will also be incorporated into the simulations. In addition, the hypothetical high-rise office building will be designed in compliance with Chapter 38, New Business Occupancy, and Chapter 11.8, High-Rise Structures of NFPA 101 (NFPA, 2003a), especially for the capacity of the means of egress, number of exits, arrangement of the means of egress and the travel distance requirements. Chapter 38 establishes the requirements on construction, means of egress, protection of structure, building services and operating features for new business occupancies. Chapter 11.8

requires additional fire protection requirements to be installed within high-rise structures. It is presumed that the hypothetical building is equipped with the systems required in these sections, including an approved, supervised, automatic sprinkler system, so that allowances can be made to increase the travel distances to stairwells within the design of the building. As a result the hypothetical building will reflect the requirements being placed on the construction of new high-rise office buildings today. (NFPA, 2003a)

CHAPTER 2

LITERATURE REVIEW

2.1 MEANS OF EGRESS STANDARDS

During the Fourth International Symposium of Fire Safety Science, Hagiwara and Tanaka (1994) authored a paper which studied the prescriptive regulations of the means of escape for several countries. The countries included were Australia, France, Japan, the United Kingdom, and the United States. The authors based their comparison for each of the countries on the 1994 regulations found at the time in those countries. The regulations used are noted in the reference section. The tables from this paper have been re-generated and compiled in Appendix 2 to focus on the information on business occupancy and the limited assembly occupancy for conference room areas that are pertinent to this thesis. The table is divided into the four areas of means of egress design (which are; minimum number of means of escape, arrangement of means of escape, capacity of means of escape, and occupant load). The number of means of escape is the minimum number of exits required per story, portion of story or building. The arrangement of means of escape is the locating of the means of escape so that they are readily available at all times. (NFPA, 2003a) The capacity of means of escape is based on the occupant load of how many individuals can use a means of escape component. The occupant load is defined as the total number of persons that might occupy a building or portion thereof at any one time. (NFPA, 2003a)

In comparing the "minimum number of means of escape" for the five countries, three (France, the United Kingdom and the United States) address large amounts of persons versus the number of means of escape. In comparing these countries, the United States has a requirement of at least 4 or more exits when the occupancy of the area is at least 1,001 persons. The French standard requires an extra exit for every 500 persons over the occupancy of 501 persons which would be fewer exits than the United States standard up to 2000 persons, but more thereafter. For the United Kingdom, the minimum number of required exits is increased by varying the occupancy from 500 persons which require 2 exits to 16,000 persons which require 8 exits. Beyond 16,000 person occupancies, the number of exits increases by one for every 5,000 persons. Two others (Australia and Japan) base their minimum numbers of exits on the height of the buildings, with a minimum requirement of two exits at all times. (Hagiwara & Takeyoshi, 1994)

The "arrangement of means of egress" was divided into maximum travel distance, common path of travel, dead-end corridor and distance between exits. For the first, maximum travel distance, office spaces fall into the category of "general" requirements, which range from 131 to 164 feet in distance in Australia, France, Japan, and the United Kingdom. The United States has a maximum travel distance of 200 feet for non-sprinkler buildings, and 300 feet for fully sprinkler protected buildings. For the second, common path of travel, requirements range from 66 to 148 feet among the five countries. Here, the United States has the only allowance to increase the common path of travel based on fully sprinkler protected buildings. In the third, dead-end corridor, requirements range from 20 to 148 feet among the five countries. Again, the United States has the only allowance to increase the dead-end corridor distance from 20 feet to 50 feet for fully sprinkler protected buildings. Finally, for distances between exits, Australia and the United States are the only two countries giving restrictions. Here, Australia allows 30 to 197 feet for the distance. This differs from the United States which requires one-third the diagonal space distance and complete sprinkler protection. (Hagiwara & Takeyoshi, 1994)

The "capacity of means of escape" is based on the occupant load factors in every country. The United Kingdom is the only county out of the five that recognizes evacuation strategies as part of the requirements for the stair widths. Australia, France, the United Kingdom and the United States have formulas on determining the stair width which are dependent on the number of persons on each floor or the total number of persons. The United States further defines the minimum stair width dependent on whether the means serves up to 49 persons or 50 persons and greater. The Japanese standard gives minimum stair widths for both general and assembly cases. The corridors and doors follow very similarly to the stair requirement with a few changes. Most notably, Australia and the United Kingdom change their formulas depending on the number of persons being served by these means of escape. (Hagiwara & Takeyoshi, 1994) This thesis will base the minimum stair width on the requirements of the United States.

The "occupant load" for office areas, Australia and France had 108 square feet per person, with France defining non-public areas as 1,076 persons per square feet. The United States uses a similar 98 square feet per person based on the gross area of the building. For buildings greater than 196 feet high, Japan defines their occupant load factor as 67 square feet per person for the owners of the building and 43 square feet per person for renters of the building. The United Kingdom defines their occupant load factor as 54 square feet per person for open plan type, and 77 square feet per person for other layouts. Even though France has the lowest occupant load factor, the United States' occupant load factors of 100 square feet per person were used for two sizes of building in the modeling. (Hagiwara & Takeyoshi, 1994)

The above discussion gives a global perspective as of 1994 on the various egress requirements regarding means of escape. The global perspective was given to frame the requirements that are used throughout these five countries in comparison to the United States. In gathering this information and comparing it to the current requirements of the three nationally recognized codes in the United States, the following information was used because it was the strictest in the three areas.

Focusing solely on the requirements in the United States, a review of the three nationally recognized codes regarding means of egress (referred to by the Confederation of Fire Protection Association-Europe in Chapter 1 as "means of escape") is given in Appendix 2. The three codes are the *Life Safety Code* (NFPA, 2003a); the Building Construction and Safety Code NFPA 5000 (NFPA, 2003b); and the International Building Code, IBC, (International Code Council [ICC], 2003). In using a similar format (minimum number of means of egress, arrangement of means of egress, capacity of means of egress, and occupant load factors) used in comparing the five countries' standards, Appendix 3 was composed using the three codes with the applicable sections referring to the business or limited assembly occupancy use.

As can be seen, there are very few differences among the three codes regarding the means of egress requirements. The differences are in the maximum travel distances in assembly occupancies, common path of travel, and maximum projections on the stairs. Regarding the maximum travel distances, the *Life Safety Code* (NFPA, 2003a) was the most restrictive, with the maximum distance of 150 feet in non-sprinkler protected assemblies, and 200 feet in fully sprinkler protected assemblies. NFPA 5000 (NFPA, 2003b) and the IBC's (ICC, 2003) requirements for maximum travel distance in a non-sprinkler protected assembly was 200 feet, and in a fully sprinkler protected assembly was 250 feet. Under the common path of travel, the IBC (ICC, 2003) designation for offices falls under the general definition which in turn is less than the maximum travel distance requirements. This would allow the maximum travel distance to be 200 feet for non-sprinkler protected business occupancies, and 300 feet for fully sprinkler protected business occupancies. For assembly occupancies, the maximum travel distance would be 200 feet for non-sprinkler protected occupancies, and 250 feet for fully sprinkler protected occupancies. These allowances are greater than the *Life Safety Code* (NFPA, 2003a) and the NFPA 5000 (NFPA, 2003b) distances, which specify maximum common path distances of 75 feet for non-sprinkler protected occupancies, and 100 feet for fully sprinkler protected occupancies. The last difference is the maximum allowed projections into stairways which is only stated in the *Life Safety Code* (NFPA, 2003a) and NFPA 5000 (NFPA, 2003b). For this, the *Life Safety Code* (NFPA, 2003a) allows a 3-1/2 inch projection, while NFPA 5000 (NFPA, 2003b) has an allowance of a 4-1/2 inch projection.

In this research, the means of egress for the hypothetical buildings will be based on the *Life Safety Code* (NFPA, 2003a).

2.2 EVACUATION STRATEGIES

In reviewing the evacuation standards, the standards do not discuss the different evacuation strategies for high-rise buildings, with the exception of the United Kingdom. The United Kingdom bases their stair width on whether the building design is based on total evacuation or phase evacuation. Currently, the nationally recognized codes in the United States, *Life Safety Code* (NFPA, 2003a), NFPA 5000 (NFPA, 2003B), and IBC (ICC, 2003), do not require a certain type of evacuation strategy for high-rise business occupancies.

Few researchers have examined in detail the advantages and disadvantages of the two type of evacuation strategies to be used in high-rise office buildings. As stated by Guylene Proulx (2001), "Evacuation of multistory office buildings can be though of as being of two types: uncontrolled total evacuation, and controlled selective evacuation. The former is dependent largely on the nature of evacuation sequencing or deference behavior required, and the latter on the type of control imposed and the availability of voice communication system to manage the evacuation." (Proulx, 2002) As stated in the previous section of this thesis, a third evacuation strategy is termed as "defend in place" or "stay-in-place". The research on this topic is limited also, with the main focus on the relative merits of having mobility-impaired occupants in high-rise buildings staying in place awaiting the fire department rescuers.

As noted, the literature on comparing uncontrolled total evacuations versus controlled selective evacuation in high-rise office buildings is limited. Jake Pauls (1977) published two articles based on observations of Canadian fire drills using these two types of evacuation. The basis of this work has been published by the Society of Fire Protection Engineers (Proulx, 2002). Based on Canadian observations of 29 evacuation drills in Canadian office buildings ranging from 8 to 21 stories in height, Pauls developed a graph illustrating the "…what can be reasonably expected in an uncontrolled total evacuation of a 15-story building occupied by 70 able-bodied persons per floor-a fairly high-population condition that would be expected with about 15,000 square feet on each floor." (Proulx, 2002, p. 3-355) He also developed a graph depicting a controlled select evacuation of a hypothetical 15-story office building. Here, floors nine through fifteen were evacuated, and then the rest of the floors. It appears as though the floors nine through fifteen are starting to evacuate at different times. The data was based on Canadian observations of ten evacuation drills. (Proulx, 2002)

2.3 OVERALL EVACAUTION MODELING

Given that no one has yet designed a building guaranteed to be free of mishaps, the evacuation process (and thus evacuation modeling) is critical to ensuring life safety. Indeed, the prediction of occupant movement one of the key elements performance-based fire protection. (NFPA, 2000) In addition, the studying of emergency movement of people has been around for numerous years. "The major contributors include Predtechenskii and Milinskii, Fruin and Pauls" (Nelson & Mowrer, 2002, p. 367)

Egress time is affected by the number of occupants, their distribution in the building, their response to the notification used, their mental and physical characteristics, level of training, and the physical design of the egress system. Modeling of movement phenomena (as affected by these variables) is based on data collected on the emergency movement of occupants through fire drills. Many different types of models exist, including hydraulically-based models, in which the relationship between speed and density of the occupants is treated in a manner analogous to the effects of water through a piping system. (Nelson & Mowrer, 2002)

In the hydraulic model, the water moves in a homogenous manner without interruptions until reaches its endpoint. The modeled persons are assumed to travel in a homogenous manner without any interruptions due to individual decision making and they are all able bodied individuals. This allows a direct correlation between the speed of the group, the density of the group and the different size buildings with respect to evacuation time. As noted in the Society of Fire Protection Engineers Handbook,

> The use of the model calculations provides a reproducible base of reference in appraising the impact of overall systems, individual components, or changes in systems. If, however, the results of the modeled evacuation time are to be compared to a realistically expected evacuation time or to expected fire growth, it is important that the user understand that the modeled evacuation time is seldom achieved in reality. (Nelson & Mowrer, 2002, p. 368)

Within the latter part of the last century, the focus of emergency movement research is being directed on human behavior, decision making and actions taken just prior to and during an emergency situation so that this information can be incorporated with the evacuation modeling. This research is in the developing states and a consensus in the published works has not yet occurred, therefore the modeling chosen for this thesis is based on hydraulic modeling.

Even though the occupant's movements are treated similar to the movement of water, there are several formulas being used in the modeling that are based on tests and observations of occupant movements in fire drills. In the *Society of Fire Protection Engineers Handbook*, Chapter 14, Emergency Movement (Nelson & Mowrer, 2002), the formulas for emergency movement are presented and a hand calculation of an office building is given. A combinational analysis can be accomplished with evacuation modeling. The analysis is able to use computer algorithms to search through the numerous combinations of the inputted networks. (Watts, 1987) Evacuation modeling has taken these formulas and developed software to assist into repetitive iterations to optimize the modelers time.

A further decomposition of evacuation modeling is provided by Gwynne and Galea (n.d.), who published a research report reviewing 16 different developed evacuation models with descriptions on the modeling approaches and capabilities of each model, and six models which were under different development stages. This research was supplemented by the review in Erica Kuligowski's (2003) thesis work, which looked at a total of 28 computer models focusing on evacuation movement. The additional models include in this review included FPETool, Pathfinder, TIMTEX, EESCAPE, EgressPro, STEPs, Gridflow, ALLSAFE, AERI, BFIRES-2, Legion and Myriad.

These reviews were divided into four main interacting aspects of evacuation design, which are “nature of the model application”, “enclosure representation”, “population perspectives”, and “behavioral perspective”. The “nature of the model application” aspect separates the evacuations models further according to three different model types which are optimization, simulation and risk assessment. Optimization models look for the optimal path for occupants to evacuate the building, given flow characteristics and exits. These models generally treat the occupants as a homogenous group or as a large group of people without the influences of individual human behavior. (Gwynne and Galea, n.d.; Kuligowski, 2003)

Simulation models attempt to combine the individual human behavioral aspects and the movements observed in evacuations in order to achieve a realistic representation of the decisions and paths that are used during an evacuation. These models vary in the representation of the behavioral characteristics of the individuals therefore the accuracy of the results will also vary. (Gwynne and Galea, n.d.)

The last model type is the risk assessment model. This model quantifies the risks associated with the identification of hazards based on the fire or related incident and the resulting evacuation. The model runs through several iterations of different scenarios to assess the risk statistically for the changes. (Gwynne and Galea, n.d.)

For this thesis, a simulation model has been chosen due to the fact that individual movements through the egress paths can be tracked and the ability to ignore peripheral and non-evacuation activities.

The “enclosure representation” in the models refers to the enclosure from which the evacuation occurs. The enclosure can be represented with a network, which can be described as: “(a) is a natural analog or the egress flows for occupants evacuating a building; (b) provides a clear, graphic description of the important spatial relationships of the building’s egress system; (c) provides a building description that is easily modified to reflect changes in design; and (d) has a number of readily available algorithms for studying flow problems (Watts, 1987).” There are two types of networks, a course network or a fine network. These networks break down the enclosure into varying degrees of sub-regions. In the case of the course network, the enclosure is broken down into sub-regions based on the actual partitions of the structure. In the course network, the enclosure is defined using nodes to represent the room or corridor, and arcs representing the actual connections within the actual structure. The occupant moves from one segment to the next segment. In the fine network, the enclosure floor space is broken into tiles or nodes which vary in size dependent on the model. This allows the representation of entire geometry of the space to include internal obstacles and the location of each individual at during the evacuation modeling. Due to the size of the buildings being used, this thesis will be using a course network model.

“Population perspectives” is also broken down into two approaches; the individual perspective and the global perspective. For the individual perspective, the personal attributes of the individuals are used as part of the movement and decision making process. This allows the trajectories and histories of the individuals to be followed during the evacuation simulation. For the global perspective, the individual's personal attributes are not recognized and the population is treated as a homogenous group. These models track the number of occupants escaping as opposed to which individual is evacuating. The model chosen for this thesis is based on a global perspective due to the size and number of people evacuating the hypothetical high-rise office buildings. (Gwynne and Galea, n.d.)

"Behavioral perspective" takes into account the occupants decision making process and applies it determining their behavior during a evacuation. The authors (Gwynne and Galea, n.d.) divide the models into five behavioral systems which are "no behavioral rules", "functional analogy behavior", "implicit behavior", "rules based behavioral system", and "artificial intelligence based behavioral system."

"Implicit behavior" models "…do not declare behavioral rules, but instead assume them to be implicitly represented through the use of complicated physical methods." (Gwynne and Galea, n.d., p. 9) This type of model will be used for this thesis, due to the fact that behavior is not considered within the model, so that the principal consideration are the physical attributes of the population and their movement through the inputted area.

The rest of the systems deal with the behavioral traits, either through assumptions of the model or inputs into the model. These traits are not addressed in this thesis, which focuses on the influence of some of the primary parameters (density, building height, etc.) on determining the penalty associated with total evacuations versus select. It should be noted (as Gwynne and Galea (n.d.) did) that "…human behavior is the most complex and difficult aspect of the evacuation process to simulate. No model to date fully addresses all the identified behavioral aspects of evacuation." (Gwynne and Galea, n.d., p. 10) "Furthermore, not all these behavioral aspects are fully understood or quantified." (Gwynne and Galea, n.d., p. 10) Therefore, this thesis is only modeling the very basics- the occupants' have no behavioral data associated with them, and move in an ideal manner.

These four characteristics and their individual sub-categories are illustrated in Appendix 4 (Gwynne and Galea, n.d., p. 11).

2.4 MODEL DESCRIPTION

As discussed, computer models are available to estimate the evacuation times from rooms to high-rise buildings with and without taking into account these influences. A brief review of some of these is presented here, in order to indicate the strengths and limitations of the software selected (EXIT89) for this research on the difference between total and select evacuations. (Fahy, 1999a)

The National Institute of Standards and Technology Center for Fire Research (NIST/CFR) developed a program called Hazard I. Hazard I has three modeling components within it which are FAST, EXITT and TENAB. Accordingly, each component models the fire growth and smoke spread in a building, the evacuation of occupants from the building, and the impact of combustion products on the occupants as they travel through the building. The Hazard I model was limited to one- and two-family dwellings. (Fahy, 1999b)

EXITT was written by Bernard M. Levin, formerly of NIST/CFR. The program input required "…a network description of the building, the geometry of the rooms, and descriptions of the occupants (age, sex, awake/sleep, dependent on assistance. etc.)" (Fahy, 1999b, p. 816) The output of the program included "…the actions and locations of the occupants as they evacuate along optimal escape routes." This program was limited to modeling 12 rooms and 35 nodes. (Fahy, 1993)

Through project developments at NFPA, the need arose to model the influences of fire growth, smoke spread and combustion products on occupants as they evacuate high-rise buildings. In order to achieve this modeling, focus was placed on modifying the evacuation model, EXITT so as to handle a large building. EXITT did not have the capability of analyzing the effects of queuing, which is a critical component for large building evacuations. Additionally, if the model had the capacity to input the information of a large building, the model would run slowly due to the amount of bookkeeping needed to monitor each individual's characteristics, capabilities, location and motivation for their actions; and the time used due to the fact the model recalculates the escape routes for the entire building each time a room or node is blocked by smoke. (Fahy, 1999b, p. 816)

The replacement version of EXITT, which is EXIT89, has been chosen to be used as the evacuation model for this thesis. EXIT89 was developed by Fahy (1999a) to model the movement of large number of people from high-rise buildings. "EXIT89 uses a coarse network description of the geometry and a global perception of the population." This model uses the Hillier and Lieberman shortest route algorithm where individuals move to the closest exit from a local perspective even though this may not be the shortest exit path out of the building. The movement equations used in the model are based on the work of Predtechenskii and Milinskii. This model has the capacity to trace the individuals as they travel to exit the building, yet they do not have identifying traits, therefore they are considered a homogenous population. (Gwynne and Galea, n.d., pp. 17-19)

As noted, EXIT89 was developed to be used as a replacement of EXITT within Hazard I program so as to handle high-rise building evacuations with large occupant populations. The development for the model design was patterned similar to EXITT with the exception of not including detailed behavioral considerations. This was due to the belief that there were less impersonal settings in offices and hotels as opposed to homes. (Fahy, 1999b, p. 817) The model uses a network description of the building based on the "…geometrical data for each room and for openings between the rooms, the number of occupants located at each node throughout the building, and smoke data if the effect of smoke blockages is to be considered." (Fahy, n.d., p. 658) Several options are given for the user to chose:

> …whether the occupants of the building will follow shortest paths of the building or will use familiar routes; whether smoke data, if any, comes from a fire and smoke model or will be input as blockages by the user; whether there are any delays in evacuation throughout the building; whether there are any additional delays in evacuation among the occupants of the building and, if so, what percentage of the occupants will delay and what are the minimum and maximum delay times. (Fahy, n.d., p. 658)

The evacuation of the occupants can begin for all the occupants at time equal to zero or delays can be included within the input parameters.

EXIT89 begins by calculating the shortest routes from each building location on the floor down or up a stairwell to a location of safety (usually outside), or sets user-defined routes through the building. (Fahy, n.d., p. 658) If smoke data are incorporated into the input of the program, the program has the occupants travel along the calculated routes until a smoke blockage is encountered. At that point, the exit route is recalculated and the occupants continue to travel until either the next smoke blockage or they have reached the outside. If the occupants are in the stairwell and encounter fire, the model moves them out of the stairs onto the nearest floor. The basis for calculating the shortest routes are based on an algorithm by Hillier and Lieberman. (Fahy, n.d.) "The algorithm begins by identifying the origin of a network and then fans out from the origin, identifying the shortest routes to all the other nodes until the destination is reached." (Fahy, 1999b) "The locations of safety can include horizontal exits or areas on the other side of fire floor. In order for the model to recognize these locations as safety, the user identifies them as part of the building description input data." (Fahy, n.d., p. 661)

EXIT89 has the ability to handle a larger occupant population than EXITT. The program's data arrays can handle up to 700 occupants in the total of 80 nodes or building spaces over 100 10-second time intervals. (Fahy, 1999b, p. 817) "EXIT89 is set to allow 1000 5-second time steps, 10,000 links, 20,000 occupants …" (Kuligowski, 2003, p.106) The maximum number of nodes per floor is 89 nodes, including 10 nodes reserved for a maximum of 10 stairwells. (Fahy, 1999a)

EXIT89 is able to track the occupants as they move through the buildings by recording each occupant's location at set time intervals during the fire. (Fahy, 1999b, p. 817) In addition, it can calculate walking speeds as a function of density to account for changes in the crowdedness of the nodes during the evacuation. This reflects the effects of queuing found in large populated buildings.

EXIT89 can be used in three different ways. One way is a modification to the first method, with no blockages assigned and having the model evacuate the building without a fire occurring. The second way is for the user to assign the smoke blocked nodes and the time those blockages occur. The third way is to have the program read the data output from a CFAST file as input into the model. (Fahy, 1999a)

The input of the model as stated before is based on a network description of the building. The nodes can either be set up as individual rooms, sections of rooms, or corridors. The nodes are to reflect the most realistic travel paths in the building being modeled. The description of each node includes the following:

- useable floor area
- the height of the ceiling
- initial occupant load
- the number of seconds the original occupants of that room will delay before beginning evacuation
- the node an occupant will move to if the user chooses the option of having occupants move along defined routes. (Fahy, n.d., p. 660)

The nodes are then connected by a series of arcs. The arcs are considered bidirectional, and described by both the distance between nodes and the width of the openings between the nodes.

EXIT89 has seven user options to choose from at the beginning of the input file. The first option allows selection of the type of measurements (standard scale will be used in the input and output file). The second option has the user select the body size of the evacuee (Austrian selected). The third option has the user choose between emergency and normal movement of occupants based on Predtechenskii and Milinskii's work. (Fahy, 1999a) Emergency movement was used in all the modeling with the exception of normal movement for the re-generation of Paul's work discussed in Chapter 6.2. The fourth option of the shortest paths between nodes is to be used. The fifth option of using smoke data was not exercised for this modeling. The full output of all the data points was chosen for the sixth option. No additional, randomly distributed delay times were used in the last option.

The occupants are tracked in the model by assigning a number to each occupant in the building. Based on this occupant number, the output of the model describes each occupant's original location node, the node it travels from, the node it travels to, the number of occupants having left the building, and the number of occupant trapped in the building by time step.

"The method chosen for EXIT89 uses walking speeds calculated as a function of density based on formulas from Predtechenskii and Milinskii (Fahy, 1999b, p. 819)." The density calculation includes an allowance for body size of the occupants. The body size is based on the measurement of the area of horizontal projection of a person. "This measure is the area of an ellipse whose axes correspond to the width of a person at shoulder level and breadth at chest level." Based on their work, the maximum density established is 0.92. Predtechenskii and Milinskii (1978) developed an equation for the "..mean values of veleocity as a function of density for horizontal paths:

For the mean values of velocity as a function of density for horizontal paths:

$$V = 112D^4 - 380D^3 + 434D^2 - 217D + 57 \quad \text{(m/min)}$$

for $0 < D \leq 0.92$.

For movement down stairs

$$V_{\downarrow} = Vm_{\downarrow} \quad \text{(m/min)}$$

where $m_{\downarrow} = 0.775 + 0.44e^{-0.39D_{\downarrow}} \bullet \sin(5.61D_{\downarrow} - 0.224)$.

For movement up stairs

$$V_{\uparrow} = Vm_{\uparrow} \quad \text{(m/min)}$$

where $m_{\uparrow} = 0.785 + 0.09e^{3.45D_{\uparrow}} \bullet \sin 15.7D_{\uparrow}$ for $0 < D_{\uparrow} < 0.6$;

where $m_{\uparrow} = 0.785 - 0.10 \sin(7.85D_{\uparrow} + 1.57)$

for $0.6 \leq D_{\uparrow} \leq 0.92$ (Fahy, 1999a).

For emergencies, Predtechenskii and Milinskii (1978) developed the following relationships between the two velocities.

$V(e)=\mu_e *v$, where $\mu_e=1.49-0.36D$,

for horizontal paths and through openings, and

$\mu_e=1.21$ for descending stairs. (Fahy, 1999b, p. 820)

Tables of velocities by density were established by Predtechenskii and Milinskii (1978) for normal, emergency and comfortable movement along horizontal paths, through openings and on stairs. "EXIT89 originally assumed that people are aware of the fire emergency when they evacuate, so only the velocities for emergency movement were included in this model." (Fahy, 1999b, p. 820)

In terms of the occupant size, the body size calculations have been based on three different measurements. The first measurement given is based on Predtechenskii and Milinskii's work on measurements of Soviet subjects. The second measurement was based on work by Ezel Kendik measuring Austrian subjects. The third measurement was based on dimensions obtained from Occupational Safety and Health in Business and Industry for American subjects. (Fahy, n.d., p. 663) For the Austrian subjects (selected for this research) EXIT89 uses a horizontal projection area of 1.22 square feet, which were cited as the mean dimensions of an adult in mid-season street dress.

Velocities are calculated for both segments of the arc between two nodes, based on the different densities and floor areas for the two nodes. Densities are calculated in the program based upon the layouts and distribution of occupants as input by the user, with usable floor area for corridors being close to that of Predtechenskii and Milinskii's. (Fahy, 1999b, p. 820) Values for density are used to look up the velocity from the tables provided, with an upper limit on density being 0.92.

Movement within EXIT89 is based upon the parameters specified in the input data (including the aforementioned density), with the program determining how long it would take to travel from the currently occupied node to the connected node based on the occupant characteristics. The event log (noting transition to a new node) is triggered when the occupant has been at a current node long enough for them to have traversed to the next node via the specified arc, at which point the waiting time at that new node is reset to 0. Here, waiting times are actually melded into the arc traversal times. At each event (node transition), densities and time to traverse arcs are recalculated until all occupants have left the building. (Fahy, 1999b, p. 821)

Queuing in EXIT89 is addressed by adjusting walking speeds that result from the increase in density. Currently, the program does not allow occupants to shift from a congested route to a less crowded route, forcing them instead to join the queue along the shortest route. (Fahy, 1999b, p. 822)

EXIT89 has been validated by the developer, Rita Fahy, by comparing the results of the model versus the fire drill results from the three studies. The first study was based on the results from a fire drill involving 100 occupants from a 9-story building. The second validation study was based on a fire drill on a 7-story office building in Newcastle-on-Tyne in the United Kingdom. The third validation study was based on a fire drill performed on a major department store by the University of Ulster in the United Kingdom. (Kuligowski, 2003, p. 102) This model has the capacity to analyze multi-story buildings which assists in the focus of this thesis.

CHAPTER 3

EVALUATION METHODOLOGY

3.1 INTRODUCTION OF METHODOLOGY

As outlined previously, the focus of this research is on evaluating the relative merits of total versus select evacuation under varying building design conditions. Specifically, the time to evacuate a building using these two evacuation methods are determined in the three varying heights of buildings, sizes of buildings and two occupant loadings, in order to determine if the optimal method changes under varying extremes and to ascertain the magnitude of the difference between the evacuation strategies in both absolute and relative terms. This not only provides a characterization of the sensitivity of the optimal evacuation method to these primary parameters, but also provides an indication of the importance of these basic parameters. The twenty-four scenarios provided by these varying values were then used as inputs to the EXIT89 model (Fahy, 1999), and evaluations made regarding the time required to evacuate the total building and the time to evacuate the select floors under each strategy, with the optimal (shortest time) strategy identified. The first method compares the overall time for evacuees to get out of the building (total evacuation time). The second compares the time to evacuate the affected region (floors at which the emergency situation exists, taken as the top five floors here). Adding this second evaluation allows consideration to be made of the increase in relative safety by being off of the affected floors enroute the exterior of the building. The results (optimal strategies) across these scenarios depicted below provide the desired insights as a function of the primary parameters mentioned previously. Each of these parameters is discussed in turn.

3.2 OCCUPANT LOAD

The first parameter considered here is initial density. Here, occupant load (inversely related to density) is taken as the proxy for density for each floor. The minimum occupant load of an office building has been established in the *Life Safety Code* (NFPA, 2003a) as stated in the previous chapter, but has been questioned based on survey work both in the United States and in Canada. The *Life Safety Code* (NFPA, 2003a) defines occupant load as "the total number of persons that might occupy a building or portion thereof at any one time." The occupant loads for the hypothetical office buildings will be using two values which establish a range of reasonable estimates based upon traditional code values and field data collected.

The maximum occupant load is provided by section 7.3.1.2 of the *Life Safety Code* (NFPA, 2003a), which states that the occupant load for "Business Use" shall not be less than 100 square feet per person. The 100 square feet per person is based on "gross floor area" which *Life Safety Code* (NFPA, 2003a) defines as "the floor area within the inside perimeter of the outside walls of the building under consideration with no deductions for hallways, stairs, closets, thickness of interior walls, columns, or other features." Due to changes in the office layouts from compartmented offices to open plan offices, this occupant load factor has been questioned as being too conservative.

One of the individuals questioning the occupant load factor as too conservative has been Jake Pauls, who puts the load factor greater, based on both his work in Canada on evacuations and his recent review of the World Trade Center collapse on September 11, 2001. In *Fires and Human Behavior*, Pauls calculates the occupant load for one of the studied buildings with a gross rentable area of 2,765,000 square feet to be 27,650 persons. He stated, "In eighteen evacuation drills in the buildings there were only 10,281 persons counted. (In buildings where more than one drill was studied only the drills with larger populations are considered in this calculation.) The mean gross rentable area per person was 26 meters squared (278 feet squared) and not 9.3 meters squared (100 feet squared)." (Canter, 1980, p. 271)

In a recent article in *Fire Engineering*, Jake Pauls (2002) commented on the varying populations and estimating of populations for the World Trade Center. "Assuming eight million square feet of total rentable area for the two towers, with about 270 square feet per occupant, an estimate based on some my work on office building evacuations in Canada 30 years ago, there would be 30,000 occupants, total, in the two towers. Based on the *Life Safety Code* (NFPA, 2003a) occupant load factor of 100 square feet of gross area, he calculates an occupant load of 80,000. According to Pauls, the Port Authority reported having 60,000 people working in the complex, with the two towers having two-thirds the rentable area. He states that based on the two-thirds rentable area this would suggest 40,000 persons total for the two towers, which would support his estimates on total population for both towers. (Pauls, 2002)

In 1996, the Milke and Caro (1996) in conjunction published a survey of occupant load factors based on 23 office buildings which included federal government, county government, and private sector buildings. The office designs were either open plan office or well-compartmented offices. Based on the walk-through and telephone surveys, the mean occupant load factor of all the observations was 248 square feet per person based on gross area, with a standard deviation of 67.3 square feet per person. The range of data from all the observations was 140 to 418 square feet per person. The 95% confidence interval for the occupant load factor for the entire sample was 230 to 266 square feet per person. (Milke and Caro, 1996, p. 13) These values are greater than the occupant load factor established in the *Life Safety Code* (NFPA, 2003a) and form the low density scenario used here. Pauls' occupant load factor appears to be within the 95% confidence interval established under the survey by the Milke and Caro (1996).

Therefore for this thesis, the "high" occupant load factor being used will be based on the Life Safety Code (NFPA, 2003a) minimum of 100 square feet per person (gross area). This value was selected given its prominence as the code standard for approximately 70 years. The "low" occupant load factor decision was based on Jake Pauls' research over the past 30 years, which is within the confidence interval established in the Milke and Caro's survey accomplished in 1996. The "low" occupant load factor being used will be based on 278 square feet per person (gross area).

3.3 BUILDING SIZE

The third parameter, paired with occupant load and occupants, will be the building's size. The building size for the hypothetical, high-rise office building will vary in dimension by both floor plan dimensions and building height. The floor plan layout will be based on a square building, with the number of corresponding exits based on the *Life Safety Code* (NFPA, 2003a).

The floor plan area will be based on achieving an occupant load of approximately 100 persons per floor and 500 persons per floor, using the two densities previously stated. The number of persons that require 2 exits is less than 500 persons, with 3 exits required for 500 persons up to 1,000 persons. The resultant areas for the 100 square feet per person density will be 10,000 square feet per floor for 100 occupants, and 50,625 square feet per floor for 500 occupants. The corresponding dimensions of the building will be 100 feet by 100 feet and 225 feet by 225 feet.

The resultant area for the 278 square feet per person density will be 27,800 square feet per floor for 100 occupants and 140,625 square feet per floor for 500 occupants. The corresponding dimensions will be 166 feet by 166 feet and 375 feet by 375 feet.

3.4 BUILDING LAYOUT

The floor plan layouts for each building will be based on capacity of the means of egress, number of exits, arrangement of the means of egress and the travel distance requirements, as previously discussed in Chapter 1. The initial basis of these layout areas are based on the maximum occupant load per exit requirement. This would result in a requirement to have two exits per floor for up to 499 occupants, and three exits per floor for 500 to 999 occupants. As the floor layouts were designed with office spaces and corridors, the maximum allowable travel distances from the *Life Safety Code* (NFPA, 2003a) based on a fully sprinkler protected building were used in combination with the exit requirements. For both the 100 feet by 100 feet and 166 feet by 166 feet layouts, two stairwells for each floor were sufficient to meet travel distance requirements. However, for the 225 feet by 225 feet building, the capacity of the stairs was insufficient with only three stairwells. As such, four stairwells were used for each floor. Similarly, for the 375 feet by 375 feet building, the travel path requirements and the egress capacity of the stairs were not met with three stairwells; therefore it also has four stairwells per floor.

Each floor layout was based on a core plan, where elevators and restrooms are located in the middle of the floor plan and an open office plan surrounds the elevators and restrooms. The stairwells have been located within the outer edges of the building to provide some equidistance for the occupants, with each having a 44 inch clear width with tread 7 inches deep by 11 inches high. Two illustrations of the 44 inch stairs are shown in Appendix 5. This compared well with Pauls, who used 44 inch stairs in his 15-story building. The doors leading into the stairwells are 36 inches, and are served by five-foot corridors, which are connected in rings, so that travel paths were not exceeded. The ceiling height on the floors is 12 feet high. To ease calculations, the open floor plan was divided up into office spaces, within which it was envisioned that the floor plan was a typical open office floor plan. The sizes of the restrooms were calculated based on typical industry requirements, as were the elevators. (ICC, 2003) The original design was to increase the 100 feet by 100 feet building in increments according to the rest of the sizes. As this was developed the floor layout has to be manipulated to adjust for the amount of occupants. For example, when going from the 100 feet to 100 feet building to the 166 feet by 166 feet building the office spaces were increased due to the fact that the occupants had more space per person. Appendix 6 has illustrations showing the floor layouts for each building.

3.5 BUILDING HEIGHT

The building height of this "high-rise" office building will begin above the previously defined height of 75 feet. Therefore, the building heights chosen are 11-story, 21-story, and a 31-story tall building. This would have the occupants actually traveling 10 stories, 20 stories, and 30 stories in the stairwells to the first floor because of the way the model recognized floors. In addition, the building heights will be based on a 12 feet floor to floor distance. The height dimensions would be 132 feet high, 252 feet high and 372 feet high, respectively

Table 3-1 captures the three parameters used in this examination, along with the values tested.

Table 3-1

Parameters used in this examination and the values being used as a basis for the input files.

Number of Exits	Density of People	Building Height		
		10-story	20-story	30-story
2 Exits	100 square feet gross area per person (High Density)	2 Exits&High Density&10-story	2 Exits&High Density&20-story	2 Exits&High Density&30-story
	278 square feet gross area per person (Low Density)	2 Exits&Low Density&10-story	2 Exits&Low Density&20-story	2 Exits&Low Density&30-story
4 Exits	100 square feet gross area per person (High Density)	4 Exits&High Density&10-story	4 Exits&High Density&20-story	4 Exits&High Density&30-story
	278 square feet gross area per person (Low Density)	4 Exits&Low Density&10-story	4 Exits&Low Density&20-story	4 Exits&Low Density&30-story

CHAPTER 4

EVACUATION MODEL

4.1 INTRODUCTION

"Prediction of occupants' movement during egress is an essential part of meeting life safety goals. The essential issue here is the estimation or prediction of the time needed for egress." (NFPA, 2000, pp. 56-57) Egress time is affected by the number of occupants, their distribution in the building, their response to the notification used, their mental and physical characteristics, level of training, and the physical design of the egress system. EXIT89 (Fahy, 1999) is a FORTRAN-based model which has the capacity to estimate the evacuation times from high-rise buildings for large populations of occupants with and without taking into account the effects of smoke and limited behavioral influences.

4.2 USER OPTIONS FOR THIS APPLICATION

As previously stated, there are ten user options to choose from at the beginning of the input file. For this thesis, the Figure 4-1 shows the options that were chosen for the all the hypothetical buildings.

UNITS (1-METRIC,2-STD) =2
SIZE (1-AUST,2-SOVIET,3-US) =1
SPEED (1-EMER,2-NORMAL) =1
PATH (1-SHORTEST,2-DIRECTED)=1
SMOKE (1-CFAST,2-USER/NONE) =2
CONTRA (1-IF CONTRA FLOWS) =0
OUTPUT (1-FULL,2-BRIEF) =1
NUM OF STAIRWAYS (00-10) =02 or 04
STAIR TRAVEL (1-DOWN, 2-UP) =1
RANDOM DELAY (1-Y,2-N) =2, PROB = 50,
MIN TIME (SEC) = 1, MAX TIME (SEC) = 5.

Figure 4-1. The ten user options chosen for the hypothetical buildings.

To explain further, the building layouts were developed in standard, i.e. English units. Next, the body size measurement selected was based on the largest area of occupant. This selection is the greatest density of the three choices, and thus the most stressing on the exit capacity.

Next, the emergency velocity was selected based on the assumption that the occupants movement will be under a fire [emergency] condition. Fourth, the shortest path option was chosen, to target the minimum evacuation time for these buildings. The fifth option, including smoke data from CFAST, was not chosen, as this thesis focuses only on the effects of the building design and evacuees. Therefore, there are no smoke blockages or the effects of smoke used during the modeling. Option six, contra flow was not chosen. The full output was chosen for option seven, so as to obtain the occupants' travel paths throughout the building with their associated time step, the summary of the floor and stairwell clearing times, the final time for all the occupants to exit the building per stairwell, and the associated number of occupants using each stairwell. The number of stairwells was inputted into option eight. This thesis will be using the two stairwells for the 100 and 166 foot square buildings, and four stairwells for the 225 and 375 foot square buildings. The downward travel direction was chosen since the building's occupants were traveling in this direction in order to leave the building.

Finally, the random delay option was not exercised, given the focus of this research on comparing the minimum time for these hypothetical building evacuations using total and select evacuation strategies. Therefore, all the occupants begin the evacuation at the same time.

4.3 NODE INPUT

The input of the model, as previously stated, is based on a network description of the building. The network consists of up to 89 nodes and 10 stairways. The nodes were established based on combining offices, combining offices and conference rooms, individual conference rooms, sections of corridors, and the stairwells due to the nodal restrictions on the model. The nodes have been chosen to attempt to reflect the most realistic travel paths in the building being modeled.

The first task for the node description input data was to establish the nodes for each building floor plan and take the appropriate measurements. The node numbering system for the 100 foot square building was completed to include the offices, conference rooms, and corridors, with nodes 98 and 99 used for the stairwells. The rest of the buildings used the nodes 1-89 throughout the floor plan, with 96-99 used for the stairwells (depending on the number of stairs for each building). In the 225 foot square and 375 foot square buildings, the node sizes were increased to include a combination of either office spaces and conference rooms, or multiple office spaces. The nodes did not include the restroom and elevator areas since the occupants were assumed not to be located in these areas, and were not traveling through these areas to reach a stairwell.

4.4 CHARACTERISTICS OF NODES

Once these nodes were established and numbered, a node description spreadsheet was developed. An example of this node table can be found in Appendix 7. For each node, the floor area was inputted. The area of each stairwell was based on the following information (Fahy, 1999, p. A-15). The ceiling height of 12 feet was entered. The capacity of the node was entered as 100, as the current version of this model does not recognize this parameter (It is a planned addition by the developer, Rita Fahy.) The number of occupants at the node at the initial time of evacuation was also entered. For the office spaces this was based on the different occupant loads, and for the conference rooms this was based on the 15 square foot per person area established in the *Life Safety Code*. (NFPA, 2003a) No disabled occupants were considered, as this was not the focus of this thesis. The designation of "intermediate exit" was given to all the stairwells, with no wait times entered for any node, the focus being on having all occupants moving at the same time (at time equal to zero). It should be noted that relaxing this assumption could remove (to an unknown degree) the congestion in the total case, and thus the difference between the two. The shortest option was selected under the above user inputs. The text file of the node input for the 100 by 100 feet, 10 story building has been included within Appendix 8.

4.5 NETWORK LINK DESCRIPTIONS

The network link descriptions (which can be thought of as arcs) were also part of the input file. The arcs established for each building were designed to balance between having the shortest paths to the stairwells and evenly dividing the occupants between stairwells. The measurements were then taken from the center of the node the occupant was located in to the center of the node they were traveling to within the floor plan. The travel paths were usually from an office to a series of one to three corridors, then into the stairwell. The width of restrictions or openings used varied from three feet for office and stairwell doors to five feet for corridor widths. (Fahy, 1999)

4.6 LOGIC AND OUTPUT DATA

According to the EXIT89 user's manual (Fahy, 1999), the program goes through the user selected options, and then reads the network links into arrays. The reverse directions of these links are stored into the arrays. The arrays are sorted by the program by order based on the from-nodes. The program then proceeds to read in the node descriptions. An array is established by the program containing the occupant locations by time interval based on the number of occupants within each node.

Since the "shortest routes" option was chosen, the model uses the network descriptions to calculate the shortest paths on each floor to the stairways or to the outside. The model then proceeds to a subroutine that checks the travel paths for both the user-defined egress and shortest paths to verify that all the nodes reach the outside. Once this is all accomplished, the evacuation begins and the model summarizes the details of the evacuation in a separate output file. An example of this output file in the form of a two-story, total evacuation, 225 foot square building has been included in Appendix 9. This output file was chosen due to the minimum size of the hypothetical building output files is over 50 pages. The file describes the user's input variables chosen, the occupant's movement by time step, the total time to evacuate with amount of occupants, the overall exiting times to clear each floor through the stairways, and the amount of occupants using each stair. (Fahy, 1999)

Chapter 5

MODEL RESULTS

5. 1 OVERALL RESULTS

This chapter provides the basic results of running EXIT89 as described in Chapters 3 and 4. It is comprised as an overview of the output of the modeling program, the overall evacuation times, the individual (floor by floor) clearance times for the various buildings tested, and an illustrative tracing of the evacuation path for an individual, each will be discussed in turn.

5.2 MODEL OUTPUT

Output from EXIT89 is separated into five sections. The first section summarizes the user options that were chosen, as discussed in Section 3. The second and third sections restate the input file nodes and arcs with introductory descriptions of the significance of each column of the data. The fourth section decomposes the time steps with the associated occupant number (assigned by the model) and their associated travel paths. Finally, the fifth section summarizes the "evacuation statistics", which shows the overall times and occupant population evacuating the building using the stairs. Table 5-1 provides an example of the "evacuation statistics" summary section. It is the summary of the 100 foot square building containing 10 stories of evacuation. The primary elements in each of these sections will be discussed in turn.

Table 5-1: *An example of the "evacuation statistics" summary section of EXIT89.*

```
                    Evacuation Statistics

         1380 Occupants escaped in 634.87 seconds
                 0 occupants were trapped

               ---Floor clearing times---

              Floor   1  at  634.87 seconds
              Floor   2  at  628.00 seconds
              Floor   3  at  600.85 seconds
              Floor   4  at  562.28 seconds
              Floor   5  at  501.69 seconds
              Floor   6  at  434.57 seconds
              Floor   7  at  363.10 seconds
              Floor   8  at  294.46 seconds
              Floor   9  at  220.56 seconds
              Floor  10  at  150.36 seconds
              Floor  11  at   83.08 seconds

               ---Stair clearing times---

             Stairway  99  at  634.87 seconds
             Stairway  98  at  429.31 seconds

                ---Exit clearing times---

      670 People used exit at node  198 by  429. sec
      710 People used exit at node  199 by  635. sec
```

"Floor clearing time" and "Stair clearing time" areas show the time associated with the last person to pass the associated nodes. For example; the time of 501.69 seconds found under the "Floor clearing time" for Floor 5 is the time associated with the last person from all the above floors (11 through 6) clearing the floors and to the middle of the landing of the 4th floor stairwell.

"Exit clearing time" details the number of occupants having used "node 198" or "node 199" which are the designated numbers associated with the two stairwells in this building's summary.

Due to the size of the runs from the 10, 20 and 30 story buildings, their output files could not be included. Therefore, a scaled down version of the 225 square foot building output file has been included within Appendix 9. It is a two-story, 225 foot square building, evacuating 506 occupants to the outside.

5.3 EVACUATION TIMES

Table 5-2 summarizes some of the primary parameters and the overall evacuation times for the 24 variations of the hypothetical buildings.

5.4 EVACUATION TIME FOR EACH BUILDING

Tables 5-3 through 5-6 are the evacuation times for the last person to pass through a given stair level enroute the outside. For example; under Floor 7 of the "100/10 Total" column, the time reflects the seconds for the last person to clear floors 11 through 7 and arrive at the middle landing of the 6^{th} floor stairwell. These data provide more detailed insight, allowing the user to identify queuing locations and other phenomena. Additionally, the user can determine the evacuation times in the affected region (top five floors).

Table 5-2: *The evacuation times for all the hypothetical buildings.*

Evacuation Statistics for Each Building			
Square Foot of Building/Stories & Evacuation Strategy	Total Number of Occupants	Number of Occupants per Floor	Time (seconds)
100/10 Total	1380	138	635
100/10 Select	690	138	503
100/20 Total	2760	138	1047
100/20 Select	690	138	947
100/30 Total	4140	138	1607
100/30 Select	690	138	1430
166/10 Total	1350	135	587
166/10 Select	675	135	521
166/20 Total	2700	135	1172
166/20 Select	675	135	765
166/30 Total	4050	135	1718
166/30 Select	675	135	1020
225/10 Total	5060	506	918
225/10 Select	2530	506	869
225/20 Total	10120	506	1882
225/20 Select	2530	506	1579
225/30 Total	15180	506	2744
225/30 Select	2530	506	2122
375/10 Total	5170	517	855
375/10 Select	2593	517	841
375/20 Total	10340	517	1768
375/20 Select	2593	517	1547
375/30 Total	15510	517	2654
375/30 Select	2593	517	2191

Table 5-3: *Time for the last occupant to pass to the next stairwell for the 100 foot square buildings.*

Time (Seconds) for the Last Occupant to Pass to the Next Stairwell						
Floor	100/10 Total	100/10 Select	100/20 Total	100/20 Select	100/30 Total	100/30 Select
31					83.08	77.11
30					150.36	130.43
29					220.56	170.06
28					294.46	223.80
27					363.10	278.45
26					434.56	329.95
25					501.69	382.59
24					562.28	429.34
23					600.85	472.21
22					640.71	524.58
21			83.08	77.11	682.84	573.76
20			150.36	130.43	732.40	625.47
19			220.56	170.06	781.96	671.98
18			294.46	223.80	831.51	176.91
17			363.10	278.45	872.95	772.58
16			434.57	329.95	900.64	820.06
15			501.69	382.59	950.20	870.68
14			562.27	429.34	997.34	926.71
13			600.85	472.21	1037.38	980.17
12			628.62	491.64	1063.39	994.60
11	83.08	77.11	668.28	540.60	1116.51	1044.43
10	150.36	130.43	723.58	588.11	1173.72	1096.02
9	220.56	170.06	758.44	634.74	1227.88	1133.28
8	294.46	223.80	814.84	685.46	1282.73	1188.60
7	363.10	278.45	871.35	722.26	1342.15	1219.52
6	434.57	329.95	895.98	777.68	1403.04	1258.68
5	501.69	382.59	932.97	833.05	1453.29	1298.84
4	562.28	429.34	972.35	865.23	1518.91	1344.10
3	600.85	472.21	1030.39	926.03	1577.52	1401.30
2	628.00	498.54	1046.71	940.79	1607.31	1426.07
1	634.87	503.02	1046.71	946.96	1607.31	1429.53

Table 5-4: *Time for the last occupant to pass to the next stairwell for the 166 foot square buildings.*

Time (Seconds) for the Last Occupant to Pass to the Next Stairwell						
Floor	166/10 Total	166/10 Select	166/20 Total	166/20 Sele	166/30 Tota	166/30 Select
31					95.70	86.25
30					134.15	126.78
29					182.40	156.87
28					217.13	187.07
27					272.44	248.77
26					318.38	277.92
25					379.06	309.90
24					416.87	327.80
23					462.07	354.99
22					534.54	389.91
21			95.70	86.25	607.02	426.66
20			134.15	126.78	636.73	452.55
19			177.52	156.87	685.27	480.36
18			217.54	187.07	711.57	500.67
17			271.36	248.77	745.44	526.91
16			316.55	277.92	792.24	541.54
15			373.81	309.90	839.87	575.76
14			426.17	327.80	897.48	594.23
13			487.02	354.99	963.69	628.73
12			559.64	389.91	1036.17	668.26
11	96.96	91.65	634.08	426.66	1108.64	706.92
10	166.22	147.12	705.47	463.41	1181.12	744.06
9	221.17	206.77	767.93	500.16	1253.59	779.07
8	284.60	262.00	821.91	538.00	1326.07	820.55
7	342.98	308.83	882.23	576.49	1398.54	856.37
6	400.72	355.52	949.92	616.49	1471.01	888.84
5	456.01	404.66	1018.31	661.07	1543.49	926.61
4	514.21	445.34	1090.48	699.51	1615.96	967.67
3	563.64	499.70	1153.35	737.47	1688.44	1001.17
2	581.02	517.36	1172.39	760.88	1718.30	1019.87
1	587.43	521.11	1172.39	765.28	1718.30	1019.87

Table 5-5: *Time for the last occupant to pass to the next stairwell for the 225 foot square buildings.*

Time (Seconds) for the Last Occupant to Pass to the Next Stairwell						
Floor	225/10 Total	225/10 Select	225/20 Total	225/20 Select	225/30 Total	225/30 Select
31					122.16	122.16
30					223.19	227.15
29					309.81	303.34
28					418.30	405.68
27					537.12	485.03
26					616.66	566.42
25					716.64	646.27
24					816.51	728.46
23					937.41	835.99
22					1055.80	920.51
21			122.16	122.16	1157.89	1013.90
20			223.19	227.15	1235.40	1058.41
19			309.81	303.34	1312.92	1131.06
18			394.24	405.68	1399.30	1195.04
17			509.13	485.03	1479.30	1243.28
16			616.66	566.42	1560.67	1306.50
15			702.93	645.62	1652.53	1370.65
14			783.66	724.90	1730.61	1426.01
13			855.05	805.67	1788.80	1491.86
12			955.31	885.94	1879.96	1543.44
11	122.16	122.06	1056.79	949.69	1994.51	1603.20
10	223.19	227.15	1143.26	1013.43	2081.50	1650.52
9	309.81	303.34	1247.20	1087.56	2164.12	1715.30
8	394.24	405.68	1329.51	1163.79	2250.23	1762.89
7	509.13	485.03	1439.76	1240.02	2336.33	1827.48
6	624.82	567.91	1539.15	1316.24	2418.02	1876.97
5	702.93	646.27	1619.20	1392.47	2499.31	1934.48
4	773.10	725.55	1722.79	1468.70	2572.77	1984.32
3	845.17	795.53	1795.24	1544.93	2658.08	2049.46
2	915.85	861.88	1872.44	1573.08	2727.38	2119.45
1	917.85	869.03	1882.46	1578.50	2743.98	2122.46

Table 5-6: *Time for the last occupant to pass to the next stairwell for the 375 foot square buildings.*

Time (Seconds) for the Last Occupant to Pass to the Next Stairwell						
Floor	375/10 Total	375/10 Select	375/20 Total	375/20 Select	375/30 Total	375/30 Select
31					192.73	184.87
30					280.94	259.37
29					391.60	333.87
28					484.19	408.36
27					549.10	482.86
26					640.58	557.36
25					741.58	631.86
24					809.63	706.36
23					895.41	780.86
22					1005.15	855.35
21			192.73	184.87	1102.04	929.85
20			280.94	259.37	1187.71	1004.35
19			391.60	333.87	1256.24	1078.85
18			484.19	408.36	1366.76	1141.56
17			549.10	482.86	1443.07	1204.28
16			640.58	557.36	1546.89	1266.99
15			741.58	631.86	1615.79	1324.23
14			809.63	706.36	1713.63	1395.18
13			895.41	780.86	1785.39	1465.92
12			1005.15	855.35	1862.55	1523.53
11	192.73	184.87	1101.02	929.85	1972.65	1593.27
10	280.94	259.37	1187.71	1004.35	2053.02	1652.83
9	378.86	333.87	1257.03	1078.85	2139.35	1720.62
8	471.11	408.36	1324.64	1141.56	2214.49	1780.59
7	543.26	482.86	1389.97	1204.28	2292.59	1850.31
6	615.17	557.36	1485.18	1266.99	2369.30	1907.52
5	677.99	631.86	1554.89	1324.23	2446.14	1975.57
4	748.97	706.36	1618.64	1395.18	2523.59	2046.06
3	819.96	780.86	1683.82	1465.92	2580.04	2108.77
2	854.74	840.51	1759.66	1547.46	2640.16	2190.12
1	854.74	840.51	1768.44	1547.46	2654.18	2190.59

5.5 TRACING AN OCCUPANT'S TRAVEL

An example of the use of the fourth section of EXIT89 output is provided in the Table 5-7. This output presents the event time log, from which it is possible to look at the temporal and geospatial path for a particular occupant. The example provided is for occupant number 1288 in the 10 story, total evacuation, 100 foot square building.

Table 5-7: *EXIT89 output regarding the travel of occupant number 1288 from the 10-story, total evacuation strategy, 100 foot building*.

TIME	OCC NUM	ORIG NUM	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
3.08	1288	1107	1107	1179	0	0
14.36	1288	1107	1179	1178	0	0
29.74	1288	1107	1178	1185	0	0
42.87	1288	1107	1185	1199	12	0
83.08	1288	1107	1199	1099	102	0
135.76	1288	1107	1099	999	296	0
212.65	1288	1107	999	899	584	0
289.55	1288	1107	899	799	926	0
363.10	1288	1107	799	699	1086	0
430.44	1288	1107	699	599	1242	0
501.69	1288	1107	599	499	1242	0
562.28	1288	1107	499	399	1242	0
600.85	1288	1107	399	299	1242	0
628.00	1288	1107	299	199	1342	0
634.87	1288	1107	199	0	1369	0

The first column in Table 5-7 indicates the time in seconds of occupant 1288 travel from one node to the next node. The second and third column show the occupant number (1288) and the original node where occupant 1288 is located. The fourth and fifth columns indicate the number of the from and to node in which occupant 1288 is traveling through. The "num out" indicates the number of occupants that have left the building at the corresponding time step. "Num trapd" is the number of occupants trapped in the building.

This route found in Table 5-7 is illustrated in the Appendix 10. Nodes 1199 through 0 indicate the stairwell nodes to the outside of the building which are not shown in Appendix 10.

CHAPTER 6

ANALYSIS OF RESULTS

6.1 OVERALL ANALYSIS

An examination of the predictive capability of EXIT89 versus the actual performance has been accomplished through the comparison of Pauls' predictions versus the hypothetical buildings' result times. The second analysis presented is the overall times to evacuate the occupants and the times to evacuate the affected floors (top five floors). This shows a comparison of how queuing affects the times of the two types of evacuation strategies.

6.2 COMPARISON OF RESULTS WITH PAULS' PREDICTIONS

In order to check if the results from all the hypothetical buildings were within reason, a comparison between Pauls' works was accomplished. In the Society Fire Protection Engineers Handbook, Proulx presents Pauls' predicted and observed total evacuation times based on Pauls' equations to predict total evacuation time for a 15 story building. To compare the results from EXIT89, the occupant load used for each of the total evacuation strategy, hypothetical buildings were divided by their effective width (in meters) and inserted in the two equations given by Pauls. The occupant loads of less than 800 persons per meter of effective stair width used Equation 6-1, and above 800 persons per meter of effective stair width used Equation 6-2 (Proulx, 2002).

$$T = 2.00 + 0.0117p \quad (6\text{-}1)$$

$$T = 0.70 + 0.0133p \quad (6\text{-}2)$$

This was then plotted against the total evacuation times (in minutes) from the results of the model runs. As seen Figure 6-1, there is a high degree of agreement between the results as predicted by Pauls and those obtained in this use of EXIT89. Furthermore, the linear regression analysis provided a "best fit" line through the data in Figure 6-1 (for the modeling performed here) indicates not only a highly linear relationship between evacuation population and overall evacuation time (as shown by the high coefficient of determination), but also a slope that lies between that of the linearized versions of the low density (less than 800 persons per meter of effective stair width) and high density (more than 800 persons per meter of effective stair width) cases. This should be expected, as this research used a combination of low and high density cases.

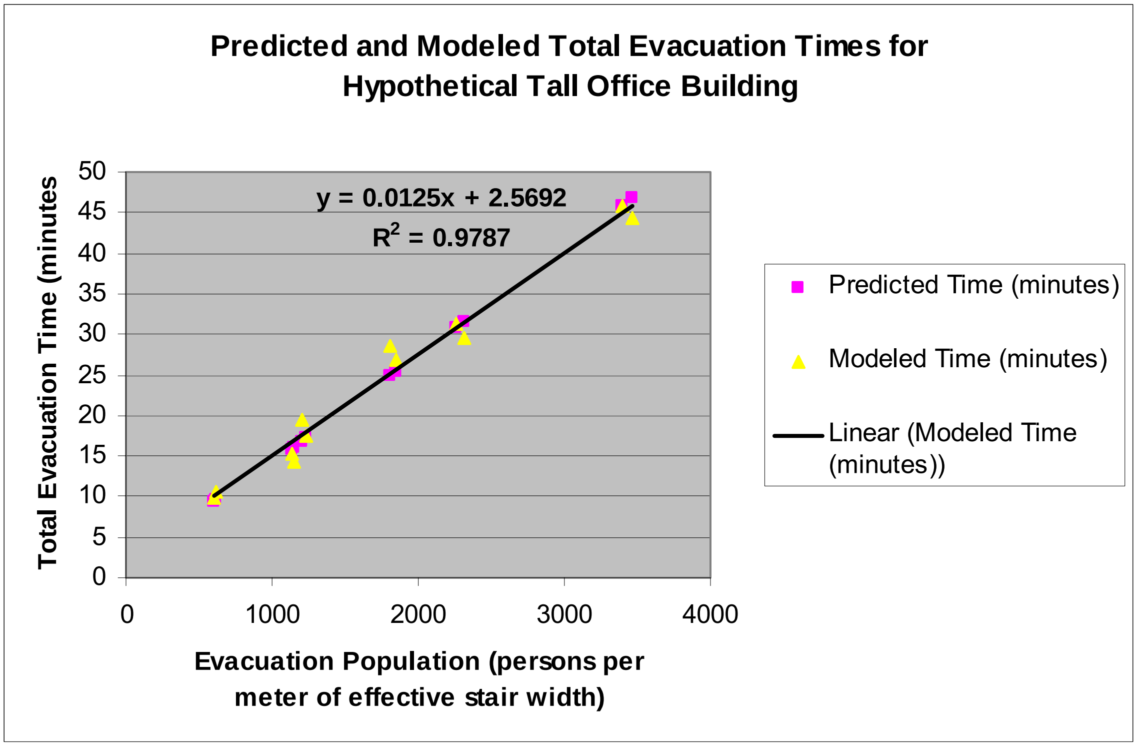


Figure 6-1. Predicted and modeled total evacuation times for hypothetical tall office buildings.

The next comparison undertaken was to develop a similar graph to Pauls work illustrating the predicted times for an uncontrolled total evacuation of a 15-story, hypothetical building. Similar charts have been used by Predtechenskii and Milinskii (Pauls, 1977, p. 283). The walking speeds used in EXIT89 are also based on formulas from Predtechenskii and Milinskii (Fahy, 1999).

The details of the building layout of Pauls' hypothetical, 15-story building are not available. Therefore, the hypothetical, 100 foot square building was used as a basis for the graph. The occupant density of each floor was reduced to 70 occupants per floor, similar to Pauls' work. The building height was increased to 15 stories with the evacuation of 14 stories. The movement parameter in the user option section of the program was changed to "normal evacuation movement" due to the fact Pauls' used fire drill information as opposed to actual fire evacuation times.

As discussed previously, time to evacuate has been considered as the sum of time spent waiting at each floor and the time spent transiting between the floors summed over all the floors. The presentation of Pauls' work in the Society of Fire Protection Engineer Handbook assumed that all the waiting time was at the floor of origin. As such, his graph shows only horizontal bands for each occupant and equal slopes afterwards (stair transit rates constant). Figures 6-2a and 6-2b relaxes the assumption that all the waiting takes place before initiating evacuation (using actual floor clearing time) which was constant as illustrated by the figure. A relative stair transit rate was then developed that took into account the fact that waiting occurred at all floors. As such, the slopes varied between initiating floors, with those starting higher in the building having a level slope.

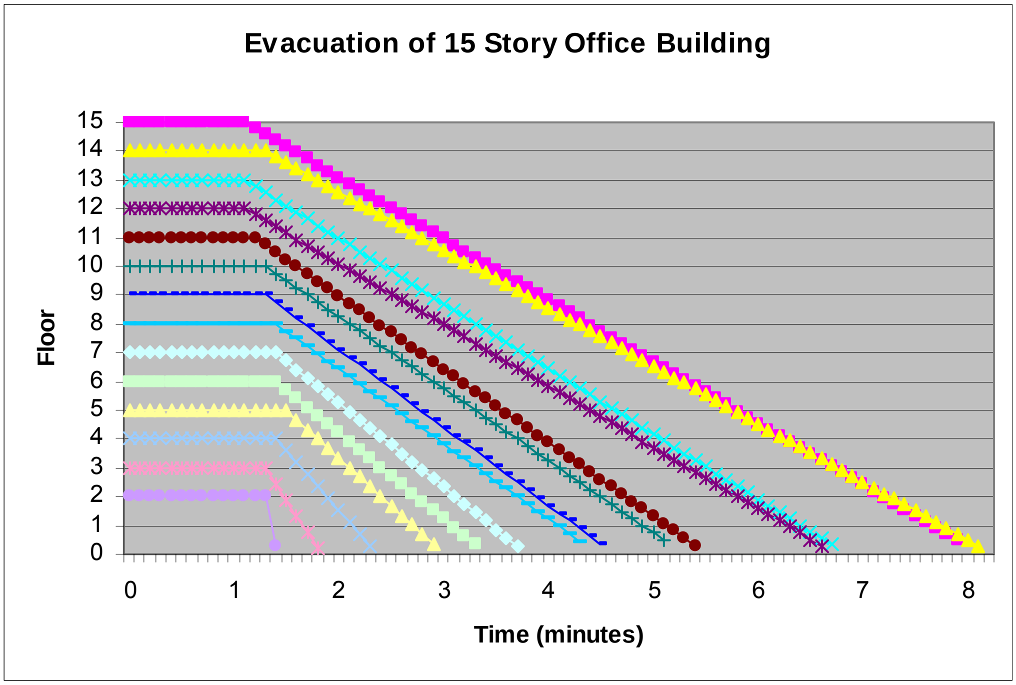


Figure 6-2a. Evacuation of a 15 story office building based on the 100 foot square hypothetical building floor plan

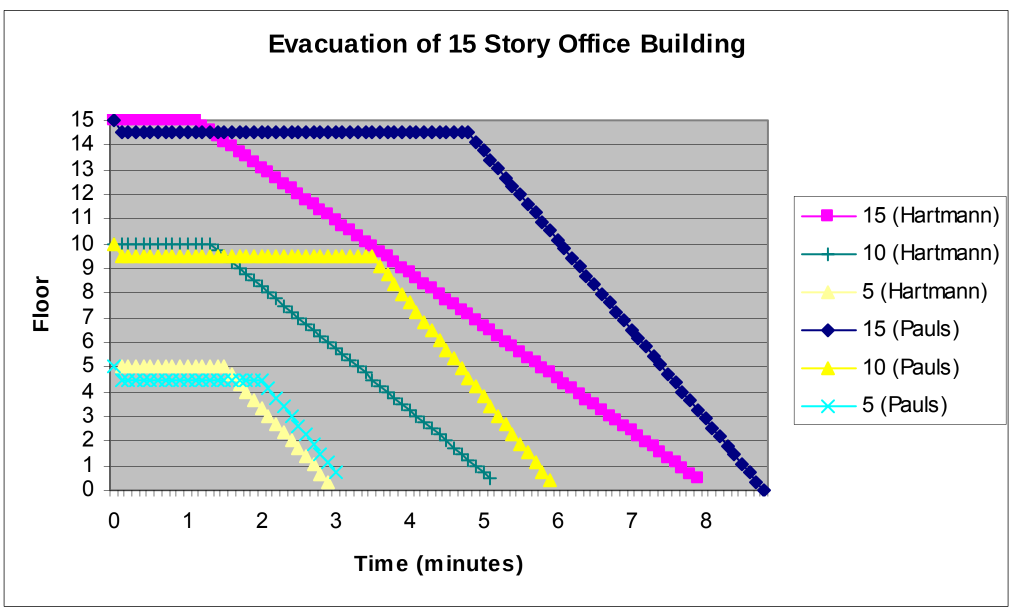


Figure 6-2b. Evacuation of floors 5, 10 and 15 of a 15 story office building based on the 100 foot square hypothetical building floor plan (Hartmann) versus Pauls' hypothetical uncontrolled total evacuation of a 15-story office building (Proulx, 2002, p. 355).

6.3 OVERALL RESULTS ANALYSIS

Before presenting the analysis of the results, it is worthwhile revisiting the focus of this research. Specifically, this research attempts to determine and explain any observed differences between total and select evacuation strategies. Furthermore, this research attempts to explore the effect of variations in key parameters (building height, area and number of occupants) on the difference between the performances of the two strategies. This is developed in two primary metrics- first, in the comparison of the overall time for evacuees to get out of the building (total evacuation time), and second, in the comparison of the time to evacuate the affected region (floors at which the emergency situation exists, taken as the top five floors here). Adding this second metric allows consideration to be made of the increase in relative safety by traveling off of the affected floors through the stairwells to the outside of the building. Here, the overall time to evacuate the building is considered first, followed by the consideration of the time to leave the affected floors. The overall times to evacuate compared by evacuation strategy establish the time differences by height and building size for the occupants to reach the outside of the buildings. The time to leave the affected floors (top five floors) establishes the evacuation times for the same number of occupants, which in comparing these to the overall time to evacuate will show the time differences due to queuing.

6.4 ANALYSIS OF OVERALL EVACUATION TIMES

Overall travel time for both total and select evacuation strategies can be considered as a combination of transit time and waiting (queuing) time. As the occupants in the comparable total and select evacuation strategies must traverse the same distance (number of stairs), the transit times for corresponding cases are expected to be equal. As such, the difference is in the waiting time, taking the difference between total and select evacuation strategies captures this absolute difference. To place this difference into context, the relative difference between total and select evacuation strategies is also considered, which is taken in the following sections as the ratio of time in the select evacuation strategy to the time in the total evacuation strategy. This is done in the subsequent sections as a function first of building floor plan area, and then as a function of building height.

6.4.1 100 FOOT SQUARE BUILDING

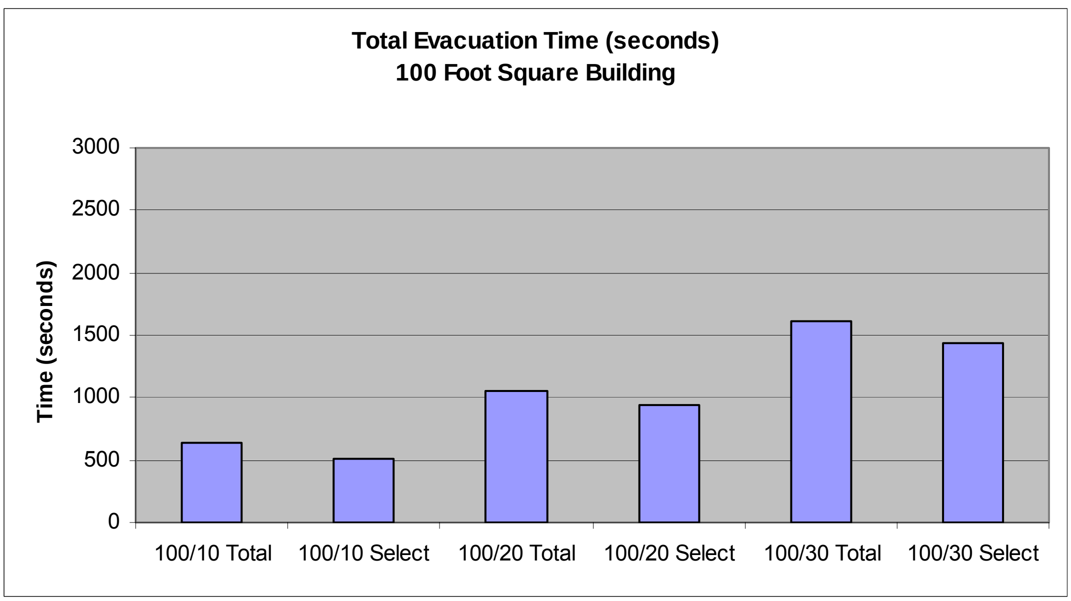


Figure 6-3. Total evacuation time for the 100 foot square building.

As can be seen by Figure 6-3, the time for the total evacuation time increases with the type of evacuation strategy (total and select) as the stories of the building increases. The total evacuation time increases approximately by a factor of approximately 2 from the 10-story building to the 20-story building. From the 20-story building to the 30-story building, the total evacuation time increases approximately by 64%. Overall the time factor from the 10-story building to the 30-story building increases approximately by a factor of 3 for the total evacuation strategy.

For the select evacuation strategy, the total evacuation time factor increases by a factor of approximately 2 from the 10-story building to the 20-story building; and by 51% from the 20-story to the 30-story building. Overall the time factor from the 10-story, select evacuation strategy to the 30-story, select evacuation strategy also increases approximately by a factor of 3.

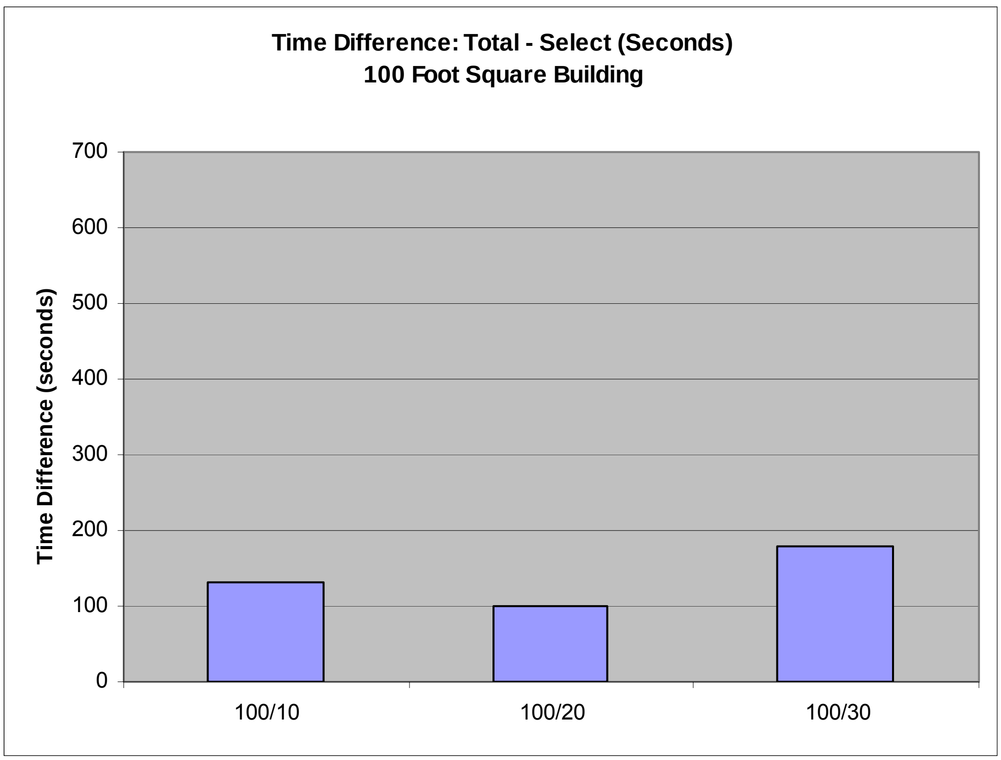


Figure 6-4. Time difference: total – select for the 100 foot square building.

In Figure 6-4, it can be seen that the time differences (total time for total evacuation strategy minus total time for select evacuation strategy) for different heights of the 100 foot square building begin at approximately 132 seconds, then decrease to approximately 99 seconds, and then increase again to approximately 178 seconds. On a relative basis between building heights, it can be seen that varying from the 10-story to the 20-story decreases the time difference slightly (25%). From the 20-story to the 30-story, this time difference increases by 75%. Overall, the time difference between the 10-story and 30-story buildings increases by approximately 35%. One may think that the trend in the time difference would increase as the stories of the building increase, although the time differences here appear to be influenced by a degree of queuing causing them to reach a plateau at the 10 story case and then not grow dramatically in the range of buildings considered. This phenomena is addressed later in the concluding chapter as an area of future study.

As a percentage of the time for the total evacuation strategy, the select evacuation strategy varies from 79% for the 10 story building to 90% for the 20 and 89% for the 30 story structure. As such, the relative time difference is not as significant as had been originally anticipated, and is relatively stable as building height varies.

6.4.2 166 FOOT SQUARE BUILDING

Figure 6-5 also illustrates (unsurprisingly) an increase of time by type of building evacuation as the stories increase. The total evacuation time increases approximately by a factor of 2 from the 10-story building to the 20-story building. From the 20-story building to the 30-story building, the total evacuation time increases approximately by approximately 47%. Overall the time factor from the 10-story building to the 30-story building increases approximately by a factor of 3 for the total evacuation strategy.

For the select evacuation strategy, the time factor again increases by approximately 47% from the 10-story building to the 20-story building; and approximately 33% from the 20-story to the 30-story building. Overall the time factor from the 10-story, select evacuation strategy to the 30-story, select evacuation strategy increases approximately by a factor of 2.

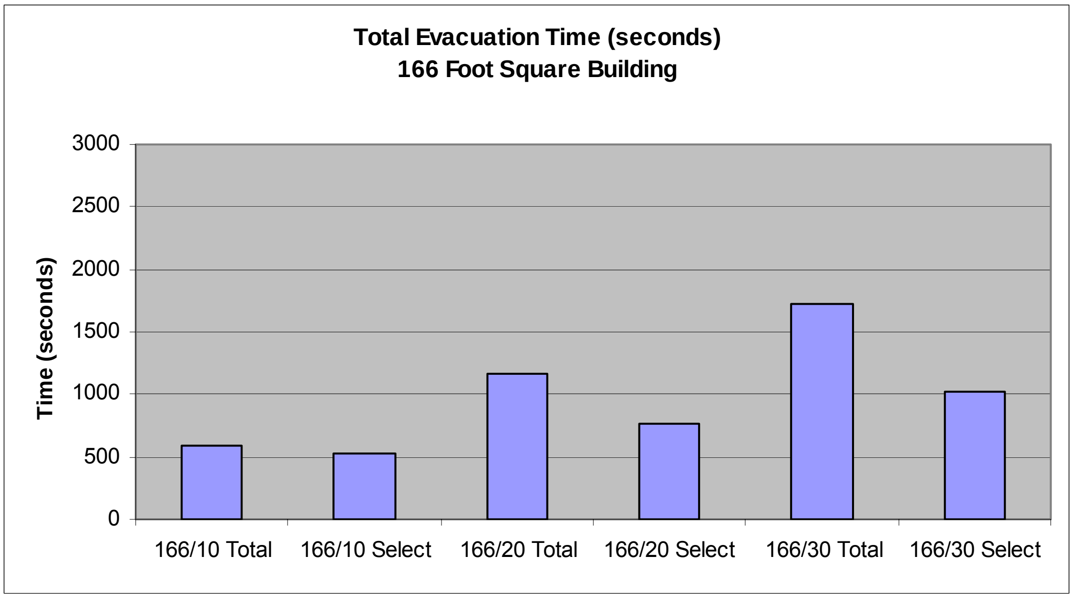


Figure 6-5. Total evacuation time for the 166 foot square building.

As can be seen in Figure 6-6, the time differences for this particular building increase as the building stories increase. This would be sensible based on the fact that more queuing is occurring in the total evacuation strategy of the taller buildings. Here, the time difference from the 10-story building to the 30-story building is approximately 632 seconds.

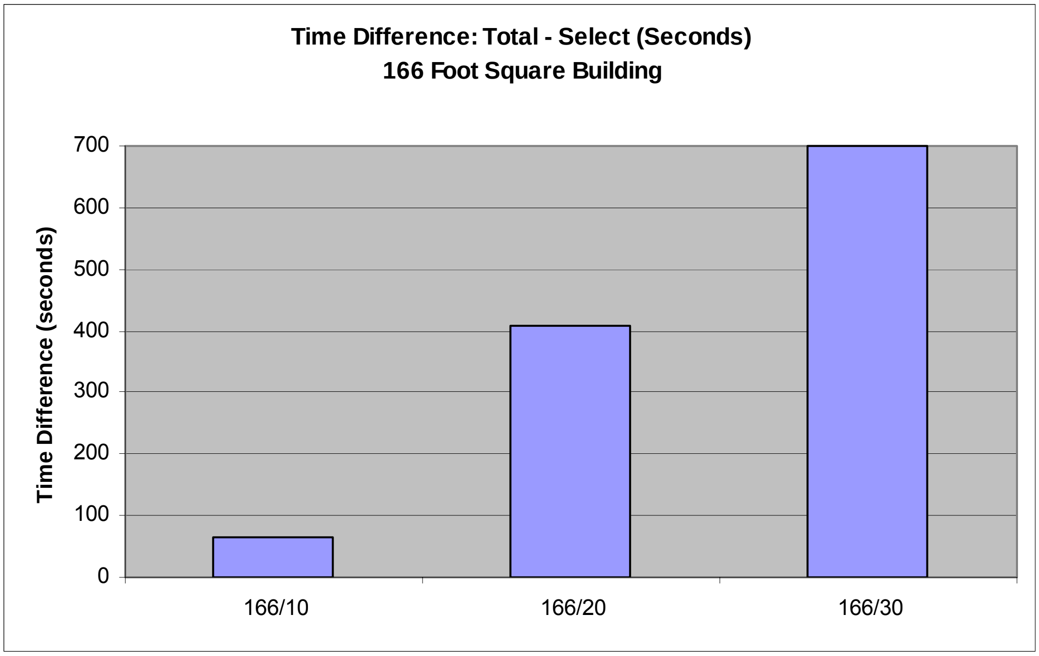


Figure 6-6. Time difference: total – select for the 166 foot square building.

From the 10-story building to the 20-story building, the time factor difference increased by a factor of approximately 6. Between the 20-story building and 30-story building time difference, the time factor only increased by approximately 72%. Overall, the time factor increases approximately by a factor of 11 between the 10-story building and the 30-story building.

As a percent of the time for the total evacuation strategy, select evacuation strategy varies from 88% for the 10-story building to 65% for the 20-story building and 59% for the 30-story building. As such, the relative time difference is more significant than in the 100 foot square building. This is perhaps due to the potential queuing in both total and select evacuation strategies for the 100 foot square building, with queuing in only the total evacuation strategy in the lower occupant load, 166 foot square building. Furthermore, the relative time difference was found to decrease with increased building height, indicating that while the time difference increased, the effects reduced in comparison to the increased transit time for the taller buildings.

6.4.3 225 FOOT SQUARE BUILDING

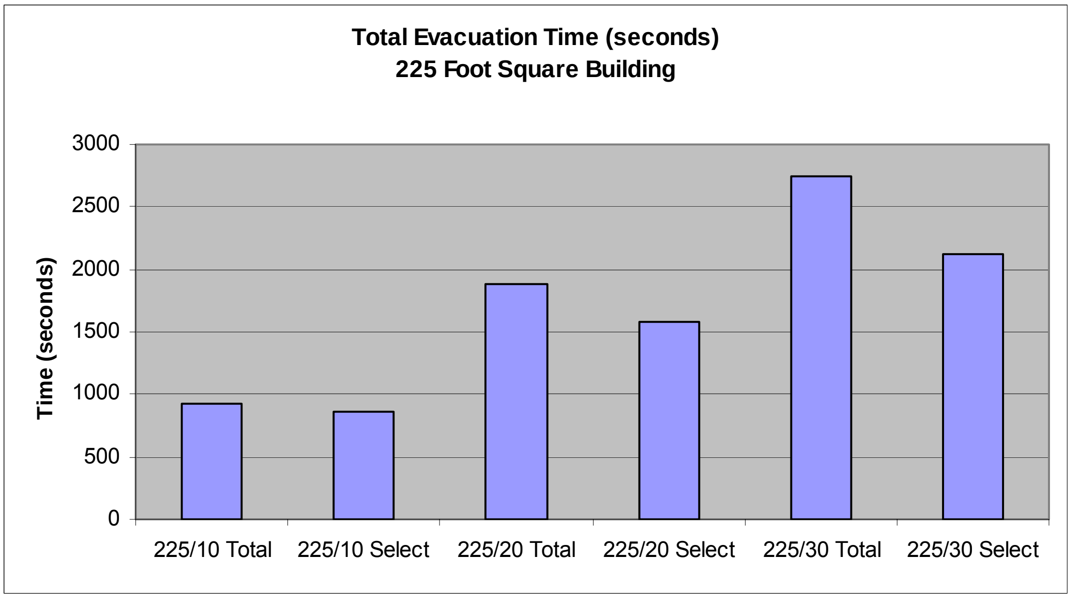


Figure 6-7. Total evacuation time for the 225 foot square building.

Figure 6-7 results are similar to the 166 foot square building illustrating an increase of time by type of building evacuation strategy as the building height increases. The time for the total evacuation strategy increases approximately by a factor of 2 between the 10-story building and the 20-story building. From the 20-story building to the 30-story building, the total evacuation time increases approximately by 46%. Overall the time factor from the 10-story building to the 30-story building increases approximately by a factor of 3 for the total evacuation strategy.

For the select evacuation strategy, the time factor increases by approximately 81% from the 10-story building to the 20-story building; and by approximately 34% from the 20-story to the 30-story building. Overall, the time factor from the 10-story select evacuation strategy to the 30-story select evacuation strategy increases by a factor of approximately 2.4.

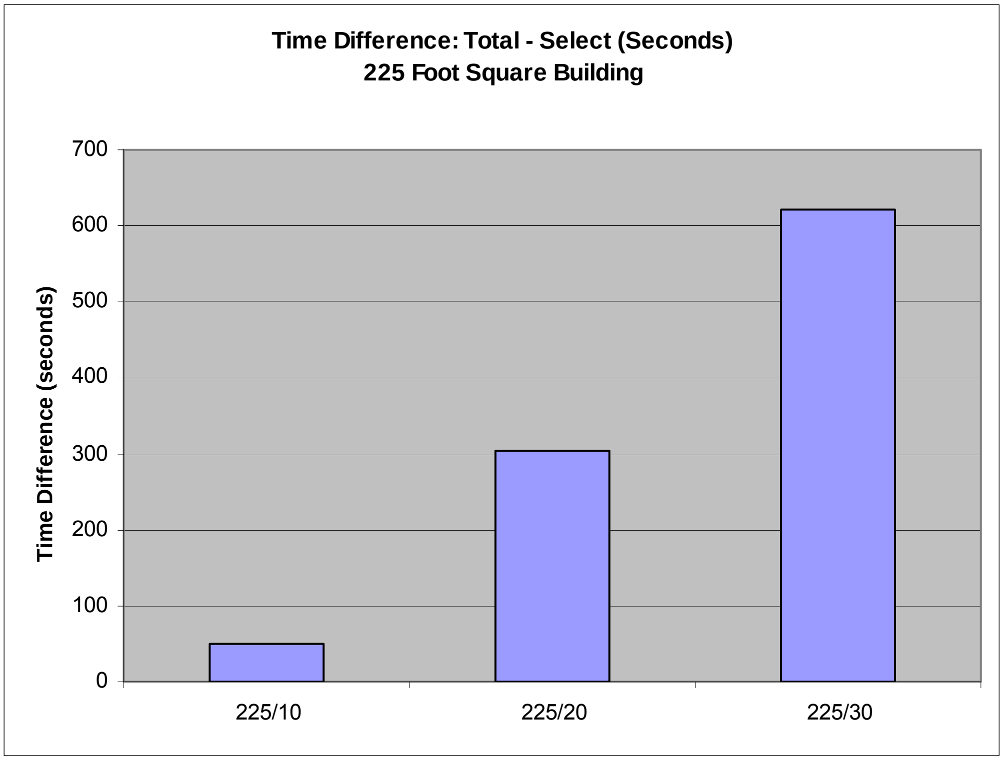


Figure 6-8. Time difference: total – select for the 225 foot square building.

As before, the time differences for the 225 foot square building increase as the number of stories increases. Here in Figure 6-8, the time differences for the 225 foot square building increased from approximately 49 seconds to approximately 651 seconds.

From the 10-story building to the 20-story building, the time difference increased by a factor of approximately 6. The time difference further increased approximately by a factor of 2 between the 20-story building and the 30-story building, with an overall time difference between the 10-story and the 30-story buildings increases approximately by a factor of 13.

As a percent of the time for the total evacuation case, select evacuation varies from 95% for the 10 story building to 84% for the 20 and 77% for the 30 story structures. As such, the relative time difference is more significant than in the 100 square foot building but less than for the 166 square foot building. This is perhaps due to the occupant load factor of the 225 foot square building (occupant load factor equaling 100 square feet per person) being between the 100 foot square building (occupant load factor equaling 72.5 square feet per person) and 166 foot square building (occupant load factor equaling 204 square feet per person). The occupant load factor has been calculated based on the area of the building divided by the actual amount of occupants used in the model. Here, as in the 166 square foot building, the relative time difference was found to decrease with increased building height, indicating that while the time difference increased, the effects reduced in comparison to the increased transit time for the taller buildings.

6.4.4 375 FOOT SQUARE BUILDING

The graph in Figure 6-9 also indicates an increase of time by type of building evacuation as the building height increases. The time for the total evacuation increases approximately by a factor of 2 from the 10-story building to the 20-story building, with another increase of approximately 50% between the 20-story building and the 30-story building. Overall the time between the 10-story building and the 30-story building increases approximately by a factor of 3 for the total evacuation strategy.

For the select evacuation the evacuation time increases by approximately 84% from the 10-story building to the 20-story building; and approximately 42% from the 20-

story to the 30-story building. Overall the time from the 10-story select evacuation to the 30-story select evacuation increases approximately by a factor of 2.6.

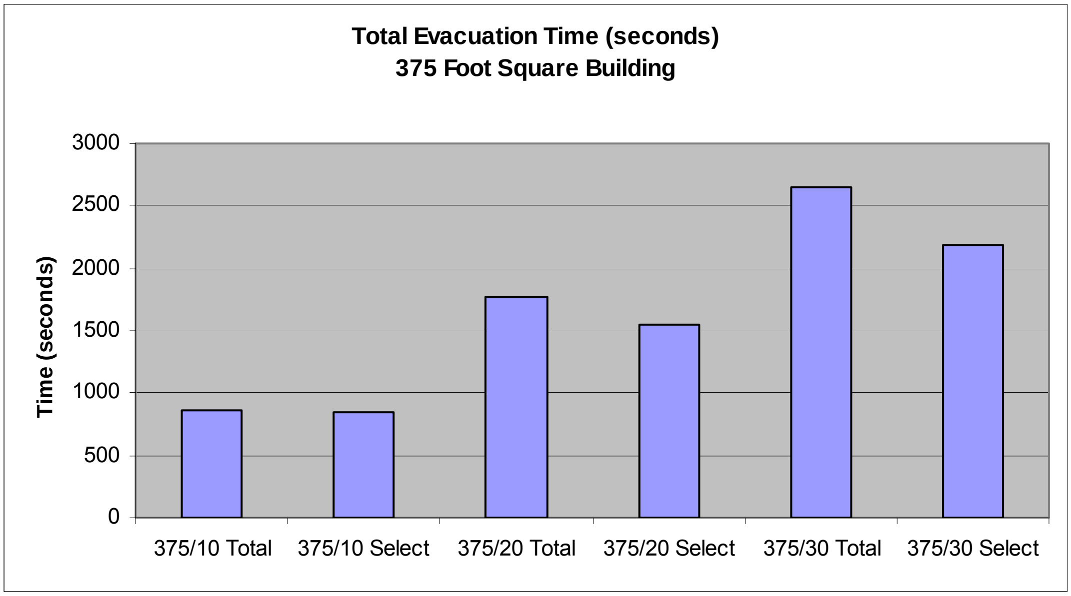


Figure 6-9. Total evacuation time for the 375 foot square building.

As shown in Figure 6-10, the time differences for this particular building increase as the building stories increase. Here, the time difference from the 10-story building to the 30-story building grew by approximately 450 seconds.

From the 10-story building to the 20-story building, the time difference increased by a factor of approximately 16. The time difference further increased approximately by a factor of 2 between the 20-story building and the 30-story building time difference, with an overall increase of the time difference between the 10-story to the 30-story building by a factor of approximately 33.

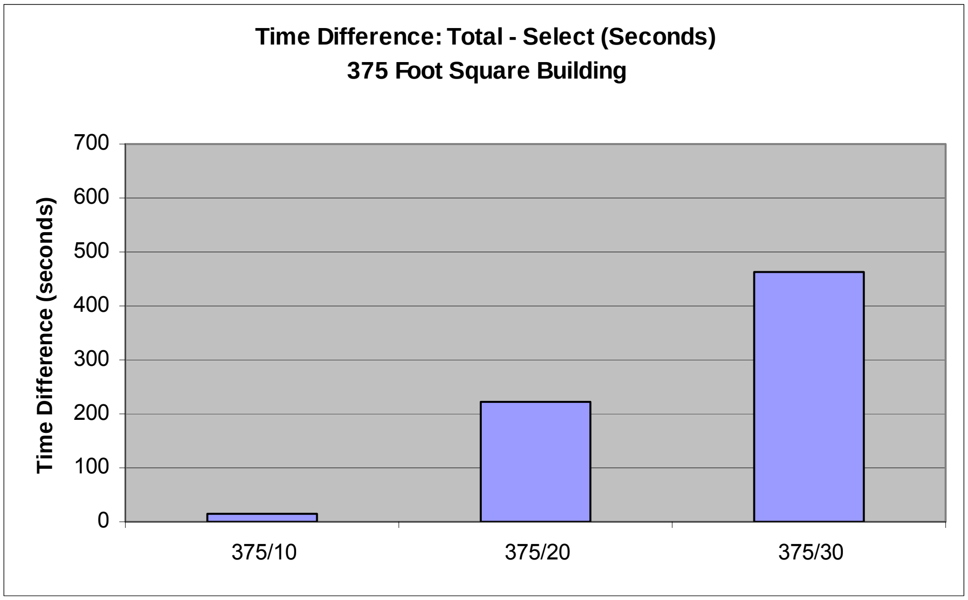


Figure 6-10. Time difference: total – select for the 375 foot square building.

As a percent of the time for the total evacuation case, select evacuation varies from 98% for the 10 story building to 88% for the 20 and 83% for the 30 story structure. As such, the relative time difference is greater than in the 100 square foot building but less than for the 166 square foot building and the 225 square foot building. Here, as in the 166 and 225 square foot buildings, the relative time difference was found to decrease with increased building height, indicating that while the time difference increased, the effects reduced in comparison to the increased transit time for the taller buildings.

In summary, unsurprisingly, the overall results from running EXIT89 with the four types of hypothetical buildings shows that the total evacuation strategy results in a longer time to get evacuees out of the building than the select evacuation strategy. However, the absolute and relative differences between the two were not as large as expected. To further review these differences, the subsequent examination of the differences (both absolute and relative) between the strategies (total and select) in terms of the time to evacuate the affected region was made.

6.4.5 ALL BUILDINGS

As shown in the following, the time differences between the total versus select evacuation type decreases as the area of the building increases.

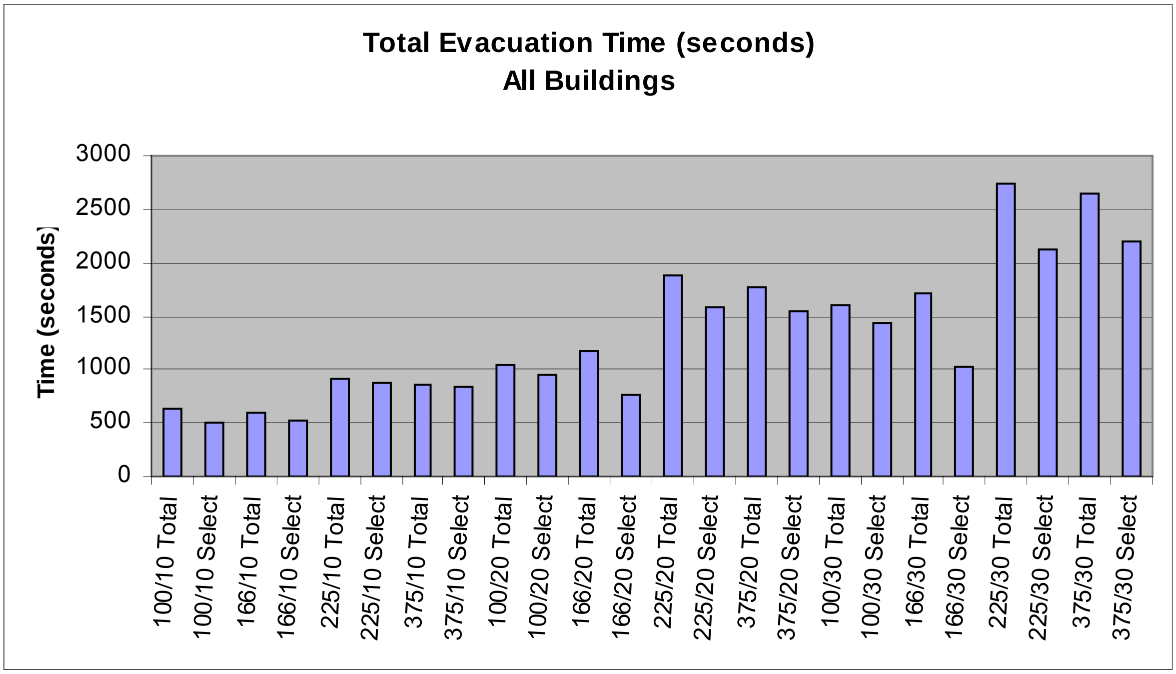


Figure 6-11. Total evacuation time for all hypothetical buildings.

This makes sense, as the occupant density (the area of the building divided by the occupant load factor) decreases.

In reviewing the times of the different stories, the total evacuation time increases for each evacuation strategy as the building heights increase, with the exception of the 20-story and 30-story, 166 foot square buildings. The time differences between the total evacuation strategies for the 10-story, 100 foot square building and the 10-story, 166 foot square buildings were approximately 48 seconds. For the select evacuation strategies for these same buildings, the approximate time difference is 18 seconds. Comparing these times to the 10-story, 225 foot square buildings and the 10-story, 375 square foot buildings, they increase by approximately 2 seconds for the total evacuation strategies, and decrease by approximately 4 seconds for the select evacuation strategies. There are several buildings with lower occupant densities per floor having greater evacuation time than the buildings with higher occupant densities per floor. This occurs among the following: 10-story, select evacuation strategy, 100 square foot building and the 166 foot square building; 20-story, total evacuation strategy, 100 foot square building and the 166 foot square building; 30-story, total evacuation strategy, 100 foot square building and the 166 foot square building; and the 30-story, select evacuation strategy, 225 foot square building and 375 foot square building.

The larger buildings have more occupants and longer travel distances which intuitively would be expected to result in greater overall evacuation times. However, the converse was determined by the model. Therefore, a further analysis of the data was accomplished to determine the speed and density of the occupants in the 100 foot square and 166 foot square buildings. This analysis led to the observation that the waiting time prior to entering the stair for the 166 foot square building was less than the waiting time in the 100 foot square building. Thus, the occupants in the 166 foot square building were reaching the stairwell in lower time than the 100 foot square building. In addition, the results showed the densities in the stair increase for the larger building, resulting in a decrease in the speed of the occupants. So, it appears that the larger buildings have reduced waiting times which are making up for their travel times to cause an overall reduction in the total building evacuation times.

The time differences for these buildings for the 10-story evacuation strategies decreased from approximately 132 seconds to approximately 14 seconds. For the 20-story cases, the time differences increase from approximately 100 seconds to approximately 407 seconds; and then decreased to approximately 221 seconds. The 30-story case also increased from approximately 178 seconds to 698 seconds; and then decreased to approximately 463 seconds.

The time differences for these buildings as seen in Figure 6-12 were more significant, with Total-Select for the 10-story, 100 foot square building being about 9 times that of the 10-story, 375 foot square building. The 20-story and 30-story buildings have a greater separation between the individual results for each building size, except for the 100 foot square building being 25% less than the 166 foot square building (greatest time difference).

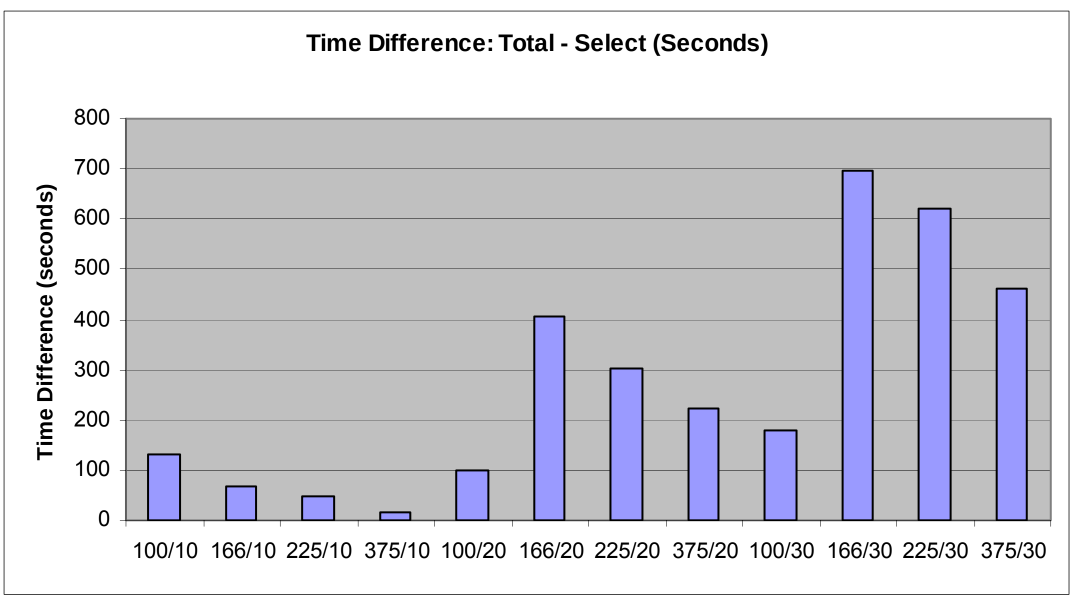


Figure 6-12. Time difference: total – select for all the hypothetical buildings.

6.5 ANALYSIS OF RESULTS BY STAIRWELL EVACUATION TIMES

While the Section 6.4 focused on the overall time for all the evacuations (total evacuation time), these sections focus on the time for occupants to move between floors (i.e., time for the last person to leave a particular floor). Additionally, these sections focuses further on the time to evacuate the more hazardous affected region (i.e. time to clear the top five floors). This is considered by building footprint and height.

6.5.1 100 FOOT SQUARE BUILDING

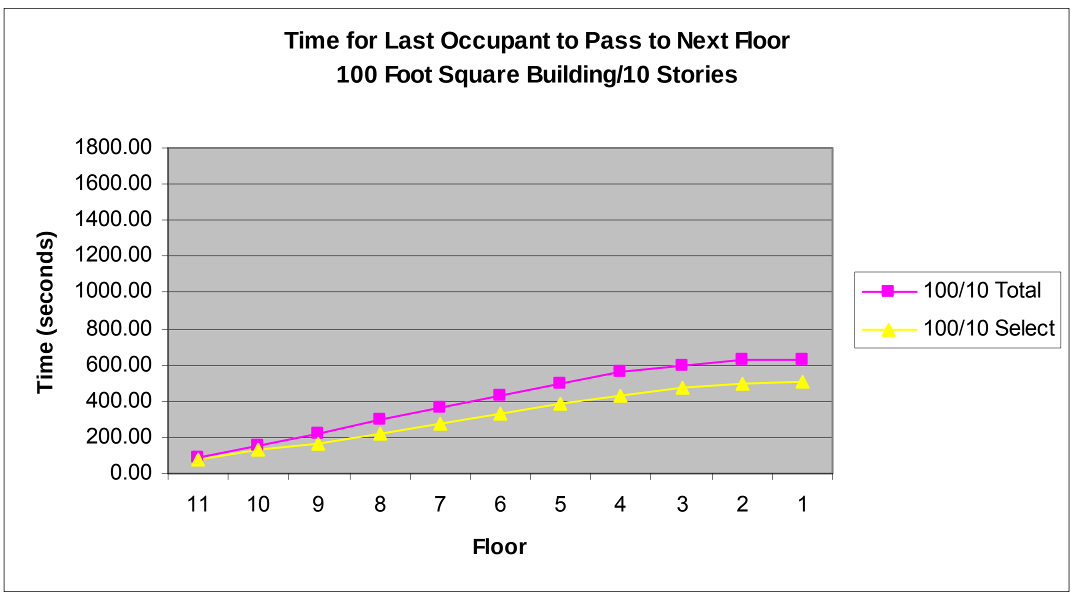


Figure 6-13. Time for last occupant to pass to the next floor for the 100 foot square building,10 stories.

As shown in Figure 6-13, to clear the ninth floor (floor at which the hazard exists), the time difference is approximately 71 seconds. However for the occupants of the top five floors (Floor 11 to Floor 7) to pass onto the next floor, Floor 6, the difference between total and select evacuation strategies ranges only from approximately 6 seconds to 105 seconds. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 6 seconds to approximately 132 seconds.

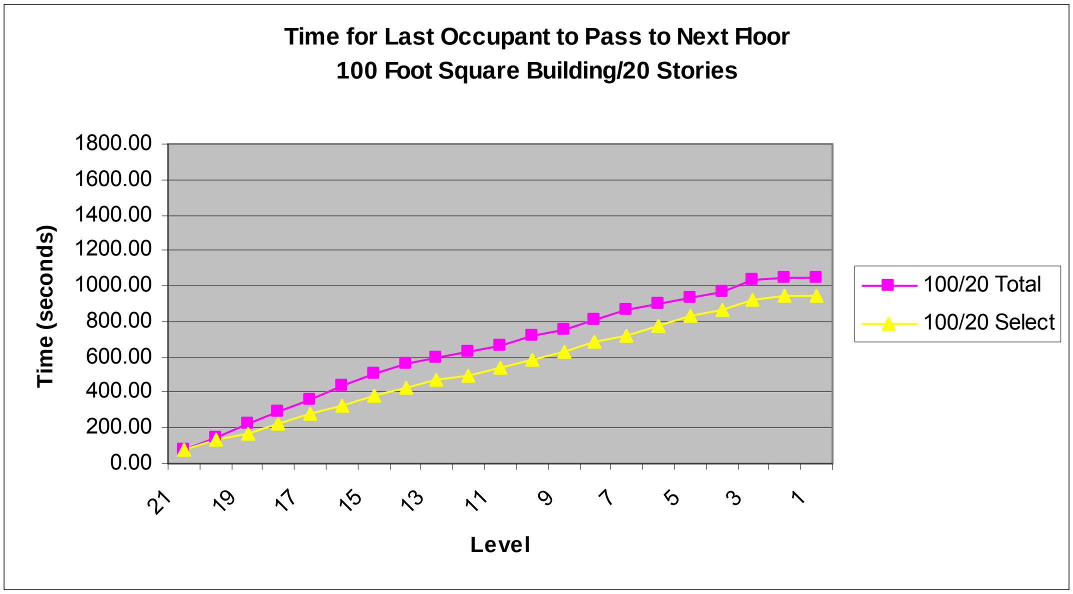


Figure 6-14. Time for last occupant to pass to the next floor for the 100 foot square building, 20 stories.

As seen in Figure 6-14, to clear the nineteenth floor (floor at which the hazard exists), the time difference is also approximately 71 seconds, again, similar to the 10-story case. However for the top five floors (Floor 21 to Floor 17) to pass onto the next floor, Floor 16, the difference ranges only from approximately 6 seconds to 105 seconds, similar to the 10-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 6 seconds to a maximum of approximately 149 seconds. Here, the peak difference occurs on the seventh floor.

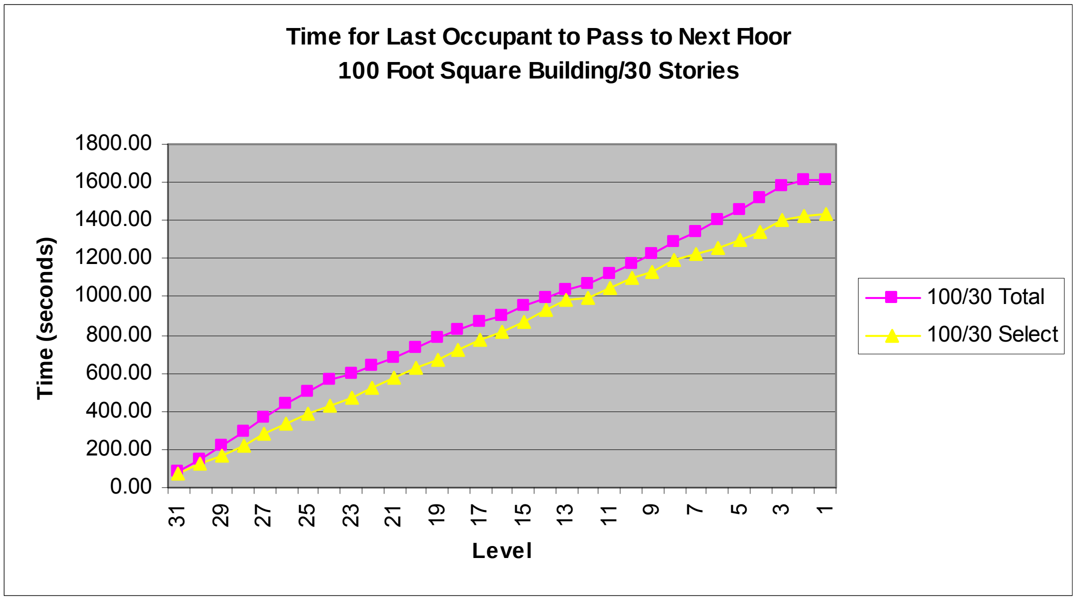


Figure 6-15. Time for last occupant to pass to the next floor for the 100 foot square building, 30 stories.

Finally in Figure 6-15, to clear the twenty-ninth floor (floor at which the hazard exists), the time difference is also approximately 71 seconds, same as the 10-story and 20-story cases. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 6 seconds to a maximum of approximately 181 seconds. The peak difference occurs on the second floor, yet there is a decrease in the differences from the 16th floor to the 8th floor, with a downward peak at the 13th floor.

Overall, at the beginning of the total and select evacuation strategies evacuation time differences are approximately 6 seconds, and at the first floor these differences are approximately 132 seconds, 100 seconds, and 178 seconds for the 10-story, 20-story, and 30-story buildings, respectively.

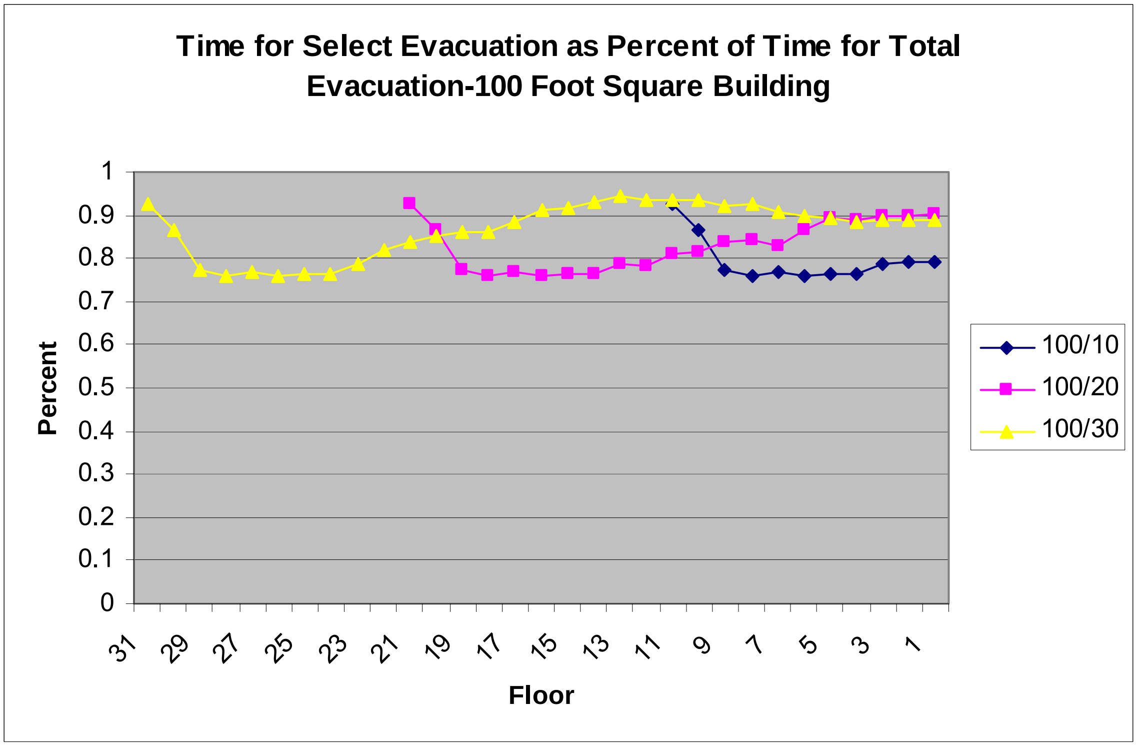


Figure 6-16. Overall time for select evacuation as percent of time for total evacuation for the 100 foot square buildings.

While Figure 6-16 shows an absolute difference, a more detailed examination was undertaken to determine how significant this difference was relative to the total evacuation time. As shown in the above for the 100 foot square building, the time for the select evacuation strategy ranges from 76% to 94% of the total evacuation strategy time. In noting the line patterns, they are relatively similar in pattern (especially for the top five floors, as should be expected).

6.5.2 166 FOOT SQUARE BUILDING

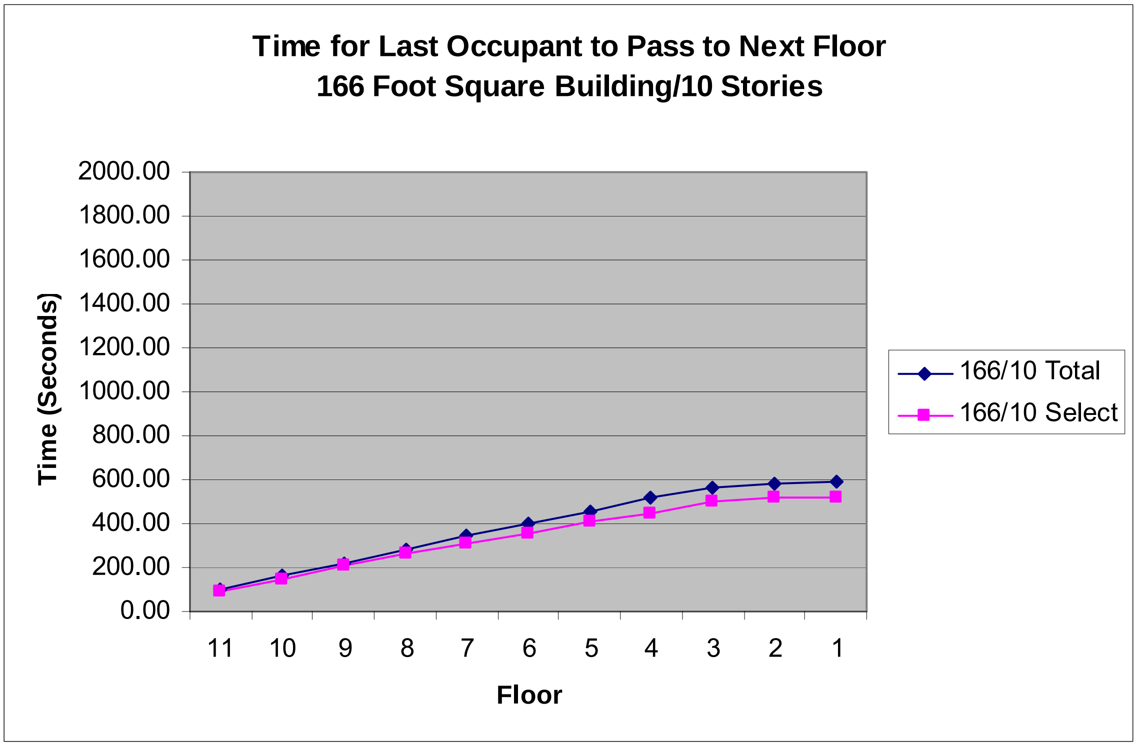


Figure 6-17. Time for last occupant to pass to the next floor for the 166 foot square building, 10 stories.

In Figure 6-17, to clear the ninth floor (floor at which the hazard exists), the time difference is approximately 23 seconds. However for the top five floors (Floor 11 to Floor 7) to pass onto the next floor, Floor 6, the difference ranges only from approximately 6 seconds to 45 seconds. The time results were somewhat similar, as shown in the 100 foot square building. Here, the time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 5 seconds to a maximum of approximately 69 seconds. This peak occurs at the fourth floor.

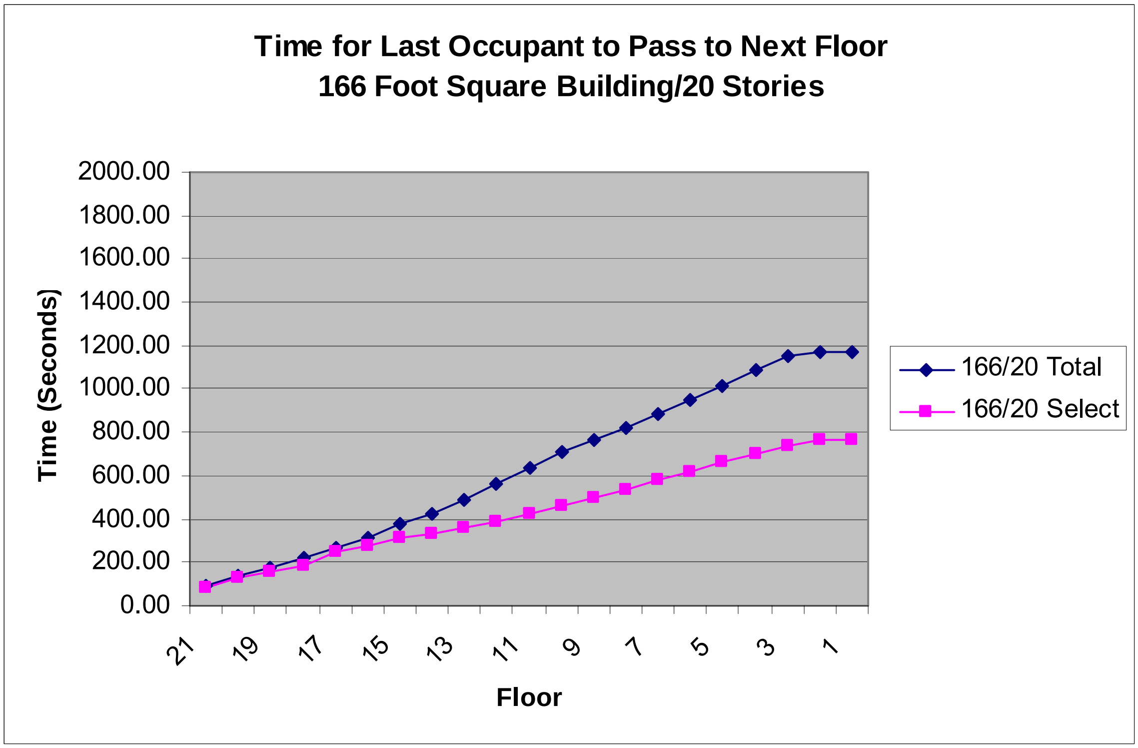


Figure 6-18. Time for last occupant to pass to the next floor for the 166 foot square building, 20 stories.

In Figure 6-18, the time difference for clearing the nineteenth floor (floor at which the hazard exists) is also significantly smaller, at approximately 30 seconds, although greater than to the 10-story case. However for the top five floors (Floor 21 to Floor 17) to pass onto the next floor, Floor 16, the difference is significantly smaller, ranging only from approximately 6 seconds to 39 seconds below the 10-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor grows from approximately 9 seconds to a maximum of approximately 407 seconds. However for the top five floors (Floor 21 to Floor 17) to pass onto the next floor, Floor 16, the difference is significantly smaller, ranging only from approximately 6 seconds to 39 seconds below the 10-story case.

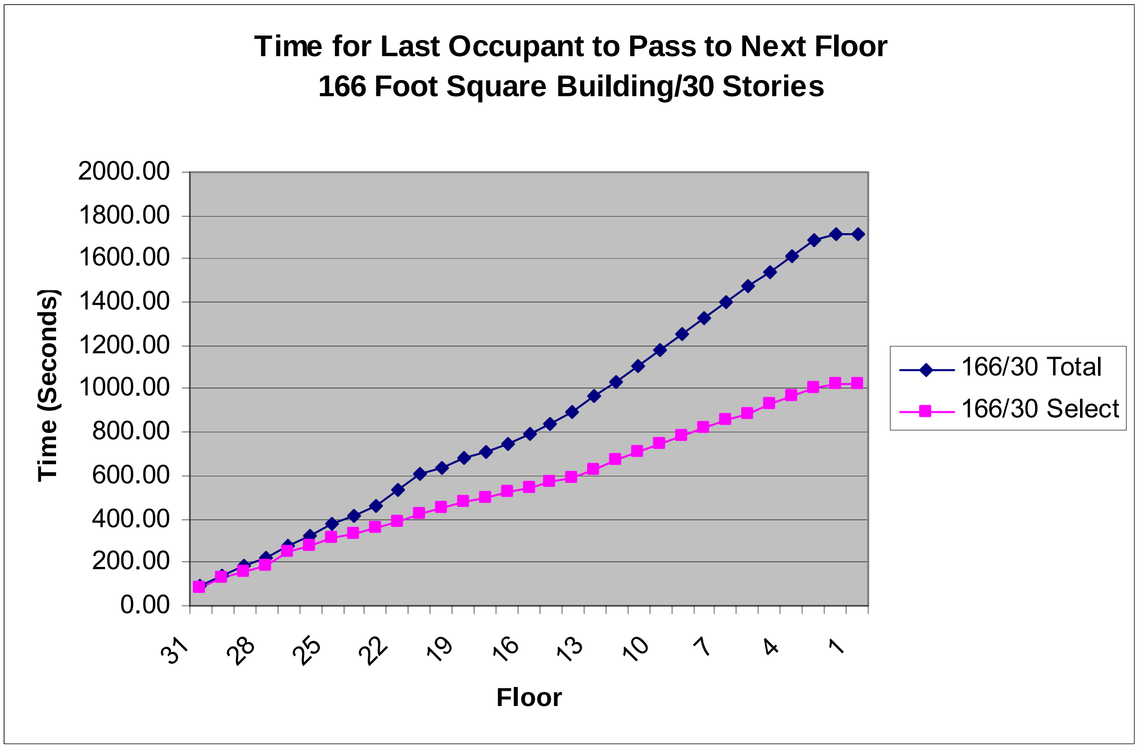


Figure 6-19. Time for last occupant to pass to the next floor for the 166 foot square building, 30 stories.

For Figure 6-19, to clear the twenty-ninth floor (floor at which the hazard exists), the time difference is also approximately 30 seconds, greater than the 10-story case, and similar to the 20-story case. However for the top five floors (Floor 31 to Floor 27) to pass onto the next floor, Floor 26, the difference ranges only from approximately 9 seconds to 40 seconds, less than the 10-story case and greater than the 20-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 9 seconds to a maximum of approximately 698 seconds.

Overall, the absolute differences between total and select evacuation strategies was initially between approximately 5 seconds to 9 seconds, and increased to 66 seconds, 407 seconds and 698 seconds at the first floor of the 10-story, 20-story, and 30-story buildings.

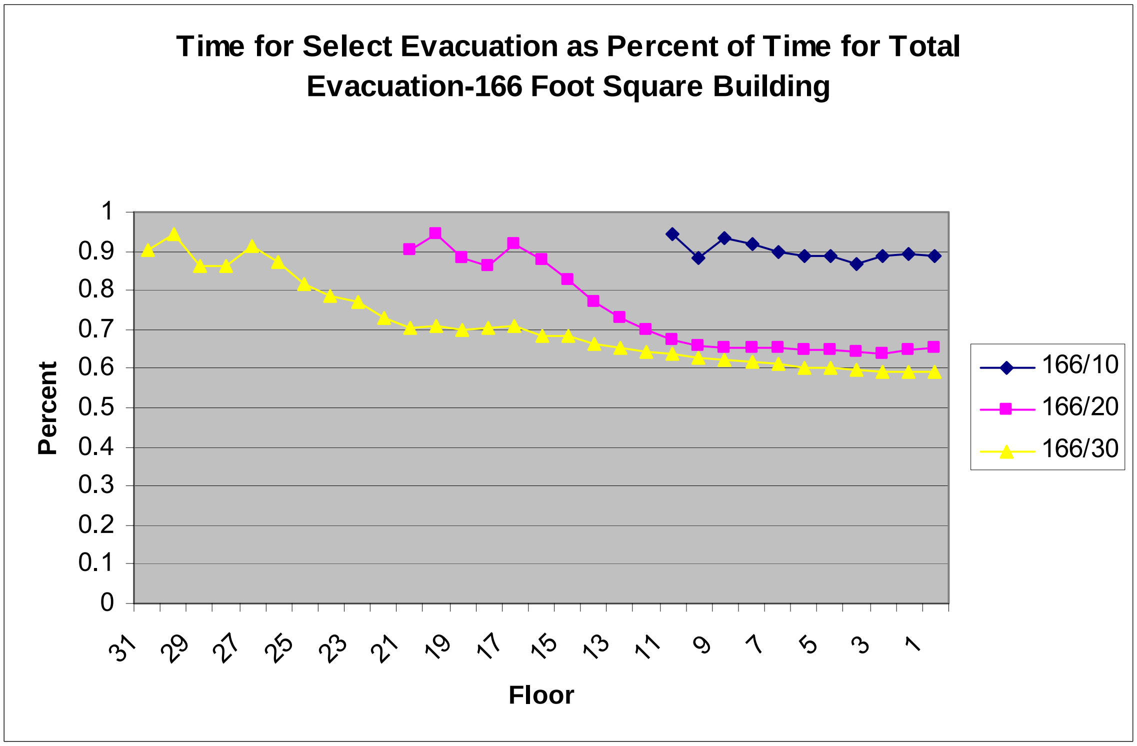


Figure 6-20. Overall time for select evacuation as percent of time for total evacuation for the 166 foot square buildings.

In Figure 6-20, the relative difference between total and select evacuation strategy times (as measured by the ratio of select to total evacuation times) shows that select evacuation strategy ranges from 59% to 94% of the time for the total evacuation strategy time. However, for the top five floors (affected region), this difference is much less significant, with select being at least 85% of total. In noting the line patterns, they are relatively similar in pattern especially for the top five floors.

6.5.3 225 FOOT SQUARE BUILDING

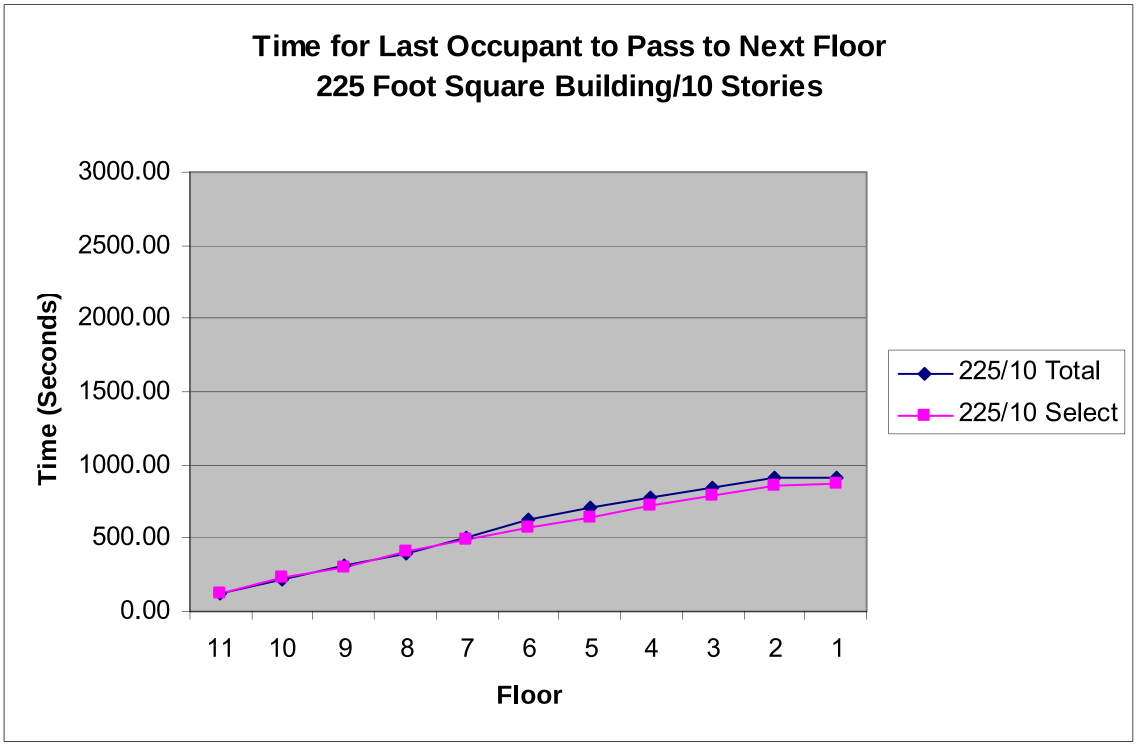


Figure 6-21. Time for last occupant to pass to the next floor for the 225 foot square building, 10 stories.

To clear the ninth floor (floor at which the hazard exists), the time difference is approximately 11 seconds as seen in Figure 6-21. However for the top five floors (Floor 11 to Floor 7) to pass onto the next floor, Floor 6, the difference goes from 0 seconds to 57 seconds. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building goes from 0 seconds to a maximum of approximately 57 seconds. This peak occurs at the sixth floor.

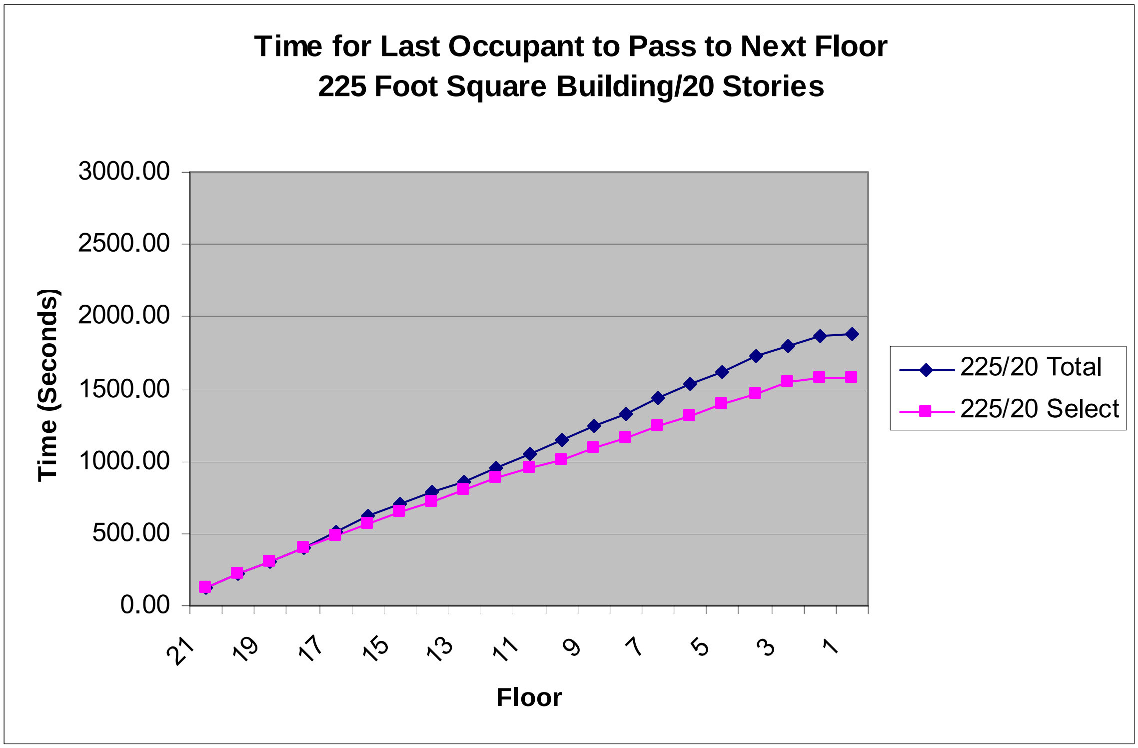


Figure 6-22. Time for last occupant to pass to the next floor for the 225 foot square building, 20 stories.

In Figure 6-22, to clear the nineteenth floor (floor at which the hazard exists), the time difference is also approximately 11 seconds, which is the same as the 10-story case. However for the top five floors (Floor 21 to Floor 17) to pass onto the next floor, Floor 16, the difference goes from 0 seconds to 50 seconds below the 10-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from 0 seconds to a maximum of approximately 303 seconds.

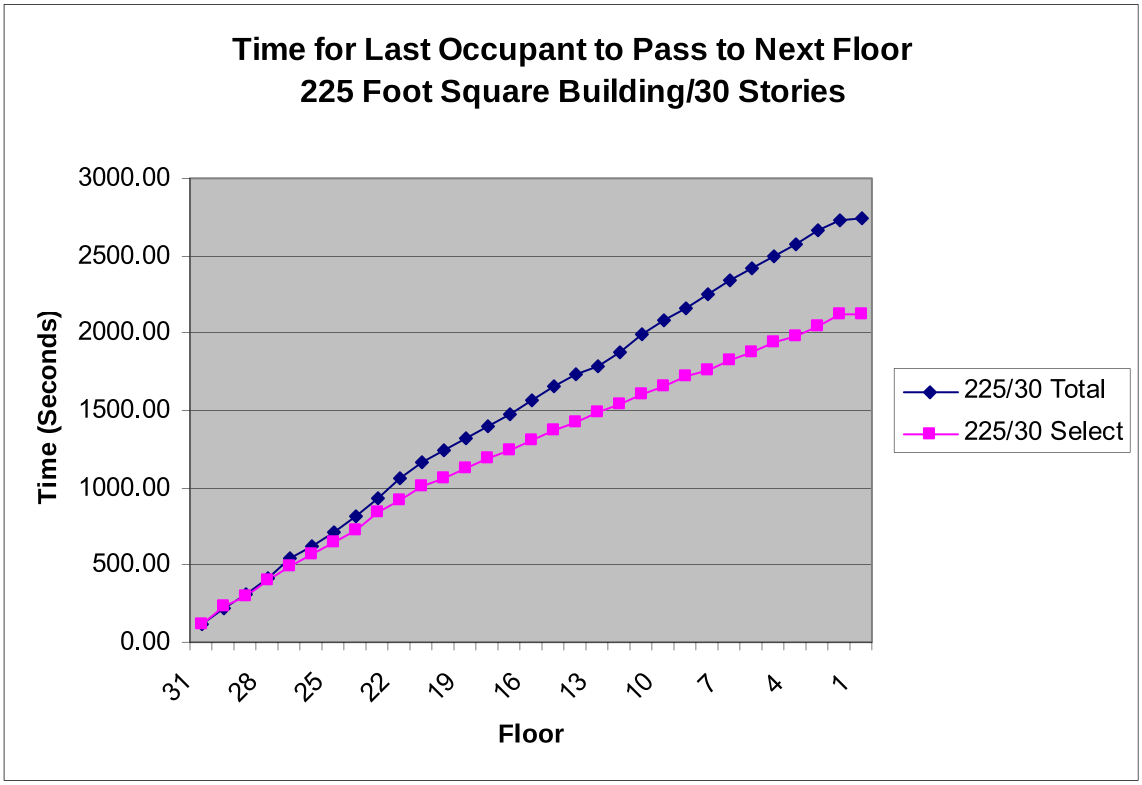


Figure 6-23. Time for last occupant to pass to the next floor for the 225 foot square building, 30 stories.

In Figure 6-23, the time difference to clear the twenty-ninth floor (floor at which the hazard exists) is also approximately 13 seconds, greater than the 10-story case and the 20-story case. However for the top five floors (Floor 31 to Floor 27) to pass onto the next floor, Floor 26, the difference goes from 0 seconds to 50 seconds less than the 10-story case and similar to the 20-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from 0 seconds to a maximum of approximately 621 seconds.

Overall, the differences begin at zero, and by the first floor the times increased to approximately 49 seconds, 304 seconds, and 622 seconds for the 10-story, 20-story, and 30-story buildings.

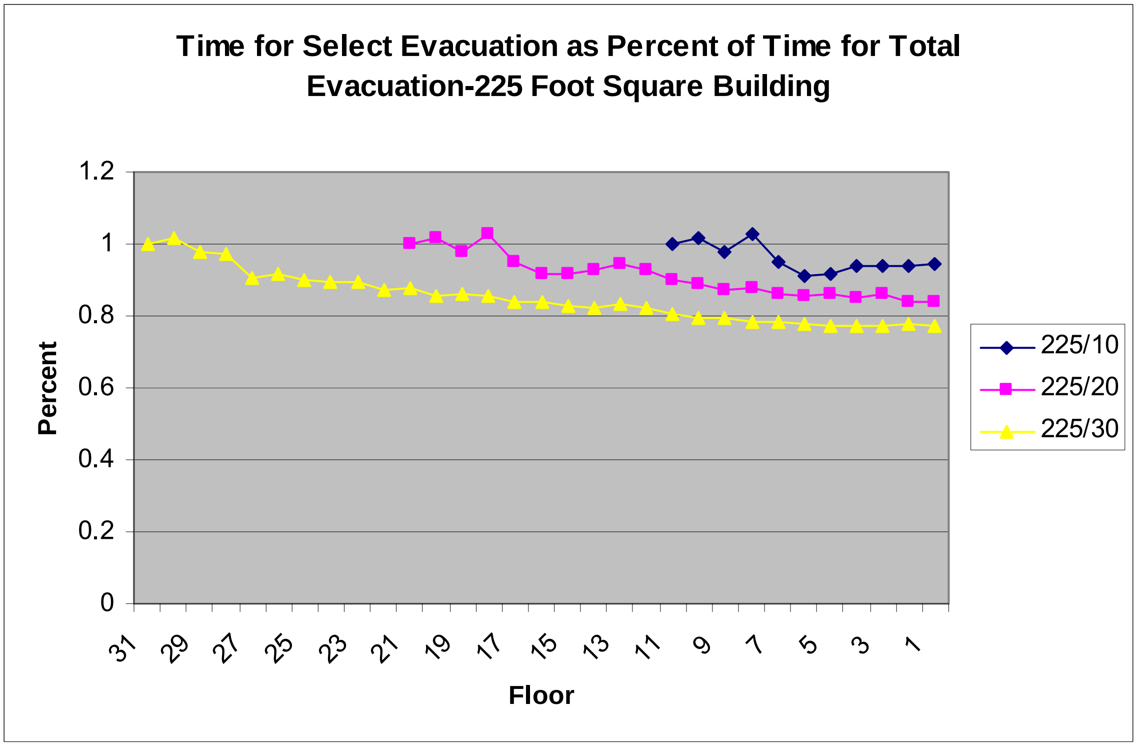


Figure 6-24. Overall time for select evacuation as percent of time for total evacuation for the 225 foot square buildings.

The time for select evacuation strategy ranges from 77% to 102% of the time for the total evacuation strategy. In noting the line patterns, they are relatively similar in pattern especially for the top five floors. The results are closer together than the 166 foot square buildings.

6.5.4 375 FOOT SQUARE BUILDING

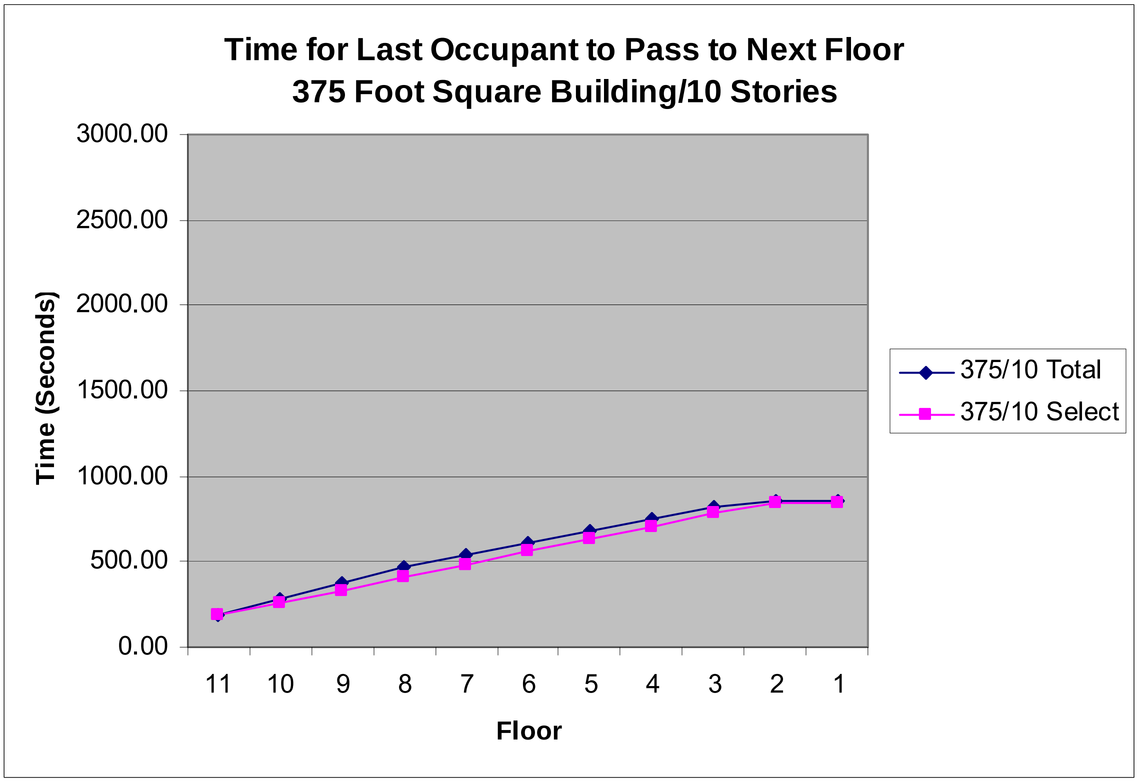


Figure 6-25. Time for last occupant to pass to the next floor for the 375 foot square building, 10 stories.

To clear the ninth floor (floor at which the hazard exists), the time difference is approximately 63 seconds as seen in Figure 6-25. However for the top five floors (Floor 11 to Floor 7) to pass onto the next floor, Floor 6, the difference goes from approximately 8 seconds to 58 seconds. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building goes from approximately 8 seconds to a maximum of approximately 63 seconds. This peak occurs at the eighth floor

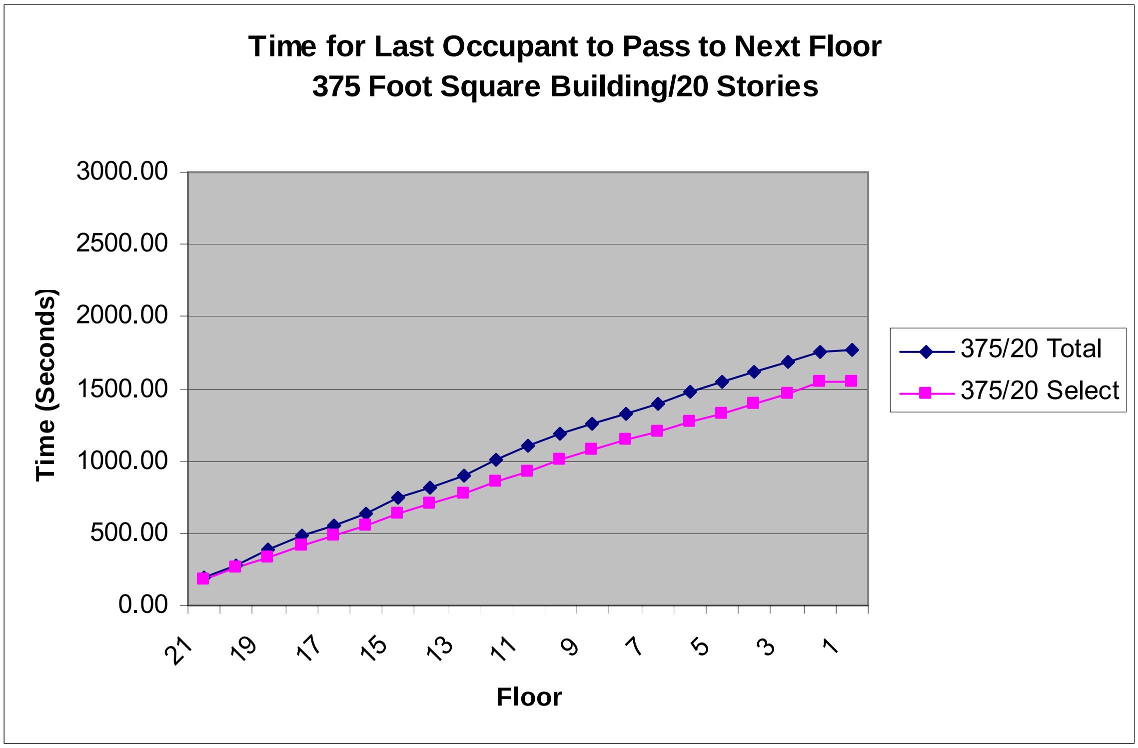


Figure 6-26. Time for last occupant to pass to the next floor for the 375 foot square building, 20 stories.

Figure 6-26 shows that to clear the nineteenth floor (floor at which the hazard exists), the time difference is also approximately 76 seconds, greater than the 10-story case. However for the top five floors (Floor 21 to Floor 17) to pass onto the next floor, Floor 16, the difference goes from approximately 8 seconds to 83 seconds greater than the 10-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 8 seconds to a maximum of approximately 221 seconds.

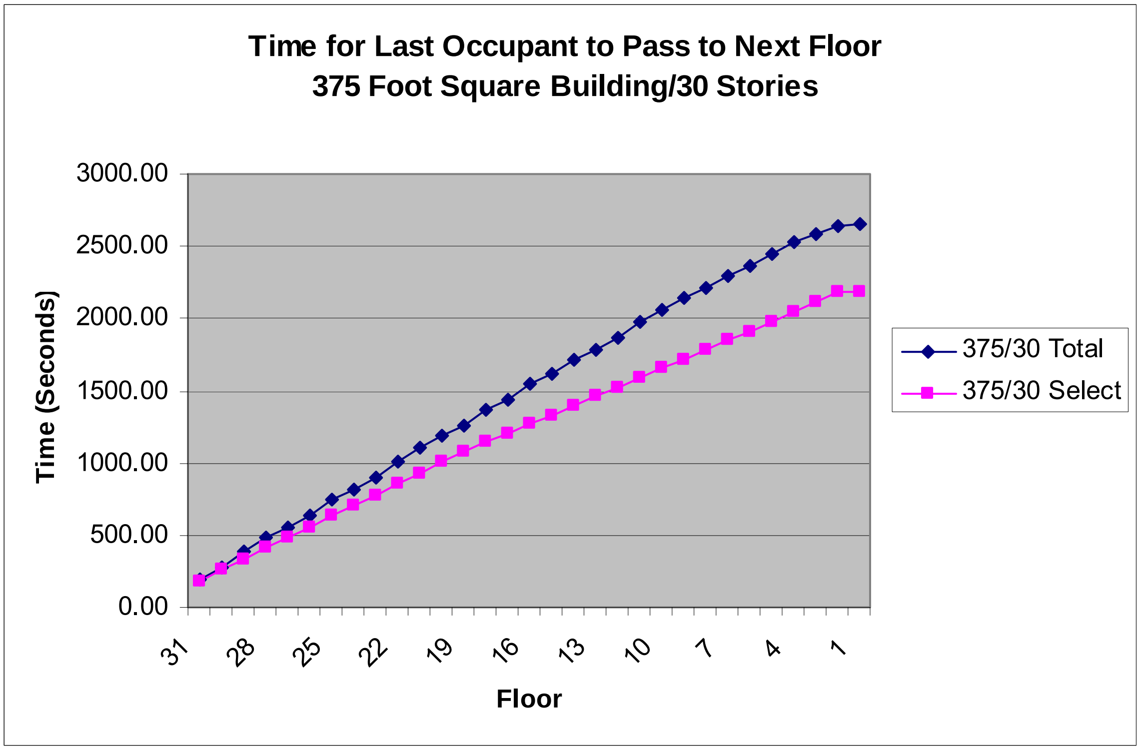


Figure 6-27. Time for last occupant to pass to the next floor for the 375 foot square building, 30 stories.

In Figure 6-27, the time difference to clear the twenty-ninth floor (floor at which the hazard exists) is also approximately 76 seconds, greater than the 10-story case and similar to the 20-story case. However for the top five floors (Floor 31 to Floor 27) to pass onto the next floor, Floor 26, the difference goes from approximately 8 seconds to 83 seconds greater than the 10-story case and similar to the 20-story case. The time difference between the total and select evacuation strategies for the last occupant to pass to the next floor of this building grows from approximately 8 seconds to a maximum of approximately 478 seconds

Overall, the time differences begin as approximately 8 seconds, and by the first floor the times increased to approximately 14 seconds, 221 seconds, and 464 seconds for the 10-story, 20-story, and 30-story buildings. These results are less than the results in the 225 building by approximately 35 seconds, 83 seconds, and 158 seconds, respectively.

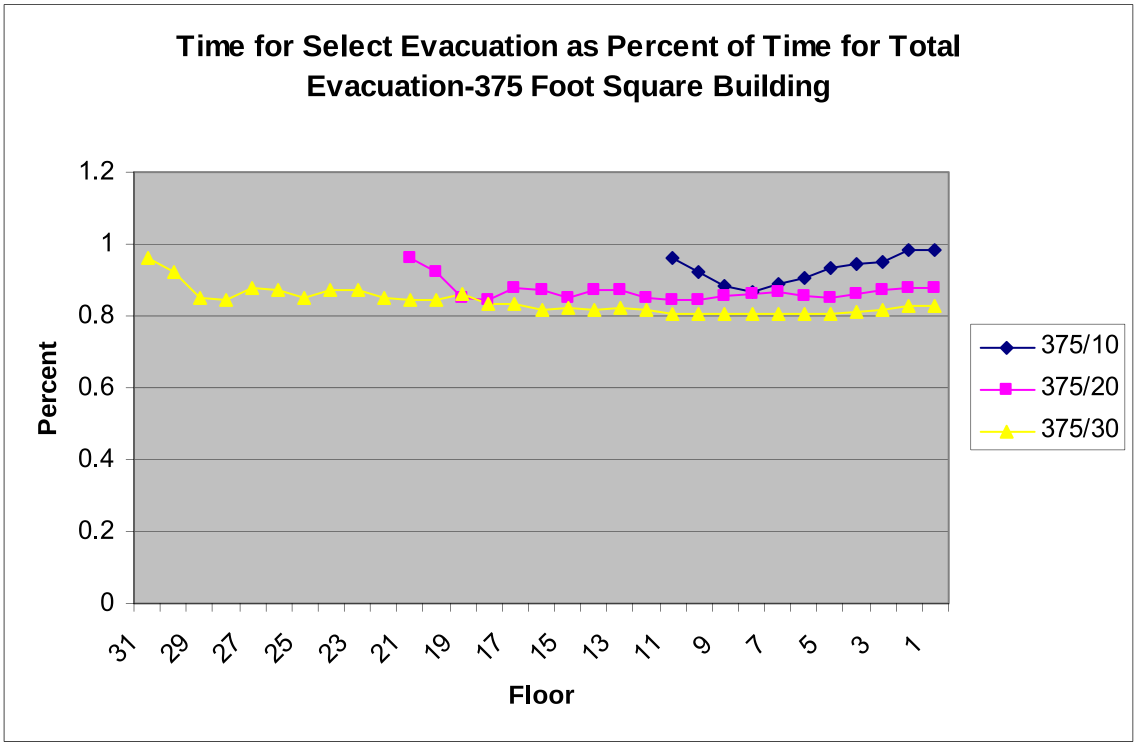


Figure 6-28. Overall time for select evacuation as percent of time for total evacuation for the 375 foot square buildings.

The time for select evacuation strategy ranges from 80% to 98% of the time for the total evacuation strategy. In noting the line patterns, they are relatively similar in pattern especially for the top five floors. The results are closer together than the 166 foot square buildings and the 225 foot square building.

6.6 CONCLUSION

In examining the model runs with the four hypothetical buildings, the total evacuation time for the total evacuation strategy shows a longer time to get the occupants out of the building than total evacuation time for the select evacuation strategy. In the overall evacuation case, this penalty ranged from 14 to 698 seconds as a function of both building size and height, as shown in Figure 6-29. The absolute and relative differences between the two evacuation strategies were not as large as expected. In addition, when evaluated on a relative basis (ratio of select to total, which attempts to address scaling issues associated with longer evacuations), this difference is less significant, as shown in Figure 6-30.

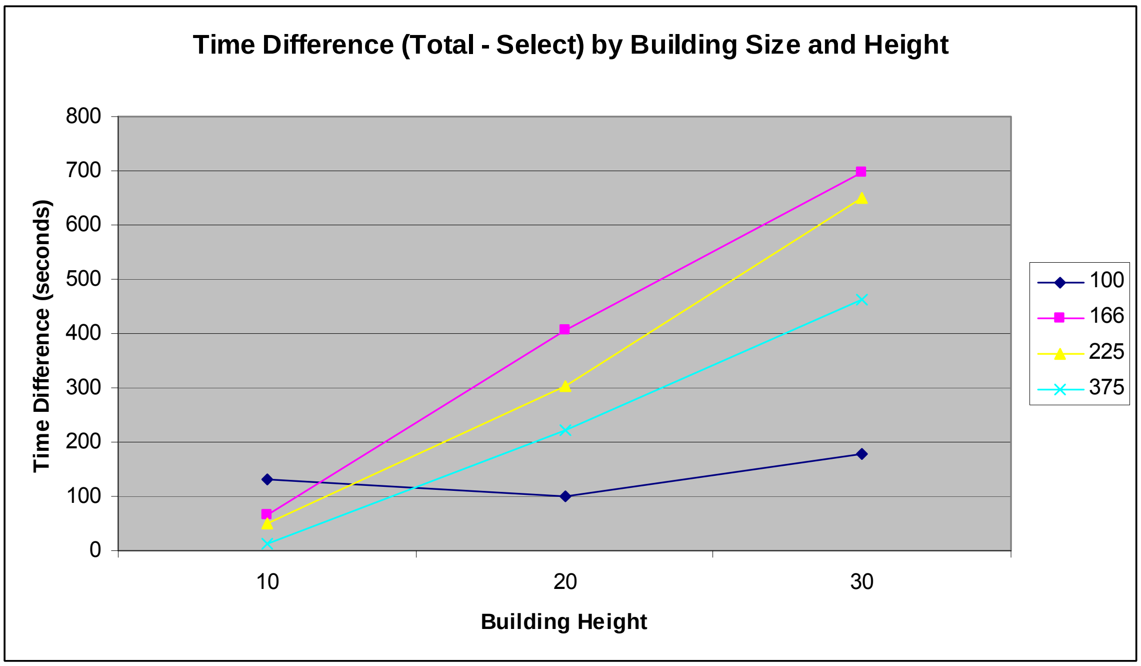


Figure 6-29. Time difference (total – select) by building size and height for all hypothetical buildings.

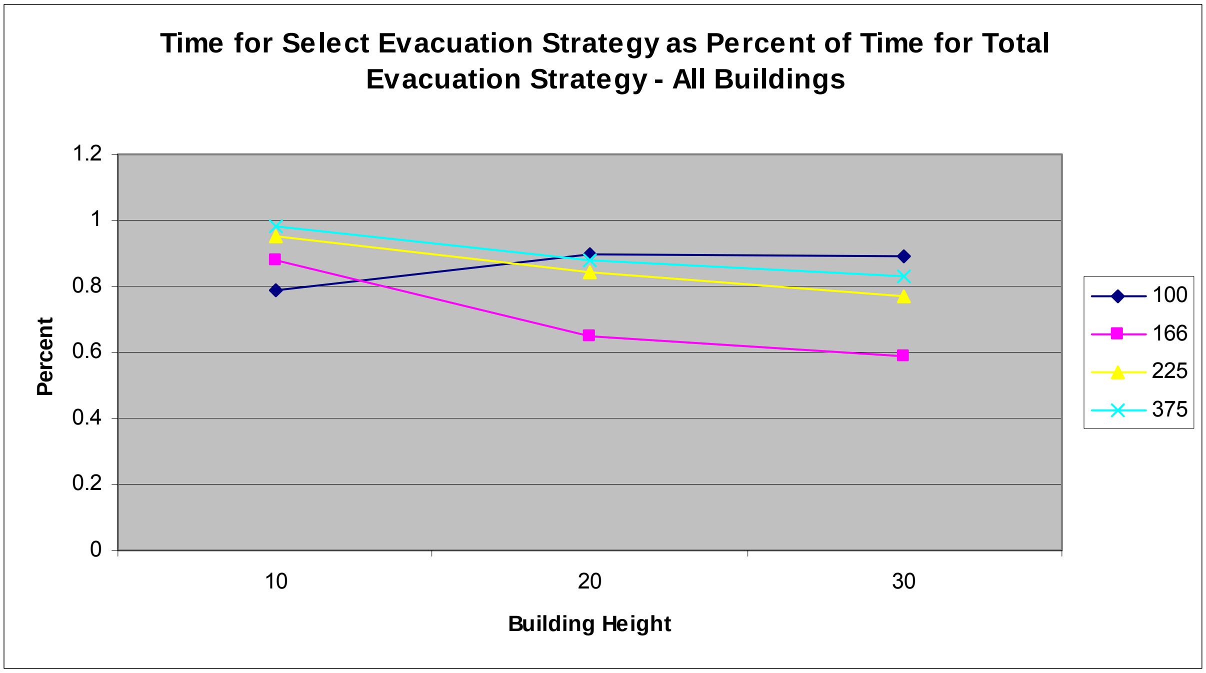


Figure 6-30. Time for select evacuation strategy as percent of time for total evacuation strategy for total evacuation – all buildings.

Regarding the times for the last occupant to pass the next floor (time for occupants to move between floors), the time differences started out relatively close, and then increased towards the end of the evacuation times as the number of stories increased. In reviewing the time to clear the top five floors (time to evacuate the more hazardous affected region), the time differences between the evacuation strategies were very close for all the buildings. This is summarized in Figures 6-31 and 6-32.

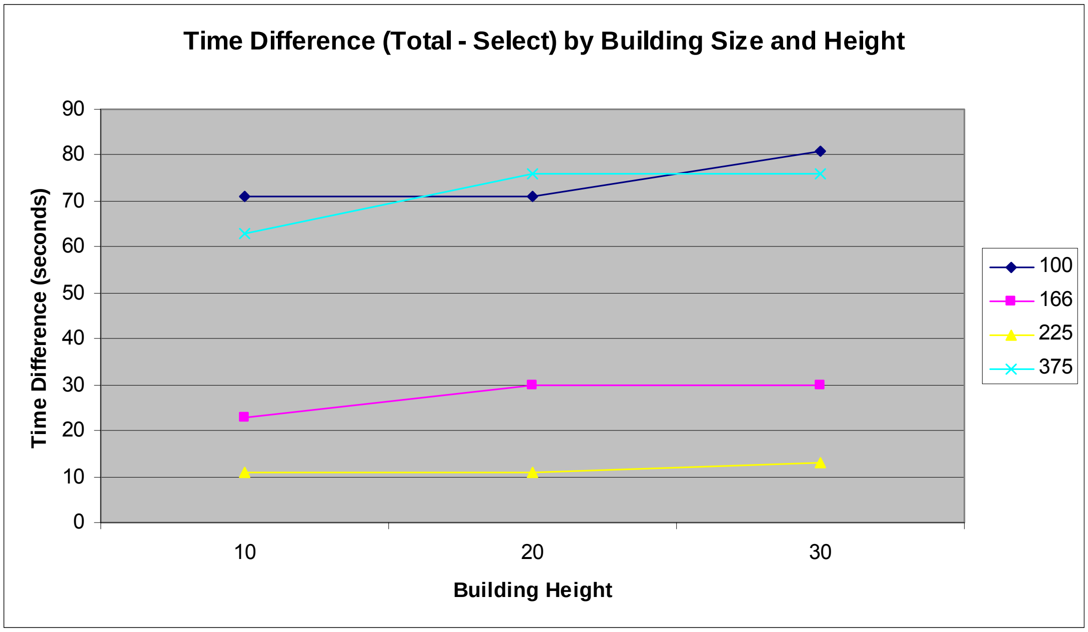


Figure 6-31. Time difference (total – select) to clear the affected floors (top five floors) by building size and height for all hypothetical buildings.

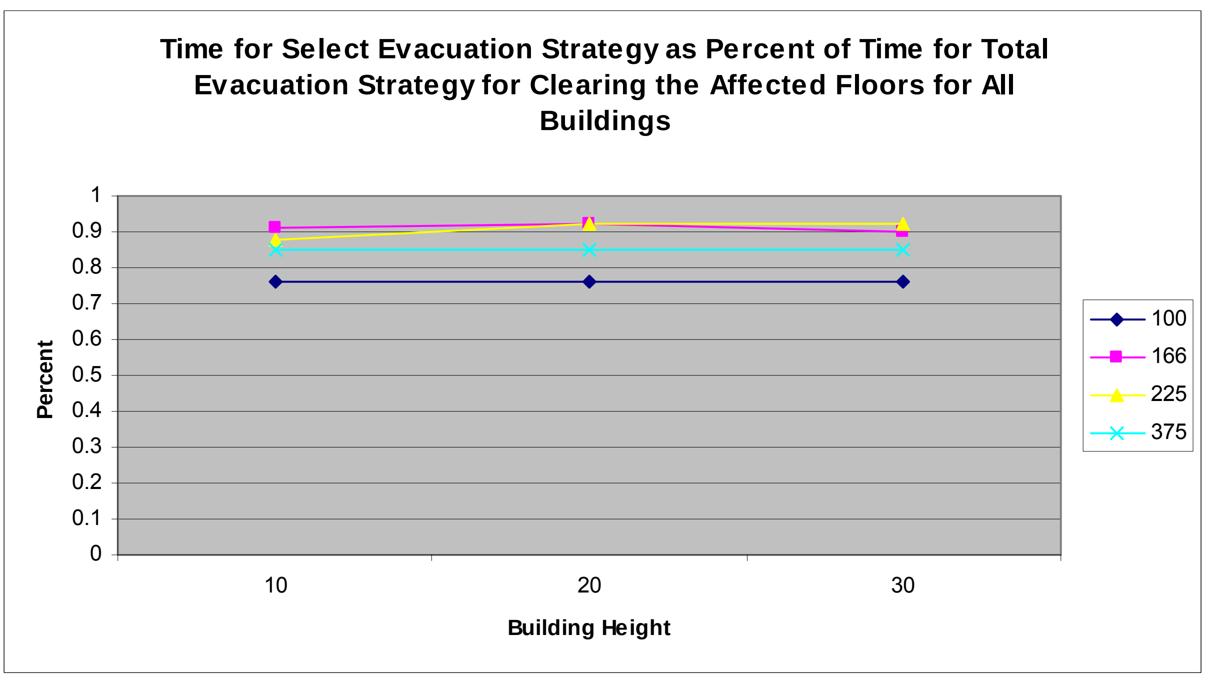


Figure 6-32. Time for select evacuation strategy as percent of time for total evacuation strategy for clearing the affected floors (top five floors) for all buildings.

CHAPTER 7

CONCLUSION

7.1 CONCLUSION

As stated previously, the focus of this research is to inform decision-makers regarding tradeoffs between total and select evacuation strategies. Specifically, this research sought to identify the performance differences between the two strategies in terms of the overall time to evacuate and the time to evacuate the affected area in this research, the top five floors).

Overall, this research has identified that there are differences in the performance of the total and select evacuation strategies, with a greater penalty in the overall evacuation case (time to get evacuees out of the building) than in the local case (time to get evacuees out of the affected area). The degree to which either difference is significant is not able to be determined here, given the lack of a stochastic element to the EXIT89 modeling, and given the interpretive aspects of the difference noted- i.e., whatever difference is noted must be considered in conjunction with other tradeoffs as associated with the strategies. These other tradeoffs include potential safety and liability issues with the select evacuation (e.g., evacuating only a few floors in the select strategy assumes that the danger will not spread beyond those boundaries- an assumption that might not bear out and could those expose occupants to danger and decision makers to liability), as well potentially avoids evacuating floors not in danger (and therefore potentially lowering the likelihood that personnel unnecessarily evacuated will evacuate in the event of subsequent emergencies).

While this research addressed some major questions pertinent to the total and select evacuation strategies, it also raised some questions as well. One such question that is recommended for further research is to determine the height at which the total and select evacuations differ significantly (this requires that "significant" be defined as noted above). This research focused on the scenario of having the affected floors located at the top of the building. Given that the time to clear the affected region would be the same for a fire at the base of the building in both total and select strategies, there is at least hypothetically a fire location at which the difference grows to a significant level. Another pertinent question pertains to the effect of fatigue (as was noted in the evacuation following first attack versus the World Trade Center), which may cause the times to vary in a very significant manner.

In conclusion, this research attempted to provide insight for decision-makers regarding the selection of the total versus select strategies. It is hoped that the results provide insights of value to building and emergency managers.

7.2 TOPICS FOR FUTURE RESEARCH

Some topics for future research based on this thesis are as follows.

- Explore the same hypothetical buildings introducing human behavior aspects, especially fatigue, to see how this would affect the evacuation times.
- Increase the number of stairwells in the hypothetical buildings until an equilibrium in time is achieved between the total evacuation strategy and the select evacuation strategy.
- Establish protocols on how to direct occupants during a wide range of

emergency scenarios with the focus on simultaneous conditions such as fire and terrorism attacks.

- Obtain more real data on both emergency evacuations and fire drills for high-rise office buildings.
- Determine the floor level in which one evacuation strategy would be used over the other.
- Introduce smoke effects into the hypothetical buildings to how this would affect the evacuation times.

Appendix 1

Extracted Listings of the Fatal Fires in High-Rise Office Buildings from 1911-2001

Date	Building	Reported Dollar Loss	Location	Number of Deaths	Floor of Origin	Height in Stories
March 25, 1911	ASCH Building (Traingle Shirtwaist Co.)	Unknown	New York, NY	146	8	10
January 19, 1912	Equitable Building	2,500,000	New York, NY	6	Basement	10
October 8, 1925	LeClede Gas Light Co.	71,000	St. Louis, MO	4	Basement	11
October 4, 1936	Liberty Building	280,000	Waco, TX	1	Basement	9
July 28, 1945	Empire State Building	500,000	New York, NY	11	79	102
November 22, 1961	The Times Tower	100,000	New York, NY	3	Sub-basement	25
June 28, 1963	Astoria Building	78,000	Rio de Janeiro, Brazil	7	14	22
November 27, 1964	Tishman Office Building	Unknown	New York, NY	1	Basement	39
December 9, 1964	Edificio Office Building	500,000	Mexico City, Mexico	1	8	12
February 22, 1966	Richmond York Office Building	210,000	Toronto, Canada	1	6	13
March 11, 1966	Four Corners Office Building	Unknown	Rochester, NY	1	4	10
December 7, 1967	Time-Life Office Building	1,300,000	Paris, France	2	8	8
February 7, 1968	Borax Building	100,000	Los Angeles, CA	1	2	9
December 5, 1968	Atlanta Gaslight Towers (Office Building)	200,000	Atlanta, GA	4	20	24
August 5, 1970	One New York Plaza	10,000,000	New York, NY	2	33	50
December 4, 1970	919 Third Avenue Office Building	2,500,000	New York, NY	3	5	47
April 8, 1971	John Hancock Building	Unknown	Chicago, IL	1	61	100
January 12, 1972	Canadian Liquid Air Building (Office Building)	371,000	Montreal, PQ	5	2	10
February 24, 1972	Andraus Building	2,000,000	Sao Paulo, Brazil	16	5	31
April 11, 1973	Sears Tower	1,000	Chicago, IL	4	33	110

Extracted Listings of the Fatal Fires in High-Rise Office Buildings from 1911-2001 (Continued)

Extracts of High-Rise Office Buildings from #						
Date	Building	Reported Dollar Loss	Location	Number of Deaths	Floor of Origin	Height in Stories
July 23, 1973	Avianca Tower	Unknown	Bogota, Columbia	4	13	36
February 1, 1974	Joelma Building (Cresfisul Bank Building)	3,000,000	Sao Paulo, Brazil	179	12	25
February 28, 1975	Idle Building	Unknown	Philadelphia, PA	1	4	8
March 10, 1975	Office Building	Unknown	Brooklyn, NY	1	13	Not reported
May 10, 1977	U.S. Fidelity & Guaranty Office Building	Unknown	Baltimore, MD	1	11	40
September 22, 1981	Willoughby Office Building	Unknown	Chicago, IL	2	25	38
July 24, 1982	Schmid Towers	3,000	Erie, PA	1	5	7
June 6, 1983	Office Building	Unknown	New Delhi, India	1	Unknown	14
August 12, 1984	Gilbralter Office Building	Unknown	Newark, NJ	1	7	14
September 5, 1984	Office Building Under Construction	Unknown	San Diego, CA	2	Sub-level	24
September 23, 1985	Bank Building	150,000	Chattanooga, TN	1	18	18
February 17, 1986	Office Building	Unknown	Rio de Janeiro, Brazil	23	Unknown	13
August 21, 1986	Office Building	100,000	Cincinnati, OH	1	8	15
November 1, 1986	Talbot Towers	Unknown	Braddock, PA	4	6	7
May 13, 1987	Office Building	Unknown	Chicago, IL	1	20	30
May 4, 1988	First Interstate Bank Building (Office Building)	50,000,000	Los Angeles, CA	1	12	62
June 30, 1989	Office Building	2,500,000	Atlanta, GA	5	6	10
February 23, 1991	Office Building	Unknown	Philadelphia, PA	3	22	38
March 26, 1991	Office Building	12,000,000	Oakland, CA	1	2	18
February 26, 1993	Office Building Complex	230,000,000	Brooklyn, NY	6	Sub-basement	110
April 19, 1995	Office Building	135,929,000	Oklahoma City, OK	168	Outside	9

These listings in Appendix 1 were extracted from "International Listing of Fatal High-Rise Structure Fires 1911-Present" (Hall, 2001, Appendix A).

Appendix 2

Re-structured International Egress Standards List from Hagiwara and Takeyoshi (1994)

	Australia	France	Japan	U.K.	U.S.
Minimum Number of Means of Escape					
General	2 exits for story	for story or part of story	2 exits for story	for story or part of story	for story or part of story
	a) >6 stories	[<=]50 persons - 1 exit	a) >5th floor	[<=] 50 persons - 1 exit	[<=] 50 persons - 1 exit
	b) >25 m height	[<=]100 persons - 2 exits	b) on 3-5th floor room area > 200 sq. m	[<=]500 persons - 2 exits	[<=]500 persons - 2 exits
		or 1+ sub-exits	c) on 2nd floor room area > 400 sq. m	[<=]1000 persons - 3 exits	[<=]1000 persons - 3 exits
		[<=]500 persons - 2 exits		[<=]2000 persons - 4 exits	[>=]1001 persons - 4 exits
		[>=}]501 persons - +1		[<=]4000 persons - 5 exits	
		per 500 persons over 500		[<=]7000 persons - 6 exits	
				[<=]11000 persons - 7 exits	
				[<=]16000 persons - 8 exits	
				[>]16000 persons - +1 exits	
				per 5000 persons over 16000	
Arrangement of Means of Escape					
Maximum Travel Distance	General - 40 m	General - 40 m	General	Assembly - 15 m/32 m (the travel distance must not be more than 32 meters whre the travel is possible in more than one direction, and must not be more than 15 meters where travel is possible in one direction only.)	Assembly - 45 m (60 m in a sprinkler protected building)
	Assembly (good) - 60 m		[<=] 14th floor - 50 m	Office - 18 m/45 m (the travel distance must not be more than 45 meters where he travel is possible in more than one direction, and must not be more than 18 meters where travel is possible in one direction only)	Office - 60 m (91 m in a sprinkler protected building)
			[>=] 15th floor - 40 m		
			good material (means interior surfaces are noncombustible or quasi-noncombustible) - +10 m		
Common Path of Travel	General - 20 m	General - 30 m	1/2 maximum travel distance	Assembly - 15 m/32 m (the travel distance must not be more than 32 meters whre the travel is possible in more than one direction, and must not be more than 15 meters where travel is possible in one direction only.)	Assembly - 6.1
				Office - 18 m/45 m (the travel distance must not be more than 45 meters where he travel is possible in more than one direction, and must not be more than 18 meters where travel is possible in one direction only)	Office - 23 m (30 m in a sprinkler protected building)
Dead-end Corridor	General - 20 m	from room door - 10 m	10 m	Assembly - 15 m/32 m (the travel distance must not be more than 32 meters whre the travel is possible in more than one direction, and must not be more than 15 meters where travel is possible in one direction only.)	Assembly - 6.1
				Office - 18 m/45 m (the travel distance must not be more than 45 meters where he travel is possible in more than one direction, and must not be more than 18 meters where travel is possible in one direction only)	Office - 6.1 m (15 m in a sprinkler protected building)
Distance between Exits	General - 9 to 60 m	not reported for this application	not reported	not reported	a) >=1/2 D
					b) sprinkler & >+1/3 D
					D:diagonal space distance

Re-structured International Egress Standards List from Hagiwara and Takeyoshi (1994) (Continued)

	Australia		France		Japan		U.K.		U.S.	
Capacity of Means of Escape										
Stairs	Pn: [<=] 100 persons	1m	∑Pn: [<=]50 persons	0.9 m	Minimum		a) Total Evacuation		General	0.008xPn meters
	[<=] 200 persons	1+0.25x[{(Pn-101)/25}+1} mete	[<=]100 persons	0.9 m x 2 or 1.4 m	General	1.2 m	∑Pn=200w+50(w-0.3)(n-1)		Minimum	
	[>=]201 persons	2+0.5x[{(Pn-201)/60}+1} meters	[>=]101 persons	1.2+0.6x[(∑Pn-1)/100] mete	Assembly	1.4 m	n: no. of stories served		[>=]49 persons	0.91 meters
							w: stairs width (m)		[>=]50 persons	1.21 meters
							b) Phased Evacuation			
							Pn: [>=] 100 persons	1 m		
							[>=] 120 persons	1.1 m		
							[>] 120 persons	1.1+0.1x[(Pmax-111)/10] meters		
								Stair with largest width is discounted.		
							Assembly		General	0.005xPn meters
							[>=] 220 persons	1.1 m	Minimum	0.81 m
Corridor, Door	same as stairs, except		same as stairs		Assembly (doors) same as stairs		Pn (served)			
	[>=]201 persons	2+0.5x[{(Pn-201)/75}+1} meters					[>=] 50 persons	0.8 m		
							[>=] 110 persons	0.9 m		
							[>=] 220 persons	1.1 m		
							[>] 220 persons	1.1+0.1x[(Pn-201)/20] meters		
	Pn: number of persons on n-th floor, ∑Pn:total number of persons, [x]:the largest interger no more than x. (Gauss' notation)									
Occupant Load Factors										
Assembly	board room-0.050 person/sq. m		not reported for this application		meeting room[<=]400 sq.m-1.5 person/sq. m		conference room-1.0 person/sq. m		less concentrated without fixed-0.72 person/sq. m	
					meeting room[>]400 sq.m-0.6 person/sq. m					
Office	0.10 person/sq. m		public access area-0.10 persons/sq. m		>60 m high - 0.125 person/sq. m		open plan type - 0.2 person/sq. m		0.11 person/ sq. m (gross)	
			no public-0.010 persons/ sq. m.		<60 m owner - 0.16 person/sq. m		others - 0.14 person/sq. m			
			If area public access are not defined. 1/3 of floor area is subjected.		<60 m for rent - 0.25 person/sq. m					

Appendix 3

Listing of United States Evacuation Standards from Life Safety Code (NFPA,2003a), Building Construction and Safety Code (NFPA 2003b), and International Building Code (ICC, 2003)

	Life Safety Code, NFPA 101, 2003 Edition			Building Construction and Safety Code, NFPA 5000, 2003 Edition			International Building Code, 2003 Edition		
Minimum Number of Means of Escape									
	Section	Reference Section	Requirement	Section	Reference Section	Requirement	Section	Reference Section	Requirement
General		7.4.1.1	The number of means of egress from any balcony, mezzanine, story, or portion thereof shall be not less than two.	28.2.4.2		The number of exits shall comply with any one of the following:	1018.1		All rooms and spaces within each story shall be provided with and have access to the minimum number or approved independent exits as required by Table 1018.1 based on the occpant load, except as modified in Section 1014.1 or 1018.2. For the pruposes of t
						(1) the minimum number of exits shall be inaccordance with Section 11.4, and not less than two separate exits that are accessible from every part of every story shall be provided. Exit access travel shall be permitted to be common for the distnaces permi		Table 1018.1	Occupant load — Minimum Number of Exits
		7.4.1.2	The number of means of egress from any balcony, mezzanine, story, or portion thereof, other than for existing buildings as permitted in Chpaters 12 through 42, shall be as follows:		11.4.1.2	The number of means of egress from any balcony, mezzanine, story, or portion thereof shall be as follows:		Table 1018.1	1-500 — 2
			(1) Occupant load more than 500 but not more than 1000-not less than 3			(1) Occupant load more than 500 but not more than 1000-not less than 3			501-1,000 — 3
			(2) Occupant load more than 1000 - not less than 4.			(2) Occupant load more than 1000 - not less than 4.			More than 1,000 — 4
					11.4.1.4	The occupant load of each story considered individually shall be required to be used in computing the number of means of egress at each story, provided that the requied number of means of egress is not decreased in the direction of egeress travel.			
Arrangement of Means of Escape									
Maximum Travel Distance									
							1015.1		Exits shall be so located on each story such that the maximum length of exit access travel, measured from the most remote point within a story to the entrance to an exit along the natural and unobstructed path of egress travel, shall not exceed the distan
Assembly	12.2.6		Exits shall be arranged so that the total length of travel from any point to reach an exit shall not exceed 150 ft (45 m) in any assembly occupancy. Exception No. 1: The travel distance shall not exceed 200 ft (60 m) in assembly occupancies protected thr	16.2.6		Exits shall be arranged so that the total length of travel from any point to reach an exit shall not exceed 200 ft (60 m) in any assembly occupancy. Exception No. 1: The travel distance shall not exceed 250 ft (75 m) in assembly occupancies protected thr		Table 1015.1	Exit travel distance sprinkler system is 250 feet. Buildings equipped throughout with an automatic sprinkler system in accodance with Section 903.3.1.1 or 903.3.1.2. See Section 903 for occupancies where sprinkler systems according to Section 903.3.1.2
	12.2.6		Exits shall be arranged so that the total length of travel from any point to reach an exit shall not exceed 150 ft (45 m) in any assembly occupancy.	16.2.6		Exits shall be arranged so that the total length of travel from any point to reach an exit shall not exceed 200 ft (60 m) in any assembly occupancy.		Table 1015.1	Exit travel distance without sprinkler system is 200 feet.
Office	38.2.6	7.5	Travel distances to exits, measure in accordance with Section 7.6, shall not exceed 200 ft (60 m). *Exception: Travel distance shall not exceed 300 ft (91 m) in buildings protected throughout by an approved, supervised automatic sprinkler system in accord*	28.2.6.1		In buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 55.3 and 55.3.2, the travel distance shall not exceed 300 ft (91 m).		Table 1015.1	Exit travel distance sprinkler system is 300 feet. Buildings equipped throughout with an automatic sprinkler system in accodance with Section 903.3.1.1.
				28.2.6.2		In all other builidngs, the travel distance to exits, measured in accordance with Section 11.6, shall not exceed 200 ft (60 m).		Table 1015.1	Exit travel distance without sprinkler system is 200 feet.
Common Path of Travel									
Assembly			Not specified in code for Assembly, Less Concentrated Use, without fixed seating.	16.2.5.1.2		Common path of travel shall be permitted for the first 20 ft (6.1 m) from any point where serving any number of occupants and for the first 75 ft (23 m) from any point where serving not more than 50 occupants.	1024.8		The common path of travel shall not exceed 30 feet (9144 mm) from any seat to a point where a person has a choice of two paths of egress travel to two exits. Exception: For areas serving not more than 50 occupants, the common path of travel shall not exc
Office	38.2.5.3	7.5	Common paths of travel shall not exceed 75 ft (23 m). *Exception No. 1: A common path of travel shall be permitted for the first 100 ft (30 m) in a building protected througout by an approved, supervised automatic sprinkler system in accordance with Sect*	28.2.5.3.1		A common path of travel shall be permitted for the first 100 ft (30 m) in a building protected througout by an approved, supervised automatic sprinkler system in accordance with Section 55.3 and 55.3.2.	1002.1		That portion of exit access which the occupants are required to traverse before two separate and distinct paths of egress travel to two exits are available. Paths that merge are common paths of travel. Common paths of egress travel shall be included wth
				28.2.5.3.3		In all other buildings, the common path of travel shall not exceed 75 ft (23 m).			

Listing of United States Evacuation Standards from Life Safety Code (NFPA,2003a), Building Construction and Safety Code (NFPA 2003b), and International Building Code (ICC, 2003) Continued

	Life Safety Code, NFPA 101, 2003 Edition			Building Construction and Safety Code, NFPA 5000, 2003 Edition			International Building Code, 2003 Edition		
Dead-end Corridor									
Assembly			Not specified in code for Assembly, Less Concentrated Use, without fixed seating.				1016.3		Sprinkler protected assembly areas not addressed.
				16.2.5.1.3		Dead-end corridors shall not exceed 20 ft (6.1 m).	1016.3		Where more than one exit or exit access doorway is required , the exit access shall be arranged such that there are no dead ends in corridors more than 20 feet (6096 mm) in length.
Office	38.2.5.2	7.5	Dead-end corridors shall not exceed 20 ft (6.1 m). *Exception: In buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 9.7, dead-end corridors shall not exceed 50 ft (15 m).*	28.2.5.2.1		In buildings protected throughout by an approved, supervised automatic sprinkler system in accordance with Section 55.3 and 55.3.2, dead-end corridors shall not exceed 50 ft (15 m).	Exception 2		Exceptions: 2. In occupancies in Groups B and F where the building is equipped througout with an automatic sprinkler system in accordancw with Section 903.3.1.1., the length of dead-end corridors shall not exceed 50 feet (15,240 mm).
				28.2.5.2.2		In all other buildings, the comon paths of travel shall not exceed 75 ft (23 m).	1016.3		Where more than one exit or exit access doorway is required , the exit access shall be arranged such that there are no dead ends in corridors more than 20 feet (6096 mm) in length.
Capacity of Means of Escape									
Stairs	38.2.2.3.1	Table 7.2.2.1 (a)	Minimum width clear of all obstructions, except projections not more than 3 1/2 in. (8.9 cm) at or below handrail height on each side [shall be] 44 in. (112 cm); 36 in. (91 cm) where total occupant load of all stories served by stairways is fewer than 50	28.2.2.3.1	Table 11.2.2.2.1	Minimum width clear of all obstructions, except projections not more than 4 1/2 in. (8.9 cm) at or below handrail height on each side [shall be] 44 in. (112 cm); 36 in. (91 cm) where total occupant load of all stories served by stairways is fewer than 50	1009.1		The width of stairways shall be determined as specified in Section 1005.1, but such width shall not be less than 44 inches (1118 mm). See section 1007.3 for accessible means of egress stairways.
	38.2.2.3.1	Table 7.2.2.1 (a)	Maximum height of risers [shall be] 7 in. (17.9 cm)	28.2.2.3.1	Table 11.2.2.2.1	Maximum height of risers [shall be] 7 in. (17.9 cm)	1009.3		Stair riser heights shall be 7 inches (178 mm) maximum and 4 inches (102 mm) minimum.
	38.2.2.3.1	Table 7.2.2.1 (a)	Minimum height of risers [shall be] 4 in. (10.2 cm)	28.2.2.3.1	Table 11.2.2.2.1	Minimum height of risers [shall be] 4 in. (10.2 cm)	1009.3		Stair riser heights shall be 7 inches (178 mm) maximum and 4 inches (102 mm) minimum.
	38.2.2.3.1	Table 7.2.2.1 (a)	Minimum tread depth [shall be] 11 in. (27.9 cm)	28.2.2.3.1	Table 11.2.2.2.1	Minimum tread depth [shall be] 11 in. (27.9 cm)	1009.3		Stair tread depths shall be 11 inches (279 mm) minimum.
	38.2.2.3.1	Table 7.2.2.1 (a)	Minimum headroom [shall be] 6 ft 8 in. (203 cm)	28.2.2.3.1	Table 11.2.2.2.1	Minimum headroom [shall be] 6 ft 8 in. (203 cm)	1009.2		Stairways shall have a minimum headroom clearance of 80 inches (2032 mm) measured vertically from a line connecting the edge of the nosings.
	38.2.3.1	Table 7.3.3.1	Capacity factors for all others [includes business and assembly] for stairways is 0.3 inches (0.8 cm) width per person.	28.2.3.1	Table 11.3.3.1	Capacity factors for all others [includes business and assembly] for stairways is 0.3 inches (0.75 cm) per person.		Table 1005.1	Egress width per occupant served wtihout sprinklers for stairways is 0.3 inches per occupant.
								Table 1005.1	Egress width per occupant served wtih sprinklers for stairways is 0.2 inches per occupant. Buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1 and 903.3.1.2.
Corridor	38.2.3.2		The clear width of any corridor or passageway serving an occupant load of 50 or more shall not be less than 44 in. (112 cm).	28.2.3.2		The clear width of any corridor or passageway serving an occupant load of 50 or more shall not be less than 44 in. (112 cm).	1016.2		The minimum corridor width shall be as determined in Section 1005.1, but not less than 44 inches (1118 mm).
	38.2.3.1	Table 7.3.3.1	Capacity factors for all others [includes business and assembly] for level components and ramps is 0.2 inches (0.5 cm) width per person.	28.2.3.1	Table 11.3.3.1	Capacity factors for all others [includes business and assembly] for level components and ramps is 0.2 inches (0.5 cm) per person.		Table 1005.1	Egress width per occupant served wtihout sprinklers for other egress components is 0.2 inches per occupant.
								Table 1005.1	Egress width per occupant served wtih sprinklers for other egress components is 0.15 inches per occupant. Buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1 and 903.3.1.2.
Door	38.2.2.2.1	7.2.1.2.3	Door openings in means of egress shall be not less than 32 in. (81 cm) in clear width. Where a pair of doors is provided, ot less than one of the doors shall provide not less than a 32-in. (81-cm) clear width opening.	28.2.2.2.1	11.2.1	Door openings in means of egress shall be not less than 32 in. (81 cm) in clear width. Where a pair of doors is provided, ot less than one of the doors shall provide not less than a 32-in. (81-cm) clear width opening.	1008.1.1		The minimum width of each door opening shall be suffiicient for the occupant load thereof and shall provide a clear width of not less than 32 inches (813 mm). Clear openings of doorways with swinging doors shall be measured between the face of the door a
	38.2.3.1	Table 7.3.3.1	Capacity factors for all others [includes business and assembly] for level components and ramps is 0.2 inches (0.5 cm) width per person.	28.2.3.1	Table 11.3.3.1	Capacity factors for all others [includes business and assembly] for level components and ramps is 0.2 inches (0.5 cm) per person.		Table 1005.1	Egress width per occupant served wtihout sprinklers for other egress components is 0.2 inches per occupant.
								Table 1005.1	Egress width per occupant served wtih sprinklers for other egress components is 0.15 inches per occupant. Buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1 and 903.3.1.2.
Occupant Load Factors									
Assembly	38.1.7	Table 7.3.1.2	Assembly Use, Less Concentrated Use, without fixed seating, 15 net square feet per person	28.1.6	Table 11.3.1.2	Assembly Use, Less Concentrated Use, without fixed seating, 15 net square feet per person	1004.1	Table 1004.1.2	Assembly Use without fixed seating, Unconcentrated (tables and chairs) 15 net square feet per occupant
Office	38.1.7	Table 7.3.1.2	Business Use 100 square feet per person	28.1.6	Table 11.3.1.2	Business Use 100 square feet per person	1004.1	Table 1004.1.2	Business Use 100 gross square feet per occupant

Appendix 4

"Figure 3.1: Diagram representing evacuation methodologies" from Gwynne and Galea (n.d., p. 11)

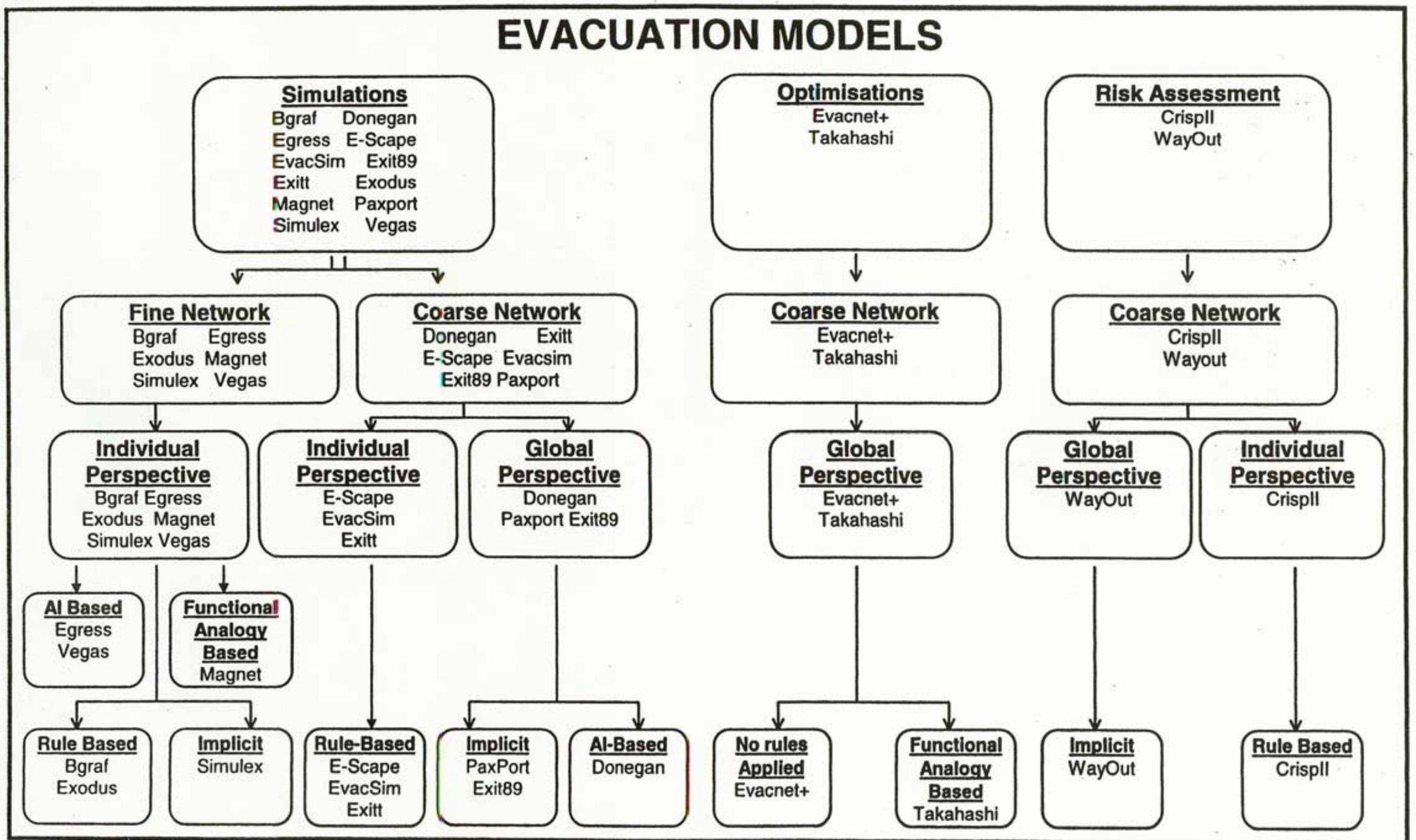
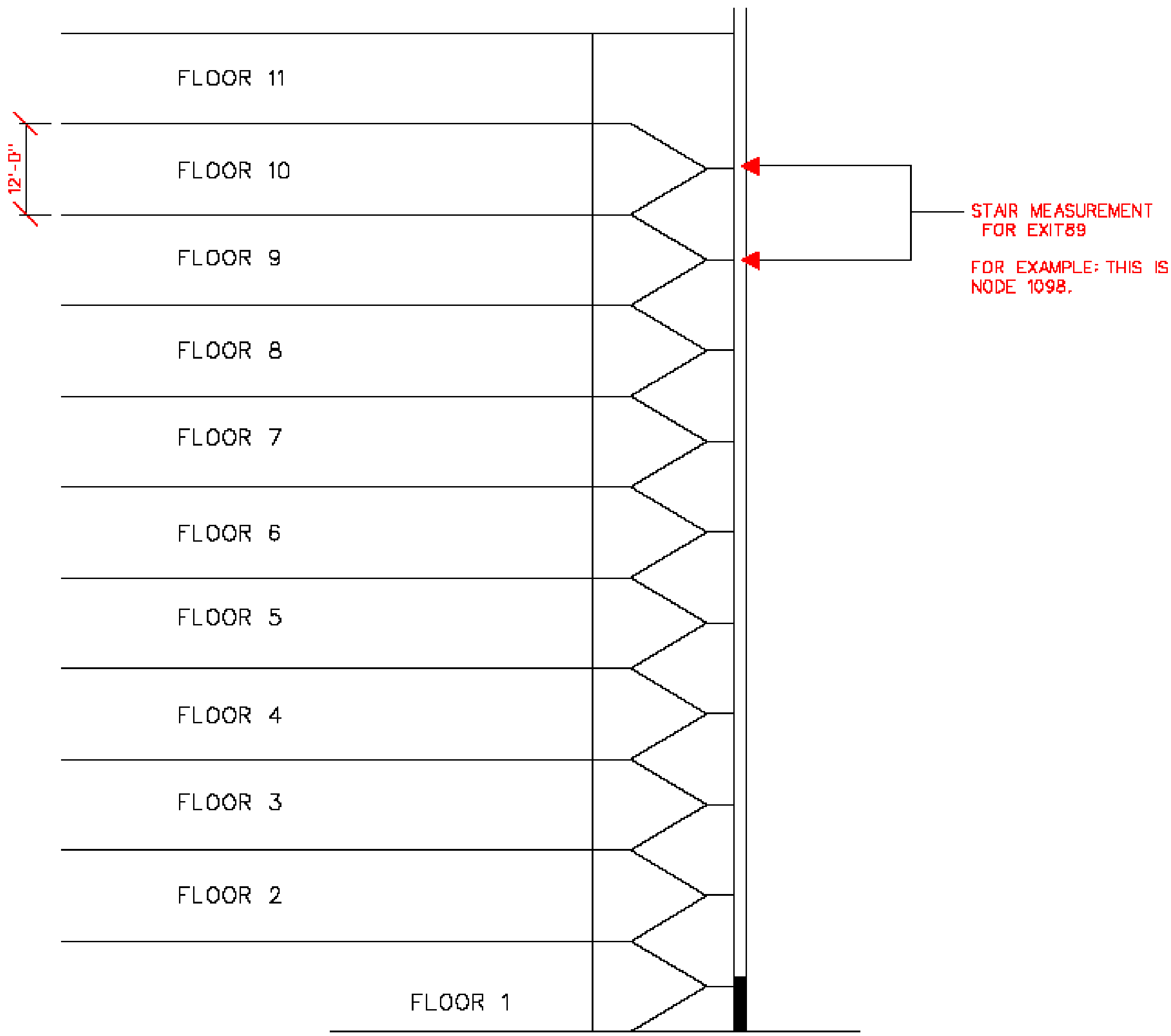
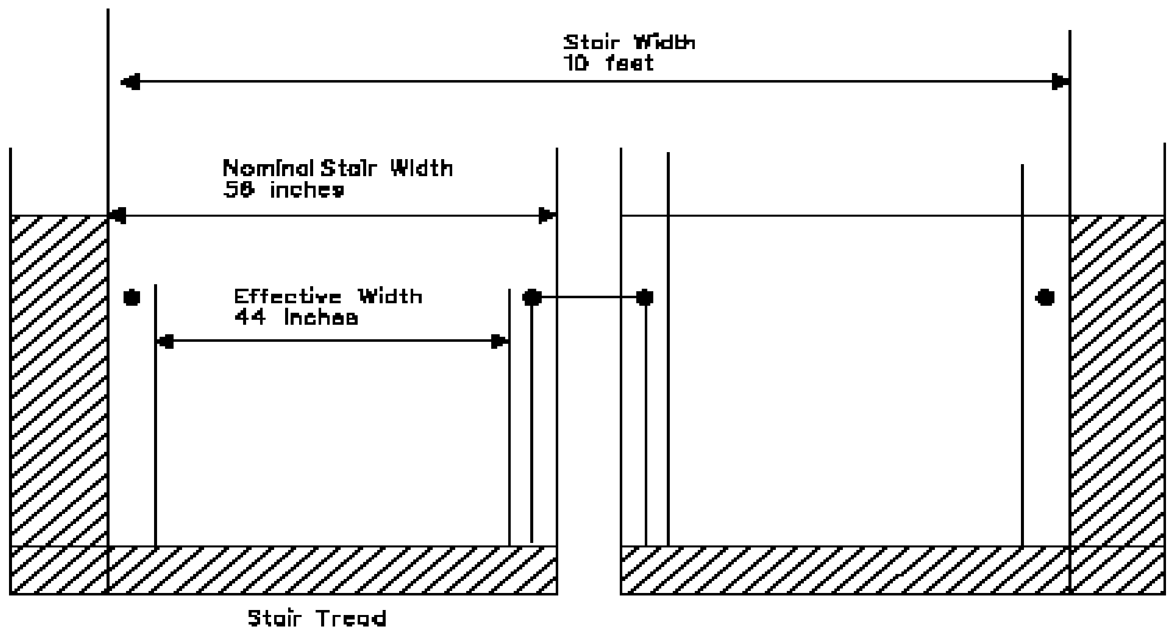


Figure 3.1:Diagram representing evacuation methodologies.

Appendix 5

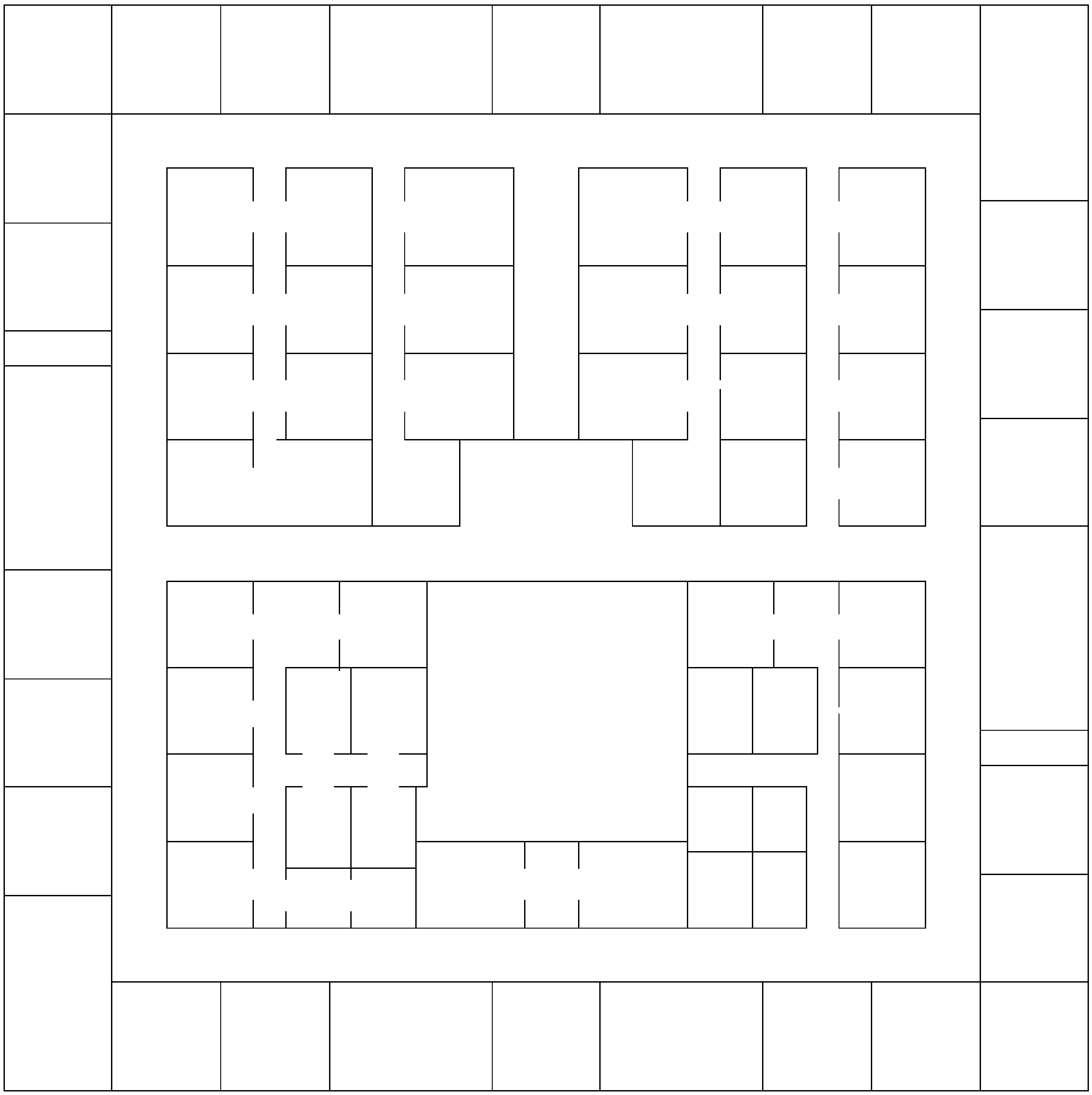
Illustrations of one of the stairwells serving the 10-story buildings (not to scale)



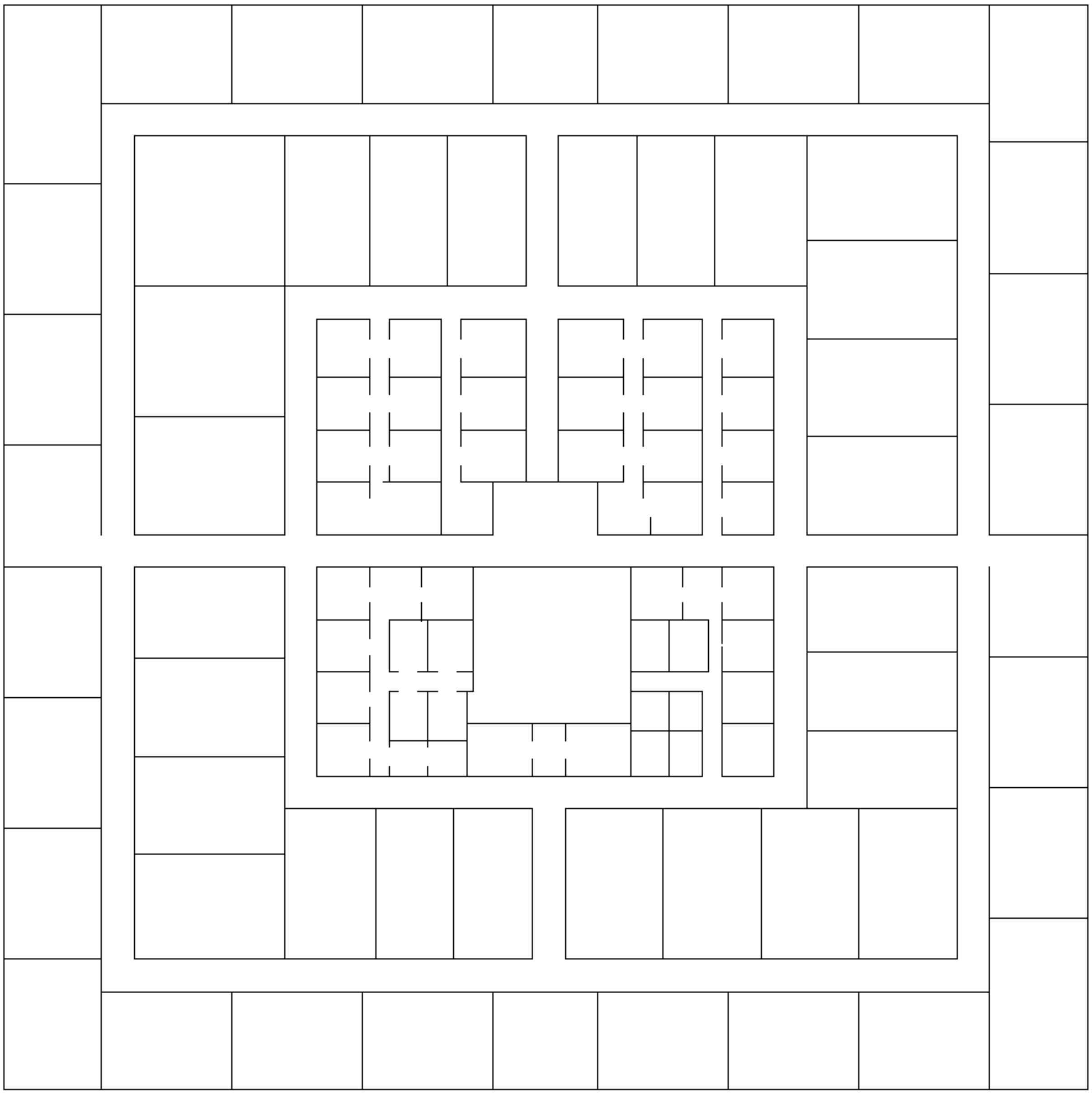

Stair Width
10 feet
Nominal Stair Width
58 inches
Effective Width
44 inches
Stair Tread

Appendix 6

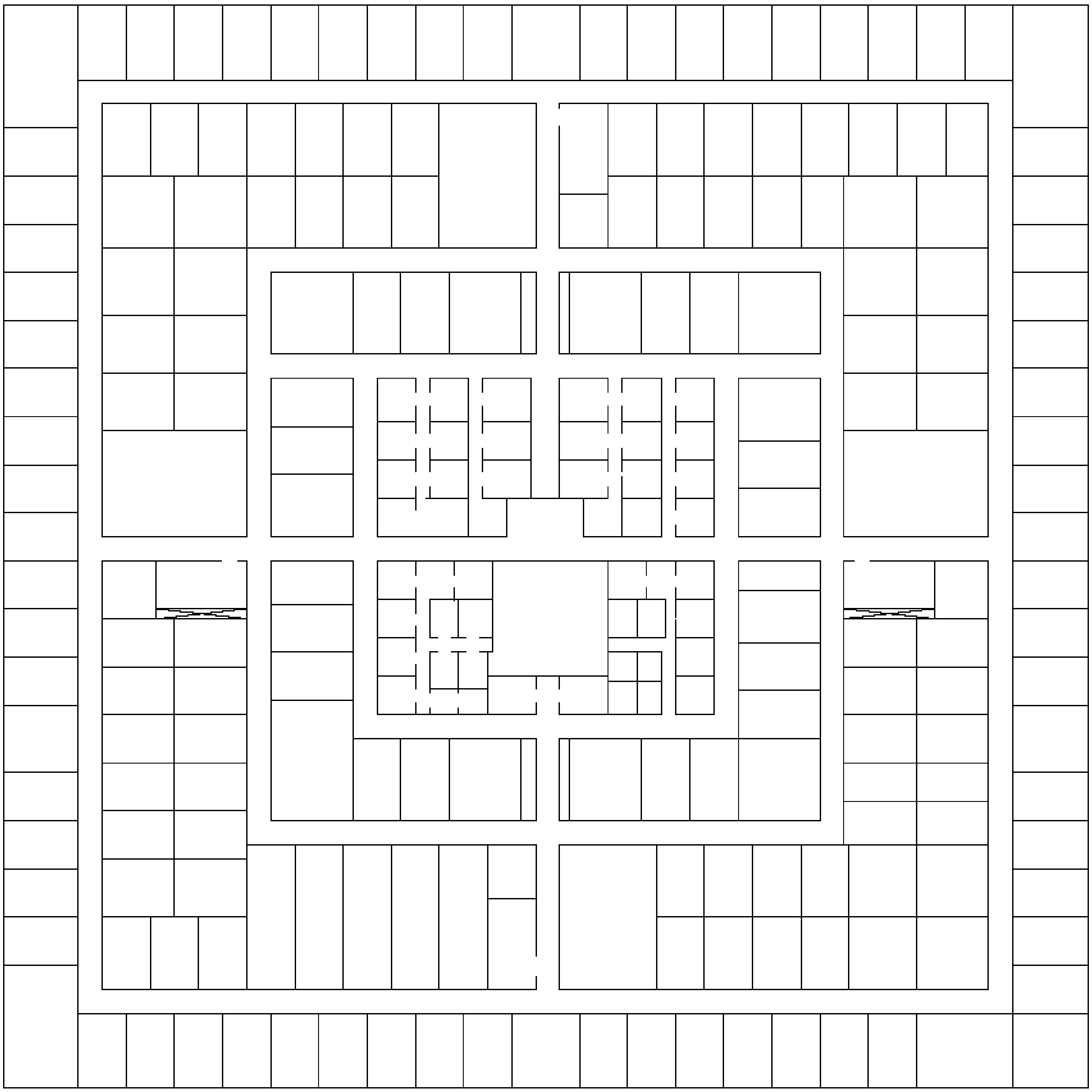
100 Foot Square Building Floor Layout (not to scale)



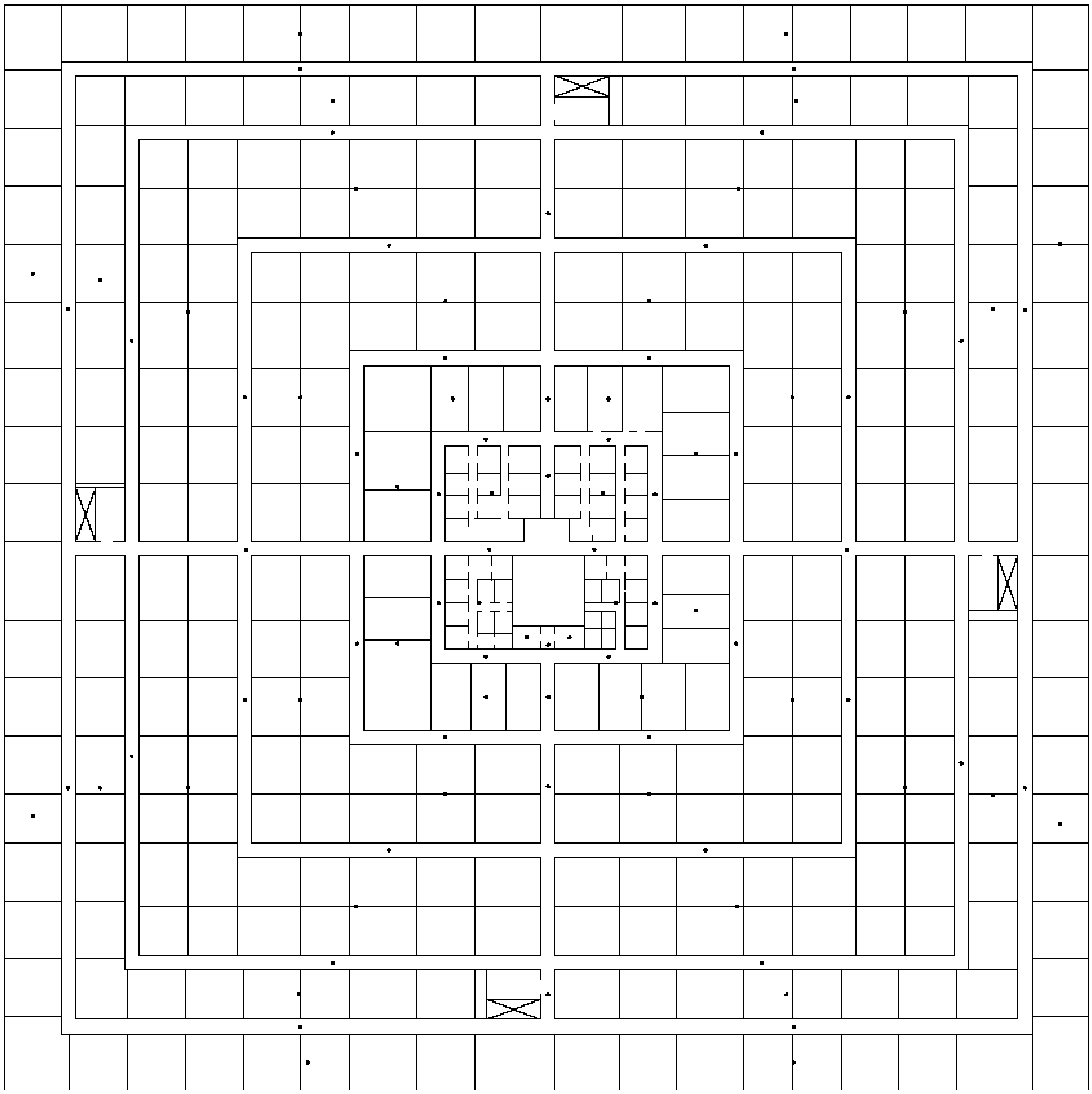
166 Foot Square Building Floor Layout (not to scale)



225 Foot Square Building Floor Layout (not to scale)



375 Foot Square Building Floor Layout (not to scale)



Appendix 7

Node Table for the One-Story, 225 Foot Square Building

NODES	AREA	H	NCAP	NOCC
196	188	12.0	100	0
197	188	12.0	100	0
198	188	12.0	100	0
199	188	12.0	100	0
201	1041	12.0	100	11
202	1016	12.0	100	11
203	704	12.0	100	12
204	736	12.0	100	12
205	848	12.0	100	37
206	935	12.0	100	22
207	918	12.0	100	22
208	629	12.0	100	36
209	918	12.0	100	4
210	112	12.0	100	1
211	1500	12.0	100	10
212	450	12.0	100	3
213	960	12.0	100	8
214	960	12.0	100	8
215	112	12.0	100	1
216	1020	12.0	100	6
217	1020	12.0	100	7
218	1185	12.0	100	7
219	1185	12.0	100	8
220	112	12.0	100	1
221	720	12.0	100	7
222	720	12.0	100	7
223	1035	12.0	100	6
224	1035	12.0	100	6
225	217	12.0	100	15
226	1395	12.0	100	9
227	1020	12.0	100	30
228	217	12.0	100	15
229	2255	12.0	100	38
230	1395	12.0	100	9
231	217	12.0	100	15
232	1395	12.0	100	9
233	2255	12.0	100	39
234	217	12.0	100	15

NODES	AREA	H	NCAP	NOCC
235	1015	12.0	100	30
236	1395	12.0	100	9
237	80	12.0	100	1
238	80	12.0	100	1
239	646	12.0	100	3
242	160	12.0	100	0
243	485	12.0	100	0
244	490	12.0	100	0
245	160	12.0	100	0
246	350	12.0	100	0
247	300	12.0	100	0
248	285	12.0	100	0
249	265	12.0	100	0
250	165	12.0	100	0
251	445	12.0	100	0
252	275	12.0	100	0
253	265	12.0	100	0
254	475	12.0	100	0
255	470	12.0	100	0
256	440	12.0	100	0
257	450	12.0	100	0
258	470	12.0	100	0
259	475	12.0	100	0
260	450	12.0	100	0
261	440	12.0	100	0
262	275	12.0	100	0
263	299	12.0	100	0
264	295	12.0	100	0
265	275	12.0	100	0
266	65	12.0	100	0
267	285	12.0	100	0
268	570	12.0	100	3
269	570	12.0	100	3
270	561	12.0	100	3
271	165	12.0	100	0
272	561	12.0	100	3
273	570	12.0	100	3
274	570	12.0	100	3
275	110	12.0	100	1

Appendix 8

Input File for the 10-Story, 100 Foot Square Building

```
Ten Story Detailed Exercise - evacuation/emergency spd
UNITS (1-METRIC,2-STD)      =2
SIZE (1-AUST,2-SOVIET,3-US) =1
SPEED (1-EMER,2-NORMAL)     =1
PATH (1-SHORTEST,2-DIRECTED)=1
SMOKE (1-CFAST,2-USER/NONE) =2
CONTRA (1-IF CONTRA FLOWS)  =0
OUTPUT (1-FULL,2-BRIEF)     =1
NUM OF STAIRWAYS (00-10)    =02
STAIR TRAVEL (1-DOWN, 2-UP) =1
RANDOM DELAY (1-Y,2-N) =2, PROB = 50,
    MIN TIME (SEC) =   1, MAX TIME (SEC) =   5.
  198   5.0   3.0  15.0  000
  199   5.0   3.0  15.0  000
  201   9.5   3.0  11.0  274
  202   5.0   3.0   4.5  274
  203   5.0   3.0  15.0  275
  204   7.0   3.0   5.5  276
  205   7.0   3.0  11.0  277
  206   5.5   3.0  13.5  278
  207   7.0   3.0   5.5  279
  208   5.5   3.0   6.5  280
  209   7.0   3.0   5.0  281
  210   6.5   3.0   5.0  282
  211   5.0   3.0  13.5  283
  212  15.5   3.0   5.5  284
  213  16.5   3.0   7.5  274
  214  15.5   3.0   9.0  276
  215  16.0   3.0   4.5  285
  216  16.0   3.0   4.5  281
  217   4.0   3.0   3.5  280
  218   4.0   3.0   3.5  280
  219  16.5   3.0   4.0  279
  274  18.0   5.0  13.0  283
  275  13.0   5.0  18.5  276
  276  16.0   5.0  16.0  277
  277  15.5   5.0  16.5  285
  278  15.5   5.0  16.5  285
  278  15.5   5.0  15.0  279
  280   5.5   5.0  17.5  279
  280   5.0   5.0  17.5  281
  281  16.0   5.0  15.5  282
  282  15.5   5.0  17.5  284
  283  15.5   5.0  16.0  284
  284  19.5   3.0   5.0  298
  285  19.5   3.0   5.0  299
  298  21.3   3.7  21.3  198
  299  21.3   3.7  21.3  199
  301   9.5   3.0  11.0  374
  302   5.0   3.0   4.5  374
  303   5.0   3.0  15.0  375
  304   7.0   3.0   5.5  376
```

305	7.0	3.0	11.0	377
306	5.5	3.0	13.5	378
307	7.0	3.0	5.5	379
308	5.5	3.0	6.5	380
309	7.0	3.0	5.0	381
310	6.5	3.0	5.0	382
311	5.0	3.0	13.5	383
312	15.5	3.0	5.5	384
313	16.5	3.0	7.5	374
314	15.5	3.0	9.0	376
315	16.0	3.0	4.5	385
316	16.0	3.0	4.5	381
317	4.0	3.0	3.5	380
318	4.0	3.0	3.5	380
319	16.5	3.0	4.0	379
374	18.0	5.0	13.0	383
375	13.0	5.0	18.5	376
376	16.0	5.0	16.0	377
377	15.5	5.0	16.5	385
378	15.5	5.0	16.5	385
378	15.5	5.0	15.0	379
380	5.5	5.0	17.5	379
380	5.0	5.0	17.5	381
381	16.0	5.0	15.5	382
382	15.5	5.0	17.5	384
383	15.5	5.0	16.0	384
384	19.5	3.0	5.0	398
385	19.5	3.0	5.0	399
398	21.3	3.7	21.3	298
399	21.3	3.7	21.3	299
401	9.5	3.0	11.0	474
402	5.0	3.0	4.5	474
403	5.0	3.0	15.0	475
404	7.0	3.0	5.5	476
405	7.0	3.0	11.0	477
406	5.5	3.0	13.5	478
407	7.0	3.0	5.5	479
408	5.5	3.0	6.5	480
409	7.0	3.0	5.0	481
410	6.5	3.0	5.0	482
411	5.0	3.0	13.5	483
412	15.5	3.0	5.5	484
413	16.5	3.0	7.5	474
414	15.5	3.0	9.0	476
415	16.0	3.0	4.5	485
416	16.0	3.0	4.5	481
417	4.0	3.0	3.5	480
418	4.0	3.0	3.5	480
419	16.5	3.0	4.0	479
474	18.0	5.0	13.0	483
475	13.0	5.0	18.5	476
476	16.0	5.0	16.0	477
477	15.5	5.0	16.5	485
478	15.5	5.0	16.5	485
478	15.5	5.0	15.0	479
480	5.5	5.0	17.5	479
480	5.0	5.0	17.5	481

481	16.0	5.0	15.5	482
482	15.5	5.0	17.5	484
483	15.5	5.0	16.0	484
484	19.5	3.0	5.0	498
485	19.5	3.0	5.0	499
498	21.3	3.7	21.3	398
499	21.3	3.7	21.3	399
501	9.5	3.0	11.0	574
502	5.0	3.0	4.5	574
503	5.0	3.0	15.0	575
504	7.0	3.0	5.5	576
505	7.0	3.0	11.0	577
506	5.5	3.0	13.5	578
507	7.0	3.0	5.5	579
508	5.5	3.0	6.5	580
509	7.0	3.0	5.0	581
510	6.5	3.0	5.0	582
511	5.0	3.0	13.5	583
512	15.5	3.0	5.5	584
513	16.5	3.0	7.5	574
514	15.5	3.0	9.0	576
515	16.0	3.0	4.5	585
516	16.0	3.0	4.5	581
517	4.0	3.0	3.5	580
518	4.0	3.0	3.5	580
519	16.5	3.0	4.0	579
574	18.0	5.0	13.0	583
575	13.0	5.0	18.5	576
576	16.0	5.0	16.0	577
577	15.5	5.0	16.5	585
578	15.5	5.0	16.5	585
578	15.5	5.0	15.0	579
580	5.5	5.0	17.5	579
580	5.0	5.0	17.5	581
581	16.0	5.0	15.5	582
582	15.5	5.0	17.5	584
583	15.5	5.0	16.0	584
584	19.5	3.0	5.0	598
585	19.5	3.0	5.0	599
598	21.3	3.7	21.3	498
599	21.3	3.7	21.3	499
601	9.5	3.0	11.0	674
602	5.0	3.0	4.5	674
603	5.0	3.0	15.0	675
604	7.0	3.0	5.5	676
605	7.0	3.0	11.0	677
606	5.5	3.0	13.5	678
607	7.0	3.0	5.5	679
608	5.5	3.0	6.5	680
609	7.0	3.0	5.0	681
610	6.5	3.0	5.0	682
611	5.0	3.0	13.5	683
612	15.5	3.0	5.5	684
613	16.5	3.0	7.5	674
614	15.5	3.0	9.0	676
615	16.0	3.0	4.5	685
616	16.0	3.0	4.5	681

617	4.0	3.0	3.5	680
618	4.0	3.0	3.5	680
619	16.5	3.0	4.0	679
674	18.0	5.0	13.0	683
675	13.0	5.0	18.5	676
676	16.0	5.0	16.0	677
677	15.5	5.0	16.5	685
678	15.5	5.0	16.5	685
678	15.5	5.0	15.0	679
680	5.5	5.0	17.5	679
680	5.0	5.0	17.5	681
681	16.0	5.0	15.5	682
682	15.5	5.0	17.5	684
683	15.5	5.0	16.0	684
684	19.5	3.0	5.0	698
685	19.5	3.0	5.0	699
698	21.3	3.7	21.3	598
699	21.3	3.7	21.3	599
701	9.5	3.0	11.0	774
702	5.0	3.0	4.5	774
703	5.0	3.0	15.0	775
704	7.0	3.0	5.5	776
705	7.0	3.0	11.0	777
706	5.5	3.0	13.5	778
707	7.0	3.0	5.5	779
708	5.5	3.0	6.5	780
709	7.0	3.0	5.0	781
710	6.5	3.0	5.0	782
711	5.0	3.0	13.5	783
712	15.5	3.0	5.5	784
713	16.5	3.0	7.5	774
714	15.5	3.0	9.0	776
715	16.0	3.0	4.5	785
716	16.0	3.0	4.5	781
717	4.0	3.0	3.5	780
718	4.0	3.0	3.5	780
719	16.5	3.0	4.0	779
774	18.0	5.0	13.0	783
775	13.0	5.0	18.5	776
776	16.0	5.0	16.0	777
777	15.5	5.0	16.5	785
778	15.5	5.0	16.5	785
778	15.5	5.0	15.0	779
780	5.5	5.0	17.5	779
780	5.0	5.0	17.5	781
781	16.0	5.0	15.5	782
782	15.5	5.0	17.5	784
783	15.5	5.0	16.0	784
784	19.5	3.0	5.0	798
785	19.5	3.0	5.0	799
798	21.3	3.7	21.3	698
799	21.3	3.7	21.3	699
801	9.5	3.0	11.0	874
802	5.0	3.0	4.5	874
803	5.0	3.0	15.0	875
804	7.0	3.0	5.5	876
805	7.0	3.0	11.0	877

806	5.5	3.0	13.5	878
807	7.0	3.0	5.5	879
808	5.5	3.0	6.5	880
809	7.0	3.0	5.0	881
810	6.5	3.0	5.0	882
811	5.0	3.0	13.5	883
812	15.5	3.0	5.5	884
813	16.5	3.0	7.5	874
814	15.5	3.0	9.0	876
815	16.0	3.0	4.5	885
816	16.0	3.0	4.5	881
817	4.0	3.0	3.5	880
818	4.0	3.0	3.5	880
819	16.5	3.0	4.0	879
874	18.0	5.0	13.0	883
875	13.0	5.0	18.5	876
876	16.0	5.0	16.0	877
877	15.5	5.0	16.5	885
878	15.5	5.0	16.5	885
878	15.5	5.0	15.0	879
880	5.5	5.0	17.5	879
880	5.0	5.0	17.5	881
881	16.0	5.0	15.5	882
882	15.5	5.0	17.5	884
883	15.5	5.0	16.0	884
884	19.5	3.0	5.0	898
885	19.5	3.0	5.0	899
898	21.3	3.7	21.3	798
899	21.3	3.7	21.3	799
901	9.5	3.0	11.0	974
902	5.0	3.0	4.5	974
903	5.0	3.0	15.0	975
904	7.0	3.0	5.5	976
905	7.0	3.0	11.0	977
906	5.5	3.0	13.5	978
907	7.0	3.0	5.5	979
908	5.5	3.0	6.5	980
909	7.0	3.0	5.0	981
910	6.5	3.0	5.0	982
911	5.0	3.0	13.5	983
912	15.5	3.0	5.5	984
913	16.5	3.0	7.5	974
914	15.5	3.0	9.0	976
915	16.0	3.0	4.5	985
916	16.0	3.0	4.5	981
917	4.0	3.0	3.5	980
918	4.0	3.0	3.5	980
919	16.5	3.0	4.0	979
974	18.0	5.0	13.0	983
975	13.0	5.0	18.5	976
976	16.0	5.0	16.0	977
977	15.5	5.0	16.5	985
978	15.5	5.0	16.5	985
978	15.5	5.0	15.0	979
980	5.5	5.0	17.5	979
980	5.0	5.0	17.5	981
981	16.0	5.0	15.5	982

982	15.5	5.0	17.5	984
983	15.5	5.0	16.0	984
984	19.5	3.0	5.0	998
985	19.5	3.0	5.0	999
998	21.3	3.7	21.3	898
999	21.3	3.7	21.3	899
1001	9.5	3.0	11.0	1074
1002	5.0	3.0	4.5	1074
1003	5.0	3.0	15.0	1075
1004	7.0	3.0	5.5	1076
1005	7.0	3.0	11.0	1077
1006	5.5	3.0	13.5	1078
1007	7.0	3.0	5.5	1079
1008	5.5	3.0	6.5	1080
1009	7.0	3.0	5.0	1081
1010	6.5	3.0	5.0	1082
1011	5.0	3.0	13.5	1083
1012	15.5	3.0	5.5	1084
1013	16.5	3.0	7.5	1074
1014	15.5	3.0	9.0	1076
1015	16.0	3.0	4.5	1085
1016	16.0	3.0	4.5	1081
1017	4.0	3.0	3.5	1080
1018	4.0	3.0	3.5	1080
1019	16.5	3.0	4.0	1079
1074	18.0	5.0	13.0	1083
1075	13.0	5.0	18.5	1076
1076	16.0	5.0	16.0	1077
1077	15.5	5.0	16.5	1085
1078	15.5	5.0	16.5	1085
1078	15.5	5.0	15.0	1079
1080	5.5	5.0	17.5	1079
1080	5.0	5.0	17.5	1081
1081	16.0	5.0	15.5	1082
1082	15.5	5.0	17.5	1084
1083	15.5	5.0	16.0	1084
1084	19.5	3.0	5.0	1098
1085	19.5	3.0	5.0	1099
1098	21.3	3.7	21.3	998
1099	21.3	3.7	21.3	999
1101	9.5	3.0	11.0	1174
1102	5.0	3.0	4.5	1174
1103	5.0	3.0	15.0	1175
1104	7.0	3.0	5.5	1176
1105	7.0	3.0	11.0	1177
1106	5.5	3.0	13.5	1178
1107	7.0	3.0	5.5	1179
1108	5.5	3.0	6.5	1180
1109	7.0	3.0	5.0	1181
1110	6.5	3.0	5.0	1182
1111	5.0	3.0	13.5	1183
1112	15.5	3.0	5.5	1184
1113	16.5	3.0	7.5	1174
1114	15.5	3.0	9.0	1176
1115	16.0	3.0	4.5	1185
1116	16.0	3.0	4.5	1181
1117	4.0	3.0	3.5	1180

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1118   4.0   3.0   3.5 1180
1119  16.5   3.0   4.0 1179
1174  18.0   5.0  13.0 1183
1175  13.0   5.0  18.5 1176
1176  16.0   5.0  16.0 1177
1177  15.5   5.0  16.5 1185
1178  15.5   5.0  16.5 1185
1178  15.5   5.0  15.0 1179
1180   5.5   5.0  17.5 1179
1180   5.0   5.0  17.5 1181
1181  16.0   5.0  15.5 1182
1182  15.5   5.0  17.5 1184
1183  15.5   5.0  16.0 1184
1184  19.5   3.0   5.0 1198
1185  19.5   3.0   5.0 1199
1198   5.0   3.7  21.3 1098
1199   5.0   3.7  21.3 1099
9999   0.0   0.0   0.0  000
 198    39  12.0  100    0    0    1   0.0    0
 199    39  12.0  100    0    0    1   0.0    0
 201   200  12.0  100    2    0    0   0.0    0
 202   250  12.0  100   11    0    0   0.0    0
 203    80  12.0  100    1    0    0   0.0    0
 204   350  12.0  100   12    0    0   0.0    0
 205   500  12.0  100   16    0    0   0.0    0
 206   300  12.0  100    3    0    0   0.0    0
 207   350  12.0  100   12    0    0   0.0    0
 208    80  12.0  100    1    0    0   0.0    0
 209   350  12.0  100   12    0    0   0.0    0
 210   500  12.0  100   16    0    0   0.0    0
 211   200  12.0  100    2    0    0   0.0    0
 212   608  12.0  100    8    0    0   0.0    0
 213   363  12.0  100    4    0    0   0.0    0
 214   599  12.0  100    8    0    0   0.0    0
 215   341  12.0  100    4    0    0   0.0    0
 216   772  12.0  100   12    0    0   0.0    0
 217    64  12.0  100    1    0    0   0.0    0
 218    64  12.0  100    1    0    0   0.0    0
 219   756  12.0  100   12    0    0   0.0    0
 274   183  12.0  100    0    0    0   0.0    0
 275   150  12.0  100    0    0    0   0.0    0
 276   185  12.0  100    0    0    0   0.0    0
 277   158  12.0  100    0    0    0   0.0    0
 278   158  12.0  100    0    0    0   0.0    0
 279   175  12.0  100    0    0    0   0.0    0
 280    75  12.0  100    0    0    0   0.0    0
 281   180  12.0  100    0    0    0   0.0    0
 282   158  12.0  100    0    0    0   0.0    0
 283   155  12.0  100    0    0    0   0.0    0
 284   196  12.0  100    0    0    0   0.0    0
 285   195  12.0  100    0    0    0   0.0    0
 298    39  12.0  100    0    0    1   0.0    0
 299    39  12.0  100    0    0    1   0.0    0
 301   200  12.0  100    2    0    0   0.0    0
 302   250  12.0  100   11    0    0   0.0    0
 303    80  12.0  100    1    0    0   0.0    0
 304   350  12.0  100   12    0    0   0.0    0
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305	500	12.0	100	16	0	0	0.0	0
306	300	12.0	100	3	0	0	0.0	0
307	350	12.0	100	12	0	0	0.0	0
308	80	12.0	100	1	0	0	0.0	0
309	350	12.0	100	12	0	0	0.0	0
310	500	12.0	100	16	0	0	0.0	0
311	200	12.0	100	2	0	0	0.0	0
312	608	12.0	100	8	0	0	0.0	0
313	363	12.0	100	4	0	0	0.0	0
314	599	12.0	100	8	0	0	0.0	0
315	341	12.0	100	4	0	0	0.0	0
316	772	12.0	100	12	0	0	0.0	0
317	64	12.0	100	1	0	0	0.0	0
318	64	12.0	100	1	0	0	0.0	0
319	756	12.0	100	12	0	0	0.0	0
374	183	12.0	100	0	0	0	0.0	0
375	150	12.0	100	0	0	0	0.0	0
376	185	12.0	100	0	0	0	0.0	0
377	158	12.0	100	0	0	0	0.0	0
378	158	12.0	100	0	0	0	0.0	0
379	175	12.0	100	0	0	0	0.0	0
380	75	12.0	100	0	0	0	0.0	0
381	180	12.0	100	0	0	0	0.0	0
382	158	12.0	100	0	0	0	0.0	0
383	155	12.0	100	0	0	0	0.0	0
384	196	12.0	100	0	0	0	0.0	0
385	195	12.0	100	0	0	0	0.0	0
398	39	12.0	100	0	0	1	0.0	0
399	39	12.0	100	0	0	1	0.0	0
401	200	12.0	100	2	0	0	0.0	0
402	250	12.0	100	11	0	0	0.0	0
403	80	12.0	100	1	0	0	0.0	0
404	350	12.0	100	12	0	0	0.0	0
405	500	12.0	100	16	0	0	0.0	0
406	300	12.0	100	3	0	0	0.0	0
407	350	12.0	100	12	0	0	0.0	0
408	80	12.0	100	1	0	0	0.0	0
409	350	12.0	100	12	0	0	0.0	0
410	500	12.0	100	16	0	0	0.0	0
411	200	12.0	100	2	0	0	0.0	0
412	608	12.0	100	8	0	0	0.0	0
413	363	12.0	100	4	0	0	0.0	0
414	599	12.0	100	8	0	0	0.0	0
415	341	12.0	100	4	0	0	0.0	0
416	772	12.0	100	12	0	0	0.0	0
417	64	12.0	100	1	0	0	0.0	0
418	64	12.0	100	1	0	0	0.0	0
419	756	12.0	100	12	0	0	0.0	0
474	183	12.0	100	0	0	0	0.0	0
475	150	12.0	100	0	0	0	0.0	0
476	185	12.0	100	0	0	0	0.0	0
477	158	12.0	100	0	0	0	0.0	0
478	158	12.0	100	0	0	0	0.0	0
479	175	12.0	100	0	0	0	0.0	0
480	75	12.0	100	0	0	0	0.0	0
481	180	12.0	100	0	0	0	0.0	0
482	158	12.0	100	0	0	0	0.0	0

483	155	12.0	100	0	0	0	0.0	0
484	196	12.0	100	0	0	0	0.0	0
485	195	12.0	100	0	0	0	0.0	0
498	39	12.0	100	0	0	1	0.0	0
499	39	12.0	100	0	0	1	0.0	0
501	200	12.0	100	2	0	0	0.0	0
502	250	12.0	100	11	0	0	0.0	0
503	80	12.0	100	1	0	0	0.0	0
504	350	12.0	100	12	0	0	0.0	0
505	500	12.0	100	16	0	0	0.0	0
506	300	12.0	100	3	0	0	0.0	0
507	350	12.0	100	12	0	0	0.0	0
508	80	12.0	100	1	0	0	0.0	0
509	350	12.0	100	12	0	0	0.0	0
510	500	12.0	100	16	0	0	0.0	0
511	200	12.0	100	2	0	0	0.0	0
512	608	12.0	100	8	0	0	0.0	0
513	363	12.0	100	4	0	0	0.0	0
514	599	12.0	100	8	0	0	0.0	0
515	341	12.0	100	4	0	0	0.0	0
516	772	12.0	100	12	0	0	0.0	0
517	64	12.0	100	1	0	0	0.0	0
518	64	12.0	100	1	0	0	0.0	0
519	756	12.0	100	12	0	0	0.0	0
574	183	12.0	100	0	0	0	0.0	0
575	150	12.0	100	0	0	0	0.0	0
576	185	12.0	100	0	0	0	0.0	0
577	158	12.0	100	0	0	0	0.0	0
578	158	12.0	100	0	0	0	0.0	0
579	175	12.0	100	0	0	0	0.0	0
580	75	12.0	100	0	0	0	0.0	0
581	180	12.0	100	0	0	0	0.0	0
582	158	12.0	100	0	0	0	0.0	0
583	155	12.0	100	0	0	0	0.0	0
584	196	12.0	100	0	0	0	0.0	0
585	195	12.0	100	0	0	0	0.0	0
598	39	12.0	100	0	0	1	0.0	0
599	39	12.0	100	0	0	1	0.0	0
601	200	12.0	100	2	0	0	0.0	0
602	250	12.0	100	11	0	0	0.0	0
603	80	12.0	100	1	0	0	0.0	0
604	350	12.0	100	12	0	0	0.0	0
605	500	12.0	100	16	0	0	0.0	0
606	300	12.0	100	3	0	0	0.0	0
607	350	12.0	100	12	0	0	0.0	0
608	80	12.0	100	1	0	0	0.0	0
609	350	12.0	100	12	0	0	0.0	0
610	500	12.0	100	16	0	0	0.0	0
611	200	12.0	100	2	0	0	0.0	0
612	608	12.0	100	8	0	0	0.0	0
613	363	12.0	100	4	0	0	0.0	0
614	599	12.0	100	8	0	0	0.0	0
615	341	12.0	100	4	0	0	0.0	0
616	772	12.0	100	12	0	0	0.0	0
617	64	12.0	100	1	0	0	0.0	0
618	64	12.0	100	1	0	0	0.0	0
619	756	12.0	100	12	0	0	0.0	0

674	183	12.0	100	0	0	0	0.0	0
675	150	12.0	100	0	0	0	0.0	0
676	185	12.0	100	0	0	0	0.0	0
677	158	12.0	100	0	0	0	0.0	0
678	158	12.0	100	0	0	0	0.0	0
679	175	12.0	100	0	0	0	0.0	0
680	75	12.0	100	0	0	0	0.0	0
681	180	12.0	100	0	0	0	0.0	0
682	158	12.0	100	0	0	0	0.0	0
683	155	12.0	100	0	0	0	0.0	0
684	196	12.0	100	0	0	0	0.0	0
685	195	12.0	100	0	0	0	0.0	0
698	39	12.0	100	0	0	1	0.0	0
699	39	12.0	100	0	0	1	0.0	0
701	200	12.0	100	2	0	0	0.0	0
702	250	12.0	100	11	0	0	0.0	0
703	80	12.0	100	1	0	0	0.0	0
704	350	12.0	100	12	0	0	0.0	0
705	500	12.0	100	16	0	0	0.0	0
706	300	12.0	100	3	0	0	0.0	0
707	350	12.0	100	12	0	0	0.0	0
708	80	12.0	100	1	0	0	0.0	0
709	350	12.0	100	12	0	0	0.0	0
710	500	12.0	100	16	0	0	0.0	0
711	200	12.0	100	2	0	0	0.0	0
712	608	12.0	100	8	0	0	0.0	0
713	363	12.0	100	4	0	0	0.0	0
714	599	12.0	100	8	0	0	0.0	0
715	341	12.0	100	4	0	0	0.0	0
716	772	12.0	100	12	0	0	0.0	0
717	64	12.0	100	1	0	0	0.0	0
718	64	12.0	100	1	0	0	0.0	0
719	756	12.0	100	12	0	0	0.0	0
774	183	12.0	100	0	0	0	0.0	0
775	150	12.0	100	0	0	0	0.0	0
776	185	12.0	100	0	0	0	0.0	0
777	158	12.0	100	0	0	0	0.0	0
778	158	12.0	100	0	0	0	0.0	0
779	175	12.0	100	0	0	0	0.0	0
780	75	12.0	100	0	0	0	0.0	0
781	180	12.0	100	0	0	0	0.0	0
782	158	12.0	100	0	0	0	0.0	0
783	155	12.0	100	0	0	0	0.0	0
784	196	12.0	100	0	0	0	0.0	0
785	195	12.0	100	0	0	0	0.0	0
798	39	12.0	100	0	0	1	0.0	0
799	39	12.0	100	0	0	1	0.0	0
801	200	12.0	100	2	0	0	0.0	0
802	250	12.0	100	11	0	0	0.0	0
803	80	12.0	100	1	0	0	0.0	0
804	350	12.0	100	12	0	0	0.0	0
805	500	12.0	100	16	0	0	0.0	0
806	300	12.0	100	3	0	0	0.0	0
807	350	12.0	100	12	0	0	0.0	0
808	80	12.0	100	1	0	0	0.0	0
809	350	12.0	100	12	0	0	0.0	0
810	500	12.0	100	16	0	0	0.0	0

811	200	12.0	100	2	0	0	0.0	0
812	608	12.0	100	8	0	0	0.0	0
813	363	12.0	100	4	0	0	0.0	0
814	599	12.0	100	8	0	0	0.0	0
815	341	12.0	100	4	0	0	0.0	0
816	772	12.0	100	12	0	0	0.0	0
817	64	12.0	100	1	0	0	0.0	0
818	64	12.0	100	1	0	0	0.0	0
819	756	12.0	100	12	0	0	0.0	0
874	183	12.0	100	0	0	0	0.0	0
875	150	12.0	100	0	0	0	0.0	0
876	185	12.0	100	0	0	0	0.0	0
877	158	12.0	100	0	0	0	0.0	0
878	158	12.0	100	0	0	0	0.0	0
879	175	12.0	100	0	0	0	0.0	0
880	75	12.0	100	0	0	0	0.0	0
881	180	12.0	100	0	0	0	0.0	0
882	158	12.0	100	0	0	0	0.0	0
883	155	12.0	100	0	0	0	0.0	0
884	196	12.0	100	0	0	0	0.0	0
885	195	12.0	100	0	0	0	0.0	0
898	39	12.0	100	0	0	1	0.0	0
899	39	12.0	100	0	0	1	0.0	0
901	200	12.0	100	2	0	0	0.0	0
902	250	12.0	100	11	0	0	0.0	0
903	80	12.0	100	1	0	0	0.0	0
904	350	12.0	100	12	0	0	0.0	0
905	500	12.0	100	16	0	0	0.0	0
906	300	12.0	100	3	0	0	0.0	0
907	350	12.0	100	12	0	0	0.0	0
908	80	12.0	100	1	0	0	0.0	0
909	350	12.0	100	12	0	0	0.0	0
910	500	12.0	100	16	0	0	0.0	0
911	200	12.0	100	2	0	0	0.0	0
912	608	12.0	100	8	0	0	0.0	0
913	363	12.0	100	4	0	0	0.0	0
914	599	12.0	100	8	0	0	0.0	0
915	341	12.0	100	4	0	0	0.0	0
916	772	12.0	100	12	0	0	0.0	0
917	64	12.0	100	1	0	0	0.0	0
918	64	12.0	100	1	0	0	0.0	0
919	756	12.0	100	12	0	0	0.0	0
974	183	12.0	100	0	0	0	0.0	0
975	150	12.0	100	0	0	0	0.0	0
976	185	12.0	100	0	0	0	0.0	0
977	158	12.0	100	0	0	0	0.0	0
978	158	12.0	100	0	0	0	0.0	0
979	175	12.0	100	0	0	0	0.0	0
980	75	12.0	100	0	0	0	0.0	0
981	180	12.0	100	0	0	0	0.0	0
982	158	12.0	100	0	0	0	0.0	0
983	155	12.0	100	0	0	0	0.0	0
984	196	12.0	100	0	0	0	0.0	0
985	195	12.0	100	0	0	0	0.0	0
998	39	12.0	100	0	0	1	0.0	0
999	39	12.0	100	0	0	1	0.0	0
1001	200	12.0	100	2	0	0	0.0	0

1002	250	12.0	100	11	0	0	0.0	0
1003	80	12.0	100	1	0	0	0.0	0
1004	350	12.0	100	12	0	0	0.0	0
1005	500	12.0	100	16	0	0	0.0	0
1006	300	12.0	100	3	0	0	0.0	0
1007	350	12.0	100	12	0	0	0.0	0
1008	80	12.0	100	1	0	0	0.0	0
1009	350	12.0	100	12	0	0	0.0	0
1010	500	12.0	100	16	0	0	0.0	0
1011	200	12.0	100	2	0	0	0.0	0
1012	608	12.0	100	8	0	0	0.0	0
1013	363	12.0	100	4	0	0	0.0	0
1014	599	12.0	100	8	0	0	0.0	0
1015	341	12.0	100	4	0	0	0.0	0
1016	772	12.0	100	12	0	0	0.0	0
1017	64	12.0	100	1	0	0	0.0	0
1018	64	12.0	100	1	0	0	0.0	0
1019	756	12.0	100	12	0	0	0.0	0
1074	183	12.0	100	0	0	0	0.0	0
1075	150	12.0	100	0	0	0	0.0	0
1076	185	12.0	100	0	0	0	0.0	0
1077	158	12.0	100	0	0	0	0.0	0
1078	158	12.0	100	0	0	0	0.0	0
1079	175	12.0	100	0	0	0	0.0	0
1080	75	12.0	100	0	0	0	0.0	0
1081	180	12.0	100	0	0	0	0.0	0
1082	158	12.0	100	0	0	0	0.0	0
1083	155	12.0	100	0	0	0	0.0	0
1084	196	12.0	100	0	0	0	0.0	0
1085	195	12.0	100	0	0	0	0.0	0
1098	39	12.0	100	0	0	1	0.0	0
1099	39	12.0	100	0	0	1	0.0	0
1101	200	12.0	100	2	0	0	0.0	0
1102	250	12.0	100	11	0	0	0.0	0
1103	80	12.0	100	1	0	0	0.0	0
1104	350	12.0	100	12	0	0	0.0	0
1105	500	12.0	100	16	0	0	0.0	0
1106	300	12.0	100	3	0	0	0.0	0
1107	350	12.0	100	12	0	0	0.0	0
1108	80	12.0	100	1	0	0	0.0	0
1109	350	12.0	100	12	0	0	0.0	0
1110	500	12.0	100	16	0	0	0.0	0
1111	200	12.0	100	2	0	0	0.0	0
1112	608	12.0	100	8	0	0	0.0	0
1113	363	12.0	100	4	0	0	0.0	0
1114	599	12.0	100	8	0	0	0.0	0
1115	341	12.0	100	4	0	0	0.0	0
1116	772	12.0	100	12	0	0	0.0	0
1117	64	12.0	100	1	0	0	0.0	0
1118	64	12.0	100	1	0	0	0.0	0
1119	756	12.0	100	12	0	0	0.0	0
1174	183	12.0	100	0	0	0	0.0	0
1175	150	12.0	100	0	0	0	0.0	0
1176	185	12.0	100	0	0	0	0.0	0
1177	158	12.0	100	0	0	0	0.0	0
1178	158	12.0	100	0	0	0	0.0	0
1179	175	12.0	100	0	0	0	0.0	0

1180	75	12.0	100	0	0	0	0.0	0
1181	180	12.0	100	0	0	0	0.0	0
1182	158	12.0	100	0	0	0	0.0	0
1183	155	12.0	100	0	0	0	0.0	0
1184	196	12.0	100	0	0	0	0.0	0
1185	195	12.0	100	0	0	0	0.0	0
1198	39	12.0	100	0	0	1	0.0	0
1199	39	12.0	100	0	0	1	0.0	0
9999	9999							

Appendix 9

Output File for 2 Stories of the 225 Foot Square Building

```
----------------------------------------------------------------------
---------
  Title and User Options
----------------------------------------------------------------------
---------

   One Story 225 Building Total Detailed Exercise - evacuation spd


          UNITS = 2   1=Metric,      2=Standard
          SIZE  = 1   1=Austrian,    2=Soviet      3=US
          SPEED = 1   1=Emergency,   2=Normal
          PATH  = 1   1=Shortest,    2=Directed
          SMOKE = 2   1=CFAST,       2=User defined or none
          CONTRA= 0   1=Contra flows will occur
          FULL  = 1   1=Full output, 2=Simple output

          NO OF STAIRS =  4  (Must be an integer from 0 to 10)
          STAIR TRAVEL = 1   1=Down stairs  2=Up stairs



          Additional randomly distributed delays value = 2  (1=Yes,
2=No)


----------------------------------------------------------------------
---------
  Building link input descriptions:

        Format is:
           x1 x2 x3 x4 x5,   where

    x1 = The from-node of the link.
          Node names are 3 or 4 digit integers where:
             The first 1 or 2 digits are the floor number.
             The last 2 digits uniquely number the spaces on that
floor.
                Space numbers 1-89 are occupant spaces on the floor.
                Numbers 90-99 are reserved for stairways.
                Locations of safety are numbered 0 (the entire node
                 name is 1 digit).
    x2 = The distance from the first node to the center of
          the opening between the two nodes of the link.
          Each link must have an "opening" in it.
    x3 = The opening width.
    x4 = The distance from the center of the opening to the
          second node.
    x5 = The to-node of the link.
----------------------------------------------------------------------
---------
```

196	5.0	3.0	15.0	0
197	5.0	3.0	15.0	0
198	5.0	3.0	15.0	0
199	5.0	3.0	15.0	0
201	17.0	3.0	29.0	244
202	17.0	3.0	30.0	243
203	15.0	3.0	25.0	243
204	15.0	3.0	24.0	244
205	8.0	3.0	9.0	245
206	8.0	3.0	2.5	263
207	8.0	3.0	3.0	264
208	8.5	3.0	3.0	242
209	8.0	3.0	3.5	248
210	5.0	3.0	3.0	247
211	14.0	3.0	6.0	246
212	7.5	3.0	27.0	254
213	7.5	3.0	4.0	261
214	7.5	3.0	16.0	253
215	5.0	3.0	39.0	244
216	7.0	3.0	25.0	263
217	7.0	3.0	3.0	259
218	7.0	3.0	20.0	264
219	7.0	3.0	3.0	258
220	5.0	3.0	38.0	243
221	7.5	3.0	8.0	249
222	7.5	3.0	10.0	256
223	7.0	3.0	25.0	248
224	7.0	3.0	8.0	248
225	7.0	3.0	28.0	247
226	7.0	3.0	4.0	254
227	16.0	3.0	26.0	254
228	8.0	3.0	8.0	261
229	8.0	3.0	8.0	260
230	7.0	3.0	3.0	259
231	7.0	3.0	28.0	267
232	7.0	3.0	3.0	258
233	8.0	3.0	8.0	250
234	8.0	3.0	8.0	256
235	8.0	3.0	32.0	256
236	8.0	3.0	3.0	255
237	5.0	3.0	3.0	266
238	5.0	3.0	3.0	266
239	8.5	3.0	11.0	246
242	16.0	5.0	12.0	243
243	30.0	3.0	2.5	299
244	17.0	3.0	2.5	298
245	18.0	5.0	12.0	244
246	30.0	5.0	9.0	247
247	20.0	3.0	2.5	297
248	29.0	5.0	9.0	247
249	26.0	5.0	12.0	243
250	17.0	5.0	12.0	243
252	27.5	5.0	8.0	262
253	27.0	5.0	12.0	244
254	47.0	5.0	26.0	247

255	46.0	5.0	26.0	247
256	44.0	5.0	46.0	243
257	45.0	5.0	46.0	243
258	47.0	5.0	26.0	267
259	47.0	5.0	26.0	267
260	45.0	5.0	47.0	244
261	44.0	5.0	47.0	244
262	28.0	5.0	12.0	244
263	33.0	5.0	9.0	267
264	32.0	5.0	9.0	267
265	28.0	5.0	12.0	243
266	6.0	3.0	28.0	247
267	21.0	3.0	2.5	296
268	7.5	3.0	5.0	260
269	7.5	3.0	14.0	262
270	8.0	3.0	2.0	271
271	17.0	5.0	11.0	244
272	8.5	3.0	2.0	250
273	7.5	3.0	13.0	265
274	7.5	3.0	6.0	257
275	5.0	3.0	3.0	267
296	21.3	3.7	21.3	196
297	21.3	3.7	21.3	197
298	21.3	3.7	21.3	198
299	21.3	3.7	21.3	199
9999	0.0	0.0	0.0	0

Building node input descriptions:

Format is:
x1 x2 x3 x4 x5 x6 x7 x8 x9,   where

x1 = The node being described.
x2 = The usable floor area at the node.
x3 = Height of the ceiling at the node.
x4 = Capacity of the space the node represents.
x5 = The number of people there initially.
x6 = The number of these people who have travel speeds differing from the norm.
If this value is non - zero, a line of the form
y1 y2 ......yn   will follow the node input description line, where y1 is the fraction of normal speed at which the first occupant of the node will move, y2 = the fraction applying to the 2nd one, etc.
x7 = A flag indicating if the node is a location of safety such as the outside, a horizontal exit, or a stairway node.
x8 = The time that occupants of the node will delay before beginning evacuation.
x9 = (optional) The next node along a directed path to which occupants will move. If shortest path

selection was chosen rather than directed, these
values are all 0.

196	94.	12.0	100	0	0	1	0.0	0
197	94.	12.0	100	0	0	1	0.0	0
198	94.	12.0	100	0	0	1	0.0	0
199	94.	12.0	100	0	0	1	0.0	0
201	1041.	12.0	100	11	0	0	0.0	0
202	1016.	12.0	100	11	0	0	0.0	0
203	704.	12.0	100	12	0	0	0.0	0
204	736.	12.0	100	12	0	0	0.0	0
205	848.	12.0	100	37	0	0	0.0	0
206	935.	12.0	100	22	0	0	0.0	0
207	918.	12.0	100	22	0	0	0.0	0
208	629.	12.0	100	36	0	0	0.0	0
209	918.	12.0	100	4	0	0	0.0	0
210	112.	12.0	100	1	0	0	0.0	0
211	1500.	12.0	100	10	0	0	0.0	0
212	450.	12.0	100	3	0	0	0.0	0
213	960.	12.0	100	8	0	0	0.0	0
214	960.	12.0	100	8	0	0	0.0	0
215	112.	12.0	100	1	0	0	0.0	0
216	1020.	12.0	100	6	0	0	0.0	0
217	1020.	12.0	100	7	0	0	0.0	0
218	1185.	12.0	100	7	0	0	0.0	0
219	1185.	12.0	100	8	0	0	0.0	0
220	112.	12.0	100	1	0	0	0.0	0
221	720.	12.0	100	7	0	0	0.0	0
222	720.	12.0	100	7	0	0	0.0	0
223	1035.	12.0	100	6	0	0	0.0	0
224	1035.	12.0	100	6	0	0	0.0	0
225	217.	12.0	100	15	0	0	0.0	0
226	1395.	12.0	100	9	0	0	0.0	0
227	1020.	12.0	100	30	0	0	0.0	0
228	217.	12.0	100	15	0	0	0.0	0
229	2255.	12.0	100	38	0	0	0.0	0
230	1395.	12.0	100	9	0	0	0.0	0
231	217.	12.0	100	15	0	0	0.0	0
232	1395.	12.0	100	9	0	0	0.0	0
233	2255.	12.0	100	39	0	0	0.0	0
234	217.	12.0	100	15	0	0	0.0	0
235	1015.	12.0	100	7	0	0	0.0	0
236	1395.	12.0	100	28	0	0	0.0	0
237	80.	12.0	100	1	0	0	0.0	0
238	80.	12.0	100	1	0	0	0.0	0
239	646.	12.0	100	3	0	0	0.0	0
242	160.	12.0	100	0	0	0	0.0	0
243	485.	12.0	100	0	0	0	0.0	0
244	490.	12.0	100	0	0	0	0.0	0
245	160.	12.0	100	0	0	0	0.0	0
246	350.	12.0	100	0	0	0	0.0	0
247	300.	12.0	100	0	0	0	0.0	0
248	285.	12.0	100	0	0	0	0.0	0
249	265.	12.0	100	0	0	0	0.0	0

250	165.	12.0	100	0	0	0	0.0	0
252	275.	12.0	100	0	0	0	0.0	0
253	265.	12.0	100	0	0	0	0.0	0
254	475.	12.0	100	0	0	0	0.0	0
255	470.	12.0	100	0	0	0	0.0	0
256	440.	12.0	100	0	0	0	0.0	0
257	450.	12.0	100	0	0	0	0.0	0
258	470.	12.0	100	0	0	0	0.0	0
259	475.	12.0	100	0	0	0	0.0	0
260	450.	12.0	100	0	0	0	0.0	0
261	440.	12.0	100	0	0	0	0.0	0
262	275.	12.0	100	0	0	0	0.0	0
263	299.	12.0	100	0	0	0	0.0	0
264	295.	12.0	100	0	0	0	0.0	0
265	275.	12.0	100	0	0	0	0.0	0
266	65.	12.0	100	0	0	0	0.0	0
267	285.	12.0	100	3	0	0	0.0	0
268	285.	12.0	100	3	0	0	0.0	0
269	570.	12.0	100	3	0	0	0.0	0
270	561.	12.0	100	0	0	0	0.0	0
271	165.	12.0	100	3	0	0	0.0	0
272	561.	12.0	100	3	0	0	0.0	0
273	570.	12.0	100	3	0	0	0.0	0
274	570.	12.0	100	1	0	0	0.0	0
275	110.	12.0	100	0	0	0	0.0	0
296	94.	12.0	100	0	0	1	0.0	0
297	94.	12.0	100	0	0	1	0.0	0
298	94.	12.0	100	0	0	1	0.0	0
299	94.	12.0	100	0	0	1	0.0	0

Notification of occupants will occur at time zero.

Start of building evacuation

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
1.79	168	247	210	247	0	0
1.84	483	266	237	266	0	0
1.84	484	266	238	266	0	0
2.24	205	259	217	259	0	0

2.24	206	259	217	259	0	0
2.24	207	259	217	259	0	0
2.24	208	259	217	259	0	0
2.24	209	259	217	259	0	0
2.24	210	259	217	259	0	0
2.24	211	259	217	259	0	0
2.24	219	258	219	258	0	0
2.24	220	258	219	258	0	0
2.24	221	258	219	258	0	0
2.24	222	258	219	258	0	0
2.24	223	258	219	258	0	0
2.24	224	258	219	258	0	0
2.24	225	258	219	258	0	0
2.24	226	258	219	258	0	0
2.24	361	259	230	259	0	0
2.24	362	259	230	259	0	0
2.24	363	259	230	259	0	0
2.24	364	259	230	259	0	0
2.24	365	259	230	259	0	0
2.24	366	259	230	259	0	0
2.24	367	259	230	259	0	0
2.24	368	259	230	259	0	0
2.24	369	259	230	259	0	0
2.24	385	258	232	258	0	0
2.24	386	258	232	258	0	0
2.24	387	258	232	258	0	0
2.24	388	258	232	258	0	0
2.24	389	258	232	258	0	0
2.24	390	258	232	258	0	0
2.24	391	258	232	258	0	0
2.24	392	258	232	258	0	0
2.24	393	258	232	258	0	0
2.36	500	250	272	250	0	0
2.36	501	250	272	250	0	0
2.36	502	250	272	250	0	0
2.47	269	254	226	254	0	0
2.47	270	254	226	254	0	0
2.47	271	254	226	254	0	0
2.47	272	254	226	254	0	0
2.47	273	254	226	254	0	0
2.47	274	254	226	254	0	0
2.47	275	254	226	254	0	0
2.47	276	254	226	254	0	0
2.47	277	254	226	254	0	0
2.58	182	213	213	261	0	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
2.58	183	213	213	261	0	0
2.58	184	213	213	261	0	0
2.58	185	213	213	261	0	0
2.58	186	213	213	261	0	0
2.58	187	213	213	261	0	0
2.58	188	213	213	261	0	0
2.58	189	213	213	261	0	0
2.58	164	209	209	248	0	0
2.58	165	209	209	248	0	0

2.58	166	209	209	248	0	0
2.58	167	209	209	248	0	0
2.58	84	206	206	263	0	0
2.58	85	206	206	263	0	0
2.58	86	206	206	263	0	0
2.58	87	206	206	263	0	0
2.58	88	206	206	263	0	0
2.58	89	206	206	263	0	0
2.58	90	206	206	263	0	0
2.58	91	206	206	263	0	0
2.58	92	206	206	263	0	0
2.58	93	206	206	263	0	0
2.58	94	206	206	263	0	0
2.58	95	206	206	263	0	0
2.58	96	206	206	263	0	0
2.58	97	206	206	263	0	0
2.58	98	206	206	263	0	0
2.58	99	206	206	263	0	0
2.58	100	206	206	263	0	0
2.58	101	206	206	263	0	0
2.58	102	206	206	263	0	0
2.58	103	206	206	263	0	0
2.58	104	206	206	263	0	0
2.58	105	206	206	263	0	0
2.62	455	236	236	255	0	0
2.62	456	236	236	255	0	0
2.62	457	236	236	255	0	0
2.62	458	236	236	255	0	0
2.62	459	236	236	255	0	0
2.62	460	236	236	255	0	0
2.62	461	236	236	255	0	0
2.62	462	236	236	255	0	0
2.62	463	236	236	255	0	0
2.62	464	236	236	255	0	0
2.62	465	236	236	255	0	0
2.62	466	236	236	255	0	0
2.62	467	236	236	255	0	0
2.62	468	236	236	255	0	0
2.62	469	236	236	255	0	0
2.62	470	236	236	255	0	0
2.62	471	236	236	255	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
2.62	472	236	236	255	0	0
2.62	473	236	236	255	0	0
2.62	474	236	236	255	0	0
2.62	475	236	236	255	0	0
2.62	476	236	236	255	0	0
2.62	477	236	236	255	0	0
2.62	478	236	236	255	0	0
2.62	479	236	236	255	0	0
2.62	480	236	236	255	0	0
2.62	481	236	236	255	0	0
2.62	482	236	236	255	0	0
2.70	106	207	207	264	0	0
2.70	107	207	207	264	0	0

2.70	108	207	207	264	0	0
2.70	109	207	207	264	0	0
2.70	110	207	207	264	0	0
2.70	111	207	207	264	0	0
2.70	112	207	207	264	0	0
2.70	113	207	207	264	0	0
2.70	114	207	207	264	0	0
2.70	115	207	207	264	0	0
2.70	116	207	207	264	0	0
2.70	117	207	207	264	0	0
2.70	118	207	207	264	0	0
2.70	119	207	207	264	0	0
2.70	120	207	207	264	0	0
2.70	121	207	207	264	0	0
2.70	122	207	207	264	0	0
2.70	123	207	207	264	0	0
2.70	124	207	207	264	0	0
2.70	125	207	207	264	0	0
2.70	126	207	207	264	0	0
2.70	127	207	207	264	0	0
2.87	491	268	268	260	0	0
2.87	492	268	268	260	0	0
2.87	493	268	268	260	0	0
3.03	506	274	274	257	0	0
3.29	128	208	208	242	0	0
3.29	129	208	208	242	0	0
3.29	130	208	208	242	0	0
3.29	131	208	208	242	0	0
3.29	132	208	208	242	0	0
3.29	133	208	208	242	0	0
3.29	134	208	208	242	0	0
3.29	135	208	208	242	0	0
3.29	136	208	208	242	0	0
3.29	137	208	208	242	0	0
3.29	138	208	208	242	0	0
3.29	139	208	208	242	0	0
3.29	140	208	208	242	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
3.29	141	208	208	242	0	0
3.29	142	208	208	242	0	0
3.29	143	208	208	242	0	0
3.29	144	208	208	242	0	0
3.29	145	208	208	242	0	0
3.29	146	208	208	242	0	0
3.29	147	208	208	242	0	0
3.29	148	208	208	242	0	0
3.29	149	208	208	242	0	0
3.29	150	208	208	242	0	0
3.29	151	208	208	242	0	0
3.29	152	208	208	242	0	0
3.29	153	208	208	242	0	0
3.29	154	208	208	242	0	0
3.29	155	208	208	242	0	0
3.29	156	208	208	242	0	0
3.29	157	208	208	242	0	0

3.29	158	208	208	242	0	0
3.29	159	208	208	242	0	0
3.29	160	208	208	242	0	0
3.29	161	208	208	242	0	0
3.29	162	208	208	242	0	0
3.29	163	208	208	242	0	0
3.44	248	224	224	248	0	0
3.44	249	224	224	248	0	0
3.44	250	224	224	248	0	0
3.44	251	224	224	248	0	0
3.44	252	224	224	248	0	0
3.44	253	224	224	248	0	0
3.55	228	221	221	249	0	0
3.55	229	221	221	249	0	0
3.55	230	221	221	249	0	0
3.55	231	221	221	249	0	0
3.55	232	221	221	249	0	0
3.55	233	221	221	249	0	0
3.55	234	221	221	249	0	0
3.74	323	229	229	260	0	0
3.74	324	229	229	260	0	0
3.74	325	229	229	260	0	0
3.74	326	229	229	260	0	0
3.74	327	229	229	260	0	0
3.74	328	229	229	260	0	0
3.74	329	229	229	260	0	0
3.74	330	229	229	260	0	0
3.74	331	229	229	260	0	0
3.74	332	229	229	260	0	0
3.74	333	229	229	260	0	0
3.74	334	229	229	260	0	0
3.74	335	229	229	260	0	0
3.74	336	229	229	260	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
3.74	337	229	229	260	0	0
3.74	338	229	229	260	0	0
3.74	339	229	229	260	0	0
3.74	340	229	229	260	0	0
3.74	341	229	229	260	0	0
3.74	342	229	229	260	0	0
3.74	343	229	229	260	0	0
3.74	344	229	229	260	0	0
3.74	345	229	229	260	0	0
3.74	346	229	229	260	0	0
3.74	347	229	229	260	0	0
3.74	348	229	229	260	0	0
3.74	349	229	229	260	0	0
3.74	350	229	229	260	0	0
3.74	351	229	229	260	0	0
3.74	352	229	229	260	0	0
3.74	353	229	229	260	0	0
3.74	354	229	229	260	0	0
3.74	355	229	229	260	0	0
3.74	356	229	229	260	0	0
3.74	357	229	229	260	0	0

3.74	358	229	229	260	0	0
3.74	359	229	229	260	0	0
3.74	360	229	229	260	0	0
3.89	394	233	233	250	0	0
3.89	395	233	233	250	0	0
3.89	396	233	233	250	0	0
3.89	397	233	233	250	0	0
3.89	398	233	233	250	0	0
3.89	399	233	233	250	0	0
3.89	400	233	233	250	0	0
3.89	401	233	233	250	0	0
3.89	402	233	233	250	0	0
3.89	403	233	233	250	0	0
3.89	404	233	233	250	0	0
3.89	405	233	233	250	0	0
3.89	406	233	233	250	0	0
3.89	407	233	233	250	0	0
3.89	408	233	233	250	0	0
3.89	409	233	233	250	0	0
3.89	410	233	233	250	0	0
3.89	411	233	233	250	0	0
3.89	412	233	233	250	0	0
3.89	413	233	233	250	0	0
3.89	414	233	233	250	0	0
3.89	415	233	233	250	0	0
3.89	416	233	233	250	0	0
3.89	417	233	233	250	0	0
3.89	418	233	233	250	0	0
3.89	419	233	233	250	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
3.89	420	233	233	250	0	0
3.89	421	233	233	250	0	0
3.89	422	233	233	250	0	0
3.89	423	233	233	250	0	0
3.89	424	233	233	250	0	0
3.89	425	233	233	250	0	0
3.89	426	233	233	250	0	0
3.89	427	233	233	250	0	0
3.89	428	233	233	250	0	0
3.89	429	233	233	250	0	0
3.89	430	233	233	250	0	0
3.89	431	233	233	250	0	0
3.89	432	233	233	250	0	0
3.99	235	222	222	256	0	0
3.99	236	222	222	256	0	0
3.99	237	222	222	256	0	0
3.99	238	222	222	256	0	0
3.99	239	222	222	256	0	0
3.99	240	222	222	256	0	0
3.99	241	222	222	256	0	0
4.30	47	205	205	245	0	0
4.30	48	205	205	245	0	0
4.30	49	205	205	245	0	0
4.30	50	205	205	245	0	0
4.30	51	205	205	245	0	0

4.30	52	205	205	245	0	0
4.30	53	205	205	245	0	0
4.30	54	205	205	245	0	0
4.30	55	205	205	245	0	0
4.30	56	205	205	245	0	0
4.30	57	205	205	245	0	0
4.30	58	205	205	245	0	0
4.30	59	205	205	245	0	0
4.30	60	205	205	245	0	0
4.30	61	205	205	245	0	0
4.30	62	205	205	245	0	0
4.30	63	205	205	245	0	0
4.30	64	205	205	245	0	0
4.30	65	205	205	245	0	0
4.30	66	205	205	245	0	0
4.30	67	205	205	245	0	0
4.30	68	205	205	245	0	0
4.30	69	205	205	245	0	0
4.30	70	205	205	245	0	0
4.30	71	205	205	245	0	0
4.30	72	205	205	245	0	0
4.30	73	205	205	245	0	0
4.30	74	205	205	245	0	0
4.30	75	205	205	245	0	0
4.30	76	205	205	245	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
4.30	77	205	205	245	0	0
4.30	78	205	205	245	0	0
4.30	79	205	205	245	0	0
4.30	80	205	205	245	0	0
4.30	81	205	205	245	0	0
4.30	82	205	205	245	0	0
4.30	83	205	205	245	0	0
4.37	485	239	239	246	0	0
4.37	486	239	239	246	0	0
4.37	487	239	239	246	0	0
4.49	169	211	211	246	0	0
4.49	170	211	211	246	0	0
4.49	171	211	211	246	0	0
4.49	172	211	211	246	0	0
4.49	173	211	211	246	0	0
4.49	174	211	211	246	0	0
4.49	175	211	211	246	0	0
4.49	176	211	211	246	0	0
4.49	177	211	211	246	0	0
4.49	178	211	211	246	0	0
4.53	433	234	234	256	0	0
4.53	434	234	234	256	0	0
4.53	435	234	234	256	0	0
4.53	436	234	234	256	0	0
4.53	437	234	234	256	0	0
4.53	438	234	234	256	0	0
4.53	439	234	234	256	0	0
4.53	440	234	234	256	0	0
4.53	441	234	234	256	0	0

4.53	442	234	234	256	0	0
4.53	443	234	234	256	0	0
4.53	444	234	234	256	0	0
4.53	445	234	234	256	0	0
4.53	446	234	234	256	0	0
4.53	447	234	234	256	0	0
4.60	503	273	273	265	0	0
4.60	504	273	273	265	0	0
4.60	505	273	273	265	0	0
4.61	308	228	228	261	0	0
4.61	309	228	228	261	0	0
4.61	310	228	228	261	0	0
4.61	311	228	228	261	0	0
4.61	312	228	228	261	0	0
4.61	313	228	228	261	0	0
4.61	314	228	228	261	0	0
4.61	315	228	228	261	0	0
4.61	316	228	228	261	0	0
4.61	317	228	228	261	0	0
4.61	318	228	228	261	0	0
4.61	319	228	228	261	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
4.61	320	228	228	261	0	0
4.61	321	228	228	261	0	0
4.61	322	228	228	261	0	0
4.82	494	269	269	262	0	0
4.82	495	269	269	262	0	0
4.82	496	269	269	262	0	0
5.27	190	214	214	253	0	0
5.27	191	214	214	253	0	0
5.27	192	214	214	253	0	0
5.27	193	214	214	253	0	0
5.27	194	214	214	253	0	0
5.27	195	214	214	253	0	0
5.27	196	214	214	253	0	0
5.27	197	214	214	253	0	0
5.46	488	267	267	296	0	0
5.46	489	267	267	296	0	0
5.46	490	267	267	296	0	0
6.60	497	271	271	244	0	0
6.60	498	271	271	244	0	0
6.60	499	271	271	244	0	0
6.84	168	247	247	297	0	0
8.25	179	212	212	254	0	0
8.25	180	212	212	254	0	0
8.25	181	212	212	254	0	0
8.42	242	223	223	248	0	0
8.42	243	223	223	248	0	0
8.42	244	223	223	248	0	0
8.42	245	223	223	248	0	0
8.42	246	223	223	248	0	0
8.42	247	223	223	248	0	0
8.48	212	218	218	264	0	0
8.48	213	218	218	264	0	0
8.48	214	218	218	264	0	0

8.48	215	218	218	264	0	0
8.48	216	218	218	264	0	0
8.48	217	218	218	264	0	0
8.48	218	218	218	264	0	0
8.61	254	225	225	247	0	0
8.61	255	225	225	247	0	0
8.61	256	225	225	247	0	0
8.61	257	225	225	247	0	0
8.61	258	225	225	247	0	0
8.61	259	225	225	247	0	0
8.61	260	225	225	247	0	0
8.61	261	225	225	247	0	0
8.61	262	225	225	247	0	0
8.61	263	225	225	247	0	0
8.61	264	225	225	247	0	0
8.61	265	225	225	247	0	0
8.61	266	225	225	247	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
8.61	267	225	225	247	0	0
8.61	268	225	225	247	0	0
8.61	370	231	231	267	0	0
8.61	371	231	231	267	0	0
8.61	372	231	231	267	0	0
8.61	373	231	231	267	0	0
8.61	374	231	231	267	0	0
8.61	375	231	231	267	0	0
8.61	376	231	231	267	0	0
8.61	377	231	231	267	0	0
8.61	378	231	231	267	0	0
8.61	379	231	231	267	0	0
8.61	380	231	231	267	0	0
8.61	381	231	231	267	0	0
8.61	382	231	231	267	0	0
8.61	383	231	231	267	0	0
8.61	384	231	231	267	0	0
9.03	35	204	204	244	0	0
9.03	36	204	204	244	0	0
9.03	37	204	204	244	0	0
9.03	38	204	204	244	0	0
9.03	39	204	204	244	0	0
9.03	40	204	204	244	0	0
9.03	41	204	204	244	0	0
9.03	42	204	204	244	0	0
9.03	43	204	204	244	0	0
9.03	44	204	204	244	0	0
9.03	45	204	204	244	0	0
9.03	46	204	204	244	0	0
9.26	23	203	203	243	0	0
9.26	24	203	203	243	0	0
9.26	25	203	203	243	0	0
9.26	26	203	203	243	0	0
9.26	27	203	203	243	0	0
9.26	28	203	203	243	0	0
9.26	29	203	203	243	0	0
9.26	30	203	203	243	0	0

9.26	31	203	203	243	0	0
9.26	32	203	203	243	0	0
9.26	33	203	203	243	0	0
9.26	34	203	203	243	0	0
10.21	199	216	216	263	0	0
10.21	200	216	216	263	0	0
10.21	201	216	216	263	0	0
10.21	202	216	216	263	0	0
10.21	203	216	216	263	0	0
10.21	204	216	216	263	0	0
10.74	227	220	220	243	0	0
10.79	278	227	227	254	0	0
10.79	279	227	227	254	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
10.79	280	227	227	254	0	0
10.79	281	227	227	254	0	0
10.79	282	227	227	254	0	0
10.79	283	227	227	254	0	0
10.79	284	227	227	254	0	0
10.79	285	227	227	254	0	0
10.79	286	227	227	254	0	0
10.79	287	227	227	254	0	0
10.79	288	227	227	254	0	0
10.79	289	227	227	254	0	0
10.79	290	227	227	254	0	0
10.79	291	227	227	254	0	0
10.79	292	227	227	254	0	0
10.79	293	227	227	254	0	0
10.79	294	227	227	254	0	0
10.79	295	227	227	254	0	0
10.79	296	227	227	254	0	0
10.79	297	227	227	254	0	0
10.79	298	227	227	254	0	0
10.79	299	227	227	254	0	0
10.79	300	227	227	254	0	0
10.79	301	227	227	254	0	0
10.79	302	227	227	254	0	0
10.79	303	227	227	254	0	0
10.79	304	227	227	254	0	0
10.79	305	227	227	254	0	0
10.79	306	227	227	254	0	0
10.79	307	227	227	254	0	0
11.28	448	235	235	256	0	0
11.28	449	235	235	256	0	0
11.28	450	235	235	256	0	0
11.28	451	235	235	256	0	0
11.28	452	235	235	256	0	0
11.28	453	235	235	256	0	0
11.28	454	235	235	256	0	0
11.39	198	215	215	244	0	0
11.56	12	202	202	243	0	0
11.56	13	202	202	243	0	0
11.56	14	202	202	243	0	0
11.56	15	202	202	243	0	0
11.56	16	202	202	243	0	0

11.56	17	202	202	243	0	0
11.56	18	202	202	243	0	0
11.56	19	202	202	243	0	0
11.56	20	202	202	243	0	0
11.56	21	202	202	243	0	0
11.56	22	202	202	243	0	0
11.60	1	201	201	244	0	0
11.60	2	201	201	244	0	0
11.60	3	201	201	244	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
11.60	4	201	201	244	0	0
11.60	5	201	201	244	0	0
11.60	6	201	201	244	0	0
11.60	7	201	201	244	0	0
11.60	8	201	201	244	0	0
11.60	9	201	201	244	0	0
11.60	10	201	201	244	0	0
11.60	11	201	201	244	0	0
11.72	483	266	266	247	0	0
11.72	484	266	266	247	0	0
12.40	497	271	244	298	0	0
12.40	498	271	244	298	0	0
12.40	499	271	244	298	0	0
13.68	228	221	249	243	0	0
13.68	229	221	249	243	0	0
13.68	230	221	249	243	0	0
13.68	231	221	249	243	0	0
13.68	232	221	249	243	0	0
13.68	233	221	249	243	0	0
13.68	234	221	249	243	0	0
14.28	164	209	248	247	0	0
14.28	165	209	248	247	0	0
14.28	166	209	248	247	0	0
14.28	167	209	248	247	0	0
14.70	248	224	248	247	0	0
14.70	249	224	248	247	0	0
14.70	250	224	248	247	0	0
14.70	251	224	248	247	0	0
14.70	252	224	248	247	0	0
14.70	253	224	248	247	0	0
14.73	35	204	244	298	0	0
14.73	36	204	244	298	0	0
14.73	37	204	244	298	0	0
14.73	38	204	244	298	0	0
14.73	39	204	244	298	0	0
14.73	40	204	244	298	0	0
14.73	41	204	244	298	0	0
14.73	42	204	244	298	0	0
14.73	43	204	244	298	0	0
14.73	44	204	244	298	0	0
14.73	45	204	244	298	0	0
14.73	46	204	244	298	0	0
14.73	494	269	262	244	0	0
14.73	495	269	262	244	0	0
14.73	496	269	262	244	0	0

14.98	503	273	265	243	0	0
14.98	504	273	265	243	0	0
14.98	505	273	265	243	0	0
15.49	370	231	267	296	0	0
15.49	371	231	267	296	0	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
15.49	372	231	267	296	0	0
15.49	373	231	267	296	0	0
15.49	374	231	267	296	0	0
15.49	375	231	267	296	0	0
15.49	376	231	267	296	0	0
15.49	377	231	267	296	0	0
15.49	378	231	267	296	0	0
15.49	379	231	267	296	0	0
15.49	380	231	267	296	0	0
15.49	381	231	267	296	0	0
15.49	382	231	267	296	0	0
15.49	383	231	267	296	0	0
15.49	384	231	267	296	0	0
15.54	190	214	253	244	0	0
15.54	191	214	253	244	0	0
15.54	192	214	253	244	0	0
15.54	193	214	253	244	0	0
15.54	194	214	253	244	0	0
15.54	195	214	253	244	0	0
15.54	196	214	253	244	0	0
15.54	197	214	253	244	0	0
15.95	485	239	246	247	0	0
15.95	486	239	246	247	0	0
15.95	487	239	246	247	0	0
15.95	169	211	246	247	0	0
15.95	170	211	246	247	0	0
15.95	171	211	246	247	0	0
15.95	172	211	246	247	0	0
15.95	173	211	246	247	0	0
15.95	174	211	246	247	0	0
15.95	175	211	246	247	0	0
15.95	176	211	246	247	0	0
15.95	177	211	246	247	0	0
15.95	178	211	246	247	0	0
17.07	106	207	264	267	0	0
17.07	107	207	264	267	0	0
17.07	108	207	264	267	0	0
17.07	109	207	264	267	0	0
17.07	110	207	264	267	0	0
17.07	111	207	264	267	0	0
17.07	112	207	264	267	0	0
17.07	113	207	264	267	0	0
17.07	114	207	264	267	0	0
17.07	115	207	264	267	0	0
17.07	116	207	264	267	0	0
17.07	117	207	264	267	0	0
17.07	118	207	264	267	0	0
17.07	119	207	264	267	0	0
17.07	120	207	264	267	0	0

	17.07	121	207	264	267	0	0
1		OCC	ORIG	FROM	TO	NUM	NUM
	TIME	NUM	NODE	NODE	NODE	OUT	TRAPD
	17.07	122	207	264	267	0	0
	17.07	123	207	264	267	0	0
	17.07	124	207	264	267	0	0
	17.07	125	207	264	267	0	0
	17.07	126	207	264	267	0	0
	17.07	127	207	264	267	0	0
	17.57	198	215	244	298	0	0
	17.86	1	201	244	298	0	0
	17.86	2	201	244	298	0	0
	17.86	3	201	244	298	0	0
	17.86	4	201	244	298	0	0
	17.86	5	201	244	298	0	0
	17.86	6	201	244	298	0	0
	17.86	7	201	244	298	0	0
	17.86	8	201	244	298	0	0
	17.86	9	201	244	298	0	0
	17.86	10	201	244	298	0	0
	17.86	11	201	244	298	0	0
	18.22	128	208	242	243	0	0
	18.22	129	208	242	243	0	0
	18.22	130	208	242	243	0	0
	18.22	131	208	242	243	0	0
	18.22	132	208	242	243	0	0
	18.22	133	208	242	243	0	0
	18.22	134	208	242	243	0	0
	18.22	135	208	242	243	0	0
	18.22	136	208	242	243	0	0
	18.22	137	208	242	243	0	0
	18.22	138	208	242	243	0	0
	18.22	139	208	242	243	0	0
	18.22	140	208	242	243	0	0
	18.22	141	208	242	243	0	0
	18.22	142	208	242	243	0	0
	18.22	143	208	242	243	0	0
	18.22	144	208	242	243	0	0
	18.22	145	208	242	243	0	0
	18.22	146	208	242	243	0	0
	18.22	147	208	242	243	0	0
	18.22	148	208	242	243	0	0
	18.22	149	208	242	243	0	0
	18.22	150	208	242	243	0	0
	18.22	151	208	242	243	0	0
	18.22	152	208	242	243	0	0
	18.22	153	208	242	243	0	0
	18.22	154	208	242	243	0	0
	18.22	155	208	242	243	0	0
	18.22	156	208	242	243	0	0
	18.22	157	208	242	243	0	0
	18.22	158	208	242	243	0	0
	18.22	159	208	242	243	0	0
1		OCC	ORIG	FROM	TO	NUM	NUM
	TIME	NUM	NODE	NODE	NODE	OUT	TRAPD

18.22	160	208	242	243	0	0
18.22	161	208	242	243	0	0
18.22	162	208	242	243	0	0
18.22	163	208	242	243	0	0
18.43	84	206	263	267	0	0
18.43	85	206	263	267	0	0
18.43	86	206	263	267	0	0
18.43	87	206	263	267	0	0
18.43	88	206	263	267	0	0
18.43	89	206	263	267	0	0
18.43	90	206	263	267	0	0
18.43	91	206	263	267	0	0
18.43	92	206	263	267	0	0
18.43	93	206	263	267	0	0
18.43	94	206	263	267	0	0
18.43	95	206	263	267	0	0
18.43	96	206	263	267	0	0
18.43	97	206	263	267	0	0
18.43	98	206	263	267	0	0
18.43	99	206	263	267	0	0
18.43	100	206	263	267	0	0
18.43	101	206	263	267	0	0
18.43	102	206	263	267	0	0
18.43	103	206	263	267	0	0
18.43	104	206	263	267	0	0
18.43	105	206	263	267	0	0
18.68	254	225	247	297	0	0
18.68	255	225	247	297	0	0
18.68	256	225	247	297	0	0
18.68	257	225	247	297	0	0
18.68	258	225	247	297	0	0
18.68	259	225	247	297	0	0
18.68	260	225	247	297	0	0
18.68	261	225	247	297	0	0
18.68	262	225	247	297	0	0
18.68	263	225	247	297	0	0
18.68	264	225	247	297	0	0
18.68	265	225	247	297	0	0
18.68	266	225	247	297	0	0
18.68	267	225	247	297	0	0
18.68	268	225	247	297	0	0
18.70	242	223	248	247	0	0
18.70	243	223	248	247	0	0
18.70	244	223	248	247	0	0
18.70	245	223	248	247	0	0
18.70	246	223	248	247	0	0
18.70	247	223	248	247	0	0
19.89	47	205	245	244	0	0
19.89	48	205	245	244	0	0
19.89	49	205	245	244	0	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
19.89	50	205	245	244	0	0
19.89	51	205	245	244	0	0
19.89	52	205	245	244	0	0
19.89	53	205	245	244	0	0

19.89	54	205	245	244	0	0
19.89	55	205	245	244	0	0
19.89	56	205	245	244	0	0
19.89	57	205	245	244	0	0
19.89	58	205	245	244	0	0
19.89	59	205	245	244	0	0
19.89	60	205	245	244	0	0
19.89	61	205	245	244	0	0
19.89	62	205	245	244	0	0
19.89	63	205	245	244	0	0
19.89	64	205	245	244	0	0
19.89	65	205	245	244	0	0
19.89	66	205	245	244	0	0
19.89	67	205	245	244	0	0
19.89	68	205	245	244	0	0
19.89	69	205	245	244	0	0
19.89	70	205	245	244	0	0
19.89	71	205	245	244	0	0
19.89	72	205	245	244	0	0
19.89	73	205	245	244	0	0
19.89	74	205	245	244	0	0
19.89	75	205	245	244	0	0
19.89	76	205	245	244	0	0
19.89	77	205	245	244	0	0
19.89	78	205	245	244	0	0
19.89	79	205	245	244	0	0
19.89	80	205	245	244	0	0
19.89	81	205	245	244	0	0
19.89	82	205	245	244	0	0
19.89	83	205	245	244	0	0
21.12	500	250	250	243	0	0
21.12	501	250	250	243	0	0
21.12	502	250	250	243	0	0
21.13	483	266	247	297	0	0
21.13	484	266	247	297	0	0
21.26	212	218	264	267	0	0
21.26	213	218	264	267	0	0
21.26	214	218	264	267	0	0
21.26	215	218	264	267	0	0
21.26	216	218	264	267	0	0
21.26	217	218	264	267	0	0
21.26	218	218	264	267	0	0
22.21	394	233	250	243	0	0
22.21	395	233	250	243	0	0
22.21	396	233	250	243	0	0
22.21	397	233	250	243	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
22.21	398	233	250	243	0	0
22.21	399	233	250	243	0	0
22.21	400	233	250	243	0	0
22.21	401	233	250	243	0	0
22.21	402	233	250	243	0	0
22.21	403	233	250	243	0	0
22.21	404	233	250	243	0	0
22.21	405	233	250	243	0	0

22.21	406	233	250	243	0	0
22.21	407	233	250	243	0	0
22.21	408	233	250	243	0	0
22.21	409	233	250	243	0	0
22.21	410	233	250	243	0	0
22.21	411	233	250	243	0	0
22.21	412	233	250	243	0	0
22.21	413	233	250	243	0	0
22.21	414	233	250	243	0	0
22.21	415	233	250	243	0	0
22.21	416	233	250	243	0	0
22.21	417	233	250	243	0	0
22.21	418	233	250	243	0	0
22.21	419	233	250	243	0	0
22.21	420	233	250	243	0	0
22.21	421	233	250	243	0	0
22.21	422	233	250	243	0	0
22.21	423	233	250	243	0	0
22.21	424	233	250	243	0	0
22.21	425	233	250	243	0	0
22.21	426	233	250	243	0	0
22.21	427	233	250	243	0	0
22.21	428	233	250	243	0	0
22.21	429	233	250	243	0	0
22.21	430	233	250	243	0	0
22.21	431	233	250	243	0	0
22.21	432	233	250	243	0	0
22.96	494	269	244	298	0	0
22.96	495	269	244	298	0	0
22.96	496	269	244	298	0	0
23.48	199	216	263	267	0	0
23.48	200	216	263	267	0	0
23.48	201	216	263	267	0	0
23.48	202	216	263	267	0	0
23.48	203	216	263	267	0	0
23.48	204	216	263	267	0	0
23.53	164	209	247	297	0	0
23.53	165	209	247	297	0	0
23.53	166	209	247	297	0	0
23.53	167	209	247	297	0	0
23.65	248	224	247	297	0	0
23.65	249	224	247	297	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
23.65	250	224	247	297	0	0
23.65	251	224	247	297	0	0
23.65	252	224	247	297	0	0
23.65	253	224	247	297	0	0
23.99	190	214	244	298	0	0
23.99	191	214	244	298	0	0
23.99	192	214	244	298	0	0
23.99	193	214	244	298	0	0
23.99	194	214	244	298	0	0
23.99	195	214	244	298	0	0
23.99	196	214	244	298	0	0
23.99	197	214	244	298	0	0

24.13	169	211	247	297	0	0
24.13	170	211	247	297	0	0
24.13	171	211	247	297	0	0
24.13	172	211	247	297	0	0
24.13	173	211	247	297	0	0
24.13	174	211	247	297	0	0
24.13	175	211	247	297	0	0
24.13	176	211	247	297	0	0
24.13	177	211	247	297	0	0
24.13	178	211	247	297	0	0
24.13	455	236	255	247	0	0
24.13	456	236	255	247	0	0
24.13	457	236	255	247	0	0
24.13	458	236	255	247	0	0
24.13	459	236	255	247	0	0
24.13	460	236	255	247	0	0
24.13	461	236	255	247	0	0
24.13	462	236	255	247	0	0
24.13	463	236	255	247	0	0
24.13	464	236	255	247	0	0
24.13	465	236	255	247	0	0
24.13	466	236	255	247	0	0
24.13	467	236	255	247	0	0
24.13	468	236	255	247	0	0
24.13	469	236	255	247	0	0
24.13	470	236	255	247	0	0
24.13	471	236	255	247	0	0
24.13	472	236	255	247	0	0
24.13	473	236	255	247	0	0
24.13	474	236	255	247	0	0
24.13	475	236	255	247	0	0
24.13	476	236	255	247	0	0
24.13	477	236	255	247	0	0
24.13	478	236	255	247	0	0
24.13	479	236	255	247	0	0
24.13	480	236	255	247	0	0
24.13	481	236	255	247	0	0
24.13	482	236	255	247	0	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
24.13	485	239	247	297	0	0
24.13	486	239	247	297	0	0
24.13	487	239	247	297	0	0
25.03	488	267	296	196	0	0
25.03	489	267	296	196	0	0
25.03	490	267	296	196	0	0
28.16	47	205	244	298	0	0
28.16	48	205	244	298	0	0
28.16	49	205	244	298	0	0
28.16	50	205	244	298	0	0
28.16	51	205	244	298	0	0
28.16	52	205	244	298	0	0
28.16	53	205	244	298	0	0
28.16	54	205	244	298	0	0
28.16	55	205	244	298	0	0
28.16	56	205	244	298	0	0

28.16	57	205	244	298	0	0
28.16	58	205	244	298	0	0
28.16	59	205	244	298	0	0
28.16	60	205	244	298	0	0
28.16	61	205	244	298	0	0
28.16	62	205	244	298	0	0
28.16	63	205	244	298	0	0
28.16	64	205	244	298	0	0
28.16	65	205	244	298	0	0
28.16	66	205	244	298	0	0
28.16	67	205	244	298	0	0
28.16	68	205	244	298	0	0
28.16	69	205	244	298	0	0
28.16	70	205	244	298	0	0
28.16	71	205	244	298	0	0
28.16	72	205	244	298	0	0
28.16	73	205	244	298	0	0
28.16	74	205	244	298	0	0
28.16	75	205	244	298	0	0
28.16	76	205	244	298	0	0
28.16	77	205	244	298	0	0
28.16	78	205	244	298	0	0
28.16	79	205	244	298	0	0
28.16	80	205	244	298	0	0
28.16	81	205	244	298	0	0
28.16	82	205	244	298	0	0
28.16	83	205	244	298	0	0
28.16	182	213	261	244	0	0
28.16	183	213	261	244	0	0
28.16	184	213	261	244	0	0
28.16	185	213	261	244	0	0
28.16	186	213	261	244	0	0
28.16	187	213	261	244	0	0
28.16	188	213	261	244	0	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
28.16	189	213	261	244	0	0
28.16	308	228	261	244	0	0
28.16	309	228	261	244	0	0
28.16	310	228	261	244	0	0
28.16	311	228	261	244	0	0
28.16	312	228	261	244	0	0
28.16	313	228	261	244	0	0
28.16	314	228	261	244	0	0
28.16	315	228	261	244	0	0
28.16	316	228	261	244	0	0
28.16	317	228	261	244	0	0
28.16	318	228	261	244	0	0
28.16	319	228	261	244	0	0
28.16	320	228	261	244	0	0
28.16	321	228	261	244	0	0
28.16	322	228	261	244	0	0
29.81	242	223	247	297	0	0
29.81	243	223	247	297	0	0
29.81	244	223	247	297	0	0
29.81	245	223	247	297	0	0

29.81	246	223	247	297	0	0
29.81	247	223	247	297	0	0
30.00	269	254	254	247	0	0
30.00	270	254	254	247	0	0
30.00	271	254	254	247	0	0
30.00	272	254	254	247	0	0
30.00	273	254	254	247	0	0
30.00	274	254	254	247	0	0
30.00	275	254	254	247	0	0
30.00	276	254	254	247	0	0
30.00	277	254	254	247	0	0
30.75	23	203	243	299	0	0
30.75	24	203	243	299	0	0
30.75	25	203	243	299	0	0
30.75	26	203	243	299	0	0
30.75	27	203	243	299	0	0
30.75	28	203	243	299	0	0
30.75	29	203	243	299	0	0
30.75	30	203	243	299	0	0
30.75	31	203	243	299	0	0
30.75	32	203	243	299	0	0
30.75	33	203	243	299	0	0
30.75	34	203	243	299	0	0
30.93	205	259	259	267	0	0
30.93	206	259	259	267	0	0
30.93	207	259	259	267	0	0
30.93	208	259	259	267	0	0
30.93	209	259	259	267	0	0
30.93	210	259	259	267	0	0
30.93	211	259	259	267	0	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
30.93	361	259	259	267	0	0
30.93	362	259	259	267	0	0
30.93	363	259	259	267	0	0
30.93	364	259	259	267	0	0
30.93	365	259	259	267	0	0
30.93	366	259	259	267	0	0
30.93	367	259	259	267	0	0
30.93	368	259	259	267	0	0
30.93	369	259	259	267	0	0
31.14	227	220	243	299	0	0
31.27	488	267	196	0	1	0
31.27	489	267	196	0	2	0
31.27	490	267	196	0	3	0
32.04	12	202	243	299	3	0
32.04	13	202	243	299	3	0
32.04	14	202	243	299	3	0
32.04	15	202	243	299	3	0
32.04	16	202	243	299	3	0
32.04	17	202	243	299	3	0
32.04	18	202	243	299	3	0
32.04	19	202	243	299	3	0
32.04	20	202	243	299	3	0
32.04	21	202	243	299	3	0
32.04	22	202	243	299	3	0

33.02	491	268	260	244	3	0
33.02	492	268	260	244	3	0
33.02	493	268	260	244	3	0
33.04	228	221	243	299	3	0
33.04	229	221	243	299	3	0
33.04	230	221	243	299	3	0
33.04	231	221	243	299	3	0
33.04	232	221	243	299	3	0
33.04	233	221	243	299	3	0
33.04	234	221	243	299	3	0
33.30	370	231	296	196	3	0
33.30	371	231	296	196	3	0
33.30	372	231	296	196	3	0
33.30	373	231	296	196	3	0
33.30	374	231	296	196	3	0
33.30	375	231	296	196	3	0
33.30	376	231	296	196	3	0
33.30	377	231	296	196	3	0
33.30	378	231	296	196	3	0
33.30	379	231	296	196	3	0
33.30	380	231	296	196	3	0
33.30	381	231	296	196	3	0
33.30	382	231	296	196	3	0
33.30	383	231	296	196	3	0
33.30	384	231	296	196	3	0
33.32	106	207	267	296	3	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
33.32	107	207	267	296	3	0
33.32	108	207	267	296	3	0
33.32	109	207	267	296	3	0
33.32	110	207	267	296	3	0
33.32	111	207	267	296	3	0
33.32	112	207	267	296	3	0
33.32	113	207	267	296	3	0
33.32	114	207	267	296	3	0
33.32	115	207	267	296	3	0
33.32	116	207	267	296	3	0
33.32	117	207	267	296	3	0
33.32	118	207	267	296	3	0
33.32	119	207	267	296	3	0
33.32	120	207	267	296	3	0
33.32	121	207	267	296	3	0
33.32	122	207	267	296	3	0
33.32	123	207	267	296	3	0
33.32	124	207	267	296	3	0
33.32	125	207	267	296	3	0
33.32	126	207	267	296	3	0
33.32	127	207	267	296	3	0
33.32	84	206	267	296	3	0
33.32	85	206	267	296	3	0
33.32	86	206	267	296	3	0
33.32	87	206	267	296	3	0
33.32	88	206	267	296	3	0
33.32	89	206	267	296	3	0
33.32	90	206	267	296	3	0

33.32	91	206	267	296	3	0
33.32	92	206	267	296	3	0
33.32	93	206	267	296	3	0
33.32	94	206	267	296	3	0
33.32	95	206	267	296	3	0
33.32	96	206	267	296	3	0
33.32	97	206	267	296	3	0
33.32	98	206	267	296	3	0
33.32	99	206	267	296	3	0
33.32	100	206	267	296	3	0
33.32	101	206	267	296	3	0
33.32	102	206	267	296	3	0
33.32	103	206	267	296	3	0
33.32	104	206	267	296	3	0
33.32	105	206	267	296	3	0
33.32	219	258	258	267	3	0
33.32	220	258	258	267	3	0
33.32	221	258	258	267	3	0
33.32	222	258	258	267	3	0
33.32	223	258	258	267	3	0
33.32	224	258	258	267	3	0
33.32	225	258	258	267	3	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
33.32	226	258	258	267	3	0
33.32	385	258	258	267	3	0
33.32	386	258	258	267	3	0
33.32	387	258	258	267	3	0
33.32	388	258	258	267	3	0
33.32	389	258	258	267	3	0
33.32	390	258	258	267	3	0
33.32	391	258	258	267	3	0
33.32	392	258	258	267	3	0
33.32	393	258	258	267	3	0
33.67	503	273	243	299	3	0
33.67	504	273	243	299	3	0
33.67	505	273	243	299	3	0
33.81	323	229	260	244	3	0
33.81	324	229	260	244	3	0
33.81	325	229	260	244	3	0
33.81	326	229	260	244	3	0
33.81	327	229	260	244	3	0
33.81	328	229	260	244	3	0
33.81	329	229	260	244	3	0
33.81	330	229	260	244	3	0
33.81	331	229	260	244	3	0
33.81	332	229	260	244	3	0
33.81	333	229	260	244	3	0
33.81	334	229	260	244	3	0
33.81	335	229	260	244	3	0
33.81	336	229	260	244	3	0
33.81	337	229	260	244	3	0
33.81	338	229	260	244	3	0
33.81	339	229	260	244	3	0
33.81	340	229	260	244	3	0
33.81	341	229	260	244	3	0

33.81	342	229	260	244	3	0
33.81	343	229	260	244	3	0
33.81	344	229	260	244	3	0
33.81	345	229	260	244	3	0
33.81	346	229	260	244	3	0
33.81	347	229	260	244	3	0
33.81	348	229	260	244	3	0
33.81	349	229	260	244	3	0
33.81	350	229	260	244	3	0
33.81	351	229	260	244	3	0
33.81	352	229	260	244	3	0
33.81	353	229	260	244	3	0
33.81	354	229	260	244	3	0
33.81	355	229	260	244	3	0
33.81	356	229	260	244	3	0
33.81	357	229	260	244	3	0
33.81	358	229	260	244	3	0
33.81	359	229	260	244	3	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
33.81	360	229	260	244	3	0
35.21	212	218	267	296	3	0
35.21	213	218	267	296	3	0
35.21	214	218	267	296	3	0
35.21	215	218	267	296	3	0
35.21	216	218	267	296	3	0
35.21	217	218	267	296	3	0
35.21	218	218	267	296	3	0
35.43	179	212	254	247	3	0
35.43	180	212	254	247	3	0
35.43	181	212	254	247	3	0
36.04	455	236	247	297	3	0
36.04	456	236	247	297	3	0
36.04	457	236	247	297	3	0
36.04	458	236	247	297	3	0
36.04	459	236	247	297	3	0
36.04	460	236	247	297	3	0
36.04	461	236	247	297	3	0
36.04	462	236	247	297	3	0
36.04	463	236	247	297	3	0
36.04	464	236	247	297	3	0
36.04	465	236	247	297	3	0
36.04	466	236	247	297	3	0
36.04	467	236	247	297	3	0
36.04	468	236	247	297	3	0
36.04	469	236	247	297	3	0
36.04	470	236	247	297	3	0
36.04	471	236	247	297	3	0
36.04	472	236	247	297	3	0
36.04	473	236	247	297	3	0
36.04	474	236	247	297	3	0
36.04	475	236	247	297	3	0
36.04	476	236	247	297	3	0
36.04	477	236	247	297	3	0
36.04	478	236	247	297	3	0
36.04	479	236	247	297	3	0

36.04	480	236	247	297	3	0
36.04	481	236	247	297	3	0
36.04	482	236	247	297	3	0
36.04	278	227	254	247	3	0
36.04	279	227	254	247	3	0
36.04	280	227	254	247	3	0
36.04	281	227	254	247	3	0
36.04	282	227	254	247	3	0
36.04	283	227	254	247	3	0
36.04	284	227	254	247	3	0
36.04	285	227	254	247	3	0
36.04	286	227	254	247	3	0
36.04	287	227	254	247	3	0
36.04	288	227	254	247	3	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
36.04	289	227	254	247	3	0
36.04	290	227	254	247	3	0
36.04	291	227	254	247	3	0
36.04	292	227	254	247	3	0
36.04	293	227	254	247	3	0
36.04	294	227	254	247	3	0
36.04	295	227	254	247	3	0
36.04	296	227	254	247	3	0
36.04	297	227	254	247	3	0
36.04	298	227	254	247	3	0
36.04	299	227	254	247	3	0
36.04	300	227	254	247	3	0
36.04	301	227	254	247	3	0
36.04	302	227	254	247	3	0
36.04	303	227	254	247	3	0
36.04	304	227	254	247	3	0
36.04	305	227	254	247	3	0
36.04	306	227	254	247	3	0
36.04	307	227	254	247	3	0
36.55	128	208	243	299	3	0
36.55	129	208	243	299	3	0
36.55	130	208	243	299	3	0
36.55	131	208	243	299	3	0
36.55	132	208	243	299	3	0
36.55	133	208	243	299	3	0
36.55	134	208	243	299	3	0
36.55	135	208	243	299	3	0
36.55	136	208	243	299	3	0
36.55	137	208	243	299	3	0
36.55	138	208	243	299	3	0
36.55	139	208	243	299	3	0
36.55	140	208	243	299	3	0
36.55	141	208	243	299	3	0
36.55	142	208	243	299	3	0
36.55	143	208	243	299	3	0
36.55	144	208	243	299	3	0
36.55	145	208	243	299	3	0
36.55	146	208	243	299	3	0
36.55	147	208	243	299	3	0
36.55	148	208	243	299	3	0

36.55	149	208	243	299	3	0
36.55	150	208	243	299	3	0
36.55	151	208	243	299	3	0
36.55	152	208	243	299	3	0
36.55	153	208	243	299	3	0
36.55	154	208	243	299	3	0
36.55	155	208	243	299	3	0
36.55	156	208	243	299	3	0
36.55	157	208	243	299	3	0
36.55	158	208	243	299	3	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
36.55	159	208	243	299	3	0
36.55	160	208	243	299	3	0
36.55	161	208	243	299	3	0
36.55	162	208	243	299	3	0
36.55	163	208	243	299	3	0
36.55	235	222	256	243	3	0
36.55	236	222	256	243	3	0
36.55	237	222	256	243	3	0
36.55	238	222	256	243	3	0
36.55	239	222	256	243	3	0
36.55	240	222	256	243	3	0
36.55	241	222	256	243	3	0
36.55	433	234	256	243	3	0
36.55	434	234	256	243	3	0
36.55	435	234	256	243	3	0
36.55	436	234	256	243	3	0
36.55	437	234	256	243	3	0
36.55	438	234	256	243	3	0
36.55	439	234	256	243	3	0
36.55	440	234	256	243	3	0
36.55	441	234	256	243	3	0
36.55	442	234	256	243	3	0
36.55	443	234	256	243	3	0
36.55	444	234	256	243	3	0
36.55	445	234	256	243	3	0
36.55	446	234	256	243	3	0
36.55	447	234	256	243	3	0
36.55	506	274	257	243	3	0
36.87	199	216	267	296	3	0
36.87	200	216	267	296	3	0
36.87	201	216	267	296	3	0
36.87	202	216	267	296	3	0
36.87	203	216	267	296	3	0
36.87	204	216	267	296	3	0
38.32	182	213	244	298	3	0
38.32	183	213	244	298	3	0
38.32	184	213	244	298	3	0
38.32	185	213	244	298	3	0
38.32	186	213	244	298	3	0
38.32	187	213	244	298	3	0
38.32	188	213	244	298	3	0
38.32	189	213	244	298	3	0
39.27	308	228	244	298	3	0
39.27	309	228	244	298	3	0

39.27	310	228	244	298	3	0
39.27	311	228	244	298	3	0
39.27	312	228	244	298	3	0
39.27	313	228	244	298	3	0
39.27	314	228	244	298	3	0
39.27	315	228	244	298	3	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
39.27	316	228	244	298	3	0
39.27	317	228	244	298	3	0
39.27	318	228	244	298	3	0
39.27	319	228	244	298	3	0
39.27	320	228	244	298	3	0
39.27	321	228	244	298	3	0
39.27	322	228	244	298	3	0
39.70	500	250	243	299	3	0
39.70	501	250	243	299	3	0
39.70	502	250	243	299	3	0
40.34	394	233	243	299	3	0
40.34	395	233	243	299	3	0
40.34	396	233	243	299	3	0
40.34	397	233	243	299	3	0
40.34	398	233	243	299	3	0
40.34	399	233	243	299	3	0
40.34	400	233	243	299	3	0
40.34	401	233	243	299	3	0
40.34	402	233	243	299	3	0
40.34	403	233	243	299	3	0
40.34	404	233	243	299	3	0
40.34	405	233	243	299	3	0
40.34	406	233	243	299	3	0
40.34	407	233	243	299	3	0
40.34	408	233	243	299	3	0
40.34	409	233	243	299	3	0
40.34	410	233	243	299	3	0
40.34	411	233	243	299	3	0
40.34	412	233	243	299	3	0
40.34	413	233	243	299	3	0
40.34	414	233	243	299	3	0
40.34	415	233	243	299	3	0
40.34	416	233	243	299	3	0
40.34	417	233	243	299	3	0
40.34	418	233	243	299	3	0
40.34	419	233	243	299	3	0
40.34	420	233	243	299	3	0
40.34	421	233	243	299	3	0
40.34	422	233	243	299	3	0
40.34	423	233	243	299	3	0
40.34	424	233	243	299	3	0
40.34	425	233	243	299	3	0
40.34	426	233	243	299	3	0
40.34	427	233	243	299	3	0
40.34	428	233	243	299	3	0
40.34	429	233	243	299	3	0
40.34	430	233	243	299	3	0
40.34	431	233	243	299	3	0

	40.34	432	233	243	299	3	0
	40.34	448	235	256	243	3	0
1		OCC	ORIG	FROM	TO	NUM	NUM
	TIME	NUM	NODE	NODE	NODE	OUT	TRAPD
	40.34	449	235	256	243	3	0
	40.34	450	235	256	243	3	0
	40.34	451	235	256	243	3	0
	40.34	452	235	256	243	3	0
	40.34	453	235	256	243	3	0
	40.34	454	235	256	243	3	0
	40.56	370	231	196	0	4	0
	40.56	371	231	196	0	5	0
	40.56	372	231	196	0	6	0
	40.56	373	231	196	0	7	0
	40.56	374	231	196	0	8	0
	40.56	375	231	196	0	9	0
	40.56	376	231	196	0	10	0
	40.56	377	231	196	0	11	0
	40.56	378	231	196	0	12	0
	40.56	379	231	196	0	13	0
	40.56	380	231	196	0	14	0
	40.56	381	231	196	0	15	0
	40.56	382	231	196	0	16	0
	40.56	383	231	196	0	17	0
	40.56	384	231	196	0	18	0
	43.47	491	268	244	298	18	0
	43.47	492	268	244	298	18	0
	43.47	493	268	244	298	18	0
	43.66	219	258	267	296	18	0
	43.66	220	258	267	296	18	0
	43.66	221	258	267	296	18	0
	43.66	222	258	267	296	18	0
	43.66	223	258	267	296	18	0
	43.66	224	258	267	296	18	0
	43.66	225	258	267	296	18	0
	43.66	226	258	267	296	18	0
	43.66	385	258	267	296	18	0
	43.66	386	258	267	296	18	0
	43.66	387	258	267	296	18	0
	43.66	388	258	267	296	18	0
	43.66	389	258	267	296	18	0
	43.66	390	258	267	296	18	0
	43.66	391	258	267	296	18	0
	43.66	392	258	267	296	18	0
	43.66	393	258	267	296	18	0
	43.66	205	259	267	296	18	0
	43.66	206	259	267	296	18	0
	43.66	207	259	267	296	18	0
	43.66	208	259	267	296	18	0
	43.66	209	259	267	296	18	0
	43.66	210	259	267	296	18	0
	43.66	211	259	267	296	18	0
	43.66	361	259	267	296	18	0
	43.66	362	259	267	296	18	0
1		OCC	ORIG	FROM	TO	NUM	NUM
	TIME	NUM	NODE	NODE	NODE	OUT	TRAPD

43.66	363	259	267	296	18	0
43.66	364	259	267	296	18	0
43.66	365	259	267	296	18	0
43.66	366	259	267	296	18	0
43.66	367	259	267	296	18	0
43.66	368	259	267	296	18	0
43.66	369	259	267	296	18	0
44.04	323	229	244	298	18	0
44.04	324	229	244	298	18	0
44.04	325	229	244	298	18	0
44.04	326	229	244	298	18	0
44.04	327	229	244	298	18	0
44.04	328	229	244	298	18	0
44.04	329	229	244	298	18	0
44.04	330	229	244	298	18	0
44.04	331	229	244	298	18	0
44.04	332	229	244	298	18	0
44.04	333	229	244	298	18	0
44.04	334	229	244	298	18	0
44.04	335	229	244	298	18	0
44.04	336	229	244	298	18	0
44.04	337	229	244	298	18	0
44.04	338	229	244	298	18	0
44.04	339	229	244	298	18	0
44.04	340	229	244	298	18	0
44.04	341	229	244	298	18	0
44.04	342	229	244	298	18	0
44.04	343	229	244	298	18	0
44.04	344	229	244	298	18	0
44.04	345	229	244	298	18	0
44.04	346	229	244	298	18	0
44.04	347	229	244	298	18	0
44.04	348	229	244	298	18	0
44.04	349	229	244	298	18	0
44.04	350	229	244	298	18	0
44.04	351	229	244	298	18	0
44.04	352	229	244	298	18	0
44.04	353	229	244	298	18	0
44.04	354	229	244	298	18	0
44.04	355	229	244	298	18	0
44.04	356	229	244	298	18	0
44.04	357	229	244	298	18	0
44.04	358	229	244	298	18	0
44.04	359	229	244	298	18	0
44.04	360	229	244	298	18	0
44.16	269	254	247	297	18	0
44.16	270	254	247	297	18	0
44.16	271	254	247	297	18	0
44.16	272	254	247	297	18	0
44.16	273	254	247	297	18	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
44.16	274	254	247	297	18	0
44.16	275	254	247	297	18	0
44.16	276	254	247	297	18	0

44.16	277	254	247	297	18	0
44.21	506	274	243	299	18	0
45.62	278	227	247	297	18	0
45.62	279	227	247	297	18	0
45.62	280	227	247	297	18	0
45.62	281	227	247	297	18	0
45.62	282	227	247	297	18	0
45.62	283	227	247	297	18	0
45.62	284	227	247	297	18	0
45.62	285	227	247	297	18	0
45.62	286	227	247	297	18	0
45.62	287	227	247	297	18	0
45.62	288	227	247	297	18	0
45.62	289	227	247	297	18	0
45.62	290	227	247	297	18	0
45.62	291	227	247	297	18	0
45.62	292	227	247	297	18	0
45.62	293	227	247	297	18	0
45.62	294	227	247	297	18	0
45.62	295	227	247	297	18	0
45.62	296	227	247	297	18	0
45.62	297	227	247	297	18	0
45.62	298	227	247	297	18	0
45.62	299	227	247	297	18	0
45.62	300	227	247	297	18	0
45.62	301	227	247	297	18	0
45.62	302	227	247	297	18	0
45.62	303	227	247	297	18	0
45.62	304	227	247	297	18	0
45.62	305	227	247	297	18	0
45.62	306	227	247	297	18	0
45.62	307	227	247	297	18	0
45.62	179	212	247	297	18	0
45.62	180	212	247	297	18	0
45.62	181	212	247	297	18	0
48.25	448	235	243	299	18	0
48.25	449	235	243	299	18	0
48.25	450	235	243	299	18	0
48.25	451	235	243	299	18	0
48.25	452	235	243	299	18	0
48.25	453	235	243	299	18	0
48.25	454	235	243	299	18	0
48.25	235	222	243	299	18	0
48.25	236	222	243	299	18	0
48.25	237	222	243	299	18	0
48.25	238	222	243	299	18	0
48.25	239	222	243	299	18	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
48.25	240	222	243	299	18	0
48.25	241	222	243	299	18	0
48.25	433	234	243	299	18	0
48.25	434	234	243	299	18	0
48.25	435	234	243	299	18	0
48.25	436	234	243	299	18	0
48.25	437	234	243	299	18	0

48.25	438	234	243	299	18	0
48.25	439	234	243	299	18	0
48.25	440	234	243	299	18	0
48.25	441	234	243	299	18	0
48.25	442	234	243	299	18	0
48.25	443	234	243	299	18	0
48.25	444	234	243	299	18	0
48.25	445	234	243	299	18	0
48.25	446	234	243	299	18	0
48.25	447	234	243	299	18	0
79.66	168	247	297	197	18	0
85.21	497	271	298	198	18	0
85.21	498	271	298	198	18	0
85.21	499	271	298	198	18	0
85.83	168	247	197	0	19	0
87.93	35	204	298	198	19	0
87.93	36	204	298	198	19	0
87.93	37	204	298	198	19	0
87.93	38	204	298	198	19	0
87.93	39	204	298	198	19	0
87.93	40	204	298	198	19	0
87.93	41	204	298	198	19	0
87.93	42	204	298	198	19	0
87.93	43	204	298	198	19	0
87.93	44	204	298	198	19	0
87.93	45	204	298	198	19	0
87.93	46	204	298	198	19	0
91.50	254	225	297	197	19	0
91.50	255	225	297	197	19	0
91.50	256	225	297	197	19	0
91.50	257	225	297	197	19	0
91.50	258	225	297	197	19	0
91.50	259	225	297	197	19	0
91.50	260	225	297	197	19	0
91.50	261	225	297	197	19	0
91.50	262	225	297	197	19	0
91.50	263	225	297	197	19	0
91.50	264	225	297	197	19	0
91.50	265	225	297	197	19	0
91.50	266	225	297	197	19	0
91.50	267	225	297	197	19	0
91.50	268	225	297	197	19	0
92.47	497	271	198	0	20	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
92.47	498	271	198	0	21	0
92.47	499	271	198	0	22	0
93.62	198	215	298	198	22	0
94.47	1	201	298	198	22	0
94.47	2	201	298	198	22	0
94.47	3	201	298	198	22	0
94.47	4	201	298	198	22	0
94.47	5	201	298	198	22	0
94.47	6	201	298	198	22	0
94.47	7	201	298	198	22	0
94.47	8	201	298	198	22	0

94.47	9	201	298	198	22	0
94.47	10	201	298	198	22	0
94.47	11	201	298	198	22	0
96.64	35	204	198	0	23	0
96.64	36	204	198	0	24	0
96.64	37	204	198	0	25	0
96.64	38	204	198	0	26	0
96.64	39	204	198	0	27	0
96.64	40	204	198	0	28	0
96.64	41	204	198	0	29	0
96.64	42	204	198	0	30	0
96.64	43	204	198	0	31	0
96.64	44	204	198	0	32	0
96.64	45	204	198	0	33	0
96.64	46	204	198	0	34	0
98.65	483	266	297	197	34	0
98.65	484	266	297	197	34	0
98.99	254	225	197	0	35	0
98.99	255	225	197	0	36	0
98.99	256	225	197	0	37	0
98.99	257	225	197	0	38	0
98.99	258	225	197	0	39	0
98.99	259	225	197	0	40	0
98.99	260	225	197	0	41	0
98.99	261	225	197	0	42	0
98.99	262	225	197	0	43	0
98.99	263	225	197	0	44	0
98.99	264	225	197	0	45	0
98.99	265	225	197	0	46	0
98.99	266	225	197	0	47	0
98.99	267	225	197	0	48	0
98.99	268	225	197	0	49	0
98.99	164	209	297	197	49	0
98.99	165	209	297	197	49	0
98.99	166	209	297	197	49	0
98.99	167	209	297	197	49	0
98.99	169	211	297	197	49	0
98.99	170	211	297	197	49	0
98.99	171	211	297	197	49	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
98.99	172	211	297	197	49	0
98.99	173	211	297	197	49	0
98.99	174	211	297	197	49	0
98.99	175	211	297	197	49	0
98.99	176	211	297	197	49	0
98.99	177	211	297	197	49	0
98.99	178	211	297	197	49	0
98.99	248	224	297	197	49	0
98.99	249	224	297	197	49	0
98.99	250	224	297	197	49	0
98.99	251	224	297	197	49	0
98.99	252	224	297	197	49	0
98.99	253	224	297	197	49	0
98.99	485	239	297	197	49	0
98.99	486	239	297	197	49	0

98.99	487	239	297	197	49	0
99.00	494	269	298	198	49	0
99.00	495	269	298	198	49	0
99.00	496	269	298	198	49	0
100.87	198	215	198	0	50	0
100.88	190	214	298	198	50	0
100.88	191	214	298	198	50	0
100.88	192	214	298	198	50	0
100.88	193	214	298	198	50	0
100.88	194	214	298	198	50	0
100.88	195	214	298	198	50	0
100.88	196	214	298	198	50	0
100.88	197	214	298	198	50	0
102.84	1	201	198	0	51	0
102.84	2	201	198	0	52	0
102.84	3	201	198	0	53	0
102.84	4	201	198	0	54	0
102.84	5	201	198	0	55	0
102.84	6	201	198	0	56	0
102.84	7	201	198	0	57	0
102.84	8	201	198	0	58	0
102.84	9	201	198	0	59	0
102.84	10	201	198	0	60	0
102.84	11	201	198	0	61	0
103.56	23	203	299	199	61	0
103.56	24	203	299	199	61	0
103.56	25	203	299	199	61	0
103.56	26	203	299	199	61	0
103.56	27	203	299	199	61	0
103.56	28	203	299	199	61	0
103.56	29	203	299	199	61	0
103.56	30	203	299	199	61	0
103.56	31	203	299	199	61	0
103.56	32	203	299	199	61	0
103.56	33	203	299	199	61	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
103.56	34	203	299	199	61	0
103.71	47	205	298	198	61	0
103.71	48	205	298	198	61	0
103.71	49	205	298	198	61	0
103.71	50	205	298	198	61	0
103.71	51	205	298	198	61	0
103.71	52	205	298	198	61	0
103.71	53	205	298	198	61	0
103.71	54	205	298	198	61	0
103.71	55	205	298	198	61	0
103.71	56	205	298	198	61	0
103.71	57	205	298	198	61	0
103.71	58	205	298	198	61	0
103.71	59	205	298	198	61	0
103.71	60	205	298	198	61	0
103.71	61	205	298	198	61	0
103.71	62	205	298	198	61	0
103.71	63	205	298	198	61	0
103.71	64	205	298	198	61	0

103.71	65	205	298	198	61	0
103.71	66	205	298	198	61	0
103.71	67	205	298	198	61	0
103.71	68	205	298	198	61	0
103.71	69	205	298	198	61	0
103.71	70	205	298	198	61	0
103.71	71	205	298	198	61	0
103.71	72	205	298	198	61	0
103.71	73	205	298	198	61	0
103.71	74	205	298	198	61	0
103.71	75	205	298	198	61	0
103.71	76	205	298	198	61	0
103.71	77	205	298	198	61	0
103.71	78	205	298	198	61	0
103.71	79	205	298	198	61	0
103.71	80	205	298	198	61	0
103.71	81	205	298	198	61	0
103.71	82	205	298	198	61	0
103.71	83	205	298	198	61	0
105.27	84	206	296	196	61	0
105.27	85	206	296	196	61	0
105.27	86	206	296	196	61	0
105.27	87	206	296	196	61	0
105.27	88	206	296	196	61	0
105.27	89	206	296	196	61	0
105.27	90	206	296	196	61	0
105.27	91	206	296	196	61	0
105.27	92	206	296	196	61	0
105.27	93	206	296	196	61	0
105.27	94	206	296	196	61	0
105.27	95	206	296	196	61	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
105.27	96	206	296	196	61	0
105.27	97	206	296	196	61	0
105.27	98	206	296	196	61	0
105.27	99	206	296	196	61	0
105.27	100	206	296	196	61	0
105.27	101	206	296	196	61	0
105.27	102	206	296	196	61	0
105.27	103	206	296	196	61	0
105.27	104	206	296	196	61	0
105.27	105	206	296	196	61	0
105.49	164	209	197	0	62	0
105.49	165	209	197	0	63	0
105.49	166	209	197	0	64	0
105.49	167	209	197	0	65	0
105.49	169	211	197	0	66	0
105.49	170	211	197	0	67	0
105.49	171	211	197	0	68	0
105.49	172	211	197	0	69	0
105.49	173	211	197	0	70	0
105.49	174	211	197	0	71	0
105.49	175	211	197	0	72	0
105.49	176	211	197	0	73	0
105.49	177	211	197	0	74	0

105.49	178	211	197	0	75	0
105.49	248	224	197	0	76	0
105.49	249	224	197	0	77	0
105.49	250	224	197	0	78	0
105.49	251	224	197	0	79	0
105.49	252	224	197	0	80	0
105.49	253	224	197	0	81	0
105.49	485	239	197	0	82	0
105.49	486	239	197	0	83	0
105.49	487	239	197	0	84	0
105.49	242	223	297	197	84	0
105.49	243	223	297	197	84	0
105.49	244	223	297	197	84	0
105.49	245	223	297	197	84	0
105.49	246	223	297	197	84	0
105.49	247	223	297	197	84	0
105.49	483	266	197	0	85	0
105.49	484	266	197	0	86	0
107.18	227	220	299	199	86	0
108.64	12	202	299	199	86	0
108.64	13	202	299	199	86	0
108.64	14	202	299	199	86	0
108.64	15	202	299	199	86	0
108.64	16	202	299	199	86	0
108.64	17	202	299	199	86	0
108.64	18	202	299	199	86	0
108.64	19	202	299	199	86	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
108.64	20	202	299	199	86	0
108.64	21	202	299	199	86	0
108.64	22	202	299	199	86	0
109.20	242	223	197	0	87	0
109.20	243	223	197	0	88	0
109.20	244	223	197	0	89	0
109.20	245	223	197	0	90	0
109.20	246	223	197	0	91	0
109.20	247	223	197	0	92	0
109.20	455	236	297	197	92	0
109.20	456	236	297	197	92	0
109.20	457	236	297	197	92	0
109.20	458	236	297	197	92	0
109.20	459	236	297	197	92	0
109.20	460	236	297	197	92	0
109.20	461	236	297	197	92	0
109.20	462	236	297	197	92	0
109.20	463	236	297	197	92	0
109.20	464	236	297	197	92	0
109.20	465	236	297	197	92	0
109.20	466	236	297	197	92	0
109.20	467	236	297	197	92	0
109.20	468	236	297	197	92	0
109.20	469	236	297	197	92	0
109.20	470	236	297	197	92	0
109.20	471	236	297	197	92	0
109.20	472	236	297	197	92	0

109.20	473	236	297	197	92	0
109.20	474	236	297	197	92	0
109.20	475	236	297	197	92	0
109.20	476	236	297	197	92	0
109.20	477	236	297	197	92	0
109.20	478	236	297	197	92	0
109.20	479	236	297	197	92	0
109.20	480	236	297	197	92	0
109.20	481	236	297	197	92	0
109.20	482	236	297	197	92	0
111.14	269	254	297	197	92	0
111.14	270	254	297	197	92	0
111.14	271	254	297	197	92	0
111.14	272	254	297	197	92	0
111.14	273	254	297	197	92	0
111.14	274	254	297	197	92	0
111.14	275	254	297	197	92	0
111.14	276	254	297	197	92	0
111.14	277	254	297	197	92	0
111.14	179	212	297	197	92	0
111.14	180	212	297	197	92	0
111.14	181	212	297	197	92	0
111.14	278	227	297	197	92	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
111.14	279	227	297	197	92	0
111.14	280	227	297	197	92	0
111.14	281	227	297	197	92	0
111.14	282	227	297	197	92	0
111.14	283	227	297	197	92	0
111.14	284	227	297	197	92	0
111.14	285	227	297	197	92	0
111.14	286	227	297	197	92	0
111.14	287	227	297	197	92	0
111.14	288	227	297	197	92	0
111.14	289	227	297	197	92	0
111.14	290	227	297	197	92	0
111.14	291	227	297	197	92	0
111.14	292	227	297	197	92	0
111.14	293	227	297	197	92	0
111.14	294	227	297	197	92	0
111.14	295	227	297	197	92	0
111.14	296	227	297	197	92	0
111.14	297	227	297	197	92	0
111.14	298	227	297	197	92	0
111.14	299	227	297	197	92	0
111.14	300	227	297	197	92	0
111.14	301	227	297	197	92	0
111.14	302	227	297	197	92	0
111.14	303	227	297	197	92	0
111.14	304	227	297	197	92	0
111.14	305	227	297	197	92	0
111.14	306	227	297	197	92	0
111.14	307	227	297	197	92	0
112.28	23	203	199	0	93	0
112.28	24	203	199	0	94	0

112.28	25	203	199	0	95	0
112.28	26	203	199	0	96	0
112.28	27	203	199	0	97	0
112.28	28	203	199	0	98	0
112.28	29	203	199	0	99	0
112.28	30	203	199	0	100	0
112.28	31	203	199	0	101	0
112.28	32	203	199	0	102	0
112.28	33	203	199	0	103	0
112.28	34	203	199	0	104	0
112.28	228	221	299	199	104	0
112.28	229	221	299	199	104	0
112.28	230	221	299	199	104	0
112.28	231	221	299	199	104	0
112.28	232	221	299	199	104	0
112.28	233	221	299	199	104	0
112.28	234	221	299	199	104	0
112.28	503	273	299	199	104	0
112.28	504	273	299	199	104	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
112.28	505	273	299	199	104	0
113.64	84	206	196	0	105	0
113.64	85	206	196	0	106	0
113.64	86	206	196	0	107	0
113.64	87	206	196	0	108	0
113.64	88	206	196	0	109	0
113.64	89	206	196	0	110	0
113.64	90	206	196	0	111	0
113.64	91	206	196	0	112	0
113.64	92	206	196	0	113	0
113.64	93	206	196	0	114	0
113.64	94	206	196	0	115	0
113.64	95	206	196	0	116	0
113.64	96	206	196	0	117	0
113.64	97	206	196	0	118	0
113.64	98	206	196	0	119	0
113.64	99	206	196	0	120	0
113.64	100	206	196	0	121	0
113.64	101	206	196	0	122	0
113.64	102	206	196	0	123	0
113.64	103	206	196	0	124	0
113.64	104	206	196	0	125	0
113.64	105	206	196	0	126	0
113.64	106	207	296	196	126	0
113.64	107	207	296	196	126	0
113.64	108	207	296	196	126	0
113.64	109	207	296	196	126	0
113.64	110	207	296	196	126	0
113.64	111	207	296	196	126	0
113.64	112	207	296	196	126	0
113.64	113	207	296	196	126	0
113.64	114	207	296	196	126	0
113.64	115	207	296	196	126	0
113.64	116	207	296	196	126	0
113.64	117	207	296	196	126	0

113.64	118	207	296	196	126	0
113.64	119	207	296	196	126	0
113.64	120	207	296	196	126	0
113.64	121	207	296	196	126	0
113.64	122	207	296	196	126	0
113.64	123	207	296	196	126	0
113.64	124	207	296	196	126	0
113.64	125	207	296	196	126	0
113.64	126	207	296	196	126	0
113.64	127	207	296	196	126	0
113.64	199	216	296	196	126	0
113.64	200	216	296	196	126	0
113.64	201	216	296	196	126	0
113.64	202	216	296	196	126	0
113.64	203	216	296	196	126	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
113.64	204	216	296	196	126	0
113.64	212	218	296	196	126	0
113.64	213	218	296	196	126	0
113.64	214	218	296	196	126	0
113.64	215	218	296	196	126	0
113.64	216	218	296	196	126	0
113.64	217	218	296	196	126	0
113.64	218	218	296	196	126	0
113.64	205	259	296	196	126	0
113.64	206	259	296	196	126	0
113.64	207	259	296	196	126	0
113.64	208	259	296	196	126	0
113.64	209	259	296	196	126	0
113.64	210	259	296	196	126	0
113.64	211	259	296	196	126	0
113.64	219	258	296	196	126	0
113.64	220	258	296	196	126	0
113.64	221	258	296	196	126	0
113.64	222	258	296	196	126	0
113.64	223	258	296	196	126	0
113.64	224	258	296	196	126	0
113.64	225	258	296	196	126	0
113.64	226	258	296	196	126	0
113.64	361	259	296	196	126	0
113.64	362	259	296	196	126	0
113.64	363	259	296	196	126	0
113.64	364	259	296	196	126	0
113.64	365	259	296	196	126	0
113.64	366	259	296	196	126	0
113.64	367	259	296	196	126	0
113.64	368	259	296	196	126	0
113.64	369	259	296	196	126	0
113.64	385	258	296	196	126	0
113.64	386	258	296	196	126	0
113.64	387	258	296	196	126	0
113.64	388	258	296	196	126	0
113.64	389	258	296	196	126	0
113.64	390	258	296	196	126	0
113.64	391	258	296	196	126	0

113.64	392	258	296	196	126	0
113.64	393	258	296	196	126	0
115.55	227	220	199	0	127	0
116.80	12	202	199	0	128	0
116.80	13	202	199	0	129	0
116.80	14	202	199	0	130	0
116.80	15	202	199	0	131	0
116.80	16	202	199	0	132	0
116.80	17	202	199	0	133	0
116.80	18	202	199	0	134	0
116.80	19	202	199	0	135	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
116.80	20	202	199	0	136	0
116.80	21	202	199	0	137	0
116.80	22	202	199	0	138	0
116.80	128	208	299	199	138	0
116.80	129	208	299	199	138	0
116.80	130	208	299	199	138	0
116.80	131	208	299	199	138	0
116.80	132	208	299	199	138	0
116.80	133	208	299	199	138	0
116.80	134	208	299	199	138	0
116.80	135	208	299	199	138	0
116.80	136	208	299	199	138	0
116.80	137	208	299	199	138	0
116.80	138	208	299	199	138	0
116.80	139	208	299	199	138	0
116.80	140	208	299	199	138	0
116.80	141	208	299	199	138	0
116.80	142	208	299	199	138	0
116.80	143	208	299	199	138	0
116.80	144	208	299	199	138	0
116.80	145	208	299	199	138	0
116.80	146	208	299	199	138	0
116.80	147	208	299	199	138	0
116.80	148	208	299	199	138	0
116.80	149	208	299	199	138	0
116.80	150	208	299	199	138	0
116.80	151	208	299	199	138	0
116.80	152	208	299	199	138	0
116.80	153	208	299	199	138	0
116.80	154	208	299	199	138	0
116.80	155	208	299	199	138	0
116.80	156	208	299	199	138	0
116.80	157	208	299	199	138	0
116.80	158	208	299	199	138	0
116.80	159	208	299	199	138	0
116.80	160	208	299	199	138	0
116.80	161	208	299	199	138	0
116.80	162	208	299	199	138	0
116.80	163	208	299	199	138	0
116.80	228	221	199	0	139	0
116.80	229	221	199	0	140	0
116.80	230	221	199	0	141	0
116.80	231	221	199	0	142	0

116.80	232	221	199	0	143	0
116.80	233	221	199	0	144	0
116.80	234	221	199	0	145	0
116.80	394	233	299	199	145	0
116.80	395	233	299	199	145	0
116.80	396	233	299	199	145	0
116.80	397	233	299	199	145	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
116.80	398	233	299	199	145	0
116.80	399	233	299	199	145	0
116.80	400	233	299	199	145	0
116.80	401	233	299	199	145	0
116.80	402	233	299	199	145	0
116.80	403	233	299	199	145	0
116.80	404	233	299	199	145	0
116.80	405	233	299	199	145	0
116.80	406	233	299	199	145	0
116.80	407	233	299	199	145	0
116.80	408	233	299	199	145	0
116.80	409	233	299	199	145	0
116.80	410	233	299	199	145	0
116.80	411	233	299	199	145	0
116.80	412	233	299	199	145	0
116.80	413	233	299	199	145	0
116.80	414	233	299	199	145	0
116.80	415	233	299	199	145	0
116.80	416	233	299	199	145	0
116.80	417	233	299	199	145	0
116.80	418	233	299	199	145	0
116.80	419	233	299	199	145	0
116.80	420	233	299	199	145	0
116.80	421	233	299	199	145	0
116.80	422	233	299	199	145	0
116.80	423	233	299	199	145	0
116.80	424	233	299	199	145	0
116.80	425	233	299	199	145	0
116.80	426	233	299	199	145	0
116.80	427	233	299	199	145	0
116.80	428	233	299	199	145	0
116.80	429	233	299	199	145	0
116.80	430	233	299	199	145	0
116.80	431	233	299	199	145	0
116.80	432	233	299	199	145	0
116.80	500	250	299	199	145	0
116.80	501	250	299	199	145	0
116.80	502	250	299	199	145	0
116.80	503	273	199	0	146	0
116.80	504	273	199	0	147	0
116.80	505	273	199	0	148	0
116.99	494	269	198	0	149	0
116.99	495	269	198	0	150	0
116.99	496	269	198	0	151	0
117.59	190	214	198	0	152	0
117.59	191	214	198	0	153	0
117.59	192	214	198	0	154	0

	117.59	193	214	198	0	155	0
	117.59	194	214	198	0	156	0
	117.59	195	214	198	0	157	0
1		OCC	ORIG	FROM	TO	NUM	NUM
	TIME	NUM	NODE	NODE	NODE	OUT	TRAPD
	117.59	196	214	198	0	158	0
	117.59	197	214	198	0	159	0
	117.59	47	205	198	0	160	0
	117.59	48	205	198	0	161	0
	117.59	49	205	198	0	162	0
	117.59	50	205	198	0	163	0
	117.59	51	205	198	0	164	0
	117.59	52	205	198	0	165	0
	117.59	53	205	198	0	166	0
	117.59	54	205	198	0	167	0
	117.59	55	205	198	0	168	0
	117.59	56	205	198	0	169	0
	117.59	57	205	198	0	170	0
	117.59	58	205	198	0	171	0
	117.59	59	205	198	0	172	0
	117.59	60	205	198	0	173	0
	117.59	61	205	198	0	174	0
	117.59	62	205	198	0	175	0
	117.59	63	205	198	0	176	0
	117.59	64	205	198	0	177	0
	117.59	65	205	198	0	178	0
	117.59	66	205	198	0	179	0
	117.59	67	205	198	0	180	0
	117.59	68	205	198	0	181	0
	117.59	69	205	198	0	182	0
	117.59	70	205	198	0	183	0
	117.59	71	205	198	0	184	0
	117.59	72	205	198	0	185	0
	117.59	73	205	198	0	186	0
	117.59	74	205	198	0	187	0
	117.59	75	205	198	0	188	0
	117.59	76	205	198	0	189	0
	117.59	77	205	198	0	190	0
	117.59	78	205	198	0	191	0
	117.59	79	205	198	0	192	0
	117.59	80	205	198	0	193	0
	117.59	81	205	198	0	194	0
	117.59	82	205	198	0	195	0
	117.59	83	205	198	0	196	0
	117.59	182	213	298	198	196	0
	117.59	183	213	298	198	196	0
	117.59	184	213	298	198	196	0
	117.59	185	213	298	198	196	0
	117.59	186	213	298	198	196	0
	117.59	187	213	298	198	196	0
	117.59	188	213	298	198	196	0
	117.59	189	213	298	198	196	0
	117.59	308	228	298	198	196	0
	117.59	309	228	298	198	196	0
	117.59	310	228	298	198	196	0
1		OCC	ORIG	FROM	TO	NUM	NUM

TIME	NUM	NODE	NODE	NODE	OUT	TRAPD
117.59	311	228	298	198	196	0
117.59	312	228	298	198	196	0
117.59	313	228	298	198	196	0
117.59	314	228	298	198	196	0
117.59	315	228	298	198	196	0
117.59	316	228	298	198	196	0
117.59	317	228	298	198	196	0
117.59	318	228	298	198	196	0
117.59	319	228	298	198	196	0
117.59	320	228	298	198	196	0
117.59	321	228	298	198	196	0
117.59	322	228	298	198	196	0
117.59	323	229	298	198	196	0
117.59	324	229	298	198	196	0
117.59	325	229	298	198	196	0
117.59	326	229	298	198	196	0
117.59	327	229	298	198	196	0
117.59	328	229	298	198	196	0
117.59	329	229	298	198	196	0
117.59	330	229	298	198	196	0
117.59	331	229	298	198	196	0
117.59	332	229	298	198	196	0
117.59	333	229	298	198	196	0
117.59	334	229	298	198	196	0
117.59	335	229	298	198	196	0
117.59	336	229	298	198	196	0
117.59	337	229	298	198	196	0
117.59	338	229	298	198	196	0
117.59	339	229	298	198	196	0
117.59	340	229	298	198	196	0
117.59	341	229	298	198	196	0
117.59	342	229	298	198	196	0
117.59	343	229	298	198	196	0
117.59	344	229	298	198	196	0
117.59	345	229	298	198	196	0
117.59	346	229	298	198	196	0
117.59	347	229	298	198	196	0
117.59	348	229	298	198	196	0
117.59	349	229	298	198	196	0
117.59	350	229	298	198	196	0
117.59	351	229	298	198	196	0
117.59	352	229	298	198	196	0
117.59	353	229	298	198	196	0
117.59	354	229	298	198	196	0
117.59	355	229	298	198	196	0
117.59	356	229	298	198	196	0
117.59	357	229	298	198	196	0
117.59	358	229	298	198	196	0
117.59	359	229	298	198	196	0
117.59	360	229	298	198	196	0

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	OCC	ORIG	FROM	TO	NUM	NUM
TIME	NUM	NODE	NODE	NODE	OUT	TRAPD
117.59	491	268	298	198	196	0
117.59	492	268	298	198	196	0

117.59	493	268	298	198	196	0
121.10	205	259	196	0	197	0
121.10	206	259	196	0	198	0
121.10	207	259	196	0	199	0
121.10	208	259	196	0	200	0
121.10	209	259	196	0	201	0
121.10	210	259	196	0	202	0
121.10	211	259	196	0	203	0
121.10	361	259	196	0	204	0
121.10	362	259	196	0	205	0
121.10	363	259	196	0	206	0
121.10	364	259	196	0	207	0
121.10	365	259	196	0	208	0
121.10	366	259	196	0	209	0
121.10	367	259	196	0	210	0
121.10	368	259	196	0	211	0
121.10	369	259	196	0	212	0
122.11	219	258	196	0	213	0
122.11	220	258	196	0	214	0
122.11	221	258	196	0	215	0
122.11	222	258	196	0	216	0
122.11	223	258	196	0	217	0
122.11	224	258	196	0	218	0
122.11	225	258	196	0	219	0
122.11	226	258	196	0	220	0
122.11	385	258	196	0	221	0
122.11	386	258	196	0	222	0
122.11	387	258	196	0	223	0
122.11	388	258	196	0	224	0
122.11	389	258	196	0	225	0
122.11	390	258	196	0	226	0
122.11	391	258	196	0	227	0
122.11	392	258	196	0	228	0
122.11	393	258	196	0	229	0
122.11	106	207	196	0	230	0
122.11	107	207	196	0	231	0
122.11	108	207	196	0	232	0
122.11	109	207	196	0	233	0
122.11	110	207	196	0	234	0
122.11	111	207	196	0	235	0
122.11	112	207	196	0	236	0
122.11	113	207	196	0	237	0
122.11	114	207	196	0	238	0
122.11	115	207	196	0	239	0
122.11	116	207	196	0	240	0
122.11	117	207	196	0	241	0
122.11	118	207	196	0	242	0
122.11	119	207	196	0	243	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
122.11	120	207	196	0	244	0
122.11	121	207	196	0	245	0
122.11	122	207	196	0	246	0
122.11	123	207	196	0	247	0
122.11	124	207	196	0	248	0
122.11	125	207	196	0	249	0

122.11	126	207	196	0	250	0
122.11	127	207	196	0	251	0
122.11	199	216	196	0	252	0
122.11	200	216	196	0	253	0
122.11	201	216	196	0	254	0
122.11	202	216	196	0	255	0
122.11	203	216	196	0	256	0
122.11	204	216	196	0	257	0
122.11	212	218	196	0	258	0
122.11	213	218	196	0	259	0
122.11	214	218	196	0	260	0
122.11	215	218	196	0	261	0
122.11	216	218	196	0	262	0
122.11	217	218	196	0	263	0
122.11	218	218	196	0	264	0
128.22	179	212	197	0	265	0
128.22	180	212	197	0	266	0
128.22	181	212	197	0	267	0
129.03	455	236	197	0	268	0
129.03	456	236	197	0	269	0
129.03	457	236	197	0	270	0
129.03	458	236	197	0	271	0
129.03	459	236	197	0	272	0
129.03	460	236	197	0	273	0
129.03	461	236	197	0	274	0
129.03	462	236	197	0	275	0
129.03	463	236	197	0	276	0
129.03	464	236	197	0	277	0
129.03	465	236	197	0	278	0
129.03	466	236	197	0	279	0
129.03	467	236	197	0	280	0
129.03	468	236	197	0	281	0
129.03	469	236	197	0	282	0
129.03	470	236	197	0	283	0
129.03	471	236	197	0	284	0
129.03	472	236	197	0	285	0
129.03	473	236	197	0	286	0
129.03	474	236	197	0	287	0
129.03	475	236	197	0	288	0
129.03	476	236	197	0	289	0
129.03	477	236	197	0	290	0
129.03	478	236	197	0	291	0
129.03	479	236	197	0	292	0
129.03	480	236	197	0	293	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
129.03	481	236	197	0	294	0
129.03	482	236	197	0	295	0
129.03	269	254	197	0	296	0
129.03	270	254	197	0	297	0
129.03	271	254	197	0	298	0
129.03	272	254	197	0	299	0
129.03	273	254	197	0	300	0
129.03	274	254	197	0	301	0
129.03	275	254	197	0	302	0
129.03	276	254	197	0	303	0

129.03	277	254	197	0	304	0
129.03	278	227	197	0	305	0
129.03	279	227	197	0	306	0
129.03	280	227	197	0	307	0
129.03	281	227	197	0	308	0
129.03	282	227	197	0	309	0
129.03	283	227	197	0	310	0
129.03	284	227	197	0	311	0
129.03	285	227	197	0	312	0
129.03	286	227	197	0	313	0
129.03	287	227	197	0	314	0
129.03	288	227	197	0	315	0
129.03	289	227	197	0	316	0
129.03	290	227	197	0	317	0
129.03	291	227	197	0	318	0
129.03	292	227	197	0	319	0
129.03	293	227	197	0	320	0
129.03	294	227	197	0	321	0
129.03	295	227	197	0	322	0
129.03	296	227	197	0	323	0
129.03	297	227	197	0	324	0
129.03	298	227	197	0	325	0
129.03	299	227	197	0	326	0
129.03	300	227	197	0	327	0
129.03	301	227	197	0	328	0
129.03	302	227	197	0	329	0
129.03	303	227	197	0	330	0
129.03	304	227	197	0	331	0
129.03	305	227	197	0	332	0
129.03	306	227	197	0	333	0
129.03	307	227	197	0	334	0
131.31	182	213	198	0	335	0
131.31	183	213	198	0	336	0
131.31	184	213	198	0	337	0
131.31	185	213	198	0	338	0
131.31	186	213	198	0	339	0
131.31	187	213	198	0	340	0
131.31	188	213	198	0	341	0
131.31	189	213	198	0	342	0
132.03	128	208	199	0	343	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
132.03	129	208	199	0	344	0
132.03	130	208	199	0	345	0
132.03	131	208	199	0	346	0
132.03	132	208	199	0	347	0
132.03	133	208	199	0	348	0
132.03	134	208	199	0	349	0
132.03	135	208	199	0	350	0
132.03	136	208	199	0	351	0
132.03	137	208	199	0	352	0
132.03	138	208	199	0	353	0
132.03	139	208	199	0	354	0
132.03	140	208	199	0	355	0
132.03	141	208	199	0	356	0
132.03	142	208	199	0	357	0

132.03	143	208	199	0	358	0
132.03	144	208	199	0	359	0
132.03	145	208	199	0	360	0
132.03	146	208	199	0	361	0
132.03	147	208	199	0	362	0
132.03	148	208	199	0	363	0
132.03	149	208	199	0	364	0
132.03	150	208	199	0	365	0
132.03	151	208	199	0	366	0
132.03	152	208	199	0	367	0
132.03	153	208	199	0	368	0
132.03	154	208	199	0	369	0
132.03	155	208	199	0	370	0
132.03	156	208	199	0	371	0
132.03	157	208	199	0	372	0
132.03	158	208	199	0	373	0
132.03	159	208	199	0	374	0
132.03	160	208	199	0	375	0
132.03	161	208	199	0	376	0
132.03	162	208	199	0	377	0
132.03	163	208	199	0	378	0
132.03	235	222	299	199	378	0
132.03	236	222	299	199	378	0
132.03	237	222	299	199	378	0
132.03	238	222	299	199	378	0
132.03	239	222	299	199	378	0
132.03	240	222	299	199	378	0
132.03	241	222	299	199	378	0
132.03	394	233	199	0	379	0
132.03	395	233	199	0	380	0
132.03	396	233	199	0	381	0
132.03	397	233	199	0	382	0
132.03	398	233	199	0	383	0
132.03	399	233	199	0	384	0
132.03	400	233	199	0	385	0
132.03	401	233	199	0	386	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
132.03	402	233	199	0	387	0
132.03	403	233	199	0	388	0
132.03	404	233	199	0	389	0
132.03	405	233	199	0	390	0
132.03	406	233	199	0	391	0
132.03	407	233	199	0	392	0
132.03	408	233	199	0	393	0
132.03	409	233	199	0	394	0
132.03	410	233	199	0	395	0
132.03	411	233	199	0	396	0
132.03	412	233	199	0	397	0
132.03	413	233	199	0	398	0
132.03	414	233	199	0	399	0
132.03	415	233	199	0	400	0
132.03	416	233	199	0	401	0
132.03	417	233	199	0	402	0
132.03	418	233	199	0	403	0
132.03	419	233	199	0	404	0

132.03	420	233	199	0	405	0
132.03	421	233	199	0	406	0
132.03	422	233	199	0	407	0
132.03	423	233	199	0	408	0
132.03	424	233	199	0	409	0
132.03	425	233	199	0	410	0
132.03	426	233	199	0	411	0
132.03	427	233	199	0	412	0
132.03	428	233	199	0	413	0
132.03	429	233	199	0	414	0
132.03	430	233	199	0	415	0
132.03	431	233	199	0	416	0
132.03	432	233	199	0	417	0
132.03	433	234	299	199	417	0
132.03	434	234	299	199	417	0
132.03	435	234	299	199	417	0
132.03	436	234	299	199	417	0
132.03	437	234	299	199	417	0
132.03	438	234	299	199	417	0
132.03	439	234	299	199	417	0
132.03	440	234	299	199	417	0
132.03	441	234	299	199	417	0
132.03	442	234	299	199	417	0
132.03	443	234	299	199	417	0
132.03	444	234	299	199	417	0
132.03	445	234	299	199	417	0
132.03	446	234	299	199	417	0
132.03	447	234	299	199	417	0
132.03	448	235	299	199	417	0
132.03	449	235	299	199	417	0
132.03	450	235	299	199	417	0
132.03	451	235	299	199	417	0

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TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
132.03	452	235	299	199	417	0
132.03	453	235	299	199	417	0
132.03	454	235	299	199	417	0
132.03	500	250	199	0	418	0
132.03	501	250	199	0	419	0
132.03	502	250	199	0	420	0
132.03	506	274	299	199	420	0
132.03	235	222	199	0	421	0
132.03	236	222	199	0	422	0
132.03	237	222	199	0	423	0
132.03	238	222	199	0	424	0
132.03	239	222	199	0	425	0
132.03	240	222	199	0	426	0
132.03	241	222	199	0	427	0
132.03	433	234	199	0	428	0
132.03	434	234	199	0	429	0
132.03	435	234	199	0	430	0
132.03	436	234	199	0	431	0
132.03	437	234	199	0	432	0
132.03	438	234	199	0	433	0
132.03	439	234	199	0	434	0
132.03	440	234	199	0	435	0

132.03	441	234	199	0	436	0
132.03	442	234	199	0	437	0
132.03	443	234	199	0	438	0
132.03	444	234	199	0	439	0
132.03	445	234	199	0	440	0
132.03	446	234	199	0	441	0
132.03	447	234	199	0	442	0
132.03	448	235	199	0	443	0
132.03	449	235	199	0	444	0
132.03	450	235	199	0	445	0
132.03	451	235	199	0	446	0
132.03	452	235	199	0	447	0
132.03	453	235	199	0	448	0
132.03	454	235	199	0	449	0
132.03	506	274	199	0	450	0
132.26	308	228	198	0	451	0
132.26	309	228	198	0	452	0
132.26	310	228	198	0	453	0
132.26	311	228	198	0	454	0
132.26	312	228	198	0	455	0
132.26	313	228	198	0	456	0
132.26	314	228	198	0	457	0
132.26	315	228	198	0	458	0
132.26	316	228	198	0	459	0
132.26	317	228	198	0	460	0
132.26	318	228	198	0	461	0
132.26	319	228	198	0	462	0
132.26	320	228	198	0	463	0

1

TIME	OCC NUM	ORIG NODE	FROM NODE	TO NODE	NUM OUT	NUM TRAPD
132.26	321	228	198	0	464	0
132.26	322	228	198	0	465	0
132.26	323	229	198	0	466	0
132.26	324	229	198	0	467	0
132.26	325	229	198	0	468	0
132.26	326	229	198	0	469	0
132.26	327	229	198	0	470	0
132.26	328	229	198	0	471	0
132.26	329	229	198	0	472	0
132.26	330	229	198	0	473	0
132.26	331	229	198	0	474	0
132.26	332	229	198	0	475	0
132.26	333	229	198	0	476	0
132.26	334	229	198	0	477	0
132.26	335	229	198	0	478	0
132.26	336	229	198	0	479	0
132.26	337	229	198	0	480	0
132.26	338	229	198	0	481	0
132.26	339	229	198	0	482	0
132.26	340	229	198	0	483	0
132.26	341	229	198	0	484	0
132.26	342	229	198	0	485	0
132.26	343	229	198	0	486	0
132.26	344	229	198	0	487	0
132.26	345	229	198	0	488	0
132.26	346	229	198	0	489	0

132.26	347	229	198	0	490	0
132.26	348	229	198	0	491	0
132.26	349	229	198	0	492	0
132.26	350	229	198	0	493	0
132.26	351	229	198	0	494	0
132.26	352	229	198	0	495	0
132.26	353	229	198	0	496	0
132.26	354	229	198	0	497	0
132.26	355	229	198	0	498	0
132.26	356	229	198	0	499	0
132.26	357	229	198	0	500	0
132.26	358	229	198	0	501	0
132.26	359	229	198	0	502	0
132.26	360	229	198	0	503	0
132.26	491	268	198	0	504	0
132.26	492	268	198	0	505	0
132.26	493	268	198	0	506	0

```
-----------------------------------------------------------------------
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   Evacuation Statistics
-----------------------------------------------------------------------
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            506 Occupants escaped in  132.26 seconds
                           0 occupants were trapped



     ---Floor clearing times---

          Floor   1  at  132.26 seconds
          Floor   2  at  132.03 seconds



     ---Stair clearing times---

          Stairway  99  at  132.03 seconds
          Stairway  98  at  132.26 seconds
          Stairway  97  at  129.03 seconds
          Stairway  96  at  122.11 seconds



     ---Exit clearing times---

            108 People used exit at node  196 by  122. sec
            117 People used exit at node  197 by  129. sec
            139 People used exit at node  198 by  132. sec
            142 People used exit at node  199 by  132. sec
```
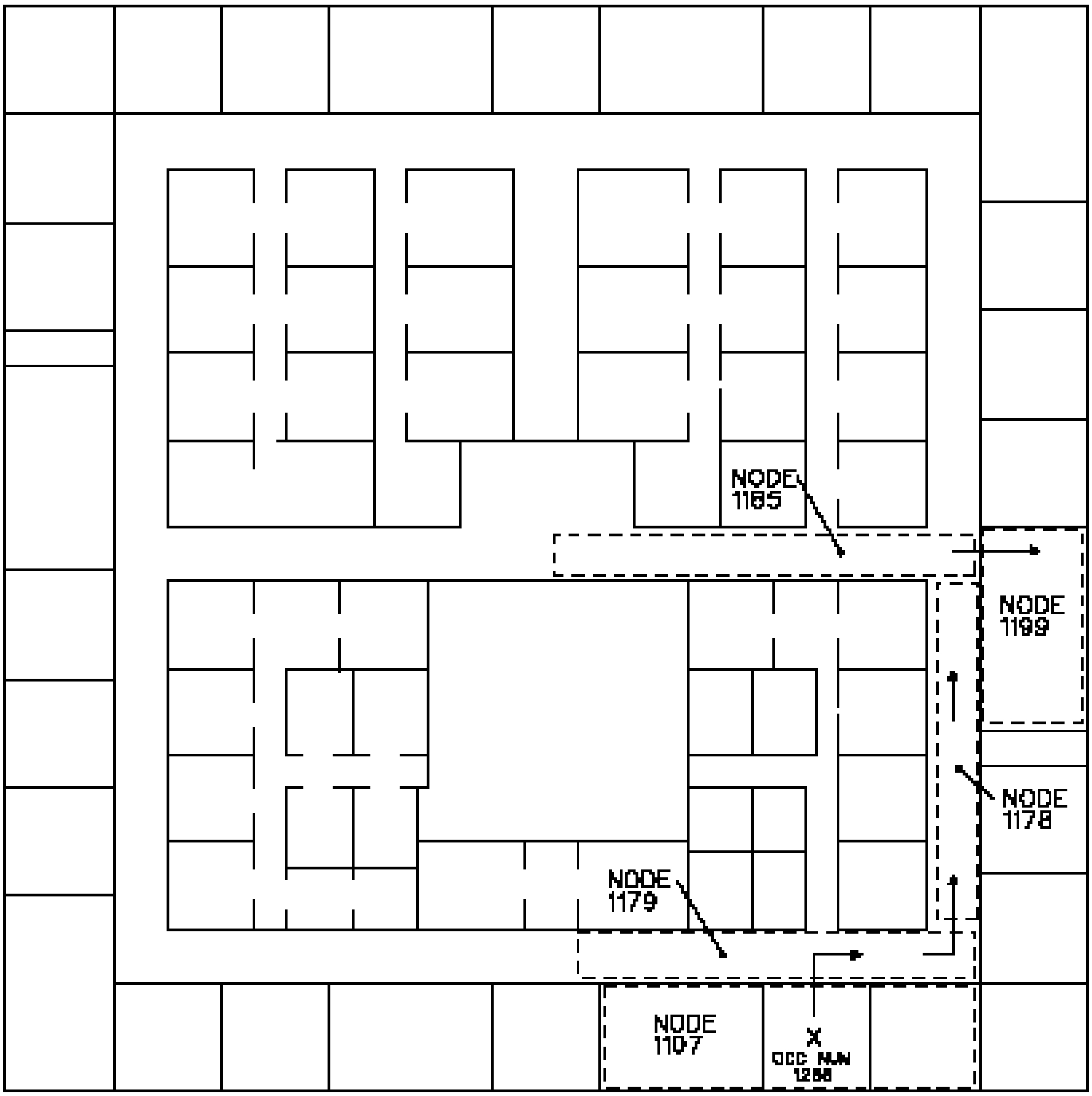

Appendix 10

100 Foot Square Building Floor Layout Illustrating the Travel Path for Occupant 1288



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