

## Original Article

# Effect of Occupational Health and Safety Management System on Work-Related Accident Rate and Differences of Occupational Health and Safety Management System Awareness between Managers in South Korea's Construction Industry



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## ARTICLE INFO

## Article history:

Received 11 April 2013

Received in revised form

11 October 2013

Accepted 22 October 2013

## Keywords:

accident rate

benefit of occupational health and safety management system

construction health and safety

occupational health and safety management system

work-related victims

## ABSTRACT

**Background:** The study was conducted to investigate the current status of the occupational health and safety management system (OHSMS) in the construction industry and the effect of OHSMS on accident rates. Differences of awareness levels on safety issues among site general managers and occupational health and safety (OHS) managers are identified through surveys.

**Methods:** The accident rates for the OHSMS-certified construction companies from 2006 to 2011, when the construction OHSMS became widely available, were analyzed to understand the effect of OHSMS on the work-related injury rates in the construction industry. The Korea Occupational Safety and Health Agency 18001 is the certification to these companies performing OHSMS in South Korea. The questionnaire was created to analyze the differences of OHSMS awareness between site general managers and OHS managers of construction companies.

**Results:** The implementation of OHSMS among the top 100 construction companies in South Korea shows that the accident rate decreased by 67% and the fatal accident rate decreased by 10.3% during the period from 2006 to 2011. The survey in this study shows different OHSMS awareness levels between site general managers and OHS managers. The differences were motivation for developing OHSMS, external support needed for implementing OHSMS, problems and effectiveness of implementing OHSMS.

**Conclusion:** Both work-related accident and fatal accident rates were found to be significantly reduced by implementing OHSMS in this study. The differences of OHSMS awareness between site general managers and OHS managers were identified through a survey. The effect of these differences on safety and other benefits warrants further research with proper data collection.

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## 1. Introduction

In most industrialized countries, the construction industry is one of the most significant in terms of contribution to gross domestic product (GDP). It also has a significant impact on the health and safety of the workers. The construction industry is both economically and socially important. In South Korea, the construction

industry contributed approximately 7% to its GDP in 2007. As of late 2012, after the financial crisis it contributed approximately 5% of the GDP (US\$116.35 billion) and ranked 15th among the construction industries in the world. The construction industry presents a substantial portion of South Korea's economy [1]. Its employment rate ranged from 24.8% to 33.6% of all industries in a 10-year period to late 2011. The construction industry accident rate (work-related

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victims/100 workers) in Korea was almost similar to the all-industry accident rate. The construction industry had the accident rate of 0.64–0.95, compared with all-industry accident rate of 0.65–0.90 during this period. However, the construction industry fatal accident rate (fatal accident/10,000 workers) in Korea (1.89–3.97/10,000 workers) was higher than the all-industry fatal accident rate (1.47–2.76/10,000 workers) during the same period [2]. The industry provides homes, buildings, infrastructures, and plants. However, in the construction industry, there were many accidental deaths or the workers had serious injuries. More workers were killed or injured each year in the construction industry than in any other industries. In the United States, the industry employs 5–6% of the labor force, but has 15% of the fatal injuries and well over 9% of all workdays are lost due to injuries [3]. Construction workers who are disabled or killed each year by work-related injuries are believed to number in the tens of thousands [3]. In addition, unlike other industries, the construction industry is project based, and the accident rates (work-related victims/100 workers) vary from one project to another. Each project is unique, and each project type (e.g., housing and office, transportation, and plant) has its own characteristics, which may include methods of working, materials used, and techniques applied for construction. These characteristics may also vary from project to project in the construction industry in South Korea.

Work-related accidents cause a loss to the company as well as the employees. Accordingly, the Accident Prevention Advisory Unit (APAU) of the Health and Safety Executive (HSE) in the United Kingdom (UK), which passed the world's first Occupational Health and Safety Act, surveyed the costs of work-related accidents in 1989. The results indicated that the loss for the companies from work-related accident was 5–10% of the profit for all industries and 8.5% of the tender price for the construction industry. The ratio of the direct cost to the indirect cost of the work-related accidents is 1:11 [4]. The indirect costs are product and material damage, loss of production time, legal costs, overtime and temporary labor, investigation time, supervisor's time, fines, loss of expertise and experience, loss of morale, and bad publicity. The occupational health and safety management system (OHSMS) was first prepared by the HSE's APAU in the UK in 1991 as a practical guide for directors, managers, health and safety professionals, and employee representatives who wanted to improve health and safety in their organization [5]. The OHSMS is part of the overall management system that facilitates the management of the occupational health and safety (OHS) risks associated with the business of the organization. This includes the organizational structure, planning activities, responsibilities, practices, procedures, processes, and resources for developing, implementing, achieving, reviewing, and maintaining the organization's OHS policy [6]. A variety of OHSMS-based standards, guidelines, and audits since then have been developed within public, private, and not-for-profit sectors. Many of these have been adopted by various workplaces [7]. In South Korea, the Korea Occupational Safety and Health Agency (KOSHA) and the Korean Accreditation Board have also developed KOSHA 2000 (revised to KOSHA 18001 in 2003) and K-OHSMS 18001 in 1999 and 2001, respectively. The OHSMS was placed to enable an organization to control its OHS risks and to improve its OHS performance [8]. The OHS is an important issue in business management, and thus, it is necessary to carry out a systematic study of the costs and benefits of OHSMS. Today, OHSMS has been recognized as not citation and moral issue but as an approach to improve the transparency, productivity, and competitiveness of business. To make OHS an essential element in decision making and effective in preventing occupational accidents, it is necessary to examine the effects of an OHSMS. Although the OHSMS has been developed and implemented by many major companies in South Korea, studies on their implementation and effect have rarely been carried out.

This study tests the following hypotheses: First, reducing the accident rate is one of the most important purposes of developing and implementing OHSMS. Hence, the construction company in which the OHSMS is established will have low accident rate. Second, in the case of South Korean construction industry, the large companies are generally aware of the need for OHSMS, but most small- and medium-sized construction companies are at an early stage in terms of the practical aspect such as the health and safety investment. The health and safety as well as the quality and productivity play an important role in the success and development of business management. Thus, the value-added management can be accomplished by providing an outstanding health and safety service. The OHS managers in the company also need to make continuous efforts to manage the work performance and cost within the scope of their tasks to improve the added value of health and safety service. It is difficult for most OHS managers to be directly involved in chief business management positions such as strategies, evaluations, organization operations, planning, and audits. For management, the decision making is generally determined at the directors' meeting by the authority of chief executive officer, and is notified to the front-line manager. The directors' meeting is responsible for establishing the business strategy, and the line manager is responsible for carrying out the business plan to perform the strategy. Therefore, the OHS manager also needs to develop the service strategy for the best value-added business [9]. However, in the case of South Korea's construction industry, there are not many opportunities for the OHS manager to participate in the strategy development for the added value of business. Accordingly, the awareness of site general manager and OHS manager for OHSMS is expected to be different. Third, unlike other industries (e.g., manufacturing industry, service industry), the construction industry is not involved in the continuous production activity at a single location. The construction industry is project based, and depending on the project, it performs the tasks in the fields of housing and office, transportation, and plant. Each field has its own characteristics and working procedures. Consequently, the OHSMS for the construction industry is expected to differ among those fields.

The objectives of this study, which are based on the above hypotheses, are as follows: (1) understanding the effect of OHSMS through the analysis of accident rates for the construction companies in which the OHSMS is established; (2) understanding the differences of OHSMS awareness between the site general managers and OHS managers through statistical analysis; and (3) understanding the differences among various construction types.

## 2. Materials and methods

### 2.1. Analysis of health and safety data

Since the establishment of KOSHA 18001 OHSMS in 1999 by the KOSHA, 876 companies had maintained the certification as of late 2011. Among these, 17 companies were in the construction industry. Although there were more than 1,000 construction companies in South Korea at the time of this study, all these 17 OHSMS-certified construction companies were among the top 100 construction companies. None of the small- and medium-sized construction companies were OHSMS certified. To examine the effect of OHSMS certification on work-related accident rate, companies of a similar size with and without OHSMS certification are to be selected. The small- and medium-sized companies cannot be included as none of them were OHSMS certified, although they represented approximately 70% of the construction workers. The top 100 companies hence were selected for this study. By doing so, the effect of company size on the work-related accident rate can

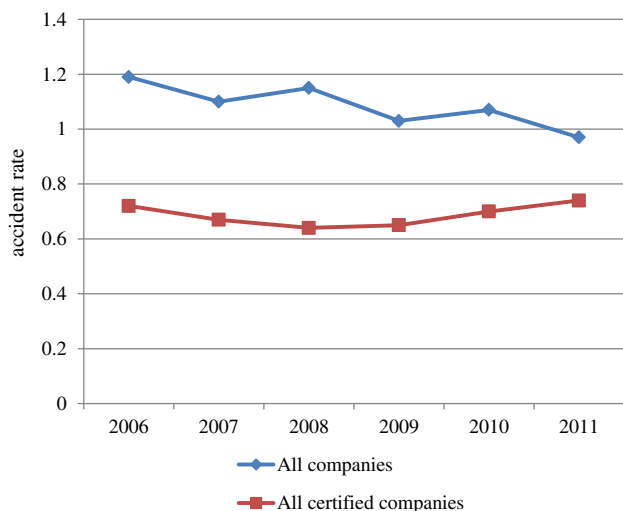


Fig. 1. Accident rate (work-related victims/100 workers).

also be mitigated as all the selected companies are in the similar size (top 100 companies). The accident rates for the construction companies from 2006 to 2011, when the construction OHSMS become widely available, were analyzed to understand the effect of OHSMS on the work-related injury in the construction industry.

## 2.2. Survey on OHSMS awareness of site general managers and OHS managers of construction companies

KOSHA 18001 is the certification to these companies performing OHSMS in South Korea. The questionnaire (see the "Appendix" section) was created to analyze the differences of OHSMS awareness between site general managers and OHS managers of construction companies. This survey was performed on approximately 60 OHSMS-certified construction workplaces of the 17 companies by e-mail and phone. The research participants were the site general managers and OHS managers of each construction workplace. Among the 60 workplaces surveyed, 36 workplaces, where both site general manager and OHS manager responded to the questionnaire, were selected as the research areas.

## 2.3. Statistical analysis

All values are presented as a number of participants and percentage for categorical variables. The differences between participant's demographics and the awareness between groups were tested using Fisher exact test or Pearson Chi-square test. All statistical analyses were performed with SPSS (version 19.0; SPSS, Inc., Chicago, IL, USA). A two-sided  $p < 0.05$  was considered to be statistically significant.

## 3. Results and discussion

### 3.1. Effect of OHSMS on work-related accident rate

All companies in Korea report their work-related accidents and organization information to KOSHA. This database was used for analyzing the accident rates in this study. The comparison of the work-related victims of all companies and all OHSMS-certified companies from 2006 to 2011 is shown in Fig. 1. It clearly shows that the certified companies have a lower work-related accident rate. However, due to the fact that large companies have a higher possibility to be OHSMS certified, the size of the company (number

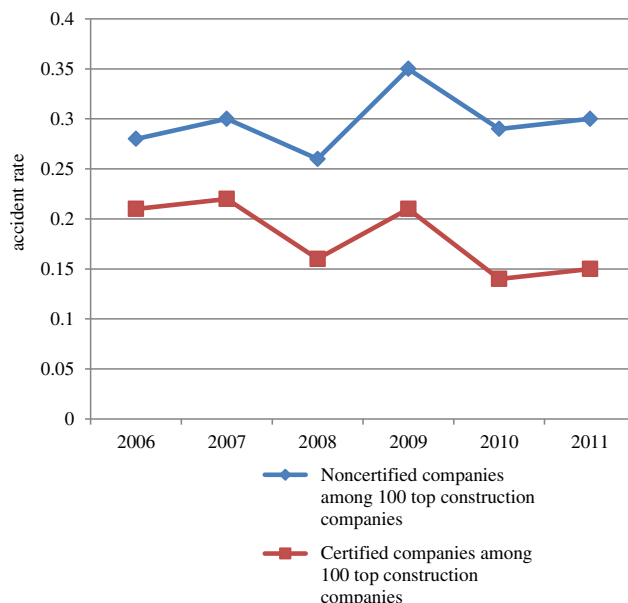


Fig. 2. Accident rate (work-related victims/100 workers).

of workers) may be a factor contributing to the accident rate. To mitigate this factor, the top 100 largest construction companies were selected from more than 1,000 construction companies in South Korea to analyze the effect of OHSMS certification on the work-related accident rate in this study. Although the comparison of accident rate for small- and medium-sized companies with and without OHSMS certification was also intended, however, as mentioned earlier, none of the small- and medium-sized construction companies were OHSMS certified. Therefore, the comparison cannot be made to examine the effect of OHSMS certification on the accident rate.

The data collected from KOSHA [2] indicate that from 2006 to 2011, the number of workers in the certified construction companies ranges from 135,981 to 322,696, whereas it ranges from 329,396 to 616,220 for the noncertified construction companies. As shown in Fig. 2, the accident rate, among the top 100 largest construction companies, is much lower for the certified companies than that for the noncertified companies. The average annual accident rates during this period were 0.30 and 0.18 victims/100 workers for the noncertified and certified companies, respectively. The average accident rate is lowered by 67% when certified companies were compared with noncertified construction companies. This reduction is likely to be due to the implementation of OHSMS, because the influencing factor of the company size has been mitigated.

As shown in Fig. 3, the fatal accident rate of the certified companies, among the top 100 largest construction companies, is also lower than that of the noncertified companies. The average annual accident rates during this period were 2.03 and 1.82 victims/10,000 workers for the noncertified and certified companies, respectively. The average fatal accident rate of the certified companies is lowered by 10.3% when compared with that of noncertified construction companies.

There may be other less important factors that can affect the work-related accident rate. However, these factors are likely to similarly affect both the OHSMS-certified and OHSMS-noncertified companies selected in this study.

It is clear that the OHSMS-certified companies have a lower accident rate and fatal accident rate among the top 100 construction companies in Korea. The implementation of OHSMS has also

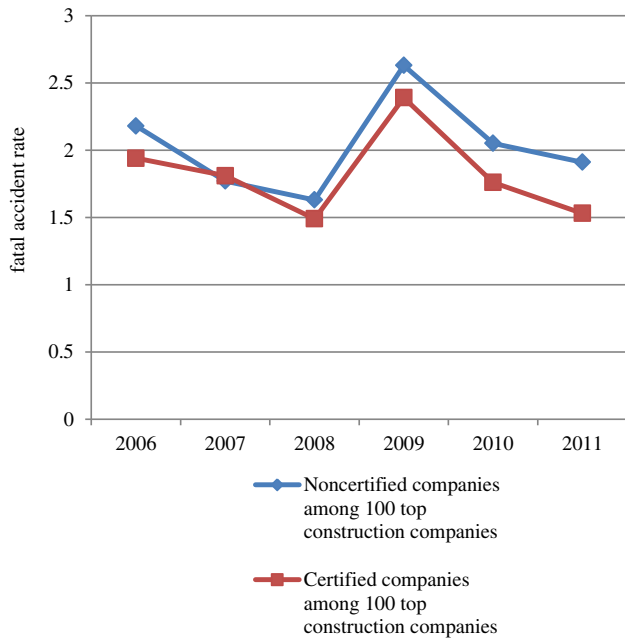


Fig. 3. Fatal accident/10,000 workers.

been reported to reduce accident rate in a study [10]. A similar effect of OHSMS is expected for small- and medium-sized construction companies in Korea and it can be examined when a number of Korea's small- and medium-sized construction companies are OHSMS certified and their safety records are available.

### 3.2. Differences of OHSMS awareness between site general managers and OHS managers

In September 2010, KOSHA 18001-certified construction companies were asked to take our questionnaire survey. There were 72 samples from 36 workplaces, where both site general managers and OHS managers responded to the questionnaire. The 36 workplaces surveyed were classified into three types of constructions. The housing and office construction includes construction of apartments, offices, and commercial buildings. The transportation construction is responsible for building ports, highways, roads, and subways. Plant construction includes construction of water-treatment plants, power plants, chemical plants, and other plants. Table 1 shows characteristics of the companies and the managers who responded to the survey.

Statistically significant differences were found between the two groups on age and professional background ( $p < 0.05$ ). The site general managers were mostly in their 40s, and the OHS managers were generally in their 30s. As for their professional background, engineering was 97.2% for the site general manager group, while safety was 66.7% and engineering 25.0% for the OHS manager group. There was no OHS manager who majored in health or hygiene. Unlike other industries such as the manufacturing industry, there were no managers with health or hygiene major in the construction industry. No other characteristics were found to be significantly different.

The motivation for developing OHSMS showed statistically significant differences between the site general manager group and the OHS manager group ( $p < 0.05$ ; Table 2). With regard to the motivation for developing OHSMS, "lack of health and safety management system" was the highest percentage for both groups. "Elimination and management of health and safety risks" was the

**Table 1**  
General characteristics of the respondents ( $n = 72$ )

Characteristics		Job position				$p^*$
		Site general manager		OHS manager		
		N	%	N	%	
Construction types	Housing and office	24	66.7	24	66.7	—
	Transportation	10	27.8	10	27.8	
	Plant	2	5.6	2	5.6	
Gender	M	36	100.0	35	97.2	>0.9999*
	F	0	0.0	1	2.8	
Age group (y)	<30	0	0.0	6	16.7	<0.0001*
	30–39	0	0.0	24	66.7	
	40–49	29	80.6	6	16.7	
	50–59	7	19.4	0	0.0	
No. of workers	<100	6	16.7	6	16.7	—
	100–199	5	13.9	5	13.9	
	200–399	14	38.9	14	38.9	
	400–599	8	22.2	8	22.2	
	>600	3	8.3	3	8.3	
Major	Environment	0	0.0	2	5.6	<0.0001*
	Safety	0	0.0	24	66.7	
	Health or hygiene	0	0.0	0	0.0	
	Engineering	35	97.2	9	25.0	
	Management	0	0.0	0	0.0	
	Other	1	2.8	1	2.8	
OHSMS training	Yes	35	(97.2)	35	(97.2)	>0.9999*
	No	1	(2.8)	0	(0.0)	
	Unknown	0	(0.0)	1	(2.8)	
Necessity of OHSMS.	Yes	36	100.0	35	97.2	>0.9999*
	No	0	0.0	1	2.8	

Fisher exact test and Pearson Chi-square test were performed to examine the statistical difference for the participant's demographic factors and awareness between site general managers and OHS managers. For reference, the Pearson Chi-square test is generally conducted for the comparison between the groups of categorical variables, but when the sample number is small (i.e., when the frequency in the cell is small), the Pearson Chi-square test could lead to incorrect result. In that case, the Fisher exact test was carried out.

OHS, occupational health and safety; OHSMS, occupational health and safety management system.

\*  $p$  value by Fisher exact test.

second highest percentage for the site general manager group, and the response of "social responsibility and legal issues" was the second highest percentage for the OHS manager group. Many surveyed companies did not have their OHSMS in place and they needed it to manage their own health and safety issues. Shearn [11] examined many cases of business benefits arising from health and safety interventions, but provided no explanation of business motivations for implementing OHS interventions [12], although it could be assumed that the businesses involved have a proactive attitude toward OHS [13]. With regard to the motivation for developing OHSMS, it was found that the site general manager group believed more highly of "elimination and management of health and safety risks" than "social responsibility and legal issues."

Regarding the implementation of OHSMS, the factors that had statistically significant differences between the two groups were "external support needed for implementing OHSMS," "any problem with the implementation of OHSMS," and "if you have problems, what kind of problem" ( $p < 0.05$ ). The "cost of OHSMS implementation and certification" did not show statistically significant differences (Table 3). For external support needed for implementing OHSMS, the site general manager group mostly selected "risk assessment," and the OHS manager group selected various factors in the order of "risk assessment," "goals and plans," and "management review." In other words, 91.7% of the site general manager group responded that the external support is the most necessary for "risk assessment," but the OHS manager group suggested that the external support is needed for various reasons

**Table 2**  
Motivation for developing company's own OHSMS ( $n = 72$ )

Factors	Job position				$p^*$
	Site general manager		OHS manager		
	<i>N</i>	%	<i>N</i>	%	
Motivation for developing OHSMS					0.0002*
Lack of health and safety management system	15	41.7	24	66.7	
Social responsibility and legal issues	7	19.4	5	13.9	
Elimination and management of health and safety risks	12	33.3	4	11.1	
Reduce the cost of health and safety management	1	2.8	2	5.6	
Responding and complying with interested party	1	2.8	1	2.8	

OHS, occupational health and safety; OHSMS, occupational health and safety management system.

\*  $p$  value by Fisher exact test.

including the “risk assessment.” For the external support needed for OHSMS implementation, “risk assessment” was the predominant support needed for the site general manager group, whereas the OHSMS group selected various needs. The risk assessment takes into account the cost, time, and an availability of reliable data. The company determines what its OHS risks are, taking into account the inputs and outputs associated with its current and

relevant past activities, processes, products, and services. A company with no OHSMS needs to establish the risk assessment [12]. For the factor of “any problem with the implementation of OHSMS,” 33.3% of the site general manager group responded that there were problems with the implementation of OHSMS, and 69.4% of the OHS manager group responded that there were problems with the implementation of OHSMS, showing a

**Table 3**  
Implementation of OHSMS ( $n = 72$ )

Parameters	Job position				$p^{*†}$
	Site general manager		OHS manager		
	<i>N</i>	%	<i>N</i>	%	
Implementation methods					—
Itself	18	50.0	18	50.0	
Part of support from consulting firm	12	33.3	12	33.3	
Support from consulting firm	6	16.7	6	16.7	
Cost of OHSMS implementation and certification					0.2214*
Inexpensive	10	27.8	8	22.2	
Reasonable cost	24	66.7	20	55.6	
Expensive	1	2.8	6	16.7	
Other	1	2.8	2	5.6	
External support needed for implementing OHSMS					0.0007*
Policy	1	2.8	2	5.6	
Risk assessment	33	91.7	20	55.6	
Legal compliance	1	2.8	2	5.6	
Goals and plans	0	0.0	7	19.4	
Organization and responsibility	0	0.0	0	0.0	
Training and communication	0	0.0	1	2.8	
Documentation	0	0.0	1	2.8	
Implementation management	1	2.8	0	0.0	
Inspection and correction	0	0.0	0	0.0	
Audit	0	0.0	0	0.0	
Management review	0	0.0	3	8.3	
Any problem with the implementation of OHSMS					0.0022†
Yes	12	33.3	25	69.4	
No	24	66.7	11	30.6	
If you have problems, what kind of problem					0.0029*
Complicated documentation management	0	0.0	10	40.0	
Noncompliance with existing OHSMS	4	33.3	6	24.0	
More complicated (organization, operation, etc.)	7	58.3	3	12.0	
No measurement of visible achievements	0	0.0	3	12.0	
Nominal certification	0	0.0	2	8.0	
Excessive cost of obtaining and maintaining certification	1	8.3	0	0.0	
No needs of external buyers	0	0.0	0	0.0	
No incentives	0	0.0	1	4.0	

OHS, occupational health and safety; OHSMS, occupational health and safety management system.

\*  $p$  value by Fisher exact test.†  $p$  value by Pearson Chi-square test.



**Table 4**  
Effectiveness of implementing and management benefits of OHSMS ( $n = 72$ )

Factors	Job position				<i>p</i>
	Site general manager		OHS manager		
	<i>N</i>	%	<i>N</i>	%	
Effectiveness of implementing OHSMS					0.0326*
Prevention of accidents	17	47.2	11	30.6	
Legal compliance	5	13.9	12	33.3	
Effective on-site safety and health management	5	13.9	8	22.2	
Improving quality	3	8.3	5	13.9	
Improving productivity	5	13.9	0	0.0	
Reducing management costs	0	0.0	0	0.0	
Improving safety consciousness of management	1	2.8	0	0.0	
Improving safety consciousness of workers	0	0.0	0	0.0	
Improving company's image	0	0.0	0	0.0	
Management benefits of OHSMS					0.0317*
Products	10	27.8	3	8.3	
Process	8	22.2	17	47.2	
Production	9	25.0	9	25.0	
Marketing	2	5.6	4	11.1	
Loss control	7	19.4	2	5.6	
R and D	0	0.0	1	2.8	

OHS, occupational health and safety; OHSMS, occupational health and safety management system.

\* *p* value by Fisher exact test.

significant difference between the two groups. While OHS managers focus on health and safety issues, site general managers also have to pay attention to many other issues including logistics, cost, completion of projects on time, etc. It is clear that the two groups have different opinions on the problems of OHSMS implementation or have poor communication between them. In addition, when there was a problem, the site general manager group responded that “complicated organization and operation” was the most serious problem, and the OHS manager group responded that “complicated documentation management” is the most serious problem. An effective OHSMS structure simplifies organization, operation, and documentation, and thus, after the implementation of OHSMS, the problems of complicated documentation management, noncompliance with existing OHSMS, and more complicated issues (organization, operation, etc.) may be eliminated or mitigated. For the implementation methods, there were no differences between the two groups and the response of “itself” showed the highest percentage as 50%. When developing and implementing OHSMS, many companies had difficulty in risk assessment and operation management and needed help from external professional organizations. However, 50% of the companies implemented OHSMS themselves. Although implementing OHSMS by the companies themselves may be cost saving, risk assessment and operational management in implementing OHSMS could become more difficult and less effective. With regard to the cost of OHSMS implementation and certification, “reasonable cost” showed the highest percentage. As a result, for the implementation of OHSMS, it is necessary for the site general manager or general manager to comprehensively understand the problems that the OHS manager is faced with, and to provide support for various needs including the “risk assessment.”

As shown in Table 4, regarding the benefits of OHSMS, all items showed statistically significant differences between the site general manager and OHS manager group ( $p < 0.05$ ). For the effectiveness of implementing OHSMS, the site general manager group believed that the OHSMS implementation is most effective in “prevention of accidents,” but the OHS manager group believed that the effectiveness is in the order of “legal compliance,” “prevention of

accidents,” and “effective on-site safety and health management.” With regard to the management benefits of OHSMS, the site general manager group selected, in order, “products,” “production,” and “process,” and the OHS manager group selected, in order, “process,” “production,” and “marketing.” The site general manager group considered that “products,” “production,” and “process” were the most important management benefits of OHSMS, whereas the OHS manager group believed that “process” was the most important management benefit of OHSMS.

### 3.3. OHSMS awareness of various construction types

Table 5 shows the statistically significant differences of OHSMS awareness among the two groups for various construction types ( $p < 0.05$ ). In the case of the motivation for developing OHSMS, “lack of health and safety management system” showed the highest percentage for housing and office and transportation constructions, whereas “elimination and management of health and safety risks” was the top selection for plant construction. It was found that “elimination and management of health and safety risks” was the top motivation for developing OHSMS for plant construction rather than “lack of health and safety management system.” In the case of the implementation methods of OHSMS, “itself” showed the highest percentage for housing and office and plant construction, whereas “part of support from consulting firm” and “support from consulting firm” showed high percentages for transportation construction. Regarding the cost of OHSMS implementation and certification, the response on “reasonable cost” was the highest percentage, and there were no significant differences among the three groups. As for the effectiveness of implementing OHSMS, for housing and office construction, “prevention of accident” had the highest percentage, whereas “improving quality” was the top selection for the transportation construction. With regard to the management benefits of OHSMS, “process” had the highest percentage for both housing and office and transportation constructions. Because of the nature of the plant construction, “production” and “loss control” were found to be the most important management benefits of OHSMS rather than “process.”

**Table 5**  
OHSMS awareness of various construction types (*n* = 72)

Factors	Construction types						<i>p</i>
	Housing and office		Transportation		Plant		
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	
Motivation of developing OHSMS							0.0191*
Lack of health and safety management system	29	60.4	9	45.0	1	25.0	
Social responsibility and legal issues	5	10.4	7	35.0	0	0.0	
Elimination and management of health and safety risks	12	25.0	2	10.0	2	50.0	
Reduce the cost of health and safety management	2	4.2	1	5.0	0	0.0	
Responding and complying with interested party	0	0.0	1	5.0	1	25.0	
Implementation methods							0.0025*
Itself	30	62.5	4	20.0	2	50.0	
Part of support from consulting firm	14	29.2	8	40.0	2	50.0	
Support from consulting firm	4	8.3	8	40.0	0	0.0	
Cost of OHSMS implementation and certification							0.0448*
Inexpensive	16	33.3	2	10.0	0	0.0	
Reasonable cost	26	54.2	16	80.0	2	50.0	
Expensive	3	6.3	2	10.0	2	50.0	
Other	3	6.3	0	0.0	0	0.0	
Effectiveness of implementing OHSMS							0.0051*
Prevention of accidents	23	47.9	4	20.0	1	25.0	
Legal compliance	11	22.9	4	20.0	2	50.0	
Effective on-site safety and health management	10	20.8	3	15.0	0	0.0	
Improving quality	3	6.3	5	25.0	0	0.0	
Improving productivity	1	2.1	4	20.0	0	0.0	
Reducing management costs	—	—	—	—	—	—	
Improving safety consciousness of management	0	0.0	0	0.0	1	25.0	
Improving safety consciousness of workers	—	—	—	—	—	—	
Improving company's image	—	—	—	—	—	—	
Management benefits of OHSMS							0.0338*
Products	12	25.0	1	5.0	0	0.0	
Process	17	35.4	8	40.0	0	0.0	
Production	12	25.0	4	20.0	2	50.0	
Marketing	4	8.3	2	10.0	0	0.0	
Loss control	2	4.2	5	25.0	2	50.0	
R and D	1	2.1	0	0.0	0	0.0	

OHSMS, occupational health and safety management system.

\* *p* value by Fisher exact test.

The difference can be used to examine the effectiveness of the factor. For example, "prevention of accidents" is the higher selection for the effectiveness of implementing OHSMS in housing and office construction (47.9%) than in the transportation (20.0%) and plant construction (25.0%; Table 5). It is our plan to collect the accident rate data of these three types of construction companies and analyze the difference between the accident rates of these companies to examine the correlation between the selection and the actual accident rate.

Differences in OHSMS awareness between the site general manager and OHS manager groups were identified. Attempts to correlate some of these differences in cost saving, work-related accident rate, and other benefits were unsuccessful due to the limited availability of related data. However, investigations on the correlations are warranted.

To sum up, an investigation on the effect of OHSMS on the work-related accident rate was conducted in this study. To mitigate the possible bias due to company size on the work-related accident rate, the top 100 largest construction companies were selected for the analyses. The average annual accident rates during the period from 2006 to 2011 were 0.30 and 0.18 victims/100 workers for the noncertified and the certified companies, respectively, with a reduction rate of 67% for the certified. The average annual fatal

accident rates in the same period were 2.03 and 1.82/10,000 workers for the noncertified and the certified companies, respectively, with a reduction rate of 10.3% for the certified. Both work-related accident and fatal accident rates were found to be significantly reduced by implementing OHSMS in this study.

The survey in this study shows different OHSMS awareness levels between site general managers and OHS managers. The differences were motivation for developing OHSMS, external support needed for implementing OHSMS, problems, and effectiveness of implementing OHSMS. The effect of the differences on accident rate reduction and cost saving can be investigated with proper data collection and it warrants further studies in the future.

### Conflicts of interest

No conflicts interest are involved by any other authors.

### Acknowledgments

The authors appreciate the KOSHA for providing the data on the OHSMS-certified companies, and Hwang Gyu-Seok, an officer at the Ministry of Employment and Labor, for helping with the survey.

**Appendix. Questionnaire**

## General information.

ID (name of site)		Construction Types	
Sex		No. of workers	
Age		Job position	

1. What is your major?

- (1) Environment (2) Safety  
 (3) Health or hygiene (4) Engineering  
 (5) Management (6) Other (\_\_\_\_\_)

2. Did you receive a proper OHSMS training?

- (1) Yes (2) No

3. Necessity of OHSMS

- (1) Yes (2) No

Motivation for developing their own OHSMS

4. Motivation for developing OHSMS?

- (1) Lack of health and safety management system (2) Social responsibility and legal issues  
 (3) Elimination and management of health and safety risks  
 (4) Reduce the cost of health and safety management  
 (5) Responding and complying with interested party

Implementation of OHSMS

5. Implementation method?

- (1) Itself (2) Part of support from consulting firm  
 (3) Support from consulting firm

6. Cost of OHSMS implementation and certification

- (1) Cheaper (2) Reasonable cost  
 (3) Expensive (4) Other

7. External support needed implementing for OHSMS

- (1) Policy (2) Risk assessment  
 (3) Legal compliance (4) Goals and plans  
 (5) Organization and responsibility (6) Training and communication  
 (7) Documentation (8) Implementation management  
 (9) Inspection and correction (10) Audit  
 (11) Management review



## 8. Any problem with implementation of OHSMS

- (1) Yes (to Question 9) (2) no (to Question 10)

## 9. If you have problems; what kind of problem

- (1) Complicated documentation management  
 (2) Noncompliance with existing OHSMS (3) More complicated (organization, operation, etc.)  
 (4) No measurement of visible achievements (5) Nominal certification  
 (6) Excessive cost of obtaining and maintaining certification  
 (7) No needs of external buyers (8) No incentives

## Effectiveness of implementing and management benefits of OHSMS

## 10. Effectiveness of implementing OHSMS

- (1) Prevention of accidents (2) Legal compliance  
 (3) Effective on-site safety and health management  
 (4) Improving quality (5) Improving productivity  
 (6) Reducing management costs  
 (7) Improving safety consciousness of management  
 (8) Improving safety consciousness of workers (9) Improving company's image

## 13. Management benefits of OHSMS

- (1) Products (2) Process  
 (3) Production (4) Marketing  
 (5) Loss control (6) R and D

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