The research of prison fire risk assessment

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ABSTRACT

Prison is a national penalty enforcement organ, and some fire problems of prison often are neglected because of its special situation. However, fire of prison will lead to many people die or injury, and cause the bad social influence. In this paper, based on the analytic hierarchy process and expert scoring system of fire risk evaluation methods, for prison fire risk assessment, and the evaluation conclusion will know the danger of prison fire more objective and more accurate. It will provide theoretical basis and technical support for preventing, controlling and extinguishing fire to create safe, stable, healthy and harmonious prison environment.

Key words: Prison; Fire; Risk Assessment; Fire Hazards

INTRODUCTION

Prison buildings are the basic facilities of the prison, all prisoner execution and corrective action must be carried out properly with the aid of prison construction. However, Prison building fire resistance rating is low, and there are few automatic fire alarm systems and automatic fire extinguishing systems in prisons. Moreover, crowded prisoners, so much fuel, and individual criminal arson and damage, all of these will result in a surge of prison fire hazard [1].

Table 1. Typical fire cases in prisons of the world

Time	Prison	The Number of Death	The Number of Injury
01.11.2002	Rabat, Morocco	49	34
17.05.2004	San Pedro Sula, Honduras	104	27
07.03.2005	Keisuke provinces, The Dominican republic	133	0
24.08.2007	Ponte Nova, Brazil	20	0
04.11.2007	Santiago del Estero , Argentina	30	0
22.08.2008	Douala, Cameroon	10	30
10.03.2009	PaulLormier, Lebanese	0	19
26.04.2009	Regional colli ,Chile	10	5
10.11.2010	El Salvador	16	27
08.12.2010	SAN miguel, Chile	83	15
15.01.2011	Munastir, Tunisia	42	0
14.02.2012	Comayagua, Honduras	360	0

As shown in table 1, prison fire easily caused heavy casualties and property losses. Therefore, it is great significant to evaluate prison fire safety analysis and reduce the risk of a prison fire fundamentally for safe, stable, healthy and harmonious prison.

RISK FACTORS OF PRISON FIRE
Prison buildings are composed with prisoners' buildings, police buildings, other accessory buildings and so on, and all kinds of buildings function are relatively complex. In order to ensure the prison safe and stable, to effectively supervise prisoners, should be set up installation to prevent escape, jail delivery, and prisoners' self-injury and suicide, but these measures might obstruct evacuation when prison fire occurred. Because of the particularity of the

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prison buildings, there is a big difference with other public buildings about the stream of people logistics facilities, roads, vigilance, capacity, and the architectural space.

The number of prisoners is increasing; the characteristics of prisoners such as intelligence, violence, organization, etc. are more obvious. Moreover, many serious criminals, violent criminals, drug traffickers and second sentence criminals in prisons may set fire to buildings.

It's much more difficult to extinguish the prison fire because of many disadvantageous factors such as site conditions, the rescued person and the prison environment. A lot of prison buildings that there are a great deal of combustible objects install few the fire automatic alarm systems and automatic fire extinguishing systems, at the same time their fire resistance rating is low. All this may spread fire fast once something burned. While the smoke from the burning caused low visibility, emergency evacuation is hard with the high temperature, easy to cause group die or injury.

RISK ASSESSMENT OF PRISON FIRE
Based on the analysis of fire risk assessment both domestic and abroad research results, combining with the characteristics of prison construction, comprehensive consider the feasibility and applicability of the evaluation, the analytic hierarchy process and expert scoring system of risk evaluation methods are more suitable for fire risk assessment in prison[2]~[4].

Prison fire risk evaluation system based on analytic hierarchy process (AHP) can be divided into three layers. The first layer includes fire hazards, building fire protection and fire safety management. The second layer includes objective factors, human factors, architectural features, passive fire protection measures and active fire protection measures, as shown in Fig.1.
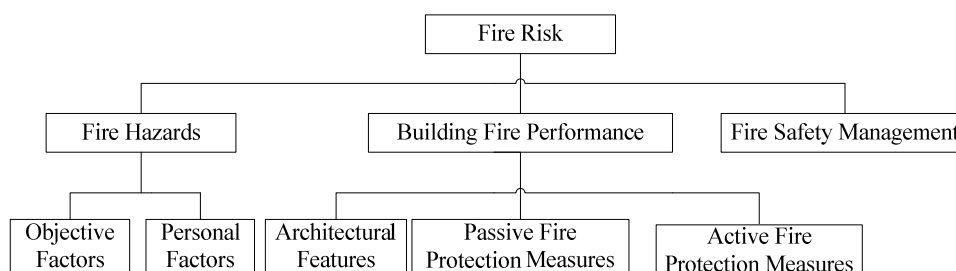

Fig. 1: The first layer factors

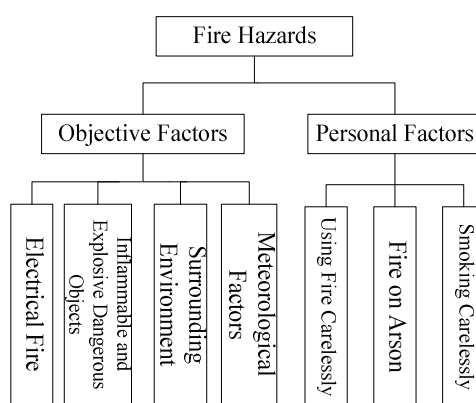The third layer as shown in Fig. 2 to Fig. 4.

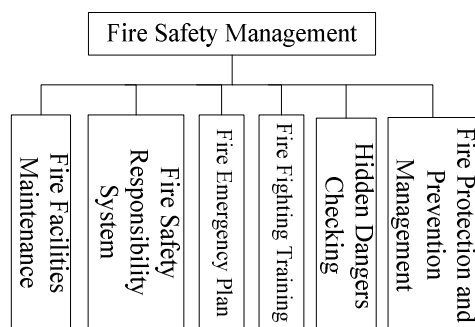**Fig. 2: The third layer factors of fire hazards**

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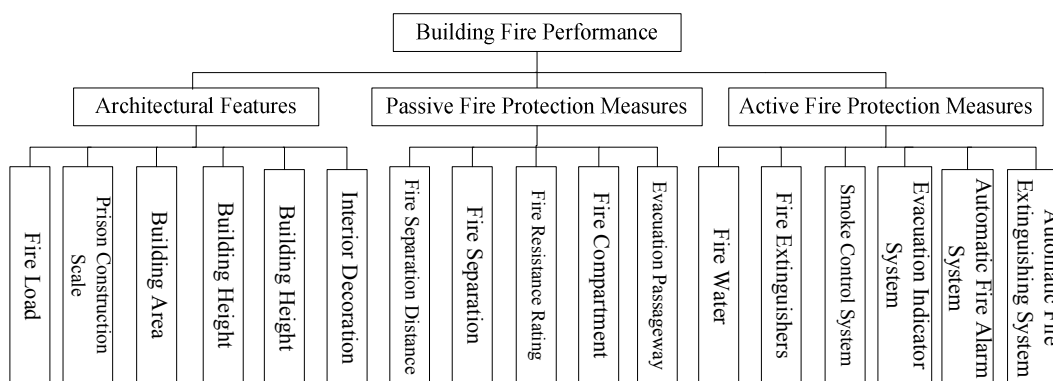**Fig. 3:The third layer factors of fire safety management**

Fig. 4: The third layer factors of building fire protection

In this paper, using expert scoring method to define the weight of each index, several experts grade fire risk factors of prison respectively.[5]~[8] If specialist j gives index weight coefficient of index system as follows:

$$\left(\lambda_{1j}, \lambda_{2j}, \ldots, \lambda_{ij}, \ldots, \lambda_{mj}\right) \quad (1)$$

If the sum of squares error within the allowed error range is

$$\max_{1 \leq j \leq n}\left[\sum_{i=1}^{m}\left(\lambda_{ij} - \frac{1}{n}\sum_{j=1}^{n}\lambda_{ij}\right)^2\right] \leq \varepsilon \quad (2)$$

Then

$$\overline{\lambda} = \left(\frac{1}{n}\sum_{j=1}^{n}\lambda_{ij}, \ldots, \frac{1}{n}\sum_{j=1}^{n}\lambda_{ij}, \ldots, \frac{1}{n}\sum_{j=1}^{n}\lambda_{mj}\right) \quad (3)$$

It's the satisfied weight coefficient set. Otherwise, if λ i is bigger then the largest λ, the experts modify it again, until satisfied. Considering the uncertainties of persons' judgment and the individual differences in understanding, based on the idea of collective decision, using score range as grade value, several experts respectively rating according to the established index system and the better situation for safety, reducing the influence on the accuracy of the results by uncertainty and understanding difference. Using fuzzy set-valued statistics method, get the results via calculated.

Let experts give an eigenvalues interval [a$_{ij}$,b$_{ij}$] in accordance with their understanding of the index case and the evaluation standard. Thus get a set-valued statistics series, the eigenvalues equation of evaluation index is:

$$x_i = \frac{1}{2}\sum_{j=1}^{q}\left[b_{ij}^2 - a_{ij}^2\right]/\sum_{j=1}^{q}\left[b_{ij} - a_{ij}\right] \quad (4)$$

Where i=1,2,···,m, j=1,2,···,q.

The equation states that prison fire risk levels can be calculated by linear weighted model:

$$R = \sum_{i-1}^{n} W_i \times F_i \quad (5)$$

Where R is prison fire risk. W_i is index weight. F_i is the evaluation score of index.

Table 2. Prison Fire Experts Assessment

Expert	Assessment Score	Risk Level	Expert	Assessment Score	Risk Level
1	51.9	High	11	46.06	High
2	55.3	High	12	47.96	High
3	57.06	High	13	32.94	High
4	52.1	High	14	30.02	High
5	24.3	Very High	15	31.36	High
6	37.36	High	16	29.62	High
7	40.02	High	17	42.96	High
8	47.04	High	18	39.14	High
9	43.36	High	19	23.18	Very High
10	50.22	High	20	37.52	High

Solution: every expert's assessment score as shown in table 2, and prison fire risk total score is R=39.13. According to the standard of the level of risk, the prison fire risk level is high risk. Prison fire risk is higher and the fire is difficult to control, therefore, must be strengthen the fire infrastructure and improve the fire management level [9] [10].

CONCLUSION

The prison fire risk assessment includes the fire hazards identification, prison buildings analysis, prison fire safety management, etc. Assessment result sates that the main problems about prison fire are electrical fire, great combustion load, dense crowd, no intelligent fire extinguishing devices, no fire pool, high proportion prison with natural smoke and exhaust ventilation, high risk of fires on arson. To solve these problems, need to strengthen the fire management of prisoners, to increase investment on fire safety and to reduce the risk of fire as possible.

REFERENCES

[1] The Justice Department of the People's Republic of China, *Prison Construction Standards (CS139--2010)*. China Plans Press. Beijing, China. **2005**.
[2] FAN Weicheng, SUN Jinhua, LU Shouxiang. *The Fire Risk Assessment Methodology,* Science Press. Beijing, China. **2010**.
[3] Junfang Zhang, Shuping Wang. *Architectural and Hydraulic Engineering*, pp. 4941-4945, August 10-12, **2012**.
[4] DU Lanping. *Fire Risk Assessment Method and Application Examples,* The Chinese People's Public Security University Press. Beijing, China. **2012**.
[5] JIANG Yongkun. *China Fire Engineering Handbook,* China Building Industry Press. Beijing, China. **1998**.
[6] Shi JY, Li YQ, Chen HC. *Tsinghua Science &Technology*, v 13, n 1, p 387-392, **2008**.
[7] WANG Weijun. *Fire Science and Technology*, v 7, n 27, p 477-481 **2008**.
[8] HUANG Ying. *Research on Fire Risk Assessment and Safety Management Methods of Public Building, Xian University of Science and Technology Building,*. **2009**.
[9] *Fire Dynamics Simulator User's Guide. National Institute of Standards and Technology (NIST) U.S. Department of Commerce.* U.S. Government Printing Office, **2007**.
[10] *BuildingEXODUS v5 Manual. University of Greenwich.* **2011**.