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Country Report

A roadmap to improve usage items to enhance the operational effectiveness of occupational safety and health management expense in Korean construction

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Abstract: Occupational safety and health management expense (OSHE) in construction industry is a statutory expense used for the purpose of preventing occupational accident and health disorders for construction workers, and the detailed usage standard is stipulated in the law and regulations governed by the Ministry of Employment and Labor in Korea. Previous studies focused on improvement of the accounting rate of OSHE and institutional improvement to secure usage transparency, but analysis showed that the review of improvement directions for usage items was insufficient. Considering recent trends, such as the increase in industrial demand to improve existing usage items and the introduction of various smart safety products incorporating the Fourth Industrial Revolution technology, it is expected that it will be necessary to review ways to improve the usage items to enhance the operational efficiency of OSHE. Accordingly, this study collected opinions from various stakeholders, and presented a roadmap to improve usage items of OSHE through importance-performance analysis (IPA) based on the data. This study is expected to meet the needs demanded by industry, and to be utilized as a reference for policy preparation to enhance the safety of construction sites.

Key words: Construction, Occupational health and safety management expense (OSHE), Usage items, Operational effectiveness, Importance-performance analysis, Roadmap

Introduction

The construction industry has been evaluated as one of the most dangerous industries in the world, and due to such characteristic, occupational safety and health management

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expense (OSHE) used to prevent occupational accidents and health disorders of workers is accounted as one of the construction cost[1–11]. Each country, such as the US, Japan, and EU countries, operates various methods to account for OSHE based on work safety and health laws, as follows. First, in the US, OSHE is calculated by using similar case information to that of projects performed in the past[10]. Second, Japan separately calculates OSHE-related items in the construction cost items, such as common temporary cost, which are differentially applied based on the type and size of project[9–11]. Third, among EU countries, Germany calculates OSHE by multiplying rates published by construction accident insurance funds, and Switzerland differentially calculates OSHE by multiplying rates for each project type (e.g., apartment 1.0%, office 0.2%, tunnel 1.0%) based on the total construction cost[10, 11]. In other words, it can be interpreted that countries worldwide have a consensus on the importance of OSHE for the purpose of ensuring the safety and preventing health disorder of construction site workers.

In the case of Korea, OSHE is included in the construction cost as an independent statutory expense, based on Article 72 of the Occupational Safety and Health Act under the jurisdiction of the Ministry of Employment and Labor (MOEL)[12]. OSHE in Korea is calculated by multiplying the sum of direct labor and material cost by the differential rates according to project type and size[7, 11]. In other words, it can be analyzed as similar to the case of Japan, in that separate regulation is prepared for the calculation of OSHE. However, the most unique characteristic of Korea compared to other countries is that regulations on the use and non-use items related to OSHE have been stipulated in the notice of MOEL[13]. In detail, the items that can be used for OSHE in the notice are composed of 8 items, such as labor cost of safety manager and safety facility installation cost, and the use and non-use regulations are stipulated in Article 7 of the main body and Attached Table 2, respectively. In the notice, only expenses that are used for the purpose of securing the safety and health of workers are recognized; if some work support purposes are included, they are defined as items that cannot be used. Such regulations can be said to be legal actions by the Korean government to induce the transparent use of OSHE. According to the unique characteristic in Korea, most of the previous studies have been conducted mainly on the aspect of rate improvement and use transparency as follows; (1) improvement of the accounting rate for OSHE[7, 14, 15]; (2) appropriate calculation method of OSHE using statistical methodologies[8, 11, 16–18]; and (3) direction of strengthening regulations to ensure use transparency in OSHE[9, 19, 20].

Despite such efforts to ensure transparency in the use of OSHE, occupational accident rates in the Korean construction industry are generally increasing. With respect to fatal accidents classified as serious accidents, the fatality accidents per 10,000 people in construction is showing an overall increasing trend from 1.30 to 2.00 in 2015 to 2020, respectively[21]. As a way of solving this problem, the Korean construction industry is demanding that the regulations on the items used for OSHE be improved, so that items for securing the safety and health of workers can be used even if some work purposes are included. Furthermore, according to the global trend of the Fourth Industrial Revolution, the need of the construction industry to use smart safety products and systems, which are recently attracting attention, as OSHE is increasing. Such demands from the Korean construction industry can be confirmed through the example in the questionnaire book published yearly by the MOEL as follows[22]; (1) the head lantern is not recognized as a usage item because it supports work in a dark place, but it needs to be recognized because it is highly effective in preventing worker accidents; (2) the safety vest with built-in airbags needs to be recognized, because it can prevent the death of workers in fall accidents. Therefore, it is expected that study on direction of the improvement of the usage items to enhance the operational efficiency of OSHE is required.

Thus, this study presents a roadmap that can review the improvement direction of the usage items of OSHE in Korea based on realistic opinions collected from various stakeholders, such as public client, safety manager, and accident prevention agency. The research procedures are as follows. First, for the Korean construction industry, the calculation method of OSHE, the status of accident, and the need for a roadmap to improve the usage items for OSHE were reviewed. Second, a pool of usage items that need improvement was established through analysis of the questionnaire book published by MOEL and interviews with stakeholders, and the final analysis target was set through expert advice. Third, data on the importance and effectiveness of each usage item were collected through a survey of target stakeholders directly related to the use of OSHE, such as safety managers. Fourth, the data was refined, and an improvement roadmap was presented based on the analysis results using the importance-performance analysis (IPA) method. Finally, to secure the reality of a roadmap, it was supplemented through expert advice, and implications for the final results were presented.

Table 1. Accounting rate of OSHE in Korea

Project type	Project size			Required to hire a safety manager (%)
	A. Less than 500 million KRW (%)	B. 500 million KRW or more and less than 5 billion KRW	C. More than 5 billion KRW (%)	
General construction (A)	2.93	1.86% + 5.349 million KRW	1.97	2.15
General construction (B)	3.09	1.99% + 5.499 million KRW	2.10	2.29
Heavy construction	3.43	2.35% + 5.400 million KRW	2.44	2.66
Railway construction	2.45	1.57% + 4.411 million KRW	1.66	1.81
Special construction	1.85	1.20% + 3.250 million KRW	1.27	1.38

Subjects and Methods

Calculation method and use regulation of OSHE

OSHE in the Korean construction industry is stipulated to be included in cases where the total construction cost is 20 million KRW or more, among the projects affected by Article 6 of the Industrial Accident Compensation Insurance Act[13, 23]. OSHE is calculated by multiplying the standard amount by the rate according to the type and size of project. Here, the standard amount is defined as the sum of direct labor cost and material cost. In cases where the standard amount cannot be calculated, such as a project ordered by the design-build method, it is estimated and applied as 70% of the total construction cost[13]. In addition, an accounting rate has been operating to be applied differentially according to the type and size of project as shown in Table 1[12, 13]. In particular, when the project size is B, the baseline cost (e.g., 5.349 million KRW) is added to prevent the problem of the OSHE being calculated lower than other sizes when operating only at the rate. Furthermore, it is characterized by separately defining the rates for projects that require the hiring of health managers based on the contents of the Occupational Safety and Health Act.

In the notice of MOEL, it is stipulated that the calculated OSHE can be used for the following 8 items[13]; (1) labor costs for safety manager; (2) costs related to safety facility installation and maintenance; (3) costs related to personal protective equipment purchase and maintenance; (4) costs for safety and health diagnosis at construction site; (5) costs for safety and health education; (6) costs for the health protection of workers; (7) cost for technical guidance of accident prevention agency; and (8) costs for the safety organization to be in the construction headquarters. These items should be used only for the purpose of protecting workers, and they are operated so that no payment is made for expenses that are used that are inconsistent with regulations.

Namely, OSHE in Korea has the unique characteristic that it is counted as an independent expense within the construction cost according to the method stipulated by law, and is recognized only for expenses operated in accordance with the usage standards.

Status analysis of accident in the Korean construction industry

The construction industry has been recognized as an industry with a high potential risk of occupational accidents worldwide[24], and the Korean construction industry is no exception. Fig. 1 shows that according to the annual statistics released by MOEL, the occupational accident rate and fatality rate in all industries and the manufacturing industry are on the decline, whereas the construction industry shows an overall upward trend[21].

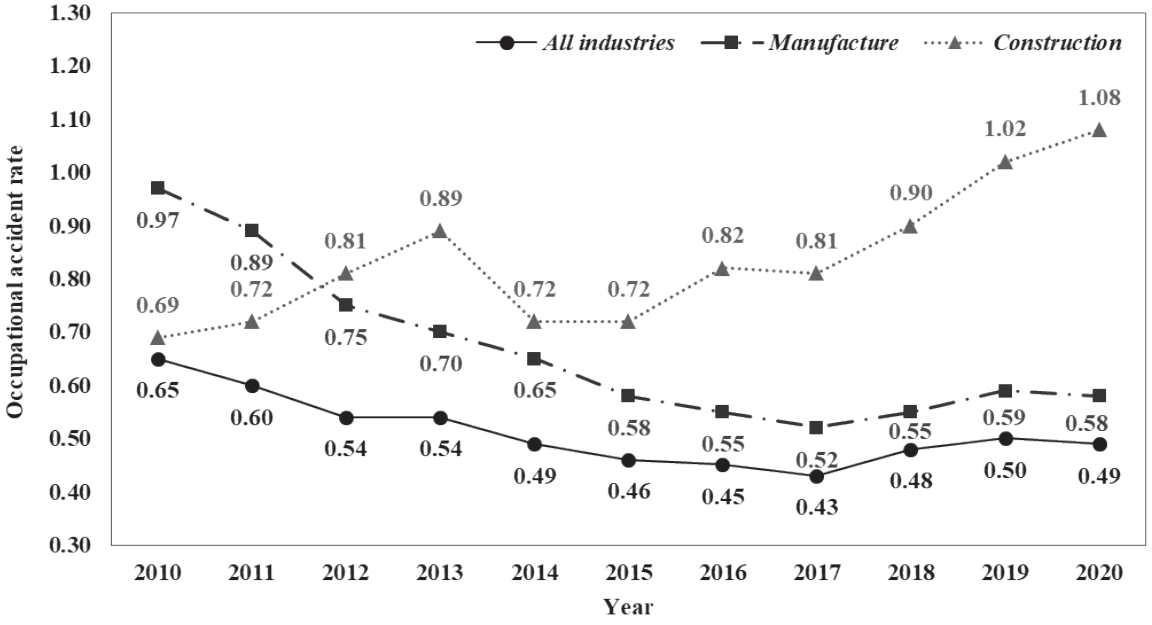
As shown above figure, it was analyzed that the rates in construction industry after 2010 showed an increasing trend in all periods except 2013 to 2014, unlike the overall downward trend in other industries. In particular, the occupational accident rate in 2020, construction industry was considered to be 1.08, which is about twice as much as 0.49 for all industries. Furthermore, the fatality rate, which is determined by the death rate in industrial accidents per ten thousand employees, it was evaluated as 2.00 in 2020, and it was analyzed that it represents the second highest figure since 2010.

Need for a roadmap to improve the usage items for OSHE

OSHE in Korea is being operated in accordance with the accounting method and usage standard stipulated by laws and regulations to ensure use transparency. Despite such a system, the accident rate in construction has been maintained a higher level than in other industries. Therefore, it is expected that it will be necessary to review the improvement direction for the usage items to improve the operational efficiency of OSHE. According to the questionnaire published by MOEL[22], as shown in Table 2, it was analyzed that the industry requesting the improvement of usage items.

Namely, it is expected that it is necessary to improve the

A



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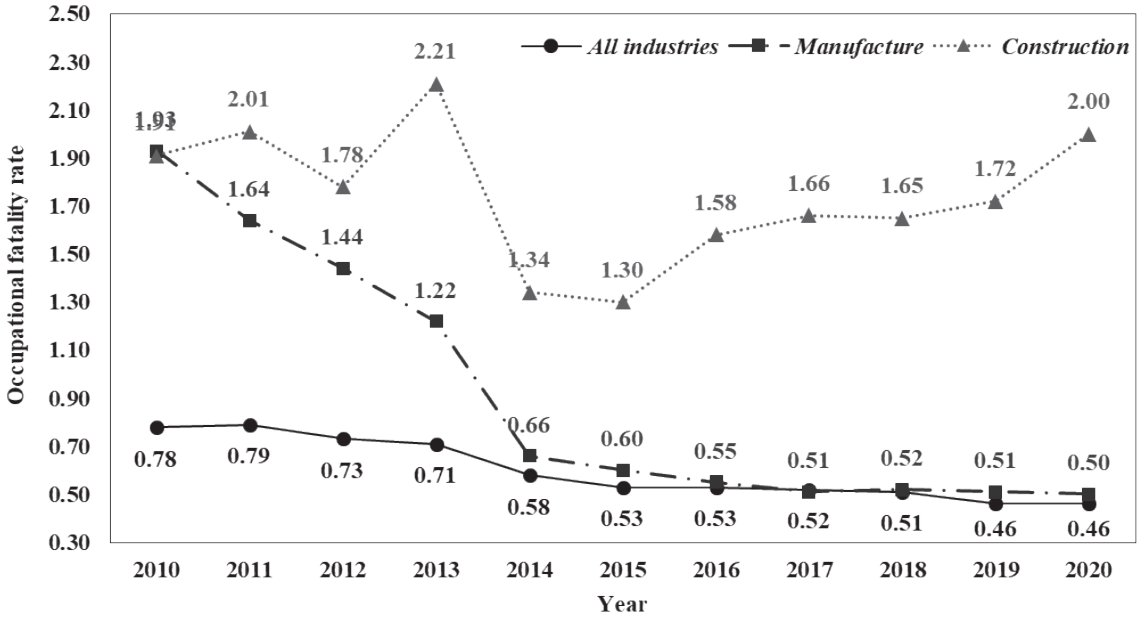


Fig. 1. Status of occupational accident rate and fatality rate in Korea; (A) Accident rate; and (B) fatality rate.

Table 2. Example of questions about usage items for OSHE

Classification	Example
Conventional item	· Head lantern that can be used in dark place where it is difficult for workers to see
	· Explosion-proof lamp for use in location where flammable materials are used
Smart safety product	· Smart management system for the purpose of preventing workers from accessing hazardous areas and preventing vehicle collision accidents
	· Safety vest with built-in airbag to prevent death in the event of a fall accident

Table 3. Recognition of the need to improve usage items for OSHE

Classification	Average Career (year)	Recognition (person)		
		Agree	Oppose	Sum
Public client	14.3	4	1	5
Construction firm	17.4	8	2	10
Accident prevention agency	22.3	3	-	3
Relevant association	18.3	3	-	3
Total	18.1	18	3	21

method of operating smart safety products with cutting edge technology, such as the IoT and existing unusable items that are highly effective in preventing workers' accidents as OSHE.

Furthermore, as results of a survey on the perception of the need for such improvement directions on a 5-point Likert scale targeting various stakeholders related to OSHE, the necessity was analyzed to be very high as shown in Table 3. In the table, responses ranging from moderate to very necessary were positive, and from not necessary to very necessary, negative, and as a result, it was analyzed that 18 out of 21 stakeholders agreed with the necessity.

The results of examining the detailed reasons for improvement of use items are as follows; (1) although the list consists of items that cannot be used in the current notice, there are items that are very helpful in preventing workers' accidents when recognized as a use item; and (2) the introduction of smart safety products offers effective alternatives to prevent occupational accidents that may occur in the gray zone of safety management. However, in the case of negative opinions, it was suggested that problems such as lack of costs for the installation of essential safety facilities may arise through improvement of the usage items.

Therefore, considering that the amount of use for OSHE is determined based on laws and regulations, a roadmap is needed to review the improvement direction in stages rather than unconditionally expanding the items to be used. The preparation of such a roadmap is expected to be a way to preemptively prevent problems such as the lack of expenses for the safety of workers, which may be caused by the expansion of usage items.

Derivation of usage items that required improvement

As a result of the investigation through the stakeholder interviews (presented in Table 3) on the items that require recognition as usage items of OSHE, a total of 57 items (33 conventional items, and 24 smart safety products) were derived, as shown in Table 4.

In particular, it was analyzed that among the items requiring improvement, safety facilities and personal protective equipment-related items accounted for a high proportion of about 79% of the total number of cases. This is expected as a result of reflecting the realistic perception that safety facilities installed on-site are a preemptive tool for preventing workers' accidents, and personal protective equipment is the last tool that can protect workers in case of an accident.

This study was conducted through expert consultations organized as shown in Table 5 on the derived items. The average experience related to OSHE of 8 experts who conducted the review was analyzed to be about 14 years. Through expert advice, the intrinsic purpose of the items that need improvement for work support, or items that are stipulated as compulsory in other laws and regulations, were excluded. In addition, ice maker and ice box can be implemented as welfare expenses and at the same time as OSHE in summer season (June to October), researchers reviewed these items as excluding then from the analysis target. However, experts suggested that they should be included in the analysis target in order to respond to the current situation where workers' accidents due to high temperature are occurring outside the period specified in the notice of

Table 4. Example of pool configuration to improve usage items for OSHE

Cost classification (number of configuration items)	Representative example	
	Conventional item	Smart safety product
Labor (conventional 4)	Traffic signaler, Assistant for ladder work, Assistant at worksites without safety and health manager	-
Safety facility installation (conventional 15, smart 13)	Safety temporary structures, Traffic safety equipment, Replacement of sling belt for crane, Explosion-proof lamp, Auxiliary device for the prevention of musculoskeletal disorders, Calcium chloride storage box	Hazardous area approach detection system, Equipment approach warning system, Smart safety management system using sensors, Bio-signal-based accident monitoring system, Bluetooth-based worker hazard warning equipment
Personal protect equipment (conventional 7, smart 10)	Equipment for musculoskeletal disorders, Head lantern, Sun-cream, Power line protection, Winter clothes and gloves, Raincoat	Wearable robot for the prevention of musculoskeletal disorders, Sensor-based smart safety helmet, Safety vest with built-in airbag
Safety and Health Diagnosis of Workplace (conventional 2)	Non-destructive testing of construction equipment, Non-destructive testing of temporary structures	-
Safety and Health Education (conventional 1, smart 1)	Safety construction education for electrical construction(for safety managers)	Educational facilities using VR
Health Care for Workers (conventional 4)	Ice maker, Ice box, Temporary rest facilities, Welfare facilities(e.g., portable bed)	-
Total Number (EA)	33	24

Table 5. Overview of experts

Classification	Number (person)	Average Career (year)
Government practitioner	1	13
Professor	3	14.4
Safety manager	2	16.5
Researcher	2	14.5
Total	8	14.6

MOEL. Reflecting such expert advice, this study included an ice maker and an ice box as analysis targets to improve usage items of OSHE.

Data analysis method

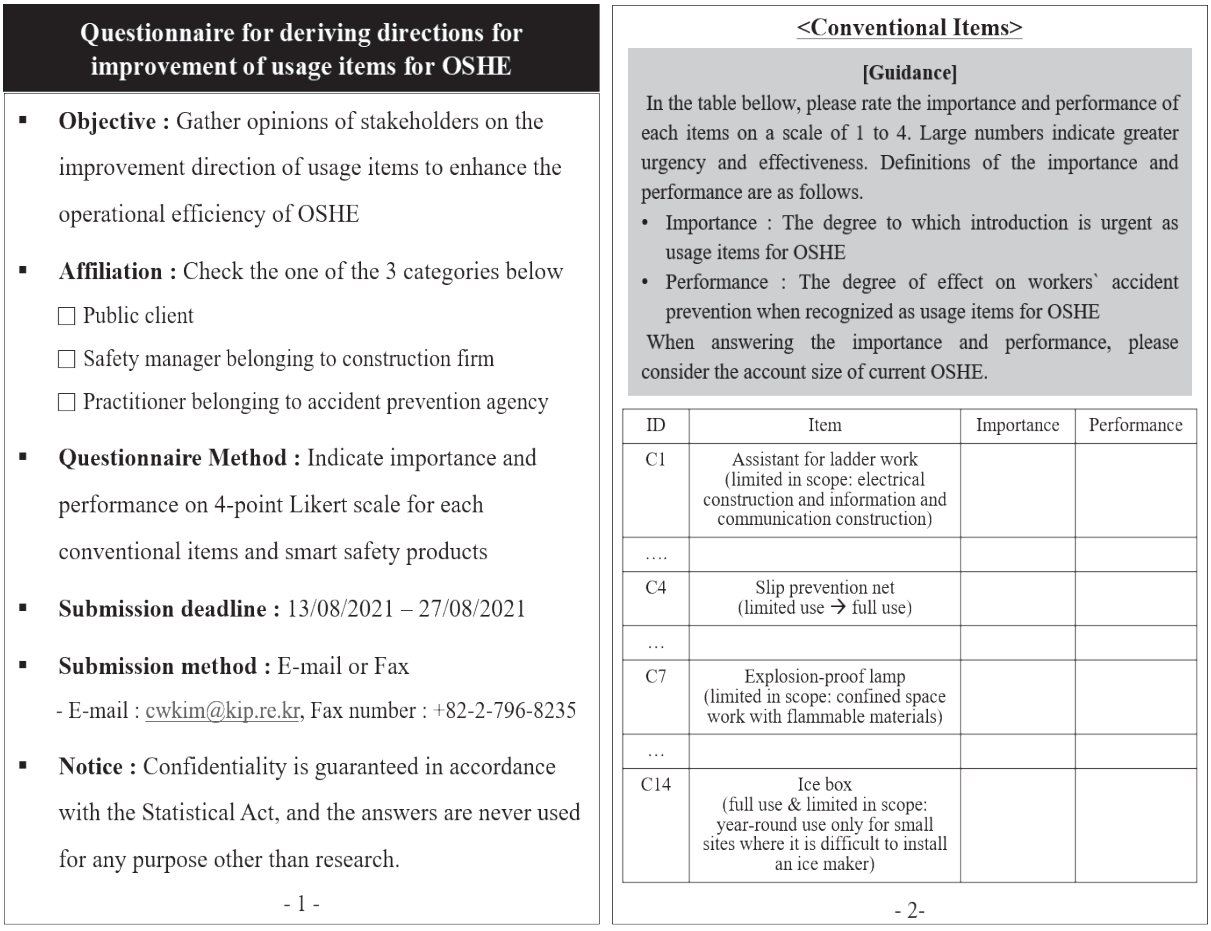
This study was conducted to derive a roadmap to improve the usage items for OSHE using importance-performance analysis (IPA). IPA is a methodology to analyze a portfolio for efficient investment within limited resources by collecting the opinions of experts, and it can be evaluated by schematically considering the relative importance and performance of the analysis target at the same time in the 4 quadrants[25]. Due to the characteristic, it is being used as a methodology to derive strategies for successful project execution and selecting priority management factors in various academic fields that include construction, management, and economics[26–29]. The analysis using IPA is expected to be appropriate considering that this study aims to review the method to improve the usage items within the fixed OSHE.

In this study, importance was defined as the urgency of the recognition as usage items, and performance was defined as the effect of preventing workers' accident according to recognition. The data used to derive a roadmap were the importance and performance of each usage item of OSHE collected on a 4-point Likert scale through survey. The purpose of collecting data with this scale was to overcome the limitation that it could be used as a means to avoid sensitive questions in the presence of a mid-point, such as 'normal'[30]. The survey form is shown in Fig. 2, the form for smart safety products is the same as that of the conventional items. Also, it was specified in the 'Guidance' that the participants should evaluate the urgency and effectiveness of the introduction as usage items while the account size of current OSHE is fixed.

The survey was conducted for two weeks, and data were collected from 1,092 stakeholders. Among them, questionnaires with errors such as incomplete were regarded as outliers, and were excluded from the analysis. The final data selected through this refinement process were analyzed as data collected from a total of 536 stakeholders as shown in Table 6.

In this study, the analysis results derived based on collected data verify the effectiveness as a method to improve usage items used for OSHE through a review process with various stakeholders. Table 7 provides an overview of the stakeholders who participated in the review.

Namely, it is expected that effectiveness of the results



Questionnaire for deriving directions for improvement of usage items for OSHE

- **Objective :** Gather opinions of stakeholders on the improvement direction of usage items to enhance the operational efficiency of OSHE
- **Affiliation :** Check the one of the 3 categories below
  - ☐ Public client
  - ☐ Safety manager belonging to construction firm
  - ☐ Practitioner belonging to accident prevention agency
- **Questionnaire Method :** Indicate importance and performance on 4-point Likert scale for each conventional items and smart safety products
- **Submission deadline :** 13/08/2021 – 27/08/2021
- **Submission method :** E-mail or Fax
  - E-mail : cwkim@kip.re.kr, Fax number : +82-2-796-8235
- **Notice :** Confidentiality is guaranteed in accordance with the Statistical Act, and the answers are never used for any purpose other than research.

- 1 -

<Conventional Items>

[Guidance]

In the table bellow, please rate the importance and performance of each items on a scale of 1 to 4. Large numbers indicate greater urgency and effectiveness. Definitions of the importance and performance are as follows.

- Importance : The degree to which introduction is urgent as usage items for OSHE
- Performance : The degree of effect on workers` accident prevention when recognized as usage items for OSHE

When answering the importance and performance, please consider the account size of current OSHE.

ID	Item	Importance	Performance
C1	Assistant for ladder work (limited in scope: electrical construction and information and communication construction)		
….			
C4	Slip prevention net (limited use → full use)		
…			
C7	Explosion-proof lamp (limited in scope: confined space work with flammable materials)		
…			
C14	Ice box (full use & limited in scope: year-round use only for small sites where it is difficult to install an ice maker)		

- 2-

Fig. 2. Survey form.

has been verified in that it comprehensively reflected opinions from the public and academic fields that establish and research policies on OSHE, as well as the private sectors that execute and receive benefits.

Results

Final pool to improve usage items

The final pool for the improvement of usage items in OSHE that consists of 34 items as shown in Table 8.

The constituent items of the pool are solely for the purpose of preventing the occupational accident of workers. In particular, the conventional items were selected based on the following criteria. First, although they were stipulated as unusable items in the notice, items that were highly effective in preventing workers' occupational accident were included. Representative examples are 'C6. Auxiliary device for the prevention of musculoskeletal disorders' and 'C8. Head lantern'. Second, a plan to fully expand the scope of use was applied to items that were specified as items for use in the notice but had limited scope of use. For example, 'C4. Slip prevention net' is stipulated to be used only for the purpose of preventing accidents such as stabbing during rebar construction, but considering that the purpose of this facility itself was to prevent occupational accidents for workers, it was considered reasonable to fully expand as usage items. Third, the scope of use was limited for items that could cause a problem of lack of OSHE when specified as items for use in the entire construction project. For example, 'C3. Traffic safety equipment', such as rubber cones, can contribute to securing the safety of workers by dividing the work section and the passage section in small-scale construction performed on the road where vehicles are running, acting likely the safety fence in large-scale construction. In this regard, it is set as an item that can be used only for small-scale electrical construction and information and communication construction.

Analysis results using IPA

Fig. 3 and 4 show the results of analysis using IPA for 14

Table 6. Overview of analysis data

Classification	Number (person)	Percentage (%)
Public client	30	5.60
Safety manager belonging to construction firm	455	84.89
Practitioner belonging to accident prevention agency	51	9.51
Total	536	100.00

Table 7. Overview of the stakeholders involved in the review

Affiliations	Number (person)	Percentage (%)
MOEL & Korea occupational safety and health agency	3	18.75
Public ordering agency	4	25.00
Construction firm	2	12.50
Relevant association	3	18.75
Academia	2	12.50
Union	2	12.50
Sum	16	100.00

conventional items and 20 smart safety products, respectively.

As a result of the analysis, the averages for the importance and performance of conventional items were 3.15 and 3.31; while in the case of smart safety products, 2.97 and 3.12 were derived, respectively. Four quadrants were constructed based on these values, and the determinations of each quadrant were as follows; (1) the 1st quadrant contains items that are urgently introduced and have high effectiveness in preventing workers' accidents; (2) the 2nd quadrant contains items that are urgently introduced, but have low effectiveness in preventing workers' accidents; (3) the 3rd quadrant contains items that are not urgently introduced and have low effectiveness in preventing workers' accidents; and (4) the 4th quadrant contains items that are not urgently introduced, but have high effectiveness in preventing workers' accidents.

Through the review of various stakeholders, analysis results were reviewed as being generally appropriate and the main contents summarized according to the determinations of each quadrant are as follows. First, the items that need to be introduced preferentially to improve the operational effectiveness of OSHE were analyzed as 16 items (7 conventional items, 9 smart safety products) from the 1st quadrant. However, among the conventional items, the opinions of stakeholders were derived that it is realistic to exclude the ice box (C14) because it can be executed from welfare expenses in a situation where OSHE are insufficient due to fixed account rate. Namely, it is considered reasonable to maintain the current standard, but to include this item in a roadmap so that it can be used entirely as OSHE after the improvement of account rate is preceded.

Second, 3 items from the 2nd quadrant (1 conventional item, 2 smart safety products) were evaluated for urgent introduction, but the effectiveness of workers' accident prevention was analyzed to be lower than the average. In a conventional item, the ice maker (C13) is expected to be reasonable to maintain the standard stipulated in current notice by MOEL, similar to the reason for ice box (C14). In addition, in the case of smart safety products such as smart safety helmet, the opinions of stakeholders derived that it is considered that the long-term review is necessary by reflecting the burden of maintenance costs; therefore continuous monitoring of the effectiveness of workers' accident prevention is expected.

Third, the items from the 3rd quadrant (3 conventional items, 7 smart safety products) were evaluated as low in both urgency of introduction and the contribution of workers to accident prevention, so it is considered reasonable not to reflect them in the improvement roadmap. However, it is expected that continuous monitoring of smart safety products is required in that the improvement of products is also accelerating with the development of technology.

Finally, the five items from the 4th quadrant need to be recognized as usage items of OSHE at the present time if only the effectiveness of workers' accident prevention is considered, but the urgency of introduction was analyzed to be lower than the average. In other words, if the effectiveness of workers' accident prevention is verified, these items can be sufficiently entered into the 1st quadrant. Therefore,

Table 8. Configuration of final pool

Cost classification (number of configuration items)	Final pool	
	Conventional item	Smart safety product
Labor (conventional 2)	C1. Assistant for ladder work (limited in scope: electrical construction and information and communication construction) C2. Assistant at workplace without safety and health manager (limited in scope: electrical construction and information and communication construction)	
Safety Facility Installation (conventional 5, smart 11)	C3. Traffic safety equipment (limited in scope: electrical construction and information and communication construction) C4. Slip prevention net (full use) C5. CCTV (limited in scope: projects with high potential for disaster exposure, such as river section work) C6. Auxiliary device for the prevention of musculoskeletal disorders C7. Explosion-proof lamp (limited in scope: confined space work with flammable materials)	S1. Hazardous area approach detection system S2. Hazard warning device of temporary structure collapse S3. IoT-based train approach detection system S4. Construction equipment approach warning system S5. Device that can prohibit turning of construction equipment S6. Device that informs whether the safety pin of the excavator bucket is fastened or not S7. Notification system about hazardous gas S8. AI-based dangerous behavior detection S9. Detection system for non-wearing personal protect equipment and emergency situation S10. Sensor-based fire response system S11. Bio-signal-based accident monitoring system
Personal Protect Equipment (conventional 4, smart 8)	C8. Head lantern C9. Equipment for musculoskeletal disorders C10. Sun-cream C11. Power line protection	S12. Wearable robot for the prevention of musculoskeletal disorders S13. Smart safety helmet using sensor S14. Smart safety helmet with holo-lens attached S15. Safety vest with built-in airbag S16. Easy-to-use fire extinguisher in case of emergency S17. Equipment attached to the safety ring that informs dangerous situations of workers S18. Advanced body harness that can be prevent fall accident S19. Smart earphone to protect worker`s hearing
Safety and Health Education (conventional 1, smart 1)	C12. Safety construction education for electrical construction (for safety managers)	S20. Educational facilities using VR
Health Care for Workers (conventional 2)	C13. Ice maker (full use: recognized for year-round use of those stipulated to be usable only in summer season) C14. Ice box (full use & limited in scope: year-round use only for small sites where it is difficult to install an ice maker)	
Total Number (EA)	14	20

it is expected that it would be reasonable to recognize these items as usage items for OSHE from a mid-term perspective.

A roadmap for the improvement of usage items

Table 9 shows the roadmap for the improvement of usage items for OSHE in the Korean construction industry that this study presents, based on the results of IPA.

The detailed analysis results of the short-term and mid- to long-term improvement roadmap are as follows. First, the short-term plan consists of items located from the 1st quadrant of the IPA results; and when the improvement of usage items is reflected in the current notice as soon as possible, high effectiveness can be expected in terms of preventing workers' occupational accidents. Furthermore, the government's policy efforts to improve OSHE regulations are considered to be capable of renewing the image of the construction industry, which is evaluated as the most dangerous industry, and to contribute to protecting people's lives through the creation of a safe industrial environment.

Second, it is considered that the items located from the 4th quadrant of the IPA results are suitable for the mid-term improvement plan. These items were evaluated positively for the effectiveness of workers' accident prevention, but the urgency of introduction was evaluated low, which is expected to reflect the perception that including these items as usage items in OSHE could lead to problems such as a shortage of essential costs. Therefore, to induce active use of these items in the future, it is expected that policies, such as improving the rate of OSHE, should be prepared in advance.

Third, the long-term improvement plan consisted of items located from the 2nd quadrant of the IPA results. In other words, although the urgency of introducing these items was highly evaluated, the effect of workers' occupational accident prevention was evaluated to be relatively low, considering the fact that it may not meet the fundamental purpose of the OSHE. However, considering that the items from this quadrant are smart safety products, it is expected that it will be possible to operate them as usage items for OSHE if the effectiveness of workers' accident prevention is confirmed, by monitoring the level of improvement of products according to technological development.

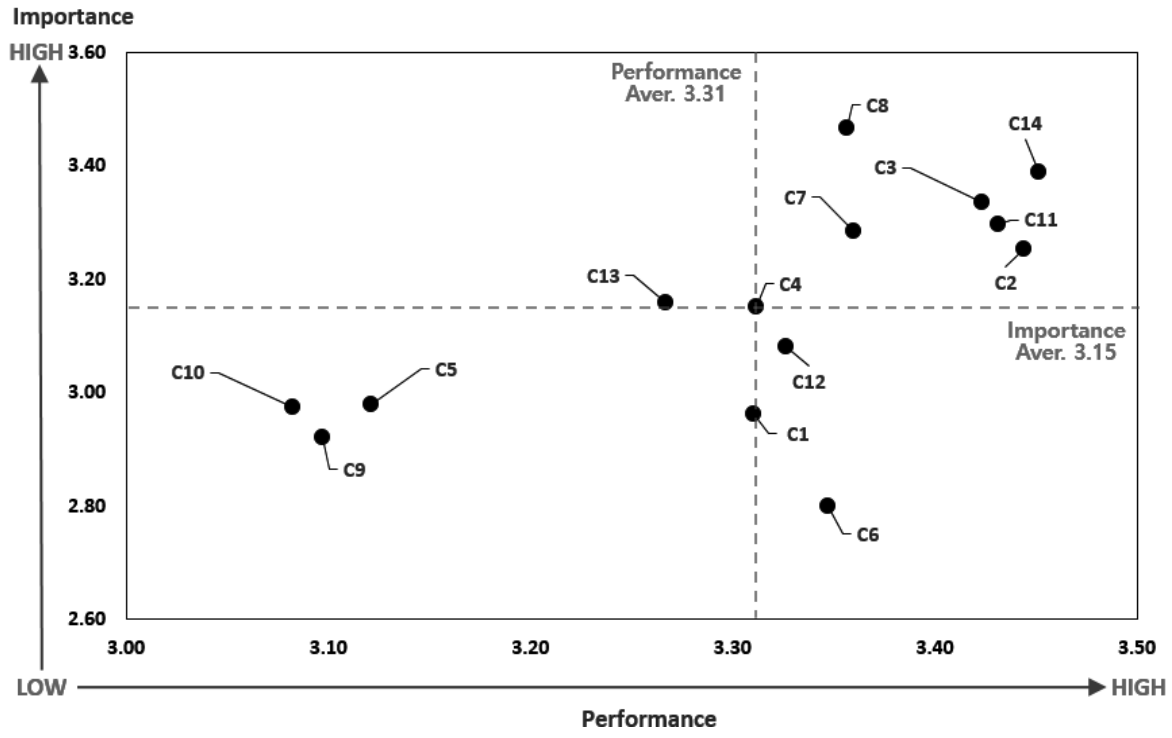


Fig. 3. Result of IPA: Conventional item.

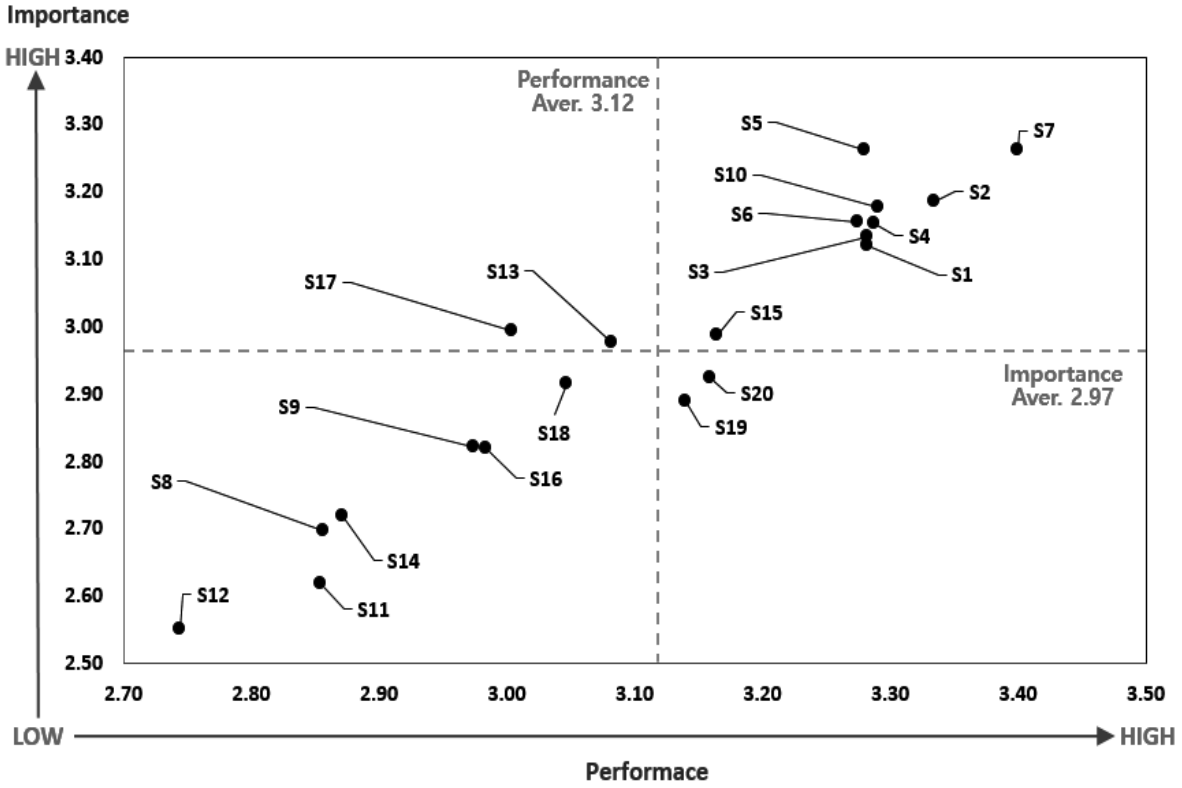


Fig. 4. Result of IPA: Smart safety product.

Table 9. A roadmap to improve usage items for OSHE

Quadrant	Conventional Item	Smart Safety Product
1	C2. Assistant at workplace without safety and health manager C3. Traffic safety equipment C4. Slip prevention net C7. Explosion-proof lamp C8. Head lantern C11. Power line protection	S1. Hazardous area approach detection system S2. Hazard warning device of temporary structure collapse S3. IoT-based train approach detection system S4. Construction equipment approach warning system S5. Device that can prohibit turning of construction equipment S6. Device that informs whether the safety pin of the excavator bucket is fastened or not S10. Sensor-based fire response system S15. Safety vest with built-in airbag
4	C1. Assistant for ladder work C6. Auxiliary device for the prevention of musculoskeletal disorders C12. Safety construction education for electrical construction	S19. Smart earphone to protect worker's hearing S20. Educational facilities using VR
2		S13. Smart safety helmet using sensor S17. Equipment attached to the safety ring that informs dangerous situations of workers

Discussion

OSHE in Korea is a statutory expense that is calculated according to the rates set in the notice, and have the characteristic of listing standard items that can be used for this expense. Therefore, even if items with high effectiveness from the aspect of occupational accident prevention for workers do not meet the standard, the execution of expense is illegal, and may cause a potential problem of lack of OSHE. This study presented a roadmap to improve the usage items for OSHE in consideration of Korea's unique operating system as a result, and the implications are as follows.

First, it is expected that if the usage items for OSHE are improved based on the results presented in this study, it will be possible to contribute to the reduction of the occupational accident rate in the construction industry in Korea. However, expanding the usage items when the expense that can be executed is limited may cause risks such as insufficient cost for installing essential safety facilities. In other words, it is expected that a method for securing expense in consideration of the expansion of usage items should be reviewed together, and as such, it is necessary to classify the expense execution method of usage items as purchase or rental, or to review an increase in the accounting rate stipulated in the notice. For example, if the rental cost is lower than the purchase cost for expensive educational facilities installed on-site for worker safety training (e.g., expensive sound equipment), or the accounting rate is differentiated according to the unique characteristics of the project (e.g., differentiation of road including bridges and tunnels with high risk in the construction process and road centered on simple pavement process, even for the same road construction project).

Second, as mentioned above, the need for improvement of usage items for OSHE is expected to continuously occur, given the increasing industrial demand for the inclusion of currently unusable items as usage items, and the increasing trend of development of the smart safety products. Therefore, it is thought that it is necessary to prepare guidelines to support the use of OSHE by timely reflecting items that are in constant demand within the notice of the MOEL. The establishment of such a policy support plan is expected to contribute to the creation of a safe working environment by continuously discovering and applying the usage items, so that the stakeholders related to OSHE are highly aware of the necessity for workers' occupational accident prevention.

Third, OSHE in Korea is a statutory expense, so securing the operational efficiency of OSHE needs to be considered along with use transparency. Therefore, it is expected that clear usage standards should be prepared for smart safety products presented as contents to be newly added as usage items for OSHE. For example, the Korean government may establish a system to certify new safety technologies and operate it so that only smart safety products that have obtained certification can be used as OSHE. However, since the introduction of a new certification system requires the establishment of an exclusive agency, it is expected in the future, that a thorough review from various aspects will be necessary.

Fourth, due to the nature of IPA, the subjective impressions of respondents on each usage item are inevitably included. Therefore, this study collected a large number of data from various stakeholders to secure the objectivity of the analysis results. However, in order to verify the practical effectiveness, it is expected that it will be necessary to continuously monitor and verity the degree of contribution to the prevention of workers' accidents after the results of this study are reflected in the notice of MOEL.

The results of this study are expected to be used as a valuable reference for establishing a roadmap for improving various government policies, including in the field of occupational safety and health. In addition, as further study, it is expected that it will be necessary to improve the accounting rate in consideration of project characteristics, establish guidelines for timely reflection of improvement contents for usage items, prepare a certification system for new safety technologies for realistic improvement of usage items for OSHE, and monitor the effectiveness of workers' accident prevention in Korea by reflecting the results of this study.

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Conflict of Interest

The authors declare no conflict of interest.

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