Novel Design of Emergency Exit Slide for High Rises

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Abstract
As the number of high rises buildings increases rabidly these days, residents safety and emergency escape solutions became crucial issue. Several hundreds of persons died or critically injured, each month, due to fire or emergency escape problems during fire or other emergency accidents in high rises around the world. This work aims to find a solution to this problem by proposing a novel design of emergency exit slide for high rises in order to reduce the number of victims during such emergencies. An emergency escaping volute slide or spiraled chute inside a tunnel including extendable accordion pleated tubing made of asbestos fabric, supported with vacuum-deposited aluminized materials padded on its inner side. A ring to its upper end, which made its base attachable with the top of the building supported with Artificial Spider Silk launchers to hold the slide during emergencies. Attachable to small slides from the escape openings of a building, the lower end of the tubing having a soft pad with low angle allowing a person sliding down the main slide can step up to assembly points on ground level, outside the building. The proposed technique resulted in enhanced results in comparison with previous techniques.

1. Introduction

High-rise buildings are a well-known target for terrorists. Fire or natural disasters are the main enemies of high-rise buildings. In an emergency, people trapped in the building can only really use emergency stairwells to make their escape. Traditional emergency techniques follow the ways, such as implementing external staircases or emergency hall, such as the escapers move to this room then the room moves down to the ground level.

Such solutions, has several problem, which reflect to the safety of the residents in case of emergencies. Some of the problems are related to the period of time required to move residents to safety. Another issue, related to the safety of people during the escape, such as getting the people away from the danger, from fire, or falling sections over the escapers. Traditional systems are being implemented on the main structure of the building, hence then, the emergency system will be affected for any disaster that targets the main building.

Thus, the proposed system is designed to solve the previously mentioned issues, and more, by designing a spiral slide inside a tunnel, implemented by fireproof material and independent of the main structure, moreover, it will be hidden in the building then extended in cases of emergency, this will add more beauty and modern technique to the building and will not affect the original design and external shape of it.

Beside this section, some related works, proposing some technique will be reviewed in the next section, the proposed technique will be explained in the third section, the fourth section will show all the calculations that evaluate the proposed design, last but not least the fifth section will summarize the entire work

2. Related Works

There are several systems designed and proposed for the problems, mentioned before, in order to enhance the safety of the residents for high-rise buildings. Researchers invested all their time to propose modern technique in their field. Erica D. Kulongoski [1] proposed a general guidance for residents on the initial three phases of evacuation modelling process, including, project requirement identification, model selection and model implementation. Aiming to provide general guidance for the users of the escape system.

Thomas F. Barry [2] Proposed a risk informed emergency evaluation system which is a risk-based decision assistance tool, in order to evaluate the consequences of emergency. This paper included the performance and reliability of the system.

On the other hand, Jacek M. Czerniak et al in their work [3], proposed a simulation for emergency for high-rise buildings in order to evaluate the decision-making processes for the emergency escape systems. This proposed simulation assists in providing proper tools for the designers to build their emergency escape systems within the budgets and enhance the safety of the residents.

Arturo Cuesta et al, in their work [4] discussed future challenges in evacuating modeling, by studying the problems of the using stochastic and deterministic methods in evacuation models. They concluded the required models for supporting timely decision in real-time manner.

Enrico Ronhi et al in their survey [5], reviewed fire evacuation techniques in high-rise buildings. Their review identified the behavioural factors affected the peoples' performance during emergencies. Moreover, they reviewed the current procedures and strategies followed during such cases. Their review, also, studied the capabilities of evacuation models by reviewing their features.

Hussain Et al, in their work [6] tried to depict the safety requirements at high-rise buildings, moreover, to emphasize on safety procedures to avoid fire risks.

Zhuyang Han et al [7] proposed an integrated real-time evacuation route planning method for high-rise building. Their system was based on wireless sensors that acquire data to calculate the risk of the emergencies to formulate the evacuation route based on the best matching method.

The mentioned previous researches and more were not able to solve key problems such as, evaluation time, escapers safety, attachment to the main structure and more. In comparison to that, the proposed method in this work is based on mimicking long water slides in some beaches and resorts, and applying the same ideas on high rises. The main features of high rises emergency escape are as below:

- Easy to be constructed within very short time as emergencies occurs
- Easy to be reached during very short time.
- Easy to use by any person regardless of age or knowledge level.
- Provide quick escape to safe zones.
- Safe; does not hurt its users.
- Independent of the main building structure

And more features will be discussed and explained in the next sections.

3. Proposed Technique: High-rise Building Emergency Slide and Tunnel

The proposed technique designed generally for emergency escapes for towers and high-rise buildings. Usually fire or emergency escape systems comprised of metal stairs outside a building or landing ladders, which are sometimes not efficient to be used in emergency cases. Because the escapers may not be protected from fire or dropping materials, moreover, they require relatively long time to get out to safe area. Therefore, researchers concentrated their efforts on developing new techniques for improvements.

Therefore, the principal goal of the proposed technique to provide an enhanced modernized type of emergency escape system for high-rises, and which comprises a volute slide or spiralled chute, covered by a completely closed tunnel to protect the escapers from any danger or fire flames alongside the slide.

Another goal is to provide an extendable accordion pleated tunnel, such that it can be collapsed in small size and modern shaped, attached on the top of the building, on its store base, when not in use.

However, as the need arise, i.e. for emergency cases, it is readily extended down to the ground level from its store base on top of a building with very short time. As it reaches the ground, small smooth slides launch from the emergency gates and attach themselves to the tunnel, to allow escapers from each floor to escape down inside of it.

This design of spiralled chute or volute slide allows any type of persons including children to easily and safely use it to move down from their location on any floor to the assembly area on ground, outside the building. Moreover, the extendable accordion pleated tubing made of asbestos fabric, supported with vacuum-deposited aluminized materials, not only protect the persons inside the tunnel from any fire flames or danger, but also provides flexibility to the tunnel at all, so that it will not be broken in case of earthquakes or when pieces of the building fall down.

One more objective of this proposed technique, which aims to enhance the reliability of the escape slide and tunnel system, is to provide Artificial Spider Silk launchers supported with ultrasonic sensors. In case of emergency, once the proposed system initiated the sensors moves in spherical way to find three stable structures away from the main building. Once the three points found, the launchers launches Artificial Spider Silk material to the three points, in order to connect the base of the tunnel and slide, which is on the top of the building, to new reliable structures away from the building, to provide stability and reliability to the proposed escape system independent of the main building.

The proposed escape tunnel and slide system, provides suitable emergency escape solution for schools, hospitals, resident or commercial towers and high-rise buildings, due to its modern design and shape, which enhances the beauty of a building, in addition to its reliability, safety and ease to use.

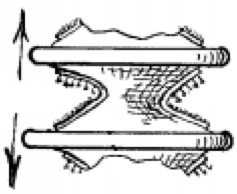

Figure 1: Tunnel Material

Figure 1 shows how the asbestos fabric, with vacuum-deposited aluminized material assist to detach to shrink the chute gently.

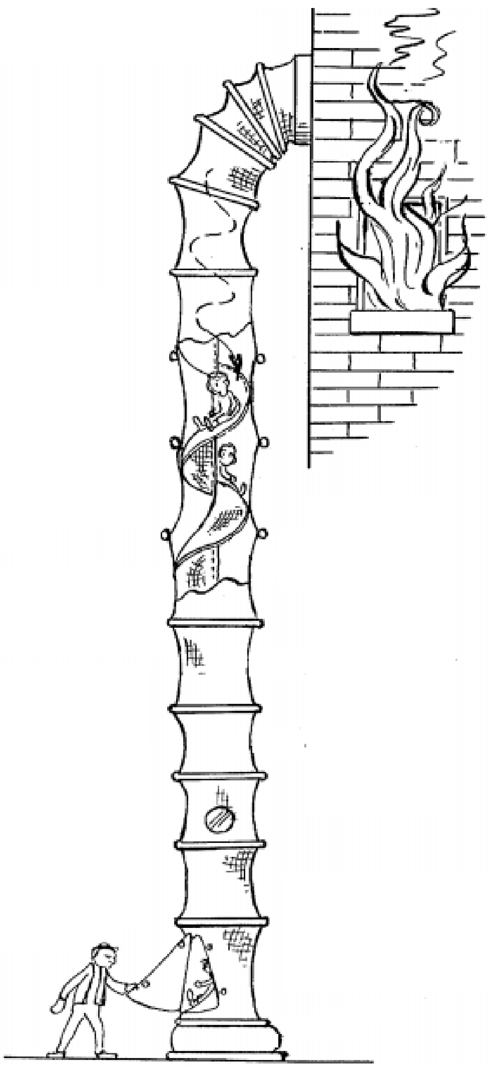

Figure 2: Proposed Emergency Slide and Tunnel

Figure 2 is a side view of the proposed technique in cross section, showing a spiral shaped slidewhich is made of very smooth and tied canvas inside the chute to make people slide down safely regardless of their age or abilities. This spiral shaped slide, allows the chute to hang vertically, to reduce the occupied area, instead of being inclined at angle.

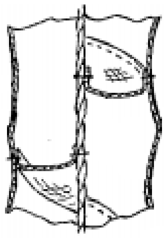

Figure 3: Cross Section of the Slide and Tunnel

Figure three, shows a cross section of figure 2, showing the bungee rope supported with fireproof materials padding the slide on its inner side.

To solve the congestion problem, which may occur inside the tunnel, they system will follow the below technique.

As mentioned earlier, the emergency gate is designed to allow one person to get out at a time, thus there will be no congestion even if persons gut out to the tunnel from each level at the same time. Because the level's distance will be converted into difference of time. For the unconditional congestion which may be caused in the middle of the tunnel for the worst cases. The system will contain sensor to be implemented along the tunnel. Then as a congestion occurs, which will be within fraction of second, the sensors will move the data to a main controller, in which it will command the slides below the emergency gates and attached to the tunnel. The controller will decrease the decline angle of the slides for all the floors before the point of congestion. This action will delay all the escapers before the point of congestion for two or three seconds until the congestion to be cleared.

4. Calculations

Initially the calculation to determine the speed of the escaper inside the spiral slide and tunnel will be shown as below:
The escaper friction with the spiral slide is:

$$F_s = \mu_s F_n \quad (1)$$

Where
F_s = Static Friction
μ_s = Coefficient of Static Friction
F_n = Force
μ_s for the vacuum-deposited aluminized materials padded on its inner side is: 0.61
In order to find the speed of the escaper, considering the Static Friction:
The main equation to find the speed is:

$$v = d/s \quad (2)$$

Where;
v is the velocity
d is the distance
s is the time in seconds
However, when considering the friction, the acceleration of the escaper on the slide of angle θ will be calculated as follows:
Consider the escaper mass m dragger on the slide with friction μ, by a force F. the weight will be

Normal Weight: $W = mg\cos(\theta)$ ……. (3)

Parallel Weight : $W = mg\sin(\theta)$ ……. (4)

The rise to a normal reaction is

$$R = mg\cos(\theta) \quad (5)$$

And the parallel reaction is

$$R = mg\sin(\theta) \quad (6)$$

The magnitude of the frictional force f. Which impedes the motion of the escaper, is basically μ times the normal reaction (eq 5-6). Hence,

$$f = \mu mg\cos(\theta) \quad (7).$$

Then the escaper's acceleration on the slide will be

$$a = (F-f)/m = F/m - \mu g\tan(\theta) \quad (8)$$

Knowing the actual speed with the acceleration of the escaper on the slide with friction μ. It will be straightforward to measure the number of the escapers getting out to safety per second, knowing the total time required to move a person from the top of the building with length lto the ground level (Assembly point).
Following the below equation:

$$s = l/v \quad (9)$$

Now it is known the required time to move a person from any level of the building to the assembly point, and it is known, how many person the proposed technique is able to move per a period of time.

5. Summary

This work targeted the issues related to the field of high-rise emergency escape systems, at the beginning this work reviewed some related studies that studied the situations of the emergencies and the behaviours of the residents during such situations. Moreover, it studied some previous emergency escape systems and their advantages and disadvantages. Then it explained the proposed technique, which targeted the problems of the current emergency escape systems, which were not solved. The proposed method in this work is based on mimicking long water slides in some beaches and resorts, and applying the same ideas on high rises. The main features of high rises emergency escape has the following features, Easy to be constructed within very short time as emergencies occurs. Easy to be reached during very short time. Easy to use by any person regardless of age or knowledge level. Provide quick escape to safe zones. Safe; does not hurt its users. And Independent of the main building structure. Which solve the problems of the previous systems, in real-time. Moreover, it provided all the required calculation to proof the previous features.

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