Validity Estimation and Improvement Scheme of Safety Certification System for Temporary Equipment and Materials in South Korea

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Abstract- In this study, safety certification system of temporary equipment and materials established in domestic and foreign countries are compared and how to improve it and how to secure the safety are suggested. Validity of the system is investigated based on the internet and/or field visit surveys and an actual implementation of the system has been investigated for currently used temporary equipment and materials. Survey results show that an appropriateness of the items, required for an approval of the safety certification is 'yes(36%)', 'no(30%)', and 'unknown(24%)', respectively. Most of respondents answer that the current system does not reflect the transitional change of construction environments. In this study, the items of the current safety certification system, its size, its practicability, and the certification methods are reevaluated and then the improvement schemes of the system are provided.

Index Terms- Temporary Equipment and Materials, Safety Certification System, Survey, Construction Environments, Improvement Schemes

I. Introduction

Large scale, high rise, complex, and underground structures of infrastructures have been built in recent years. Disasters are caused by temporary equipment and materials (TEMs) installed and dissected during construction (Kim & Paik, 2010; Oh et al., 2014) [1-2]. TEM are installed in the process of construction associated with an essential safety facility to prevent disasters at construction sites. To prevent disaster, a safety certification system of TEM has been performed based on the occupation safety and health acts. There is an enforced safety certification system controlling twelve types of protection facilities, such as fall and collapse, and an autonomic safety certification system with eight types of protection facilities.

Manufacture and lease companies for TEM imported the enforced safety certification system and the autonomic safety certification system to secure its safety. As it is installed, the installation methods and standards developed by its regulations and the standards of industrial safety health care have been provided to employers, installers, and users. It has been reused by the management standards of automotive registration for reuse of TEM. The system was initiated in 2009 (Lee et al., 2015) [3] and a ratio of overall accidents has been reduced except particular items after it is enforced. However, the number of accidents related to TEM has been increased at construction sites. KOSHA(Korea Occupational Safety Health Agency) reported for the cases and countermeasure of serious construction disaster shows increased number of accidents (Table 1) (Korea Occupational Safety & Health Agency, 2016) [4].

Although a policy to prevent disasters induced by the TEM has been established, the accidents are continuously occurred at construction sites. Therefore, the safety certification system should be reexamined with regard to suitability of currently used certified TEM for safety. Estimation of its validity should be carried out and also improvement scheme should be proposed. In this study, international criteria of TEM are compared and then statistical analysis of survey results of 281 employees (manufactures (n=50), distribution (n=51), and usage (n=170)) working in the construction company related to the TEM is performed to improve the system and to secure its stability.

II. Background

Case Studies of Failures

In previous research, the problems and limitation of the system were examined in previous research (Kim et al, 2011) [5] (Table 2). It shows that the problems occurred in the process of manufacture and distribution. Various types of disasters occurred in construction sites have been mostly induced by unsafe structures of temporary equipment. It shows the collapse

of upper plate during construction of bridge slabs on March 2015 and it resulted in nine life loss (NEWSIS, 2015a) [6] (Fig. 1(a)). The collapse of complex gymnasium during construction of cast-in-place concrete on February 2015 and eleven workers were buried in the building (NEWSIS, 2015b) [7] (Fig. 1(b)). It was induced by a lack of resistance of self-weight. Fall of seven workers and the problem was induced by connection between scaffold and building on July 2015 (Daejeonilbo, 2015)[8] (Fig. 1(c)) and scaffold for new building of school was collapsed on June 2014 (Kyungbookmaeil, 2015) [9] (Fig. 1(d)). These failures were resulted from workers' carelessness and insufficient safety inspection. Disasters related to TEM have been occurred even after enforced inspection of safety certification system. Therefore, it is necessary to figure out how temporary structures are manufactured and distributed.

Safety Certification System

The research has been carried out to investigate how the management system certification influences on safety management and performance (Vinodkumar & Bhasi, 2011; Granerud & Rocha, 2011; Wachter & Yorio, 2014; Yorio et al., 2015; Mohammadfam et al., 2017; Ghahramani & Salminen, 2019) [10-15]. Safety certification system is similar in Japan, Europe, and the US. The system in Japan is managed by the association of temporary structures and is quite similar to that in South Korea. There is no registration process for reuse of temporary structures and defective products are prohibited to be used in both Europe and the US (Table 3). Therefore, after the safety of TEM is secured, TEM should be reevaluated and redistributed to automotive safety verification report in South Korea.

After amendments of regulations for scaffold provided by Occupational Safety and Health Administration (OSHA) in the US, the inspections of 4,224 were conducted and violations of 10,820 were found per year (Fig. 2). Before its amendments, the inspections of 3,228 were performed and violations of 6,912 were found per year (Yassin & Martonik, 2004) [16]. Inspections and violations were increased by 1.3 and 2 times after the amendments. It reflects that the number of inspections is very important.

Twenty six items are required to be inspected based on standard safety work guidelines for construction of temporary structures in South Korea. Eleven items are related to scaffold in both New Zealand and the US (Occupational Safety and Health Administration, 2002) [17] (Table 3). Work guidelines in South Korea provide both allowable stress and materials of items. In New Zealand, it is managed by provision of law in addition to the guidelines work specification. Provided items are described in detail with respect to specific precise photographs and pictures (Worksafe, 2009) [18].

In England, various certification levels for both installation and disassembling of scaffold are issued (CISRS, 2013) [19] after one-day training for scaffold installation (Fig. 3(a)). The certified person, a trainee scaffolder, has a work limitation not to progress task without an approval of officer for scaffold installation. It is a first step of a certification for scaffolds.

It shows a certification issued to a scaffolder who experiences six-month practices and completes an education of introductory and of intermediate level for two weeks, respectively (Fig. 3(b)). Finally, a trainee scaffolder should pass the test for an introductory level of vocational qualification (VQ) and VQ2 Shows a certification issued to an advanced scaffolder who experiences more than twelve-month practices and completes education of VQ3 (Fig. 3(c)). Advanced scaffolder, a qualified leader to install, change, and disassemble scaffolds, is able to interpret complicated design drawings.

Qualification system associated with various certifications and education required for the officers handling TEM should be adopted for certified person to have a responsibility within his own work scopes.

III. Surveys

Objectives of Survey

Surveys were carried out to examine both utilization and validity of current safety certification system for TEM used in manufacture, lease, and construction companies. In this study, improvement plan of currently used safety system is suggested for newly developed TEM and items and completely assembled items to reflect the conditions of construction sites.

Questionnaire Survey Target

It was conducted a survey of 50, 51, and 170 employee working in manufacture, lease, and construction companies, respectively (Table 5). Lists employee's work experience categorized as 'greater than twenty years', 'greater than fifteen years and less than twenty years', 'greater than ten years and less than fifteen years', 'greater than five years and less than ten years', and 'less than five years' (Table 6). The number of employee working in the company is categorized by as 'greater than three hundreds', 'greater than one hundred and less than three hundreds', 'greater than fifty and less than one hundred', 'greater than twenty and less than fifty', and 'less than twenty' (Table 7). Surveys were carried out by using internet and field visit interview for two months from June to July 2015. Survey results for twenty-five survey questions have been analyzed.

Survey Questions

Surveys include downsize or expansion plan of the items for both obligation of safety certification and automotive safety verification suggested by employee working in manufacture, lease, and construction companies. Regulations and standards for TEM have been examined to figure out appropriateness of currently used legislative and institutional conditions.

How safety check is carried out for both members of structure and completely assembled structures and how the safety certification system is flexible to approve for new materials and items associated with various shapes, structures, and materials. Construction using upgraded TEM has been internationally carried out. It is questionnaire how safety certification is approved for both new materials and new shape of internationally certified TEM. There is a survey how durable and economic TEM is utilized and how efficiently establish

maintenance, termination, expansion, and improvement for currently safety system.

IV. Survey Results

Perception of Safety Certification System

It indicates how much employee percepts safety certification system for TEM and chi-square test results representing statistical validation with significance level of 5% (Table 8). Survey results show that only 38% of respondents percepts the safety certification system. Education and publicity for the safety certification system should be activated and the certification should be issued only to the person who has a full responsibility.

Suitability of TEM Items

Survey results show that the suitableness, unsuitableness, and imperceptions for TEM items have proportions of 36%, 30%, and 34% of respondents, respectively. It shows that most of respondents are unsatisfied with current TEM items issued by safety certification system. 49% and 25% of respondents say that it doesn't reflect site conditions and a large amount of unnecessary required documents needs to be submitted, respectively. Therefore, standardized types and materials of TEM should be reexamined and reorganized to reflect construction site conditions and to increase construction stability.

Accident rates of TEM and Application Process of Safety Certification System

Survey results show that 47% of respondents answered for the question of which the safety certification system for the TEM has been successfully carried out to reduce accident rates. It explains that current safety certification system helps to prevent accidents in construction sites. However, most problematic issues are an excessive application process to be certified (43%), high standards of safety certification system (21%), and excessive application fee (21%). Therefore, the current safety certification system is to be revised.

Method of Marking for TEM Certification

Survey results show that 52% and 28% of respondents suggest that TEM can be efficiently marked by seal carving and should have the least number of marking, respectively. Therefore, more appropriate methods should be developed to avoid that the mark is erased or hard to be figured out as time goes.

Perception Level of Automotive Registration System for Reusable TEM

Survey results show that 46% and 33% of respondents fully and partially perceive an automotive registration system, respectively. However, most of respondents agree that the system is inappropriate because it requires an excessive and an excessive amount of required specimens (7%). The current system should be revised to increase the safety for reused TEM.

Certification Schemes for Newly Developed Domestic and Imported TEM Item

Current system certifies just for specifically fixed types and materials of TEM. Therefore, the system does not reflect a rapidly changed industrial field and newly developed TEM are prohibited to be certified. The current system should be revised to resolve these problems.

Use of Sub-Quality TEM Items

Use of illegal TEM is resulted from lower price (37%), a simple process of use (25%) and purchase (20%), and disuse (17%).

Solution to Prevent Continuously Manufactured and Distributed Sub-quality TEM

To resolve the problem of widely used sub-quality TEM is education and publicity (46%) to workers, strict law application to manufacture and distribution companies (28%), reinforcement of surveillance and supervise market (19%).

V. Conclusions

Survey results show that employee currently working in the company related to TEM should figure out its characteristics. The upgraded systematic education system and the certification system for scaffold installation in England need to be settled down in South Korea to increase their own responsibility and to clearly define the responsible object.

Unfortunately, newly developed TEM are prohibited to be used in the fields. TEM controlled by both an enforced safety certification system and autonomic safety certification system should be changed to reflect field conditions not to be restricted as fixed shapes and materials.

Large portion of disasters is induced by the use of illegal or sub-quality TEM. Its use is mainly from 'lower price' and 'simple process to purchase and use'. Therefore, it is recommended that the process to certify TEM should be simple and the safety certification system should cover only for essential items. Automotive registration for reuse of TEM should be managed by expertise recommended by evaluation committee. Supervision of installation, use, and maintenance is necessary with enhancement of the penalty and fines.

The last issue is a marking method to certify TEM and post management for the reuse of TEM. The problem is mostly due to excessive application and certification process, which is unnecessary and overlapped. Since post management of TEM is not adequately carried out, the certified mark in TEM is erased or disappeared with elapsed time. Therefore, efficient management is required to avoid duplicated regulation for frequently identified items. TEM should be managed by carving a seal for reuse.

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Validity estimation and improvement scheme of safety certification system for temporary equipment and materials in South Korea

Table 1
Accidents and life loss during construction in South Korea.

	Type	Total	Drop	Fall	Hit	Beat	Collapse	Other
Dec. 2015	Number of accidents	24,287	8,259	3,594	2,219	3,168	327	6,720
	Number of deaths	437	257	3	46	28	27	76
Dec. 2014	Number of accidents	22,935	7,908	3,385	2,045	3,002	308	6,287
	Number of deaths	434	256	5	35	29	29	80
Increment or Decrement	Number of accidents	1,352	351	209	174	166	19	433
	Number of deaths	3	1	-2	11	-1	-2	4
Increment or Decrement ratio (%)	Number of accidents	5.9	4.4	6.2	8.5	5.5	6.2	6.9
	Number of deaths	0.7	0.4	-40.0	31.4	-3.4	-6.9	-5.0

Table 2
Problems of currently used safety certification standards for temporary equipment and materials.

Enforced safety certification system	- Standardized item products - Lack of technical development
Autonomy safety certification system	- Difficult to manage reusable temporary equipment and materials
Discretionary certification	- Insufficient standards - Use of disqualified items

Table 3
System for temporary equipment and materials

TYPE	South Korea	Japan	The US & Europe
Verification system	Safety Certification System	Accreditation and inspection systems	-Absence of performance verification for TEM
Legal basis	Section 34 and 35 of Industrial Safety Health	Accreditation and inspection systems	-Legal standardization based on verification standards
Targeted items	-12 types & 3 items for obligated safety certification for TEM -8 types of autonomy safety certification for TEM	-19 types of regulatory targets -30 types of scaffolding and construction equipment association	Mainly scaffolds and its members
Reuse management system	Reusable TEM voluntary registration system	-Management system for secular TEM -Automotive management of manufacturers association for TEM	Absence

Table 4
Work Specification for Scaffolding in Foreign Countries

Classification	The US	New Zealand
Organization	**OSHA**	**MBIE**
Specification	Scaffold use in the construction industry	Scaffolding - Best practice guideline for scaffolding in New Zealand
Inspection Item	-Fall protection or fall arrest systems -Guardrail height -Cross bracing -Midrails -Footings -Platforms -Guying ties, and braces -Capacity -Training -Inspections -Erecting and Dismantling	-Scaffold tube -Couplers -Base plates -Adjustable leg /baseplate/castor -Castors -Prefabricated structural components -Timber planks -Metal scaffold planks -Steel wire ropes -Chains -Shackles

Table 5
Number of Respondents

Objects	Respondents	%
Manufacture Company	50	18
Lease Company	51	19
Construction Company	170	63
Total	271	100

Table 6
Respondents' work experience

Work experience (years)	Respondents	%
20 years ≤ x	41	15
15 years ≤ x < 20 years	56	21
10 years ≤ x < 15 years	68	25
5 years ≤ x < 10 years	64	24
x < 5 years	42	15
Total	271	100

Table 7
Number of employee working in the company

Number of employee	Respondents	%
300 ≤ x	32	12
100 ≤ x < 300	74	27
50 ≤ x < 100	54	20
20 ≤ x < 50	51	19
x < 20	60	22
Total	271	100

Table 8
Survey Results

Variables	Category	Respondent						
		Manu -facture	P-value	Lessor	P-value	User	P-value	Total
			0.007		0.001		0.001	
Perception of safety certification system	Yes	13		16		71		100(38%)
	No	9		6		16		31(12%)
	Partial perception	26		27		82		135(51%)
			0.49		0.08		0.467	
Appropriateness of safety certification items	Yes	18		15		63		96(36%)
	No	13		11		56		80(30%)
	Unknown	19		24		51		94(35%)
			0.736		0.287		0.001	
Certification problems TEM	No reflection of construction conditions	8		8		44		60(49%)
	Inappropriate process	6		6		1		13(11%)
	Excessive document materials	7		9		14		30(25%)
	Long period to be certified	5		3		3		11(9%)
	etc.	2		1		5		8(7%)
			0.646		0.486		0.001	
Appropriateness of safety certification process and application	Yes	13		14		43		70(27%)
	No	17		14		44		75(28%)
	Unknown	18		21		80		119(45%)
			0.074		0.947		0.001	
Improvement for certification labeling	Carving a mark	23		18		94		135(52%)
	Sticker attachment	11		16		33		60(23%)
	Mark with least description mark	12		16		33		61(23%)
	etc.	0		1		5		6(2%)
			0.390		0.003		0.002	
Perception of self registration system for reusable TEM	Yes	21		27		75		123(46%)
	No	13		7		38		58(21%)
	Unknown	16		16		57		89(33%)
			0.068		0.010		0.064	
Reason to approve new TEM	Reflection on environmental construction conditions	14		19		43		76(29%)
	Use of current certification system	17		16		36		69(27%)
	Introduction of new certification system	6		3		30		39(15%)
	Supplement of current certification system	9		11		53		73(28%)
	etc.	0		0		2		2(1%)
			0.162		0.035		0.001	
Reason of sale, lease, and use for sub-quality TEM or no use of TEM	Lower price than certified item	14		17		66		97(37%)
	Simple process to purchase	9		17		27		53(20%)
	Simple process to use	7		11		47		65(25%)
	No use for disqualified item	18		5		21		44(17%)
	etc.	0		0		4		4(2%)
			0.057		0.003		0.008	
New Classification of TEM	Keep current item	11		12		28		51(22%)
	Reduce to least number of items	20		5		56		81(35%)
	Change the item in reference to foreign country	9		4		34		47(20%)
	Change the item from certification system to self-control safety confirmation registration	7		0		39		46(20%)
	etc.	0		0		6		6(3%)

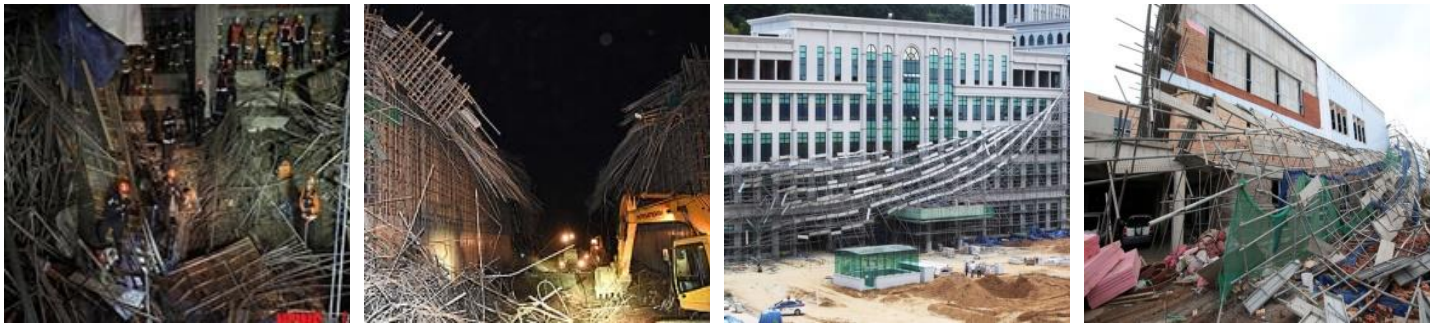

Fig. 1. Failures induced by use of inappropriate temporary equipments and materials: (a) Nengsumulcheon Bridge in Yongin city; (b) Sadang Complex Gymnasium in Seoul city; (c) University Building in Cheonan City; (d) New Construction Sites in Pohang City

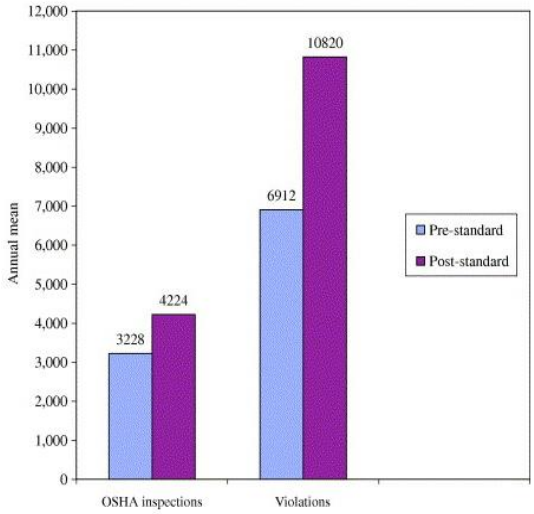

Fig. 2. Annual mean OSHA inspections and cited violations of scaffold safety in the pre-standard and post-standard periods [19]

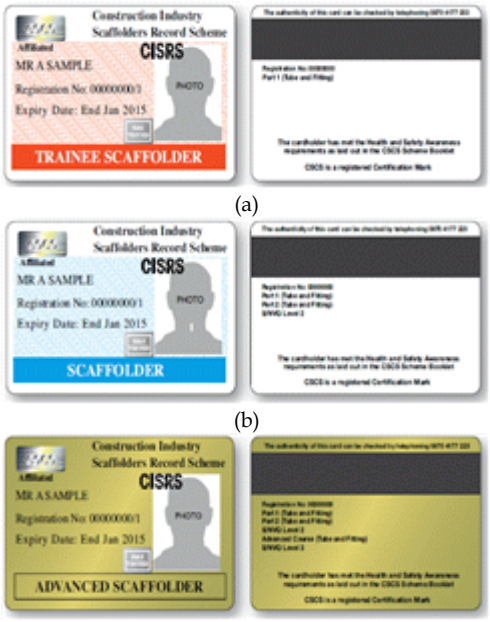

Fig. 3. Various certification levels: (a) trainee scaffolder - tube and fitting; (b) scaffolder - tube and fitting; (c) advanced scaffolder [22]