IMPROVEMENT OF DFS PERCEPTION OF CONSTRUCTION STAKEHOLDERS THROUGH COMPARISON BETWEEN DIFFERENT COUNTRIES

SEUNG-HYEON SHIN1, JEONG-HUN WON2, HYEON-JI JEONG3, NAM-GWON JANG2, MIN-GUK KANG2, and MINJUN KIM3

1Dept of Big Data, Chungbuk National University, Cheongju-si, Republic of Korea
2Dept of Safety Engineering, Chungbuk National University, Cheongju-si, Republic of Korea
3Dept of Disaster Engineering, Chungbuk National University, Cheongju-si, Republic of Korea

All construction stakeholders have to participate in the safety and health management of workers in order to prevent possible accidents during the construction life cycle. Moreover, it is most effective to control risks from the design stage. For this reason, many countries have implemented systems to eliminate risks at the design stage under the name Design for Safety (DfS). Numerous studies have shown that the effectiveness of DfS is influenced by stakeholders' perception. In this study, meta-analysis was conducted to analyze the level of awareness of DfS by stakeholders, and through this, a plan to improve the DfS system in Korea was proposed. While the awareness of stakeholders in Korea for DfS was estimated at 63.9%, it was estimated that 87.5% of the respondents agreed with the necessity of DfS. The awareness in Korea for DfS is lower than that of other countries. However, analysis has shown that the level of necessity for DfS implementation in Korea is higher than that of others i.e., although DfS was evaluated as a highly effective method of preventing construction accidents at sites by the stakeholders, the low awareness of DfS can be a significant obstacle in deriving effective DfS results. In addition, analysis has shown that the prejudice resulting from low awareness of stakeholders in relation to DfS could cause problems of attitude of stakeholders. Therefore, it is thought that the enhancement of awareness of DfS among stakeholders is the first necessary step to promote the positive perception of DfS.

Keywords: Design for safety, Awareness, Necessity, Meta-analysis.

1 INTRODUCTION

The number of construction workers worldwide is about 7% of the number of workers in all industries, but the fatalities for a much larger proportion, making the construction industry one of the most dangerous industries (Park 2020). About 20% of the fatalities from occupational accidents in the United States and the United Kingdom in 2018 occurred in the construction industry (Shin 2021). As a result of analyzing the fatality rate of construction and manufacturing industries in South Korea from 2010 to 2020, the fatality rate of the construction industry continues to increase. Especially, the fatality rate of the construction industry (2.00) in 2020 is about four times higher than that of the manufacturing industry (0.50) (Shin 2021). Government
has introduced various systems to reduce the industrial accidents, but the effect of reducing construction accidents is not clearly visible (Shin et al. 2019).

According to a number of studies about reduce accidents in the construction industry, the construction project includes a number of stakeholders consisting of clients, designers, supervisors, and contractors, and it can be solved only when safety responsibilities and obligations are properly assigned to all stakeholders (Buchholz et al. 1996, Szymberski 1997, Gambatese et al. 2005, Bong et al. 2015). Recently, the Korean government has changed its policy to involve the clients as the subject of the construction safety inspection and all construction officials. In particular, in 2016, the Design Safety Review System (DfS), which includes all construction industry stakeholders, including designers, as participants in safety management, was introduced, but controversy over their effectiveness continues to arise (Kim and Kim 2019, Shin et al. 2019). According to many studies, the effectiveness of the DfS system was found to be greatly affected by the level of perception of stakeholders in the construction industry (Jannadi and Bu-Khamsin 2002, Gambatese et al. 2005, Lee et al. 2019). Therefore, this study attempts to derive the level of awareness of stakeholders in Korea through meta-analysis and propose improvement measures.

2 METHOD

2.1 Literature Search

Korean and other countries literatures that studied the perception of DfS targeting construction stakeholders were searched. The literature search was conducted twice in total from August 24, 2020 to August 31, 2020, and from September 7 to September 9, 2020, and was searched more than twice per session. The subject of this study is Korean and other countries papers published from January 1, 1985, the year DfS was introduced by the International Labor Organization (ILO), to August 31, 2020. The academic database was used by a total of seven databases: Web of Science, Scopus, PubMed, Research Information Sharing Service (Korea), Science ON (Korea), National Assembly Electronic Library (Korea), and Korea Citation Index (Korea). Korean papers were limited to KCI-listed or higher, and other countries' papers were limited to SCI, and conference papers were excluded from this study because there was no peer-review process. The main search words were “DESIGN FOR SAFETY”, “PREVENTION THROUGH DESIGN”, “CONSTRUCTION DESIGN AND MANAGEMENT”, and other words related to DfS.

Literature selection was conducted in accordance with PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines (Cooper 2009, Higgins and Green 2011). There were 11,683 literatures searched, and 33 papers were added through a reference, and a total of 7,541 literatures were searched, excluding 4,175 duplicated them. Among the documents surveyed according to the PRISMA procedure, 6,841 articles unrelated to construction were excluded, and 64 articles were excluded through the second review. In addition, the final 135 DfS documents were derived, excluding 501 documents that were not directly related to DfS. Among the derived data, the survey data were surveyed to conduct meta-analysis on the perception of DfS stakeholders, and if the degree thesis and academic journals overlap, they were treated as academic journals. There is a total of 14 final selected data to be used for meta-analysis.
2.2 Characteristic of Papers

There is a total of 13 papers to analysis the DfS awareness and necessity of stakeholders. The total number of Korean samples totaled 463, of which 120 (25.92%) designers, 97 (20.95%) clients, 103 (22.25%) contractors, 84 (18.14%) supervisors, and 59 (12.74%) others, such as academia, public servant, etc. The total number of other countries’ samples is 782, of which 354 designers (45.27%), Civil and structural engineers consist of 179 (22.8%), 58 contractors (7.42%), and 34 clients (4.35%). Table 1 shows the information of the papers used in this study.

Table 1. Information of papers used in this study

<table>
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<tr>
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2.3 Meta-Analysis

Meta-analysis was conducted using the Comprehensive Meta-Analysis 3.0 (CMA 3.0) program. In the meta-analysis, the effect size was estimated by determining a random effect model or a fixed effect model according to the heterogeneity (Cooper 2009). Q-value and I-square statistics were used to examine the heterogeneity of the study, and Funnel diagrams and Egger's test, and trim-and-fill methods were used to estimate publication bias (Cooper 2009).

3 RESULTS

3.1 Awareness of Stakeholders About DfS

In order to analyze the awareness of stakeholders about DfS in Korea, the means effect size was analyzed for 463 people included in a total of 5 papers. As a result of analyzing the heterogeneity of the selected studies, the I2 values were 90.50%, indicating that the studies were not homogeneous with each other (Q=136.870, p<0.001, df(Q)=7). Therefore, studies were analyzed to be heterogeneous, and the means event size was measured by applying a random effect model. The Forest plot of the meta-analysis results on the awareness of DfS by other countries’ stakeholders is shown in Figure 2, and the mean effect size was 0.741, which is analyzed that 74.1% of stakeholders are aware of DfS. However, the results were found to be different depending on the timing of the introduction of the DfS by country.
In order to confirm the bias of publication, funnel chart analysis, Egger's regression verification, and Trim-and-Fill techniques were applied. First, a funnel chart was prepared to visually check whether the effect size distribution of the research papers was symmetrical, and there was no significant asymmetry. Egger’s test for a regression intercept gave a p-values of 0.491, indicating no evidence of public bias. As a result of applying the Trim-and-Fill method, there were no additional studies, and there was no change in the effect size. Therefore, it was judged that there was no problem with the publication bias.

![Funnel Chart](image1)

**Figure 1.** Forest plot of awareness of DfS (Korea).

**Figure 2.** Forest plot of awareness of DfS (Other countries).

### 3.2 Necessity of Implementing DfS by Stakeholders

Meta-analysis was conducted to analyze the necessity of implementing DfS by stakeholders. In order to analyze the necessity of DfS implementation of Korea, the means effect size was analyzed for 447 people included in a total of 4 papers. The random effect model was applied because the I2 value of necessity papers was 91.58% (Q=35.628, p<0.001, df(Q)=3). The means effect size of the necessity of implementing DfS measured by the random effect model was 0.875, indicating that 87.5% of the respondents said DfS is necessary to prevent accidents at construction sites (Figure 3). This is quite high compared to the awareness of DfS, and it shows that most stakeholders, regardless of their affiliation, agree that DfS is necessary for reducing accidents. In the case of other countries, the means effect size was analyzed for 489 people included in a total of 5 papers. The p-value and I2 value of the studies are 0.627 and analyzed as 0.00%, respectively, indicating that they are very homogeneous (Q-value=2.602, df(Q)=4). Therefore, a fixed effect model was applied when performing meta-analysis. The means effect size of the necessity of implementing DfS by the fixed-effect model was 0.837, which was analyzed to be 83.7% of the opinions that DfS is necessary to prevent accidents at construction sites (Figure 4).

![Forest Plot](image2)

**Figure 3.** Forest plot of necessity of implementing DfS (Korea).

**Figure 4.** Forest plot of necessity of implementing DfS (Other countries).
The publication bias test of data on the necessity of implementing DfS was conducted in order to determine whether the analysis results were distorted. In the case of Korea, it is biased to the right around Funnel's central baseline, but as a result of Egger's test, it was confirmed that the intercept value was \(-3.204\), the standard error was \(9.955\), and the p-value was \(0.778\) (2-tailed), which was not publication bias. Trim-and-Fill also changed from \(3.76\) to \(3.67\) when one data was added, so it was finally judged that there was no problem with publication bias. In the case of countries excepted Korea, first of all, in the funnel chart, it is estimated that there is no bias because it can be seen that the distribution of effect sizes in all studies is symmetrically distributed within the funnel. Egger's test result also showed that there was no asymmetry (intercept: \(0.135\), standard error: \(1.174\), p-value: \(0.916\) (2-tailed)). In addition, as a result of using the trim-and-fill method, when one study was introduced, it was adjusted from \(0.837\) to \(0.833\) and showed little change. Therefore, it was found that no publication bias occurred.

4 CONCLUSION

This study presented problems about the perception of the DfS system among Korean construction stakeholders compared with other countries through meta-analysis. The results showed stakeholders in Korea had low awareness of DfS compared to other countries. However, after explaining to stakeholders in Korea about DfS, as a result of analyzing the need for DfS implementation, they claimed that DfS implementation is necessary for construction safety. Therefore, although Korean stakeholders consider it necessary to implement DfS for effective safety management at construction sites, it can be seen that the DfS implementation rate is low due to the low level of awareness of what work is needed to properly implement DfS implement DfS. As a result of analyzing the causes of low awareness of DfS, the biggest reason was the insufficient promotion and education related to the system’s laws and regulation (Kim and Kim 2019, Lee et al. 2019, Ji 2020). In addition, most stakeholders are aware of the outline and meaning of the system, but have little experience in DfS work, and argued that it is difficult to implement due to the lack of systematic work manuals and education (Kim and Kim 2019, Park 2020, Ji 2020). It was found that these problems resulted in poor performance and negative perceptions of DfS. Therefore, in order to improve the implementation of DfS, it is necessary to improve the negative perception of DfS by construction stakeholders. To achieve this, educational programs should be opened and operated.

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References


