Research on Risk Identification and Evaluation of Large-Scale Activities

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Abstract: With the rapid economic development and the acceleration of urbanization, China is organising and hosting larger-scale events more frequently. However as large-scale events are likely to cause death and injury of people, safety has increasingly become an issue of social concern. In this article, the author analyses risks factors like environment, personnel, technology, and organizational management, and construct a risk evaluation index system for large-scale activities. By using fault tree analysis method, disasters and their consequences can be effectively predicted through this system. It can provide theoretical support for the avoidance, transfer and control for large-scale activities, minimize the possibility of hazards and accidents, to the greatest extent protect the safety of people, property and even national interests, and thus maintain social order and stability.

1 INTRODUCTION

With the 29th Beijing Olympic Games and the 2010 Shanghai World Expo, more and more large-scale events can meet the material and spiritual needs of the public and help enhance China's influence and competitiveness in the world. But since these activities are easily affected by factors of nature, human beings, technology, economy, and politics and so on, they are likely to cause casualties. Therefore, the safety of these activities has become a social concern. (Zhang, Xu, Xiang Zhang 2019) T Therefore, the risk factor analysis of large-scale activities and the evaluation of the analysis results, as well as the corresponding countermeasures and suggestions are of great significance.

2 CHARACTERISTICS AND CURRENT SITUATION OF LARGE-SCALE ACTIVITIES

2.1 Characteristics

According to the second paragraph of the second provision of "Regulations on safety management of large-scale social activities in Beijing city", large-scale social activities refer to group activities in which the organizers rent or use sites in other ways for public performance, sports competition, exhibition, fair, job fair, exhibit of lanterns (Yaju, Tsubaki 2019). Large-scale activities have the following specific characteristics:

(1) A large number of participants. In this case, once any contradiction and friction occur, it can easily lead to accident, such as chaos and heavy casualty.

(2) Venue is not fixed, and many security risks. Large-scale social activities do not have fixed places, some are in rented venues, and some are held in parks, plazas and even on public roads. The safety level and fire protection level of these places directly affect the safety of large-scale events. Large-scale events usually require redecoration, which will lead to more security risks and unimaginable consequences.

(3) Large-scale social events have complexity and high rate of suddenness. In the event of an accident, it may cause a chain reaction, along with other accidents. For large-scale activities in enclosed spaces, due to the high population density, if a fire occurs, secondary disasters such as building collapse and crowd trampling caused by delayed evacuation and unqualified construction quality will increase the impact of the accident accordingly.

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(4) Large-scale activities are diverse in content and complex in form. The content of large-scale social activities is very extensive, covering almost all aspects of social life. Some activities even integrate culture, business and other aspects with rich contents. As far as the form of large-scale activities is concerned, there are cultural performances, sports competitions, business talks, exhibitions, lantern festivals and celebrations, etc. (Willis, Elviss, Aird, Fenelon, Mc Lauchlin 2012)

The characteristics of large-scale social activities increase the difficulty of the security of large-scale social activities. It can be said that the safety of most large-scale social activities is caused by human. In supervision and management process of large-scale social activities, if the organizers, managers and participants are able to pay attention to safety issues and perform their duties with due diligence, many accidents can be avoided.

2.2 Current Situation

According to statistics, from 1983 to 2004, there were 37 accidents in large cultural and sports activities in our country, with 686 persons dead, 1376 persons injured, including 6 buildings collapsed, accounting, 8 evacuation and lighting accidents, accounting, 2 accidents related to the weather factors and crowded stampede, 18 accidents related to crowded stampede caused by excessive number of audience and negligence of workers, and 3 accidents related to sports riot, accounting respectively for 16.21%, 21,62%, 5.4%, 48.64% and, 8.1%. They are really painful lessons. The cause of the accident is shown in the figure 1 below.

According to the data of large-scale social activity accidents promulgated by relevant state departments, more than half of them have safety problems in site designing and building quality, and 20% of those activities have problems in fire doors and fire hydrant facilities, 40% of them have problems in safety channel width and exit sign, 25% of them have irregularities in electric inspection, lamps, electrical wiring installation, and 15% of them have problems in safety assessment of special equipment and stage height. The cause of the accident is shown in the figure2 below.

In addition, the lack of investment in safety, safety responsibilities, and the rule of safety law all make the holding of large-scale social events in our country at this stage have safety hazards.

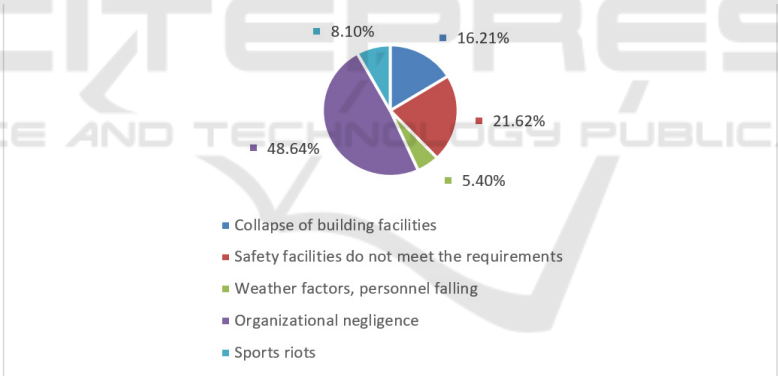

Figure 1: Cause of the Accident.

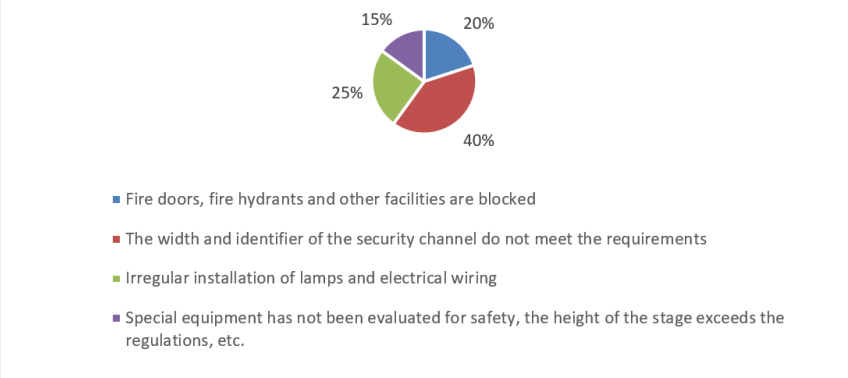

Figure 2: Cause of the Accident.

Research on the assessment of risks of large-scale activities in China is far behind the western developed countries, basic theories, methods and application software of risk evaluation have been in place in those countries, but systematic standards have not be established, their key techniques and methods are highly confidential. (Sun, Guo, Dong Chen 2016) Although China has initially gained some results of theoretical research and practical experience, the introduction of risk evaluation in large-scale activities is still at the exploratory stage, Risk assessments are mainly carried out for a few influential official large-scale events (such as the Olympic Games and World Expos) by the public security organs, but rarely conducted for average official large-scale events, and almost no assessments are conducted for non-governmental large-scale events.

First of all, there are many problems in related laws in China. Relevant laws and regulations only define performance direction of large-scale events. They have not been implemented in practical work of risk evaluation. As a result, there are not implementation standards and codes in practical work. Take folk activities as an example:

For folk activities, according to the third provision of "Regulations on safety management of large public events", organizers need to be responsible for large mass activities, and the government need to take on the supervision role. According to the 4th provision, public security organs above the county level shall be responsible for safety management of large-scale mass activities, but the subject of risk assessment of large-scale events is not clearly defined. Secondly, public security organs in China have some problems in practical operation. (Wang 2016) Over the years, public security organs mainly adopt the empirical mode in management of large-scale activities, public security organs in different regions have different safety requirements, which make organizers of large-scale activities confused. Meanwhile, the police's understanding towards the risk assessment model is not deep enough, so it has no practical significance.

3 ACCIDENT RISK ANALYSIS OF LARGE-SCALE EVENTS

Risk refers to the possibility of certain loss under a particular environment during a certain period of time. Risk is composed of risk factors, risk accidents and risk loss. In other words, the gap between people's desired objective and actual result during a certain period of time is called risk. In 1991, "Light of Coal Sea" exhibition was held at Yangzi Park in Taiyuan city, Shanxi. Due to poor ticket management, 10,000 people poured into a park that could only accommodate 40,000 people. Participants squeezed each other, which caused a person was tripped over a stone bridge, and thus resulted in 106 deaths and 98 injuries.

At the night of the Lantern Festival in Beijing city in February 5, 2004, a Spring Festival Lantern Exhibition was held in Miyun County, and there occurred the crowded stampede, with 37 persons died, and 37 persons injured on the rainbow bridge, due to the poor leadership and fulfillment of management responsibilities.

On January 12, 2006, crowded stampede occurred in Hajj, Saudi Arabia when the pilgrims were attending a religious activity, at least 345 people were killed, and 289 persons injured.

On February 14th, 2010, a Spring Festival Temple Fair was held in Suiyang District of Shangqiu city. The Qilu Disabled Art Troupe came to the stage to perform. The stand collapsed, causing 1 death and 13 injuries, with the direct property losses of more than 420,000 yuan and compensation for 180,000 yuan.

In the evening of January 14, 2011, a major stampede accident took place in the southwest of Kerala, India, killing at least 109 people and injuring dozens of persons. Before the incident, the local India Christians were celebrating a religious festival. (Sun, Tan, Hao, Yan 2016)

From the above cases, it can be found that large-scale social activities have the following risk factors:

3.1 Environmental Risk Factors

(1) Natural environment. Natural factors refer to heavy rain, snow, typhoon, earthquake, tsunamis and other natural disasters that have great impact on large social activities during the period of organization. For example, during opening ceremony of Shanghai Tourism Festival which was held in September, 2002, The sudden rainstorm caused great damage to the main power control circuit, which made all the lighting and sound equipment unavailable, and the event had to be postponed, causing huge economic and reputation losses to the organizer (People's Government of Huangpu District) and the contractor (a Polish businessman).

(2) Surrounding environment. The surrounding environment directly affects the safety of large-scale social activities. If the public security of the

neighboring area is good, the traffic is in good condition, community members have an active cooperation and support large-scale social activities in aspects of site selection and logistics, all these will greatly improve the quality of large-scale social activities. If the public security situation is not good, it is very likely that someone will commit robbery, assault and other illegal and criminal activities in large-scale social activities, which will seriously affect the normal conduct of large-scale social activities.

(3) Social environment. When hosting some far-reaching social events such as the Olympics, it is necessary to fully take the economic strength and political environment of the host country into account. According to the social risk pre-warning system proposed by Prof. Linfei Song, social risks include: income stability, polarization between the rich and the poor, unemployment, inflation, corruption, social security and unexpected events. In this article, mainly local employment rate, crime rate and income were considered.

3.2 Factors of Personnel Risk

The human is the subject of large-scale social activities, in which a large number of people gather and flow in large-scale social activities during a short period of time. Poor safety consciousness of the public means a new challenge to the security of major events.

Personnel risk factors in large social activities include: personnel density, flow of persons, characteristics of human beings and their psychology, personnel's safety awareness, and technical risk factors.

(1) Personnel density. The main reason for fire, riot, stampede and other serious consequences in large-scale social activities is high personnel density. High personnel density affects the normal operation of equipment and sites, and even causes damage to the equipment, sites and order, and at the same time, increasing risk of all the unsafe factors and hidden dangers, even causing the occurrence of accident.

(2) Flow of persons. Some people are highly mobile and have a dynamic impact on the activity guarantee system. Therefore, it is necessary to consider the population as a whole and analyze the impact of its mobility characteristics on the accident. First, different directions of flow: clustering phenomenon is caused by different directions of flow. (Liu 2017) People from different directions crowded on roads, bridges, stair intersections, entrances and exits, causing confusion and congestion. Second, flow speed. Collision and stampede are likely to occur when the activity is over and the channel is open.

(3) Characteristics of human beings and their psychology. Participants of large-scale social events have different crowd characteristics, and some people are mixed. For example, festivals and carnivals are composed of families, couples, young people, old people, etc., Participants like businessmen and professionals of some activities have simple backgrounds. Since large-scale social activities generally occur when participants are not well prepared, and they tend to lose rationality because of panic and show herd mentality and desperation psychology, causing more confusions and even an accident. (Ku 2017) Although the crowd has many characteristics, it is necessary to take precautions in advance to prepare for emergencies.

According to mental states of population, accidents can be divided into "escape disaster" type and "scramble" type. The cause of "escape disaster" accident is a sudden disaster. Because the process is generally very short, unprepared people are often frightened, lose their minds for a while, show conformity and despair, and cause more chaos and even accidents. In "scramble" type accident, people are initially sober, they have clear objectives, and this can make the occurrence of danger more likely.

In case of fire and crowd stampede when people are in a state of panic, people's behaviors have the following characteristics:

①People's behaviors are less affected by laws and morals, showing crazy behaviors.

②People are very nervous, resulting in a number of blindly behaviors, such as blindly following the crowd without making their own judgments.

③Individuals try to move at abnormal speed.

④The crowd have more physical touch.

⑤The panicky crowd may congregate in one exit when there are more than one evacuation exits, while other exits are rarely used and even be completely ignored.

(4) Personnel's safety awareness. Security awareness is people's correct estimates and judgments towards dangers that may exist in the environment. It can help people get out of danger as much as possible. Safety skills enable people to understand the nature and extent of danger and take correct measures to protect themselves and others when encountering danger. At present, the low quality of public safety is an important reason for accidents and a major factor in increasing losses. Poor safety awareness and weak safety skill among the public are the important reasons, and lack of self-

aid skill is the main reason, and the poor safety consciousness among managers is also one of the causes of many tragedies.

(5) Technical risk factors. Technical risks of large-scale social events are mainly venue, equipment and facilities. They are tools to make events go smoothly. The risks include design risk, layout risk and equipment decoration risk. There may be safety issues in the design of large-scale social event venues, such as unclear fire-fighting equipment, fire doors and hydrants, unreasonable design of safety passages, and unclear signs of safe exits and facilities. (Zhang, Jiang, Li, Ma, Yang, Yang 2018) The impacts of equipment and facilities on large-scale social activities are mainly reflected in two aspects: First, the poor reliability of buildings and public facilities may lead to the collapse of building structures and electrical fires. Second, the poor evacuating ability of evacuation facilities which can lead to blocking of the crowd and crowd stampede accident.

3.3 Organization and Management Factors

(1) Crowd management. Improper crowd control can lead to highly intensive population, and is the main hidden danger for stampede. Crowd management should include personnel capacity calculation, personnel control, peak point, crowded point, duration budget, personnel number control, crowd guidance, information dissemination, evacuation program development, panicky crowd management.

(2) Emergency Treatment. Crowded places need to make emergency preparations, formulate scientific and reasonable emergency plans, ensure that they have sufficient emergency response capabilities, and make adequate arrangements for emergency measures and emergency personnel organization. (Mansukhani 2015) In some events, improper emergency treatment increase the risk of accident, for example, in a riot in a soccer field of Congo in 2004, the police set off tear gas, which caused a stampede tragedy.

(3) Information Management. Error message can lead to blind flow of the crowd, and it is one of the important reasons for rumor spreading. Information communication can be divided into information communication between the management and the crowd and that among the crowd.

① Management and information management. If managers fail to convey, or convey incorrect or incomplete information, failing to prevent the spread of misinformation, this may cause a stampede. The managers should convey the following information in a timely and accurate manner: general information such as time of activities, content arrangement, evacuation routes, emergency exits information, temporary change information, such as performance delay, cancellation, change, relevant recommendation, warning, etc.

② Information communication among the crowd. The crowd can be seen as a series of units, it is difficult for its members to understand the whole group, and this increases the likelihood of unsafe behaviors. In some accidents, the front part of the crowd is intensive and can't move, but the part in the back do not know that and go on moving forward. The management should provide relevant information about the crowd and guide them to maintain a good order.

4 ACCIDENT RISK ASSESSMENT OF LARGE-SCALE ACTIVITIES

4.1 Content and the Indicator System of Risk Assessment

Risk assessment is a qualitative or quantitative analysis of risks that exit in large-scale social activities on the basis of risk identification, and sorting of influence degree of risks on activity targets.

In this paper, the author establishes an evaluation index system of risk factors for large-scale activities with environmental factors, human factors, technical factors, organizational factors as the evaluation content.

4.2 Risk Assessment Method- the Accident Tree Analysis Method

According to the characteristics of large-scale activities, the severity of hazards and harmful factors, and the possibility of accidents, the scientific, reasonable and applicable risk assessment methods can be selected. On the basis of different criteria, risk assessment methods can be divided into qualitative analysis method, quantitative analysis method, and semi quantitative analysis method. Those methods have branch methods, for example, qualitative evaluation method mainly includes fault tree analysis method, brainstorming method, Delphic method, and subjective probability method. In this paper, mainly fault tree analysis method is used in analyzing and evaluating of risks of large-scale activities.

Fault tree analysis method is also called accident tree analysis method, by which causes for the occurrence of the accident are analyzed until the basic causes (bottom events) of the accident is found. These bottom events are also called basic events, and their data may be known or have statistics or experimental results. The fault tree analysis method can realize the identification and assessment of various system risks. It can not only analyze the direct reason of the accident, but also reveal potential cause of the accident. It is intuitive, clear and logical in describing the casual relationship of the accident. It can be used in both qualitative analysis and quantitative analysis, and is one of the important analysis methods in safety system engineering. The basic steps are as follows:

(1) Determine the target system and the specific incident (top-level event) to be analyzed.

(2) Determine the probability of accidents in large-scale social activities and the safety target value of accident losses.

(3) Investigate the causes of events. Investigate all direct causes and factors related to the accident.

Prepare a fault tree. Find all the reason events from the top events, until the basic reason events, and draw the fault tree based on the logic relation.

(4) Qualitative analysis. Conduct simplification according the structure of the fault tree, obtain minimal cut sets and the minimal path sets, and determine the structure importance of each basic event.

(5) Quantitative analysis. Obtain the probability of each basic event, calculate the probability of the top events, and obtain important degree and the critical importance degree.

(6) Conclusion. When the probability of the accident exceeds a predetermined target value, find out all possible solutions for reducing the probability of the accident from minimum cut sets, find out the best solution from the minimum path sets, then determine the key point and sequence of countermeasures based on degree of importance, then bet analysis and assessment results.

However, in this paper, because of the lack of necessary data on the probability of the accident, it is difficult to carry out quantitative analysis with fault tree analysis method, so mainly qualitative analysis method is used. Assuming stampede is the top event, firstly, analyze the fault tree for the occurrence of the accident figure.

5 CONCLUSION

5.1 Risk Aversion

Risk aversion refers to that an organization carries out a systematic analysis on hidden dangers and the probability of a major accident before any large-scale activities, and make decision on whether to organize based on the analysis results.

If the organizer cannot or do not want to assume the responsibility for the accident, the activity should be canceled or be replaced by other activity. This method is quite suitable for activities that have high risks or those that produce serious consequences. Nowadays, some large-scale social activities are canceled or held in another place, this is a kind of risk avoidance behavior. For example, the world cup opening ceremony in Germany in 2006 was canceled due to certain reasons, and the performance which was scheduled in the Olympic movement floor was held in Brandenburg, this was due to FIFA's decision with intention of avoiding risks.

5.2 Risk Transfer

Risk transfer refers to that the organizer transfer risks to other organizations and individuals through signing contract or other means. Generally speaking, risk transfer methods can be divided into financial non-insurance transfer and financial insurance transfer. Financial non-insurance transfer refers to the transfer of risks and risk-related financial results to others by signing economic contracts. Financial insurance transfer refers to the transfer of risks to insurance company through signing insurance contract and paying a premium. Once the expected risk occur and cause any loss, the insurer must make economic compensation within the responsibility scope of the contract. For example, the stand collapse accident in Faye Wong's concert in Chongqing city makes many performance organizations aware of the importance of public liability insurance. In general, the organizer will buy accident injury insurance for actors, singers and staff (including handling personnel), and accident insurance for the audience. In this way, the organizer transfer risks to other parties. It is necessary to abide by relevant laws and regulations when signing those insurance contracts.

5.3 Risk Control

Risk control refers that the organizer takes various measures and methods to eliminate or reduce risks, or the possibilities of events, or reduce loss caused by

accidents. Risk control is the core of risk management. People should be aware of the existence of risks, and take preventive measures that are effective and legitimate, thereby reducing the possibility of injury accident and negative effects and loss caused by the accident. The specific content includes risk assessment, formulation of emergency plans, strengthening employee safety education and training, carrying out emergency drills, equipment and site maintenance, strengthening safety supervision and management, sorting and storing various data, and handling related accident lawsuits. Taking a solo concert as an example, once the event is canceled due to bad weather, the organizers and the audience will suffer great economic loss. From the perspective of risk management, the following methods can be adopted. The first is to avoid it. Outdoor concerts have strict requirements on weather conditions, which require accurate understanding of historical weather data to avoid severe weather conditions. The second is to reduce or eliminate risks, the organizers can take effective measures to reduce the impact of weather, such as offering rain gear to the audience. Finally, consider risk transfer and risk financing.

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