A study on the assessment criteria for the safety grade of public use buildings and facilities

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Abstract

A checklist was made and presented for the safety investigation of architecture, civil engineering, fire fighting, electricity, gas and lifts. The evaluation basis of the synthesized level was provided through the estimating index and basis, considering the individual area. The proposed assessment criteria for the safety grade of Public Use Buildings and Facilities (PUBF) have been developed on the basis of circumstance estimation in order to provide the safety level. Consequently, three assessment methods of absolute evaluation and three of relative evaluation are proposed, based on normal or log normal distribution. Evaluation domains, fields and items were decided to estimate the safety of the PUBF; the safety grade was also decided as being five levels.

Keywords: safety grading system, safety investigation, assessment criteria, evaluation domain, evaluation field, evaluation item, weights decision method, public use buildings and facilities.

1 Introduction

As urban structures are integrated and concentrated, the number and variety of hyper architectures, high-rise buildings, Public Use Buildings and Facilities (PUBF) increases, which results in an increase in the type of accidents and disasters. The recent trend of accidents in an amusement park, the collapse of a construction site and conflagrations of PUBF can be good examples. Therefore, safety supervision for disaster prevention has become a very serious issue.

A safety management schedule for entire facilities has not been carried out systematically and many agencies have attempted to enforce policies which

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have, at most, partial impact. In addition, owners and officers of buildings and facilities are confused by and have to deal with various circumstances, as there are various agencies in the government for the safety management of buildings and facilities have been managed individually. Safety management in particular is separately carried out by responsible agencies, as the safety management system and conditions are not standardized and established in the individual fields. So the expenses for buildings and facilities management are increased and spent redundantly. Consequently, the present safety management of facilities remains perfunctory.

Therefore, the purpose of this research is to prepare a checklist for the safety inspection of individual fields, such as architecture, civil engineering, fire fighting, gas and lifts by integrating the separated safety supervision and systems and to suggest a safety grading system to ensure the overall safety of buildings and facilities.

2 Consideration of laws and provisions

PUBF are defined as buildings for sale, lodgings, medical service, religion, performance, assembly, leisure and training, and they are controlled by the concerning laws as shown in Table 1.

Generally, PUBF correspond to mostly small scale buildings except for some middle or large scale buildings. However, as the scale of PUBF gets smaller, the current laws and regulations applied to the PUBF get more relaxed relatively, especially in the field of fire fighting.

Table 1: Laws of public use buildings and facilities.

Major use	Comprehensive safety management	Fire fighting	Architecture	Gas	Electricity	Lift	Boiler
Sales	CFA, CDIA	FIA	ABA	GUA	EEA	LMA	BEA
Lodging	CFA, CPHA, CTPA	FIA	ABA	GUA	EEA	LMA	BEA
Transportation	CFA, CPTA, CAA, CHA	FIA	ABA	GUA	EEA	LMA	BEA
Performance	CFA, CPPA, CPMA	FIA	ABA	GUA	EEA	LMA	BEA
Assembly	CFA, CPHA, CKRA, CADA, CICA	FIA	ABA	GUA	EEA	LMA	BEA
Exhibition	CFA, CIUA, CPGA	FIA	ABA	GUA	EEA	LMA	BEA
Medical service	CFA, CMSA, CFSvA	FIA	ABA	GUA	EEA	LMA	BEA
Religion	CFA, CADA, CTTA	FIA	ABA	GUA	EEA	LMA	BEA
Leisure	CFA, CFSA, CIUA	FIA	ABA	GUA	EEA	LMA	BEA
Youth training	CFA, CAPA, CIUA	FIA	ABA	GUA	EEA	LMA	BEA
Video and PC game	CFA, CAPA, CSRA	FIA	ABA	GUA	EEA	LMA	BEA

ABA : Building act
BEA : Energy use rationalization act
CAA : Aviation act
CADA : Assembly and demonstration act
CAPA : Adolescent activity promotion act
CDIA : Distribution industry development act
CFA : Framework act on the management of disasters and safety
CFSA : Food sanitation act
CFSvA : Funeral service act
CHA : Harbor act
CICA : International conference industry promotion act
CIUA : Installation and utilization of sports facilities act
CKRA : Korea racing authority act
CMSA : Medical service act
CPGA : Promotion of the museum and art gallery act
CPHA : Public health control act
CPMA : Promotion of the motion pictures act
CPPA : Public performance act
CPTA : Passenger transport service act
CSRA : Sound records, video products and game software act
CTPA : Tourism promotion act
CTTA : Traditional temple preservation act
EEA : Electric utility act
FIA : Act on the installation maintenance and safety management of fire facilities
GUA : Urban gas business act
LMA : Manufacture and management of elevators act

3 Decision of assessment criteria and safety grading system

3.1 Background and purpose of safety grading system

To establish an effective safety management system for buildings and facilities, which should prevent facility disasters and reduce the burdens on people, the standardization of safety criteria required by the existing laws and regulations is necessary and important. Also, it works as the basis for the 'Framework Act on the Management of Disasters and Safety', enacted to integrate safety management and disaster prevention. Consequently, the safety grading system is proposed to augment the overall safety of PUBF by systematic assessment criteria.

3.2 Decision of evaluation domains, fields and items

For the application of the safety grading system, it is necessary to describe clearly the framework of inspection and assessment for PUBF and to define assessment criteria and terms. The evaluation framework is categorized into three large groups (large, medium and small). Large, medium and small groups are named as 'evaluation domains', 'evaluation fields' and 'evaluation items', respectively. Two evaluation domains, five fields and fifty items are set up as shown in Tables 2 and 3.

3.3 Determination of safety grade

Evaluation items and criteria were selected by several site inspections and expert meetings. The evaluation result is classified into five grades (A–E) according to the procedures shown in figure 1. First of all, the site inspection for safety grade assessment of PUBF is executed using the checklists with evaluation items, and each building or facility is given an appropriate safety grade. The inspection results are collected and reviewed at the committee for safety grade of buildings and facilities, and finally the committee decides the safety grade of each building or facility.

4 Evaluation methods using weighting factor

4.1 Generals

An evaluation method using a weighting factor for the individual items has generally been used in the decision making theory. In the life cycle assessment-

Table 2: General management in the evaluation domains.

No.	Evaluation item	Weight factor		
1	management & preparation of record form of individual fields	1.0	1.4	1.2
2	assignment of safety manager & establishment of response plan in absence	1.0	1.2	1.1
3	preparation of construction & design documents	1.0	1.0	1.0
4	preparation of emergency evacuation instructions	1.0	0.8	0.9
5	preparation of emergency contact form	1.0	0.6	0.8
	sum	5.0	5.0	5.0

Table 3: Evaluation items with weight factors in the fields.

Fields	No.	Evaluation item	Weight factor	
Architecture	1	adequacy of fireproofing	1.0	1.4
	2	status of principal structural members (crack, deflection, etc.)	1.0	1.3
	3	status of retaining wall, rubble masonry & fence (crack, exfoliation, tilting, etc.)	1.0	1.2
	4	potentiality of flooding in heavy rainfall & typhoon	1.0	1.1
	5	access route for emergency vehicles	1.0	1.0
	6	fireproof capacity of interior partition	1.0	1.0
	7	adequate status of stairway (height, width, nonslip, etc.)	1.0	0.9
	8	stability of handrails	1.0	0.8
	9	protrusion & danger factor of finishing materials	1.0	0.7
	10	defects of accessories (exfoliation, efflorescence, corrosion, etc.)	1.0	0.6
Sum			10.0	10.0
Fire fighting	1	blocking of refuge path & fireproof shutter	1.0	1.4
	2	blocking or multi-use of emergency exit	1.0	1.3
	3	status & adequate number of fire extinguisher	1.0	1.2
	4	status of maintenance & installation of refuge instruments	1.0	1.1
	5	status of maintenance & installation of refuge induction lamp & sign	1.0	1.0
	6	status of maintenance & installation of sprinkler	1.0	1.0
	7	status of maintenance & installation of water pipe & equipment	1.0	0.9
	8	status of maintenance & installation of emergency alarm equipment	1.0	0.8
	9	status of maintenance & installation of emergency lighting equipment	1.0	0.7
	10	isolation of combustible articles	1.0	0.6
Sum			10.0	10.0
Electricity	1	use of certificated electric cord	1.0	1.4
	2	status of electric cord cover, plug & contact part	1.0	1.3
	3	earthing status of electric instrument	1.0	1.2
	4	safe splicing of electric cords	1.0	1.1
	5	protection of electric cord on a walking way	1.0	1.0
	6	degradation of safety equipments	1.0	1.0
	7	status of safe & normal use of electric instruments	1.0	0.9
	8	maintenance of dangerous equipment in the substation	1.0	0.8
	9	simplicity of inspection & operation	1.0	0.7
	10	safe status of distributing panels	1.0	0.6
Sum			10.0	10.0
Gas	1	status of gas leakage (bubble test)	1.0	1.4
	2	status of maintenance & installation of gas leakage alarm box	1.0	1.3
	3	use of combustible articles around a storing vessel	1.0	1.2
	4	status of accessories & pipes	1.0	1.1
	5	draft status around the gas equipments	1.0	1.0
	6	distance of storing vessels	1.0	1.0
	7	passed year after installation & repair of gas equipments	1.0	0.9
	8	installation of MOV & auto interception instrument	1.0	0.8
	9	removal of static electricity	1.0	0.7
	10	protection of corrosion	1.0	0.6
Sum			10.0	10.0
Lift	1	status of emergency call button & interphone	1.0	1.4
	2	status of overloading sensor	1.0	1.3
	3	status of safety device of doors	1.0	1.2
	4	status of limit switch	1.0	1.1
	5	status of door interlock & switch	1.0	1.0
	6	status of emergency stop switch	1.0	1.0
	7	status of tension of belt & cable	1.0	0.9
	8	status of shock absorber	1.0	0.8
	9	status of speed regulator	1.0	0.7
	10	status of emergency lamp	1.0	0.6
Sum			10.0	10.0

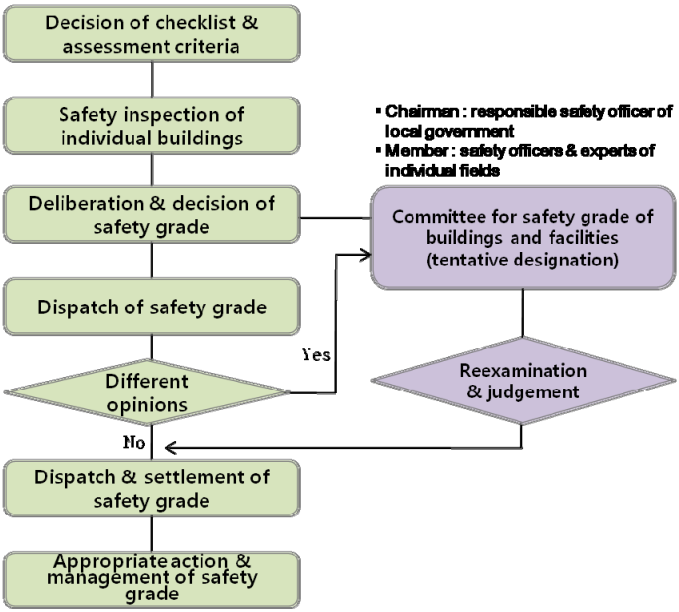

Figure 1: Assessment procedure for the safety grade.

multiple criteria decision making (e.g. Drucker [3]) method, main and sub criteria are decided, and then appropriate weighting factors are given to the individual criteria, which are determined by the Analytical Hierarchy Process using experts' opinions. Therefore, this method is correspondingly applied to assessment criteria for safety grade of PUBF. In addition, there are two methods to determine the weighting factors for the assessment criteria; in one of the method, a uniform weighting factor is used, and in the other, a varying weighting factor for each of the criterion. In this research, assessment criteria with 24 weighting factors are proposed as the result of this research.

4.2 Decision method in the evaluation domains

The evaluation domains are classified into general management and facility management, so decision methods of weighting factors are simply decided as two from the result of expert meeting. Those are uniform way or not; one is to treat the weights of individual domains equally, and the other is to treat the weights of evaluation items equally. The method is shown in Table 4.

Table 4: Weight factors of the evaluation domains.

Evaluation domain	Uniform weight factor (A-1)	Different weight factor (A-2)
General management	0.50	0.33
Facility management	0.50	0.67
Sum	1.00	1.00

A-1: In case of uniform weight factor, A-2: In case of different weight factor

Table 5: Weight factors of the evaluation fields.

Evaluation field	Uniform weight factor (B-1)	Different weight factor (B-2)
Architecture	0.20	0.22
Fire fighting	0.20	0.24
Electricity	0.20	0.18
Gas	0.20	0.20
Lift	0.20	0.16
Sum	1.00	1.00

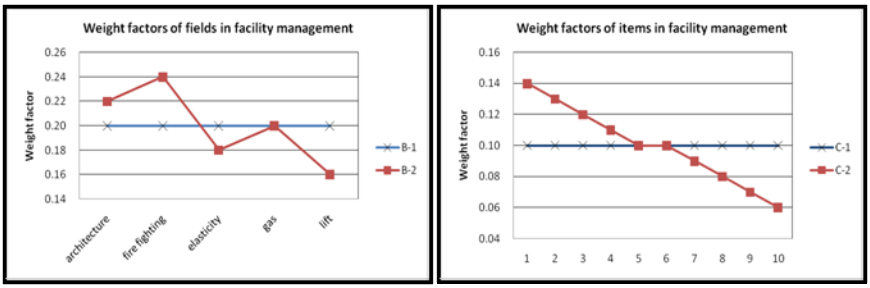

Figure 2: Weight factors for fields and items.

Table 6: Absolute and relative evaluation methods.

Safety grade	Absolute evaluation method			Relative evaluation method		
	Assessment Type α1	Assessment Type α2	Assessment Type α3	Assessment Type β1	Assessment Type β2	Assessment Type β3
A(excellent)	90-100	95-100	95-100	10%	15%	20%
B(high)	75-89	85-94	90-94	20%	30%	40%
C(moderate)	50-74	75-84	80-89	40%	40%	25%
D(low)	40-49	50-74	60-79	20%	10%	10%
E(vulnerable)	Less than 40	Less than 50	Less than 60	10%	5%	5%

4.3 Decision method in the evaluation fields

There are two methods to decide weighting factors in the evaluation fields, they are also uniform way or not as shown in Table 5. According to the related significance to frequency and casualty of accident or fire, the priority of the fields was decided by the result of expert meeting.

4.4 Decision method in the evaluation items

There are also two methods to decide weighting factors in the evaluation items: using uniform weighting factor or varying factors as shown in Table 3 and Figure 2.

4.5 Proposal of safety grading system for PUBF

Assessment methods to decide safety grade for PUBF can be diverse. In this research, we propose 3 methods of absolute evaluation and also 3 of relative evaluation as shown in Table 6.

Relative evaluation methods are based on normal or log normal distribution, etc. of the probability theory, so it is required to calculate the average and standard deviation and probabilistic distribution function of the sample set.

5 Assessment of safety grade for PUBF

The safety grade of PUBF was actually estimated to apply to safety grading system by the absolute evaluation method. The total number of PUBF in S city was 320, and they were considered in the assessment of safety grade.

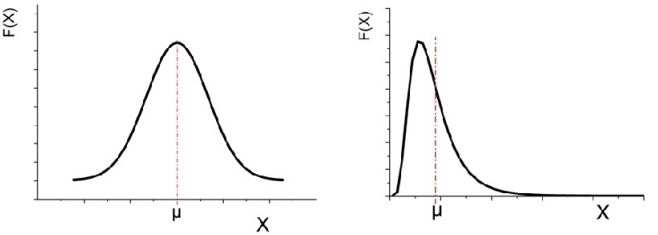

Figure 3: Normal and lognormal distribution.

Table 7: Assessment results of PUBF by the assessment type α2.

Major use	Grade					Sum
	A	B	C	D	E	
Sales	9	1	1	0	0	11
Lodging	14	30	0	4	0	48
Transportation	0	0	0	0	0	0
Performance	16	10	0	3	0	29
Assembly	1	0	0	0	0	1
Exhibition	7	7	1	0	0	15
Medical service	16	8	4	2	0	30
Religion	57	30	4	0	0	91
Leisure	15	40	1	7	0	63
Youth training	0	0	0	1	0	1
Video and PC game	24	2	0	5	0	31
Sum	159	128	11	22	0	320

This result was based on Dec. 2007 by NEMA, Korea.

Table 8: Transformation into the relative evaluation method.

Safety grade	Absolute evaluation method	Relative evaluation method		
	Assessment Type α2	Assessment Type β1	Assessment Type β2	Assessment Type β3
A	159	32	48	64
B	128	64	96	128
C	11	128	128	80
D	22	64	32	32
E	0	32	16	16
Sum	320	320	320	320

The assessment were performed and selected by assessment type α2 of the Absolute evaluation method and A-2, B-1 and C-1 in the weighting factors. The transformation from assessment result of PUBF into assessment type β1, β2 and β3 of relative evaluation methods is expressed in Table 8.

6 Conclusions

In this research we established a reasonable way to estimate safety grade of PUBF reasonably. Based on the result of the study, the following conclusions can be reached.

1) Analysis of related laws and regulations of PUBF
Most of PUBF are small scale ones, and for the smaller ones, relatively relaxed current laws and regulations are applied. And the expenses for PUBF management are increased and spent redundantly, since the separate inspections are executed for each sectors.

2) Decision of evaluation domains, fields and items
Evaluation domains, fields and items were decided to estimate safety of PUBF; evaluation domains were general and facility management, and 5 evaluation fields and 50 items were decided.

3) Decision of safety grade
Safety grade was decided as 5 levels: A (excellent), B (high), C (moderate), D (low) and E (vulnerable).

4) Proposal of safety grading system
3 assessment methods of absolute evaluation and 3 of relative ones are proposed, based on normal or log normal distribution.

5) Actual assessment result of safety grade for PUBF
The safety grade of PUBF was actually estimated by the type α2 of the absolute evaluation method and A-2, B-1 and C-1 in the weighting factors, and the result was decided as A of 159, B of 128, C of 11 and D of 22.

6) Future research
Further research of site inspection and feedback by expert meeting comprehensively is needed to establish evaluation model based on the assessment criteria proposed in this research.

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