Ekoloji 28(107): 359-364 (2019)

Discussion on Critical Factors in Passenger Evacuation based on the Environment Management of Metro Stations – A Case of Shanghai

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Abstract

The convenient, rapid, and economical metro has become the transportation for people fast moving in the city, releasing the long-term traffic problem, improving the urban traffic flow and function, and enhancing the boom of downtown and the satellite towns. Metro stations therefore become the important nodes for crowds' gathering, dispersion, and transit. The past experience revealed that a lot of passengers could not find reference for evacuation when disasters occurred, but searched routes for evacuation by themselves, to result in delayed evacuation. Moreover, the lack of effective integration of disaster prevention functions of fire disaster rescue, police directing, medical care, and material delivery could easily cause the waste of rescue resources and seriously affect rescue time. Aiming at metro passengers in Shanghai, total 500 copies of questionnaire are distributed, and 378 valid copies are retrieved, with the retrieval rate 76%. The research results are summarized as followings. 1. "Public awareness" is mostly emphasized among the evaluation dimensions in hierarchy 2, followed by "environment design" and "policy actions". 2. The overall weight of the evaluation indicators reveals top 5 indicators, among 13 ones, as risk perception, sign system, confidence in government, disaster experience, and smooth traffic flow. According to the results, suggestions are proposed, expecting to enhance the quality of environment safety in metro, guarantee the life safety of metro passengers, and better complete the mass transit safety system.

Keywords: environment perspective, evacuation, critical factor

Liu D-Q, Sun S-R, Qian Z-W (2019) Discussion on Critical Factors in Passenger Evacuation based on the Environment Management of Metro Stations – A Case of Shanghai. Ekoloji 28(107): 359-364.

INTRODUCTION

The past experience revealed that a lot of passengers could not find the reference for evacuation in disasters, but searched routes for evacuation on their own, to delay the evacuation time. Besides, the lack of effective integration of disaster prevention functions of fire disaster rescue, police directing, medical care, and material delivery could easily result in the waste of rescue resources (personnel, materials, sites, devices, and equipment) to seriously affect rescue time. Even though the central and the neighboring counties and cities could engage in rescue resources, the worse weather and blocked traffic might cause ineffective assistance. For this reason, the preparation of "disaster reduction, preparation, response, and reconstruction" in the disaster prevention should be reinforced to strengthen the effectiveness of "evacuation". The establishment and implementation of disaster evacuation mechanism could reduce the losses of human life and property. The proper execution of evacuation could reduce the trapped people for disaster rescue, without getting into "urgent response and evacuation". When the crowd is trapped, the disaster response center should immediately dispatch air and ground rescue troops. The harsh environment would make the rescue task harsher. The life of both the crowd waiting for rescue and the rescue personnel are threatened by the harsh environment.

The convenient, rapid, and economical metro has become the transportation for people rapidly moving in cities to release long-term traffic problems, improve urban traffic flow and functions, and enhance the boom of downtown and the satellite towns. Metro stations therefore become the important nodes for crowds gathering, dispersing, and transit. A metro station, presenting close relations with passengers, is an important facility for passengers taking the metro

 Received: 17 Jul 2017 / Accepted: 7 Feb 2018

system. The design could affect the operation efficiency of the system and reflect national image. Overcrowded space, unclear signs, unsmooth traffic flow, narrow waiting space, conflict on the traffic flow, and obstacle on passenger routes often appear during the boarding of passengers. Moreover, crowd gathering due to local development, station facilities conforming to passenger convenience, and environment and design for disaster evacuation might reduce the probability of people being rescued from disasters. For this reason, critical factors in evacuation, from environment perspective, is discussed in this study to enhance the quality of environment safety in metro so as to guarantee the life of metro passengers and better complete the mass transit safety system.

LITERATURE REVIEW

Environment Management of Metro Stations

Hung et al. (2016) mentioned that metro stations were designed according to current goals and considering the speed and convenience of passenger evacuation in peak and off-peak periods. The platform space and the traffic flow space in a metro station therefore should be completely taken into account for passengers. In consideration of the space planning in a metro station, Li et al. (2017) proposed the following principles for the environment management of metro stations.

(1) Smooth traffic flow: Passengers' traffic flow should be direct, simple, and continuous, meaning that the distance from passengers entering the station and passing through the hall to the platform should be the shorter the better. The direction change on the traffic flow should be as few as possible to avoid passengers' selection contradiction. Besides, the traffic flow should keep the continuity, without bottleneck effect.

(2) Public safety: Metro was the public transportation that the public safety under normal operation and emergency should be guaranteed. Adequate equipment capacity and safety design of facilities should be taken into account. Adequate equipment capacity contained public facilities of elevators, stairs, platforms, channels, and turnstiles. The emergency evacuation flow should satisfy the demands for peak hours, and the space layout should conform to the safety regulations in order to ensure the public safety. The safety design of facilities covered the least gap between the elevator edge and the structure, warning line or guard gate on the edge of platform, the least gap between the train and the platform, dead corner in public space, layout of fire equipment, use of fire-proof materials, definite signs, and flood prevention facilities at exits.

(3) Ease of management and maintenance: A metro station was operated for long period with numerous users that the maintenance was time limit. To enhance the operation effectiveness, the convenient maintenance in the future should be considered in the station design and material use.

(4) Accessible environment: Accessible design in metro included hardware of wheelchair ramps, accessible elevators, accessible departures waiting rooms, accessible turnstiles, and accessible public telephones in the station as well as equal height of car and platform for the boarding of the disabled, accessible restrooms for the disabled and software of professional service personnel for the disabled passing through the metro station and getting on metro.

(5) Layout of civil defense facilities: In addition to the transportation function, metro presented the function of civil defense with two design points. One was the reinforcement of station structure. It referred to the strength of a station being able to bear the direct attack of a traditional 225kg bomb with the speed of 183m/s. The station roof was explosion-proof or enhanced at least 15% thickness of the structure wall. Besides, it conformed to the relevant regulations and paid attention to the water-proof design of the station so that the station could keep high density water to guarantee the station facilities and human safety. The other is the provision of facilities and equipment. It referred to the public being able to used station halls and platforms as the air-raid shelters in wars. At least two exits were equipped; the emergency exit with 50% penetration was equipped on the vent; generators which could work for at least 6 hours, oil sump, drinking water, and easy toilet were installed; and, emergency rooms, fire protection equipment, communication systems, and broadcast equipment were set up.

(6) Styling management: The styling management of a metro station was important for urban landscape. The match with regional environment should be considered in the styling management, and the local characteristics as well as economic, social, and cultural contents should be highlighted. Besides, the styling could not affect the traffic function and the landscape performance of the building.

(7) Sign system: Sign design of a metro station especially stressed on the provision of sufficient, definite, and beautiful information signs with text,

pattern, and color design at proper locations, including direction instruction, identification, explanation, and warnings to guide passengers rapidly and correctly moving to the metro station. Moreover, emergency exit signs were extremely important for smoothly guiding the crowd to the shelters during accidents.

Evacuation Behavior Characteristics

Xu et al. (2016) explained evacuation as moving the public from a dangerous place, through the route with less danger, to safe locations and shelters. In other words, the crowd evacuated from dangerous areas to safe environment under time limit. Evacuation behavior should be planned according to local culture and disaster characteristics along with the operation of alert systems. Afshari et al. (2015) analyzed evacuation behaviors of households suffered from flood in Denver, USA, and pointed out three processes of warning, confirmation, and evacuation. The warning process contained official warning to governmental sections (county government, office of township, chief of village, police, and fire stations), relatives, friends, and neighbors, as well as media. The confirmation process referred to official confirmation, relative & friend confirmation, self-confirmation, and potential confirmation. The evacuation process contained not evacuation, requested evacuation, forced evacuation, and self-evacuation. Lovreglio et al. (2015) regarded alert and evacuation as a series complicated decision-making and operation processes. Such processes included the stages of data collection and analysis, evacuation decision, evacuation order release time and content, delivery of evacuation order, the public awareness of evacuation, the public confirmation of evacuation order, and the public self-protection measure. Thobaity et al. (2015) indicated that data collection and analysis belonged to technology; evacuation decision, evacuation order release time and content, delivery of evacuation order belonged to governmental decision and policy actions; the public evacuation awareness, the public confirmation of evacuation order , and the public self-protection measure belonged to the public awareness, decision-making, and reaction (Grimwood and Sanderson 2015). Aiming at a mountain tribe in northern Italy, Hatamura (2015) studied the relationship between flood preventive behavior and risk awareness and pointed out the same conclusion of the disaster decision-making behavior of people living in high disaster potential areas and the relationship between risk perception and decision-making behavior of people in the areas with earthquake and tornado disasters that distinct disaster risk awareness of people would directly affect the self-protection measure when facing disasters. Ardalan and Schnelle (2016) also indicated that people's risk perception would directly affect the response to disaster threats. By comparing passenger evacuation in different disasters through literatures, Groner (2016) concluded that natural signs and threats, official request, and friends' persuasion were the key factors in the public evacuation from natural disasters (flood, volcanic eruption). D'Orazio et al. (2015) discovered that the public willingness to evacuation was proportional to the strength of storm and the level of risk information (typhoon warning, persuasion of evacuation, and forced evacuation), revealing that the strength of storm and the level of evacuation requirement would have passenger tend to evacuation.

Critical Success Factor

Hosseini and Keshavarz (2017) stated that "critical success factor" (CSF; or Key Success Factor, KSF) was a method, promoted by Massachusetts Institute of Technology, to define organizational information requirements. Beskese et al. (2015) indicated that Daiel regarded the information system of a company requiring differentiation and selection as well as focusing on the success factors in the industry; most industries would present 3-6 critical success factors. Research on critical success factors was increased after 1979, when the opinions about critical success factors became consistent. Most researchers advocated that critical success factors were the asset, technology, resource, activity, and managers' capability performed (Chaudhary and Uprety 2016) and presented uniqueness. A manager should have such conditions to be successful in the industry, be more competitive, and have longer advantages than other businesses. Masudin and Saputro (2016) indicated that the characteristics of critical success factors should be paid attention to when taking critical success factors into account. Researchers analyzed the basic characteristics and organized the following common points.

(1) Critical success factors would change with time.

(2) Critical success factors would change with industries, products, and markets.

(3) Critical success factors would change with the life cycle of industry.

(4) Critical success factors should take the future development trend into consideration.

Table 1. Overall weights of factors in evacuation from environment perspective

dimension	hierarchy 2 weight	hierarchy 2 order	indicator	overall weight	overall order
environment design	0.327	2	smooth traffic flow	0.083	5
			public safety	0.063	10
			facility layout	0.074	7
			sign system	0.106	2
policy actions	0.285	3	disaster decision	0.046	13
			release time	0.052	12
			order hand-down	0.066	9
			confidence in government	0.099	3
public awareness	0.388	1	disaster experience	0.090	4
			risk perception	0.117	1
			information source	0.070	8
			planning awareness	0.057	11
			reasons for evacuation	0.077	6

(5) It would result in business failure when investing in the industry without understanding the critical success factors.

(6) A manager should focus on specific affairs or critical work to decide critical success factors.

(7) A manager should stress the management on critical success factors.

(8) A manager should deeply understand and devote to critical success factors as the basis for making strategies (Boselli et al. 2015).

RESEARCH DESIGN AND METHOD

Delphi Method

The AHP dimension criteria are established in this study according to Delphi Method. Delphi Method, also named expert survey, is a decision-making method by separately sending questions to experts through mails for the opinions, which are collected and organized the comprehensive opinions. Such comprehensive opinions and predicted questions are feedback to the experts for further opinions. The experts would revise the original opinions according to such comprehensive opinions. By repeating several times, a more consistent prediction results are gradually acquired.

According to the system program, anonymous opinions are given in Delphi Method, i.e. no mutual discussion among experts, but simply the relationship with the researcher. With several runs of expert survey, the opinions are repeatedly inquired, generalized, revised, and eventually organized as the basically consistent opinions of experts. Such a method is more reliable due to the general representativeness.

Establishment of Evaluation Indicator

The questionnaire is emailed to the experts in different fields. The first feedback is organized to discuss the programs considered for evacuation from environment perspective. The considered factors with similar properties are further categorized and returned to the experts for the opinions. The back and forth inquiries are preceded for several times. Eventually, an expert conference is called for making the critical success factors in the discussion of evacuation from environment perspective, including the major categories of environment design, policy actions, and management unit. Such critical factors are the AHP dimensions, and the correspondent categories are regarded as the criteria for the AHP questionnaire. The research criteria, after the revision with Delphi Method, contain

(1) Environment design: smooth traffic flow, public safety, facility layout, sign system.

(2) Policy actions: disaster decision, release time, order hand-down, confidence in government.

(3) Public awareness: disaster experience, risk perception, information source, planning awareness, reasons for evacuation.

Research Object

Aiming at metro passenger in Shanghai, total 500 copies of questionnaire are distributed, and 378 valid copies are retrieved, with the retrieval rate 76%.

DATA ANALYSIS RESULT

After completing the weights of all hierarchies, the relative importance of the indicators in various hierarchies is distributed to show the importance of an indicator in the entire evaluation system. Besides, the overall weight of factors in the discussion of evacuation from environment perspective is acquired, **Table 1**.

CONCLUSION

In the empirical analysis in this study, the following conclusions are summarized.

Among the dimensions in hierarchy 2, "public awareness, weighted 0.388, is mostly emphasized, about 38.8% of overall weight, followed by "environment design" (weighted 0.327) and "policy actions" (weighted 0.285). The results show that public awareness is the most emphasized dimension in the discussion of evacuation from environment perspective.

Among evaluation indicators in hierarchy 3, the weights are ordered as below.

1. Under environment design, the evaluation indicators are ordered sign system, smooth traffic flow, facility layout, and public safety.

2. Under policy actions, the evaluation indicators are ordered confidence in government, order hand-down, release time, and disaster decision.

3. Under public awareness, the evaluation indicators are ordered risk perception, disaster experience, reasons for evacuation, information resource, and planning awareness.

According to the overall weight of the evaluation indicators of critical success factors in the discussion of evacuation from environment perspective, top 5 evaluation indicators, among 13, are ordered risk perception, sign system, confidence in government, disaster experience, and smooth traffic flow.

SUGGESTION

According to the conclusion, the following suggestions are proposed in this study, expecting to provide definite instruction and directions for the promotion of metro evacuation.

1. The government units in Shanghai are suggested to reinforce the public evacuation education & training and promotion and have the public understand that the possible life and property loss caused by disasters might be overloaded; they therefore should conform to the government units for evacuation. Furthermore, the government units should comprehensively and deeply understand the assistance required by the public (e.g. medical equipment, route direction, transportation) and provide proper assistance for the public evacuation so as to enhance the evacuation effectiveness.

2. The public risk perception of disasters could be established and passengers' awareness of evacuation could be deepened by conducting the understanding of disaster potentials in communities, disaster protection of communities, evacuation exercise, and disaster protection education, setting obvious evacuation directions at intersections, making and distributing propaganda, and reinforcing the promotion in community meeting or village activities.

3. The government units in Shanghai are suggested to reinforce the preparation of rescuers and the equipment (including the dispatch mechanism of disaster rescue energy) as well as shelters and materials in order to promote the public confidence in the government and enhance the public willingness to evacuation.

4. More text messages or safety propaganda about evacuation and self-rescue should be increased in the metro stations in Shanghai. Besides, the locations of guiding signs should be obvious, the height and position should be available for the disabled, or the guiding tiles with different colors could be established for the disabled smoothly completing the evacuation.

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