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Importance Degree Evaluation of the Affecting Factors on Exhibition Security Accidents

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Abstract: The occurrence of exhibition security accidents is the result of the mutual coupling factors of "man-machine-environment-management". This study is going to elaborate 11 influencing factors of exhibition security accidents from four aspects, i.e., man, mechanical equipment, environment and management. With the help of grey relational analysis, this study evaluates the importance degree of the affecting factors in exhibitions. The result shows that affecting factors of facilities and equipments failure is of the greatest importance degree and site maintenance personnel, site design, building material quality are the secondary important factors; another important factors are safety management body, social environment, activity organization management, safety management system, natural environment and event participant behavior which are considered as the third important ones. Evaluation of the importance degree of affecting factors on exhibition security incidents will provide a theoretical basis for exhibition security control.

Key words: Exhibition security accidents, affecting factors, importance degree evaluation, grey relational analysis

INTRODUCTION

With the rapid development of exhibition industry, exhibition activities were increasingly frequently held which effectively promoted the development of regional economy. Meanwhile it is reported that exhibition security accidents have also happened occasionally, causing great personal injury and property damage to the participants of those exhibitions. According to the statistic fact: From 1983 to 2004, there were 37 casualties in China's large-scale mass sports activities, with 686 people killed and 1376 injured. Causes of the accidents were some collapsed buildings and facilities, or evacuation routes and lighting did not meet the requirements; and there were also some accidents caused by weathers or staff's falling down; people stampede, riots happened in sporting events (Tong, 2007). Exhibition events are held in a particular time and space conditions with complex and diverse affecting factors. Mutual coupling of the factors may lead to security incidents, therefore, exhibition security issues should be paid closer attention.

Exhibition accidents refer to the phenomenon that natural disasters, accidents, public health incidents and social safety incidents endanger the stable operation normal activities, causing personal injury or property damage. Exhibition security issue has gained a lot of attention from scholars and has achieved significant research results. The affecting factors of exhibition accidents were studied mainly from the following two aspects: the first one is risk analysis of exhibition security. For example (Ji, 2006) based on the "man-machine-environment" security systems, analyzed the causing factors of exhibition accidents from the perspective of single-factor and multi-factor. Chen (2007) found that large exhibition events are confronted with risks of natural disasters, accidents, technical malfunctions or man-made sabotage. The second is case studies of large-scale exhibition activities. Li and Dai (2004) analyzed the security management case of 2002 Boao Asia Travel Forum in Guilin. Huang (2007) studied the potential risks of Beijing Olympic venues. Qi (2010) analyzed the emergency risk during the Sixteenth Asian Games in Guangzhou city. Many scholars analyzed the affecting factors on exhibition security risks according to their own research needs which, however, haven't formed a system. Meanwhile, research methodologies are mainly qualitative analysis while quantitative analysis is rare. Based on the previous researches, this study will have a quantitative analysis of the selected exhibition accident cases by using the grey relational analysis model, explore the importance degree of the affecting factors, with a hope to provide a theoretical basis for exhibition security control.

EXHIBITION SECURITY INCIDENTS AFFECTING FACTORS

In the late 1940s, White from America Cornell University attributed the accident cause to the "man-machine-environment" security system. This theory was

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Table 1: Affecting factor index system of exhibition security accidents

Affecting factors on exhibition security accidents	Level-one index	Level-two index	Level-three index
	Human factors	Activity participant behavior (F_1)	The negative effects of conformity behavior; The impact of group communication
		Events organization and management personnel (F_2)	Unclear responsibilities, management inefficiency; inconsiderate checking, improper mistake prevention; inadequate training; lack of knowledge; information distortion, poor communication
		Site maintenance personnel (F_3)	Low personnel quality; irregular management operation; poor physical and mental conditions; team mismatch; poor adaption to working conditions and duties management
	Space and equipment factors	Site reassignment (F_4)	Narrow aisles, inappropriate event site layout and the lack of safe passages
		Building material quality (F_5)	Building materials don't meet requirement; building quality of the project
		Equipment instrument malfunction (F_6)	Equipment instrument failure will directly cause security accidents or poor conditions of lighting, ventilation and temperature also threaten the security of activity participants
	Activities environment factors	Social environment (F_7)	National policies and regulations; terrorism; market competition; economic development level
		Natural environment (F_8)	Poor weather conditions; complicated geographical environment.
		Artificial environment (F_9)	Site environment factors£»scene management; site management environment: activity site environment, communication connection environment, activity roadmap conflicts)
	Organization management factors	Safety management body (F_{10})	Weak security awareness; fluke mind or emphasis on immediate interests;
		Safety management system (F_{11})	Unreasonable management system, unsmooth relationship within the system; improper organization structure design, organizational overlapping, functional defects and improper management process

widely applied to fields like coal mine, road, aviation safety, achieving a series of research results which is of great enlightenment significance to the analysis of security accidents (Ji, 2006). Because exhibition activities are held at specific time and space conditions, the operation of them will involve many factors. This study holds that the occurrence of safety accidents in exhibition activities is due to the coupling effect of the four factors, i.e., "man-machine-environment-management". By summering the previous literature, this study will generalize the affecting factor index system as three levels which is shown in Table 1.

IMPORTANCE EVALUATION METHODS OF THE AFFECTING FACTORS ON EXHIBITION SECURITY ACCIDENTS

Grey relational analysis evaluation method: Grey relational analysis determines the difference and proximity between various sequences through the analysis of the distance between reference sequences and comparative sequences and judge the relational degree of grey process development trend according to the proximity degree of sequence curve geometry. Grey relational analysis describe the strength and sequence between the factors through grey relational degree. If the sample data reflects that the changing trend between two factors is basically the same, then their relevance degree is much greater, or else the relevance degree is smaller. Compared with traditional multivariate analysis method, grey relational analysis's data and computation requirements are lower, so it has been more widely used (Xia *et al.*, 2011), especially successfully in fields like coal and road safety.

The steps of grey relational analysis computation are shown as follows:

- There are n group(s) of time sequence in the preliminary data of exhibition security accidents sample and m affecting factor(s). The occurrence frequency of the annual safety accidents' affecting factors constitutes a data column which is named primitive data column and is marked as:

$$X_i = [X_i(1), x_i(2),..., x_i(n)\ (i = 1, ..., m) \qquad (1)$$

The magnitude orders of sequence numbers in the system may differ greatly, so usually the primitive data need to be transferred into a data sequence for comparison, i.e., initialized transformation nondimensionalizes the evaluation index::

$$X_i(j) = \frac{X_i(t)}{\frac{1}{n}\sum_{i=1}^{n} X_i(t)} \quad j = 1,...,n; \qquad (2)$$

- Determine comparative sequence and reference sequence. After the unification process, dimensionless numbers constitute sequence $\{X_i(j)\}$ (j = 1, ..., n) as comparative sequence. nondimensional ideal index values constitute sequence $\{X_0(j)\}$ (j = 1, ..., n) as reference sequence. So the absolute difference between $X_0(j)$ sequence and $X_i(j)$ sequence:

$$\Delta_{0j}(j) = |X_0(j) - X_i(j)| \quad (3)$$

- Computing correlation coefficients. The correlation coefficient of comparative sequence X_i to reference sequence at point k :

$$\xi(k) = \frac{\min_i \min_k |X_0(k) - X_i(k)| + \rho \max_i \max_k |X_0(k) - X_i(k)|}{|X_0(k) - X_i(k)| + \rho \max_i \max_k |X_0(k) - X_i(k)|} \quad (4)$$

In the above equation: $\rho \in (0, +\infty)$ is the distinguishing coefficient. The smaller p is, the greater the distinguishing ability is. $\rho \in (0, 1)$, generally p = 0.5.

- Computing grey relational degree. Because what the computation of correlation coefficient get are correlation coefficient values of various comparative sequence and reference sequence at each point. There are many results and information is too scattered which are not convenient to be compared. Therefore it is necessary to make the correlation coefficients of each comparative sequence at each time focused in a value, i.e., relational degree. The computation of relational degree that the author uses is mean value method:

$$\gamma_i = \frac{1}{n} \sum_{k=1}^{n} \xi(k), \xi(k) \quad (k = 1, 2, ..., n) \quad (5)$$

- Sequence according to the relational degree. If the relational degree is great it shows that the changing trends is quite the same which can better reflect the importance degree of the affecting factors

Evaluation steps of the grey relational analysis:

- **Collecting sample data:** Through the report of in internet or newspaper, collect exhibition accident cases material over the years, including the occurrence time, place and content
- **Confirm the affecting factors:** Systematically comb the collected sample data of exhibition accident cases, have case analysis of the sample data one by one and the specific affecting factors. Confirm the affecting factors through splitting and merging methods, etc
- **Grey relational analysis:** According to the sample data, analyze the occurrence frequency of the affecting factors on exhibition accidents
- **Determine the correlation degree:** Determine the importance degree of exhibition accident affecting factors according to the specific characteristics of the affecting factors and the evaluation criterion (Table 2)

Analyze the importance degree of the affecting factors on exhibition accidents and provide relevant management protection of exhibition security.

DATA COLLECTION AND ANALYSIS

Data collection: The author selected the 41 exhibition accidents happened from 2007 to 2012 as sample data (data source is from internet reports). Due to the limitation of paper length, only 6 typical cases' analysis processes are listed which is shown in Table 3.

Grey relational analysis

- Calculate the occurrence frequency of affecting factors during the exhibition accidents, nondimensionalize the original data according to a formula and select the sequences composed by the accidents data of each sequence as reference sequence, marked as a_0 which is shown in Table 4.
- Compute the absolute difference value of the comparative sequence and reference sequence from 2007 to 2012 which is shown in Table 5
- Grey relational coefficient and its relational degree sequencing of the affecting factors as shown in Table 6

Importance degree evaluation analysis of the affecting factors in exhibition security accidents: According to Table 6, we get the importance degree levels of the 11 affecting factors which is shown in Table 7.

After the relational degree analysis of the affecting factors on exhibition security accidents from 2007 to 2012, we get the following findings:

- The importance degree of F_6 is the greatest one. Convention and exhibition centers need to be held with the help of all kinds of facilities and equipment, such as lighting facility, temperature-controlled equipment, monitoring equipment and so on. Once one of them doesn't work it will generate a series of chain reaction, resulting in the occurrence of safety accidents
- F_3, F_4, F_5 are the second important ones. On-site maintenance personnel's timely detection of problems, quick reaction and immediate report can greatly control the development and expansion of the accidents and offer help to emergency rescue, thus reduce the occurrence of accidents and the damage caused by them. Scientific and reasonable forecast and advanced exhibition venue design concept will play a positive role in reducing the occurrence of traffic or people congestion during the exhibition events. Building material quality is also an important

Table 2: Importance degree evaluation

Importance degree level	One	Two	Three	Four	Five
Level	Very important	important	Comparatively important	Generally important	unimportant
Value range	[1.00~0.85)	[0.85~0.75)	[0.75~0.65)	[0.65~0.60)	[0.60~0]

Table 3: Exhibition accidents sample data (2007-2012)

				Affecting factors			
The coding of the accidents	Time	Place	Accident situation	Human factor	Facility instrument	Environmental factor	Management factor
A1	June, 16th, 2012(noon)	Sanya International Convention and Exhibition Center	Traffic accident, resulting in 2 deaths	Activity participants' behavior, activity organization and management personnel's factor, on-site maint enance personnel	Site design factor	man-made environment	Safe management body's problems; inherent defects of the safety management system.
A2	January 1, 2011(noon)	Hangzhou International Exhibition Center	Fire, without any reported casualties	Activity organization and management personnel's factor, on-site maintenance personnel	Equipment malfunction factors	social environ-ment man-made environment;	The quality of security management body
A3	Mar, 14th, 2010 (a.m.)	Guiyang International Convention and Exhibition Centre	Collapse accident construction site, resulting in 7 deaths and 19 causalities quality	activity organization and management personnel's factor, on -site maintenance personnel		social environ-; ment man-made environment	The quality of security management body
A4	Aug, 18th, 2009	Handan International Convention and Exhibition Center	Pipe leaking of the first floor, which caused several merchants' exhibits to be wet with direct economic damage of several hundred thousand RMB	Activity organization and management personnel's factor, on -site maintenance personnel	Site design factor	Natural environment; man-made environment;	The quality of security management body;problems of the safety management system
A5	Nov, 29th, 2008 (a.m.)	Shanghai Pudong New International Expo Centre	An advertising board fell down from a high place in E6 hall, with 1 was killed and 3 were injured	Activity organization and management personnel's factor, on-site maintenance personnel	Building material quality;	Social environment; man-made environment;	The quality of security management body;
A6	Nov, 14th, 2007	Shawan International Convention and Exhibition Center	During the West China International Arts Gifts and Collections Fair 2012, a micro-carved ivory fan of "The Art of War" was stolen	Management personnel's factor, on-site maintenance personnel	---------	man-made environment	Inherent defects of the safety management system;

(Data source: Comprehensive analysis according to the internet reports)

Table 4: Dimensionless data of the affecting factors of exhibition safety accidents

Affecting factors	2012	2011	2010	2009	2008	2007	a_0 sequence
F_1	2.5000	1.7187	1.5714	0.7857	0.8684	0.8148	1.5000
F_2	0.5000	0.6875	1.0476	1.5714	1.7368	1.2222	1.0625
F_3	2.2500	2.4062	2.0952	1.5714	1.7368	2.0370	2.0625
F_4	0.2500	0.0000	0.5238	0.7857	0.0000	0.4074	0.2500
F_5	0.0000	0.3437	0.5238	0.0000	1.1578	0.4074	0.4375
F_6	0.2500	0.3437	0.0000	0.7857	0.2894	0.4074	0.3125
F_7	0.0000	0.6875	0.0000	0.7857	1.7368	0.8148	0.6875
F_8	0.0000	0.0000	1.0476	0.7857	1.7368	0.4074	0.6250
F_9	2.7500	2.4062	2.0952	1.5714	0.0000	2.0370	1.8125
F_{10}	0.5000	0.6875	1.0476	1.5714	1.4473	1.2222	1.0000
F_{11}	2.0000	1.7187	1.0476	0.7857	0.2894	1.2222	1.2500

affecting factor. For the past few years, because the quality of building material didn't conform to requirements, collapsing accidents of the exhibition constructions happened quite frequently

- F_{10}, F_7, F_2, F_{11}, F_8, F_1 are the third important affecting factors. Security management body, activity organization and management personnel and safety consciousness in the safety management system have an important impact on the accidents. Even though some management body or management personnel have receive rectification notices from safety supervision departments, they are still careless

Table 5: Summary table of dimensionless absolute difference of the affecting factors in exhibition accidents

Affecting factors	2012	2011	2010	2009	2008	2007	max Δ	min Δ
F_1	1.0000	0.2187	0.0714	0.7142	0.6315	0.6851	1.0000	0.0714
F_2	0.5625	0.3750	0.0148	0.5089	0.6743	0.1597	0.6743	0.0148
F_3	0.1875	0.3437	0.0327	0.4910	0.3256	0.0254	-0.4910	0.0254
F_4	0.0000	0.2500	0.2738	0.5357	0.2500	0.1574	0.5357	0.0000
F_5	0.4375	0.0937	0.0863	0.4375	0.7203	0.0300	0.7203	0.0300
F_6	0.0625	0.0312	0.3125	0.4732	0.0230	0.0949	0.4732	0.0230
F_7	0.6875	0.0000	0.6875	0.0982	1.0493	0.1273	1.0493	0.0000
F_8	0.6250	0.6250	0.4226	0.1607	1.1118	0.2175	1.1118	0.2175
F_9	0.9375	0.5937	0.2827	0.2410	1.8125	0.2245	1.8125	0.2245
F_{10}	0.5000	0.3125	0.0476	0.5714	0.4473	0.2222	0.5714	0.0476
F_{11}	0.7500	0.4687	0.2023	0.4642	0.9605	0.0277	0.9605	0.0277

Table 6: Grey relational coefficient and its relational degree sequencing of the affecting factors

Affecting factors	2012	2011	2010	2009	2008	2007	Relational degree	Sequence
F_1	0.4754	0.8056	0.9269	0.5592	0.5893	0.5695	0.6543	10
F_2	0.6170	0.7073	0.9838	0.6404	0.5734	0.8502	0.7287	7
F_3	0.8286	0.7250	0.9651	0.6486	0.7356	0.9727	0.8126	2
F_4	1.0000	0.7838	0.7680	0.6285	0.7838	0.8520	0.8027	3
F_5	0.6744	0.9063	0.9130	0.6744	0.5571	0.9679	0.7822	4
F_6	0.9355	0.9667	0.7436	0.6570	0.9752	0.9052	0.8639	1
F_7	0.5686	1.0000	0.5686	0.9022	0.4634	0.8768	0.7300	6
F_8	0.5918	0.5918	0.6820	0.8494	0.4491	0.8064	0.6617	9
F_9	0.4915	0.6042	0.7622	0.7899	0.3333	0.8014	0.6304	11
F_{10}	0.6444	0.7436	0.9501	0.6133	0.6695	0.8031	0.7373	5
F_{11}	0.5472	0.6591	0.8175	0.6612	0.4855	0.9703	0.6901	8

Table 7: Importance degree levels of the affecting factors on exhibition safety accidents

Importance degree level	One	Two	Three	Four	Five
Level	Very important	Important	Comparatively important	Generally important	Unimportant
Range of values	[1.00~0.85]	[0.85~0.75]	[0.75~0.65]	[0.65~0.60]	[0.60~0]
Affecting factors	F_6	F_3, F_4, F_5	F_{10}, F_7, F_2 F_{11}, F_8, F_1	F_9	----

and don't rectify, thus causing the collapsing of constructions, fire or stampede accidents. Safety consciousness and precaution are also very important factors. In some accident cases, many merchants lost their cautions, so that thieves posed as visitors would enter the exhibition centers and stole some valuable exhibits

- F_9 is another one that should not be ignored. When accidents happened because of the imperfection of directional signs or road signs in emergency exits, people congestions or disorderly stampedes will also happened.

RESEARCH FINDINGS AND MEASURES

Research finding: This study analyzed the affecting factors of exhibition accidents and evaluate the importance degree of them by grey correlation analysis method. Here are the findings:

- The affecting factors of exhibition safety accidents include four aspects, i.e., man, mechanical equipment, environment and management. The occurrence of accidents is the mutual coupling effect of the four factors
- The affecting factors of man, mechanical equipment, environment and management are subdivided, among which human factor are activity participants behavior (F_1), activity organization and management personnel (F_2) and on-site maintenance personnel (F_3); site and equipment factors are site design factors (F_4), building material quality (F_5), equipment instrument failure factors (F_6); activities environmental factors are social environments factors (F_7), natural environment factors (F_8), man-made environment factors (F_9); organizational management factors are security management body (F_{10}) and safety management system (F_{11})
- Select exhibition accident cases from 2007 to 2012 as the sample data and evaluate the importance degree of the affecting factors on exhibition accidents through grey relational analysis model. The results show that F_6 (facilities and equipment failure affecting factors) is of the greatest importance. F_3 (on-site maintenance personnel), F_4 (site design factors), F_5 (building material quality) are the second important factors. F_{10} (security management body), F_7 (social environment), F_2 (activity organization and management personnel)F_{11} (safety management system), F_8 (natural environment), F_1 (activity participants'behavior) are of the third importance

Prevention and control measures of exhibition safety: In order to have better prevention and control for

exhibition safety, according to the results of the importance degree evaluation, this study attempts to propose the following methods:

- Perfect the safety management regulations of exhibitions. Generally, the regulations involve fire safety regulations, electrical safety regulations, booth construction and exhibits transportation safety regulations, exhibits safety regulations, contingency plans for emergencies, etc. Because of the difference of exhibition types, properties, places and the possible emergency, these regulations should have their focus
- Do well the job of exhibition security warning and risk prevention. Establish an early-warning system and quickly handle the emergencies to reduce risks and damage. In addition, insurance work of exhibition security is also a must
- Improve the management of exhibition site and facilities. Exhibition sites and facilities are comparatively fixed, so daily checking, record an report of the safe conditions should be done well
- Establish safety awareness and increase exhibition safety education. Safety awareness: One the one hand, managers should have a comprehensive checking towards the exhibition activities; on the other hand, establish emergency information platform and information monitoring system. What's more, to improve safety awareness and response to emergency, persons in charge of exhibition safety and managerial personnel need to receive effective trainings and learn the safety knowledge

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