

Available online at www.sciencedirect.com

Procedia Engineering 11 (2011) 40–44

Engineering
Procedia

The 5th Conference on Performance-based Fire and Fire Protection Engineering

Smoke Control – Discussion of Switching Elevator to Evacuation Elevator in High-rise Building

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Abstract

When fire disaster happens in high-rise building, stairwell is to be the unique way for evacuation, and the effect is not ideal. The elevator has a huge potential to be the one of those evacuation manners as it is the fastest and the most convenient Vertical Transportation Equipment. To solve the problems of using elevator transportation as a evacuation manner, the paper makes some meaningful conclusions from the sides of Power Guarantee、Evacuation Tactics、Smoke Control etc.

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Keywords: High-rise building, evacuation, Elevator, smoke control;

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1. Prospect of Elevator Evacuation

Traditional emergency evacuation methods exclude the evacuation elevator because of two reasons. One is that elevators are easy to lose power that will difficult to the rescue. The other reason is the stack effect of the elevator shaft will be threat to escaping people. But as the elevator is the fastest and the most convenience vertical transporting equipment, how to find out its great potential capacity of the fire safety evacuation is a focus issue now.

There are many examples to use elevators to successful evacuate at home and abroad: 31 staff members at the 91st floor of the South tower used elevators to escape only for 72 seconds at the attack of “9.11” in New York, US. A building with more than 20 floors caught fire in the year of 2006 at Shanghai. Before the firemen came, some residents had escape to downstairs with the elevator. At a simulate fire exercise in the year of 2009 at Shanghai, the residents who lived in the 28th floor at the 4th building of San He Garden in Shanghai Jing’an district evacuated successfully with the elevator when the building was on fire. It has been found that using elevators to evacuate is feasible under particular circumstances when high-rise buildings are on fire.

From the year of 2004, many organizations in our country have done a lot researches to the elevator evacuation system, but the system has not many practical applications yet in the emergency evacuation because of following problems [1] ~ [3]:

- (1)How to use the elevator evacuation system if there are many people need to evacuate and if there are many uncertain and confiscated factors around. Because the fire has the great effect on human’s health and psychology in the matter of its outburst, uncertainty and toxicity, the evacuation has many uncertain factors and an appropriate evacuation model relies on human behaves.
- (2)The evacuation theories and models are not matured and still at the computer simulation stage. Because the elevator evacuation system is at the forefront of the research field, many evacuation theories and models are still based on the theories in the lab. There are not much practice materials at home and abroad, so the evacuation theories lack realistic support.
- (3)The settings of the evacuation elevator need to considerate the economy and safety. Because the settings are mainly referred to the standards of the fire elevator, the construction investment cost will be very high. How many evacuation elevators are appropriate is a hot spot in the elevator evacuation research field.

2. The research directions of the elevator evacuation

It is a comprehensive and systemic problem to make the escape safe and effective. As a new unconventional and breakthrough approach, we suggest doing researches with seven directions as follows:

1. Reliability of power supply

1.1 Power supply. We should install a back-up generator besides setting two power supplies in the first class high-rise buildings, namely, we need three independent power supplies.

1.2 Power supply circuit. We need high reliability distributing lines. The evacuation elevator need use the mineral insulated cable to be the power supply circuits besides installing an independent power supply circuit referring to the conventional fire elevator.

2. The study of evacuation tactics

There are some problems if we use traditional way to evacuate people with emergency staircase in the high floors of the high-rise buildings: (1) those that are old weak, ill or disabled can not be evacuated vertically for a long time; (2) unexpected outburst problems cannot be predicted in the long time vertical evacuation.

The tactics are crucial when high-rise buildings are on fire. KLOTE give a calculation method of the whole elevator evacuation time—ELVAC Method. It is also the basis of the elevator evacuation scheme research. We mainly use MATLAB or SMULEX software to do the computer simulation to study the elevator evacuation tactics [4] [5].

How to choose an optimal evacuation scheme is the focus of the researchers all the time in the study of compound evacuation of staircase and elevators. The researches mainly concentrate on two directions before: (1) elevator evacuation in the high floors and staircase evacuation in the low floors; (2) both elevator evacuation and staircase evacuation in the high and low floors. Because the elevator evacuation speed will be impacted by the number of escaped people, if we only use the elevator to evacuate people in the high floors, it will be slow, especially to evacuate those that are old weak, ill and disabled. If we use elevator and staircase to evacuate both in

the high and low floors, it will cost time to evacuate people in the low floors. So we suggest using both elevator and staircase to evacuate in the high floors and using only staircase to evacuate in the low floors. We believe the method can solve the problems above and give the best effect of the elevator evacuation.

3. Smoke control measures of the elevator evacuation system

We use smoke prevention measures such as air supply with pressure in the elevator shaft, antechamber and automatic high airtight door. The relevant specifications in our country emphasis on air supply with pressure in order to prevent the smoke from outside. But because the fireproof door can not always close tightly, the smoke prevention effect is not good. If we supply air with pressure in the evacuation elevator shaft, the effect is better to prevent the smoke from outside the lift car. The building smoke control system technical specifications (draft) [6] give clear formulas to calculate the air output in the shaft.

When there is a antechamber: $L_d = 0.0014 \cdot F_4 \cdot (C_2 \cdot a_4 + A_4)$

When there is no antechambers: $L_d = F_4 \cdot (0.0038 \cdot C_1 \cdot f \cdot d_4 + 0.0014 \cdot C_2 \cdot a_4)$

In the formulas, L_d —air output in the shaft (m³/s) ;

F_4 —the coefficient of the air output in the shaft;

C_1 —equals 1, when the airtight measures are used in the door gap, it equals 0.5;

f —the gap length of each door (m);

d_4 —the number of the doors in front of the shaft;

C_2 —equals 1; When the shaft surrounding walls use three concrete walls and one masonry wall, or use all concrete walls, it equals 0.5;

a_4 —the area of the shaft surrounding walls (m²);

A_4 —the area of antechamber surrounding walls (m²).

As the formulas above, the air output can reduce to one half of originals when using automatic high air tight doors. We can also install more air inlets and outlets at the vertical directions of the shaft to make sure the positive pressure are well-proportioned.

4. Water draining and waterproof in the shaft [7]

There is much draining water during the extinguishment. So we must adopt appropriate measures to prevent water drain to the elevator: 1. we should adopt waterproof measures at the gate of the elevator door. 2. We should make a draining gradient from the elevator door to the room door. 3. We should use draining measures at the bottom of the shaft.

5. The safety performance of the elevator

5.1 We use non-inflammable materials in the elevator cars: the elevator car decorative materials should use non-inflammable ones.

5.2 The waterproof measures of the power and control cables or wires: during extinguishment, there is much water drain into the shaft. To guarantee the normal running of the elevator, the power and control cables or wires should adopt waterproof measures.

6. The control strategies of the evacuation with elevators

In the initial stage of fire, fire control center should operate two evacuation elevators evacuate people in the floor which is on fire and relevant above and below floor, besides controlling the fire fighting apparatus, fire alarm and emergency broadcast [8].

If we use the smoke prevention scheme with pressurizing air to the antechamber, when fire detectors detect the smoke in a floor, the evacuation elevator should stop at that floor. If we use the smoke prevention scheme with pressurizing air to the shaft, we should install fire detectors at the entrance of the evacuation elevator. When fire detectors detect the smoke, the fire control center will operate the elevator down to the first floor and stop running.

When evacuating, we should display or broadcast the operating status through the emergency broadcast system, including the information of the floor which the elevator is getting to and the status whether the elevator is full, in order to help people make right choice of evacuation methods.

7. The design of the quantity and position of the evacuation elevators [9]

The quantity of the evacuation elevators depends on the number of evacuation people. The number of evacuation people depends on the floor and the proportion of the evacuation people at that floor. For example, if there is a 30 floors high-rise building. We can conclude with computer simulation: the effect is the best to evacuate with staircase under the 10th floor and elevators above 10th floor. When the proportion of evacuation people is 23%, the evacuation time is the least. So the quantity of the evacuation elevators can be chosen by the proportion of the people at the floors above the 10th floor. Certainly, the right evacuation floor quantities and proportion should be determined based on the characteristics of different buildings.

The position of the evacuation elevators should be determined by fire zones. The elevators should set an antechamber to prevent the smoke. Because the ordinary elevator lobby and the fire elevator antechamber have shared together, the architectural composition design will not change no matter where the evacuation elevators are. So it is very convenient to reform the evacuation elevators of the buildings already constructed.

3. Copyright

The elevator evacuation gives an effective approach to people in the high floors of the high-rise building when the fire is on its early stage. The appendix of the American Fire Code requires that elevators should be allowed using conditionally when on fire. The study to use elevators for evacuation purposes is on its early stage. It needs to make further research based on the seven directions which the authors suggest above. And it needs design institute, relevant equipment manufactures join together to solve the problems relate to the elevator evacuation.

Acknowledgements

This work was supported by *Guangzhou Tai-chang Industry (Fire Protection) Co. Ltd.*

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