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Analysis of workers' perception for enhancing on-site safety climate in small-sized construction enterprises in South Korea

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Abstract: The construction industry is labor-intensive and exhibits a higher fatality rate compared to other sectors. Small to medium-sized construction sites often lack systematic safety management, highlighting the need for enhanced safety measures. Previous studies suggest that, due to the characteristics of these sites, deploying smart technologies presents challenges, making safety education a more feasible approach. This study reorganized existing literature to explore safety factors and the local atmosphere, creating survey questions based on research applied to general sites. A survey was conducted with 59 workers at small- to medium-sized construction sites in Korea, categorized into workers, skilled laborers, and managers. Independent variables (safety factors) and dependent variables (safety climate) were analyzed using bivariate correlation and multiple regression analysis. The results indicated that the emphasis on safety awareness varies depending on the role—worker, skilled laborer, or manager. This study aims to contribute to the effective improvement of safety standards at small construction companies by proposing practical safety management measures.
Keywords: *Construction safety management, Construction safety, Safety climate, Small-sized construction enterprises, Worker perception.*

1. Introduction

According to the U.S. Bureau of Labor Statistics (BLS), which monitors worker injuries, illnesses, and fatalities, a total of 5,486 fatalities were reported in 2022 [1]. Of these, 1,069 deaths (19.5%) occurred in the construction industry, representing a significantly higher rate of fatal incidents than in other industries [1]. The construction industry in Korea is also labor-intensive and experiences a higher rate of fatalities compared to other sectors [2].

Research from the Korea Construction Industry Institute reveals that many fatalities in the construction industry occur at private construction sites valued at less than 5 billion KRW, primarily in small-scale projects. This underscores the need for advanced strategies to prevent accidents, particularly focusing on small-scale construction projects [3]. Approximately 99% of construction sites with fewer than 50 workers are operated by small and medium-sized construction companies, which often struggle to secure professional safety managers and other specialized personnel. Consequently, even a single accident can severely disrupt company operations [4, 5]. These small and medium-sized construction sites frequently lack systematic safety management and fall outside government oversight, accentuating the necessity to bolster safety management at these sites [6, 7].

An analysis of fatal accidents in the construction industry in Korea revealed that worker error was the primary cause of fatalities, with 132 cases (18%) attributed to simple negligence. Other significant causes included carelessness (6%, 43 cases), improper use of personal protective equipment (5%, 32 cases), and unsafe working postures (4%, 30 cases). This indicates that many accidents result from

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workers' mistakes rather than external factors [3]. Additionally, workers and contractors are often the primary parties responsible for these incidents [3]. The statistical data compiled shows that most accidents occur due to simple negligence and carelessness by workers and contractors. Also, workers' perceptional process has significant effects on their unsafe behavior based on the results of system dynamics simulation [8]. Therefore, this study shows the necessity of safety management based on workers' perceptional factors to decrease hazardous accidents at the construction site [8].

Recent efforts have aimed to develop and implement smart safety management technologies to reduce the high accident rate in the construction industry [9, 10]. A testbed for smart construction safety technology has been established and operated at small and medium-sized construction sites to collect data; however, observing changes in worker behavior has proven challenging [9]. This suggests that the effectiveness of smart construction safety technologies is limited without worker cooperation. Jeong, et al. [10] conducted a survey to improve regulations to promote the on-site application of smart safety management technologies and identified areas for improvement [10]. However, issues such as insufficient reliability and effectiveness of the technology, excessive focus on specific technologies, and lack of practical applicability have been raised [7]. Notably, there is a need for realistic solutions tailored to the circumstances of small and medium-sized construction sites. Due to poor working environments, small and medium-sized construction companies find it difficult to independently solve safety issues related to labor, skills, and equipment. Moreover, these companies often neglect safety management for accident prevention, partly due to economic concerns about investing in safety measures [11]. Small and medium-sized construction companies, lacking systematic safety management organizations and technology, frequently focus on shortening construction periods and minimizing costs due to the short duration and low contract value of projects. This results in frequent safety accidents due to a lack of pre-safety inspections, non-compliance with basic safety regulations, and insufficient safety training [11].

Considering the characteristics of small and medium-sized construction sites, numerous studies have undertaken to identify accident root causes and develop solutions through case studies and the collection of opinions Lim, et al. [12] and Choi and Oh [13]. Lim, et al. [12] concentrated on reinforced concrete work, which has the highest accident rate in construction projects, analyzing cases to ascertain major risk factors and accident types [12]. This research also explored accident causes and preventive measures from multiple project participant perspectives. Although safety accident causes varied among participants, all respondents, except workers, agreed that enhancing safety education is essential for prevention Lim, et al. [12]. Choi and Oh [13] carried out a survey on special safety and health education in construction sites, recognized effective safety training as a method for mitigating unsafe worker behavior—a primary human factor in accidents at these sites [13].

Efforts to quantify safety awareness levels and analyze the impact of each indicator on safety culture continue Jang and Go [11]. Jang and Go [11] investigated accident cases and safety management systems to address the high risk of accidents in construction and evaluated the current state of safety at construction sites in Korea [11]. They used the Analytic Hierarchy Process (AHP) to identify key safety management items and to underscore their significance Jang and Go [11]. Mohamed [14] introduced a conceptual model of construction safety culture in the context of safety management practices at construction sites Mohamed [14]. Kim, et al. [15] developed a survey based on these items and conducted assessments among different job roles at construction sites [15]. While these studies impartially identified safety factors and emphasized crucial aspects for enhancing safety culture, they failed to consider construction site size variability. Notably, there is a lack of studies focusing on the safety awareness of workers at small construction sites and on analyzing elements to improve safety culture.

Raising awareness of workplace accidents among workers and promoting behavioral changes toward safer construction sites are vital components of an effective corporate safety management system. For small-scale sites, which significantly contribute to construction accidents, providing targeted safety education to the primary culprits—workers and contractors—can markedly reduce incidents caused by simple negligence and carelessness.

Thus, to address the chronic issue of high accident rates in the construction industry, moving beyond conventional safety training to conduct detailed on-site evaluations of workers' safety awareness is necessary. Analyzing relationships and identifying improvement strategies that deliver substantial benefits with minimal investment are underscored as critical.

2. Literature Review

2.1. Safety Incidents in Small and Medium-Sized Construction Companies

An analysis of data on fatal accidents in the construction industry over the past three years indicates that specific measures for small-scale sites with budgets under 5 billion KRW are crucial to prevent and mitigate accidents, supported by initiatives like public worker safety training [3]. Research aimed at resolving the higher accident rate in the construction industry compared to other sectors has been extensively conducted.

To proactively prevent accidents on construction sites, there has been a significant shift toward implementing smart safety technologies that incorporate digital advancements such as big data, artificial intelligence, and sensors Choi, et al. [16]. Lee and Ahn [17] developed a smart safety control system based on ultrasonic sensors to prevent falling and contact accidents at the jobsite Lee and Ahn [17]. Kim [9] categorized smart construction safety technologies into installation-type and attachment-type and analyzed their effects by establishing testbeds at small-scale sites. They suggested combinations of smart construction safety equipment based on disaster type, construction type, and scale [9]. To encourage the adoption of smart construction safety technologies at small-scale sites, it is necessary to implement support plans from the government or public institutions, with the expectation that such support will reduce fatal accidents and create safer construction environments Kim [9]. Park and Lee [18] discovered that it is difficult to cover the costs associated with applying smart safety technologies at sites under 5 billion KRW using current cost estimation methods based on indirect expense rates [18].

Consequently, small-scale sites operate with limited budgets due to the nature of small and medium-sized construction companies, necessitating government-level interventions such as subsidies, grants, and institutional improvements for the application of smart construction safety technologies. It has been established that relying solely on small companies for technology application has limitations as an immediate strategy for reducing accidents.

Previous research involved collecting opinions and conducting surveys among personnel at small construction sites operated by small companies to analyze safety awareness [12, 19, 20]. One study analyzed accident cases in reinforced concrete construction, which has the highest accident rate among construction activities, to identify major risk factors and types of accidents. It utilized surveys from project participants to examine causes and preventive measures [12]. Another example involved analyzing 70,618 accident cases from formwork construction to address frequent injuries at small-scale sites with low safety awareness, deriving risk factors, accident prevention strategies, and having them validated by safety management experts Cho, et al. [19]. Lee [20] identified and evaluated the factors impeding scaffold safety at various stages—design, contracting, and construction—by surveying experts in each role involved in construction projects [20]. The results indicated that in the design phase, major issues included insufficient site investigation due to low-cost demands and pressure to reduce expenses; in the contracting phase, estimates lacked detailed drawings; and in the construction phase, the most critical issue was the avoidance of responsibility for additional costs when design changes were requested Lee [20].

Fargnoli and Lombardi [21] studied the application of the Preliminary Human Safety Assessment (PHSA) procedure to two small construction companies to enhance the safety environment concerning worker safety behaviors [21]. Using this method, they assessed the probability and severity of risks associated with concrete mixer truck operations and analyzed workers' risk perceptions, highlighting time pressures and unsafe behaviors among workers at construction sites Fargnoli and Lombardi [21]. Jang and Go [11] conducted a theoretical review of accident cases and safety management systems at construction sites to understand the current state of safety management in small-scale construction projects in Korea and identified issues through brainstorming with site stakeholders [11]. Through the analysis of accident case statuses and the survey of safety management practices at small-scale construction sites, they identified and presented key safety management items suitable for various site sizes Jang and Go [11].

Niciejewska, et al. [22] examined the influence of technical, organizational, and human factors on accident rates in 45 small and medium-sized construction companies in Poland. They found that human factors, such as inadequate safety awareness and behaviors of workers, were perceived as the greatest risks, leading to accidents Niciejewska, et al. [22]. Topal and Atasoylu [23] developed the Fuzzy Risk Assessment Model (FRAM) and employed it at four small construction sites for risk assessments. FRAM, a checklist, classifies types of accidents, their severity, and related work content based on historical accident data to evaluate the safety level and accident likelihood at construction sites [23]. Also, Jeong, et al. [24] analyzed the level of construction safety management of mid-size construction enterprises. While the safety management of the companies has been enhanced, it is still required to improve "procuring personnel in charge of safety management" and "analyzing the safety accident cases" to improve the safety climate at the small- and mid-size jobsites Jeong, et al. [24].

Yoon [25] analyzed that variations in accident types and causes were budget-dependent, emphasizing the need for tailored safety management at small and medium-sized construction sites [25]. Additionally, a regression analysis of 1,608 accident data points from the South Korean construction industry from 2000 to 2018 identified potential correlations among several factors significant in accident occurrence [26]. Based on these insights, it was concluded that factors such as employment type, working hours, and workdays are crucial for small construction sites, and a comprehensive safety management system that encompasses risk factors, safety education, and management of current workers is essential to reduce accident rates [26].

A review of the literature indicates that surveys of stakeholders at construction sites are commonly used to gather opinions, while case studies aim to analyze the causes of accidents at small-scale sites from multiple perspectives. However, these studies often vary in survey items based on the researcher's perspective and typically recommend "appropriate safety education" as a countermeasure, but they fail to provide specific improvement strategies. Safety management encompasses various factors beyond merely wearing protective gear, including communication and procedures [14]. Consequently, there is a need for studies proposing improvement measures that consider workers' perceived levels of safety awareness for each safety factor.

2.2. Safety Awareness Factors at Construction Sites

Recent studies have concentrated on quantifying onsite safety culture by assessing safety awareness factors and determining their impact on overall safety culture [14, 27-30]. Regarding safety education to enhance safety awareness, 83.7% of supervisors and workers indicated either "neutral" or "disagree," noting that safety training is often superficial [27]. The survey results revealed low scores in areas such as compliance with safety regulations, pre-work safety checks, and active participation in safety training for both workers and supervisors, yet there was inadequate analysis of complex safety awareness factors Jang [27]. Mohamed [14] introduced a conceptual model of construction safety culture that addresses safety management practices on construction sites, relying on ten distinct determinants [14]. In this study, 10 factors affecting the safety climate in the construction jobsite have been identified as in figure 1. The 10 factors identified in this previous study are as follows. (Figure 1):

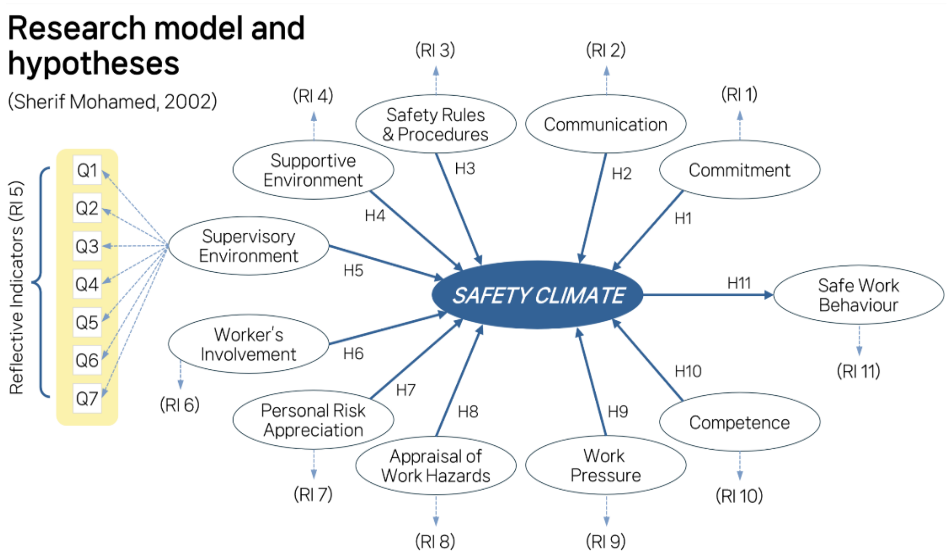

Figure 1.
Hypothesis and proposals for the safety awareness factor model (Adopted from Mohamed [14]).

Kim, et al. [15] analyzed safety climate by job category (Superintendent, Management, Skilled Labor, General Labor) Kim, et al. [15]. Choudhry, et al. [28] identified two key factors influencing construction safety performance: management commitment and inadequate safety procedures, which were used to measure the safety climate Choudhry, et al. [28]. Glendon and Litherland [29] analyzed six factors affecting safety climate and performance at road construction sites, identifying communication, safety procedures, work pressure, personal protective equipment, relationships, and safety rules as crucial elements Glendon and Litherland [29]. Chen, et al. [30] developed a safety climate resilience model to predict safety performance at construction sites, identifying seven indicators: accountability, supervisor safety awareness, peer perception, reporting of safety issues, training, prediction, and awareness of workplace conditions [30]. From the contractor's perspective, this study emphasized that individual-level management commitment is vital for enhancing safety performance, and the perception of safety functions is the most significant factor in promoting an improved safety climate at construction sites [30]. Similarly, a high safety climate was deemed particularly important for site managers and workers.

2.3. Starting Point of the Study

A review of prior studies indicates that applying smart safety technologies at small-scale construction sites is challenging, and the most practical way to enhance safety is by improving workers' safety awareness through effective training. Current research specifically focusing on small construction sites and presenting concrete safety improvement measures is lacking. This study aims to derive survey items from general construction site safety awareness evaluation indicators, conduct a survey at small-scale sites, and analyze workers' perceptions. Thus, the objective is to propose effective safety improvement measures and develop solutions to reduce accidents at small-scale construction sites. Figure 2 illustrates the starting point of the study.

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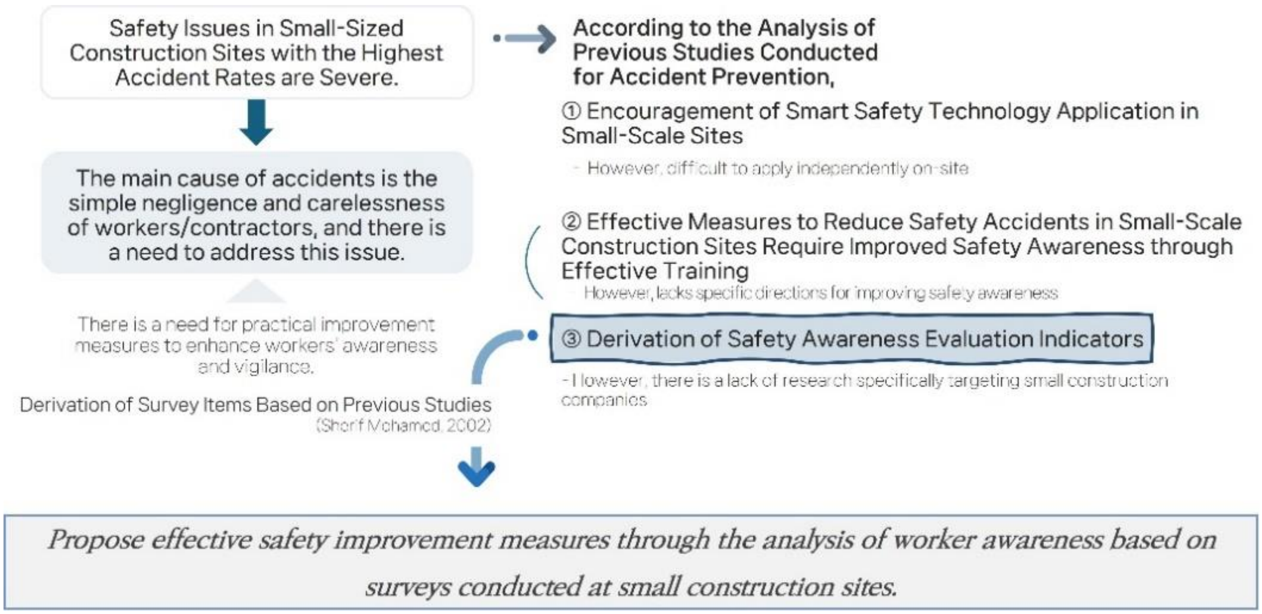

Figure 2.
The starting point of the study.

3. Research Method

3.1. Survey Questionnaire

This study is depicted in Figure 3. A survey involving 59 workers from small construction companies identified key factors influencing safety awareness in small businesses. The survey items, derived from studies by Mohamed [14] and Kim, et al. [15] were categorized into independent variables (IV) and dependent variables (DV) for analyzing safety factors and culture, as illustrated in Table 1 [14, 15]. The data were analyzed with the SPSS program to identify significant correlations between job categories and to discern commonly and individually selected items. The study concludes by analyzing responses to seven detailed questions that define the selected safety factors, enhancing safety awareness, and proposing strategies for items with low scores.

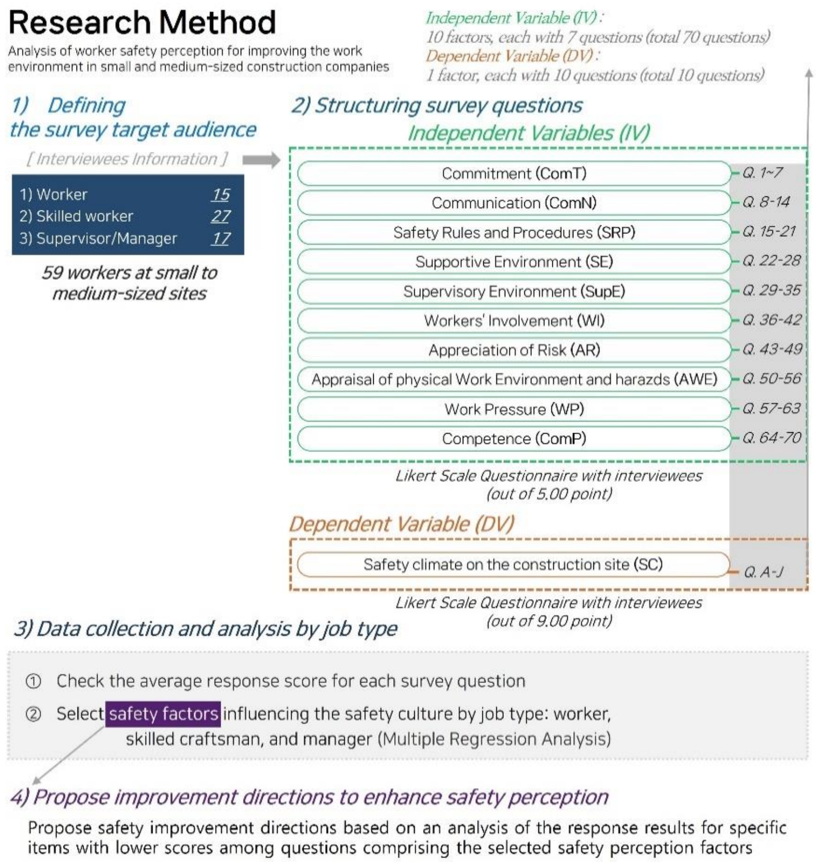

Figure 3.
Research method.

Table 1.
Define the Types of Variables (Adopted from Mohamed [14]).

Type of Variables	Variable Descriptions [14]	Acronym [14]
Independent Variables (IV)	Commitment	ComT
	Communication	ComN
	(Safety rules and procedures	SRP
	Supportive environment	SE
	Supervisory environment	SupE
	Workers' involvement	WI
	(Appreciation of risk	AR
	Appraisal of physical work environment and hazards	AWE
	Work pressure	AP
	Competence	ComP
Dependent Variable (DV)	Safety climate	SC

3.2. Survey Participants

The survey participants are categorized into workers, skilled workers, and managers. The definitions of each term are as follows: An "employee" is defined according to the Labor Standards Act as a person who provides labor in any occupation for wages. In this paper, the term "employee" encompasses workers, skilled workers, and managers [31]. A "worker" is defined as a laborer who predominantly performs physical tasks on-site, dealing mainly with basic construction tasks and repetitive activities. A "skilled worker" possesses specialized skills in a certain area, capable of executing complex tasks based on advanced skills and experience. A "manager" supervises and manages workers and skilled workers onsite, ensuring smooth progress in construction activities. Given that data collection was conducted anonymously by the individuals employed in the construction industry, formal ethical approval was not required. Informed consent was obtained from all participants involved in the survey. Table 2 provides basic information about the survey participants

Table 2.
Basic Information of the Survey Respondents.

Background of respondents		Number	Ratio(%)
Age	under 20 years old	1	1.7
	21 to 25 years old	4	6.8
	26 to 30 years old	8	13.6
	31 to 35 years old	10	16.9
	36 to 40 years old	6	10.2
	over 40 years old	30	50.8
Gender	Male	56	94.9
	Female	3	5.1
Years of experience in construction	0 to 5 years	14	23.7
	6 to 10 years	8	13.6
	11 to 15 years	7	11.9
	over 15 years	30	50.8
Years with company	0 to 5 years	45	76.3
	6 to 10 years	4	6.8
	11 to 15 years	4	6.8
	over 15 years	6	10.2
Job Professions	Labor	15	25.4
	Skilled Labor	27	45.8
	Superintendent	17	28.8

Each safety factor comprised seven sub-items, totaling 80 questions. The questionnaire was designed so that higher scores suggest more positive responses. This survey utilized the Likert Scale for quantitative measurement, where questions 1 to 70 (focused on specific awareness by field) were rated on a 5-point scale, and questions 71 to 80 on a 9-point scale (1=Strongly disagree, 3=Neutral, 5=Strongly agree). The 9-point scale was chosen for the safety behavior field to suit the item types. Introduced by Rensis Likert in 1932, the Likert Scale is an analytical method that posits a single item as inadequate for accurate variable measurement; rather, a scale of multiple, carefully selected, and analyzed items provides more precise measurements [16, 32]. It facilitates the creation of a vast array of items that exhibit clear positive-negative or agree-disagree tendencies towards any topic or subject. In this study, the Likert Scale was employed to gauge awareness levels among various safety management categories in small-scale construction sites, attributing uniform value to all items for straightforward and exact measurement and efficient data gathering.

The survey results will be objectively analyzed using the Statistical Package for the Social Sciences (SPSS) program. SPSS, a widely used statistical software in social sciences and related fields, offers comprehensive functions for data analysis, management, and reporting [33]. Essential functionalities include descriptive statistics, regression and factor analyses, cluster analysis, t-tests, and ANOVA [33].

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Renowned as a pivotal research analysis tool, SPSS facilitates the extraction of significant insights from data and ensures an objective presentation of findings based on robust statistical evidence [33].

4. Survey Results

4.1. Overview of Survey Results

The survey categorized safety awareness factors into ten classifications: Commitment, Communication within the organization, Safety rules and procedures, Supportive environment for safety-related work, Supervisory environment for safety management, Workers' involvement, Appreciation of risk and accidents, Appraisal of physical work environment and hazards, Work pressure, and Competence. Each factor was analyzed through seven survey items, with average respondent scores depicted in Figure 4.

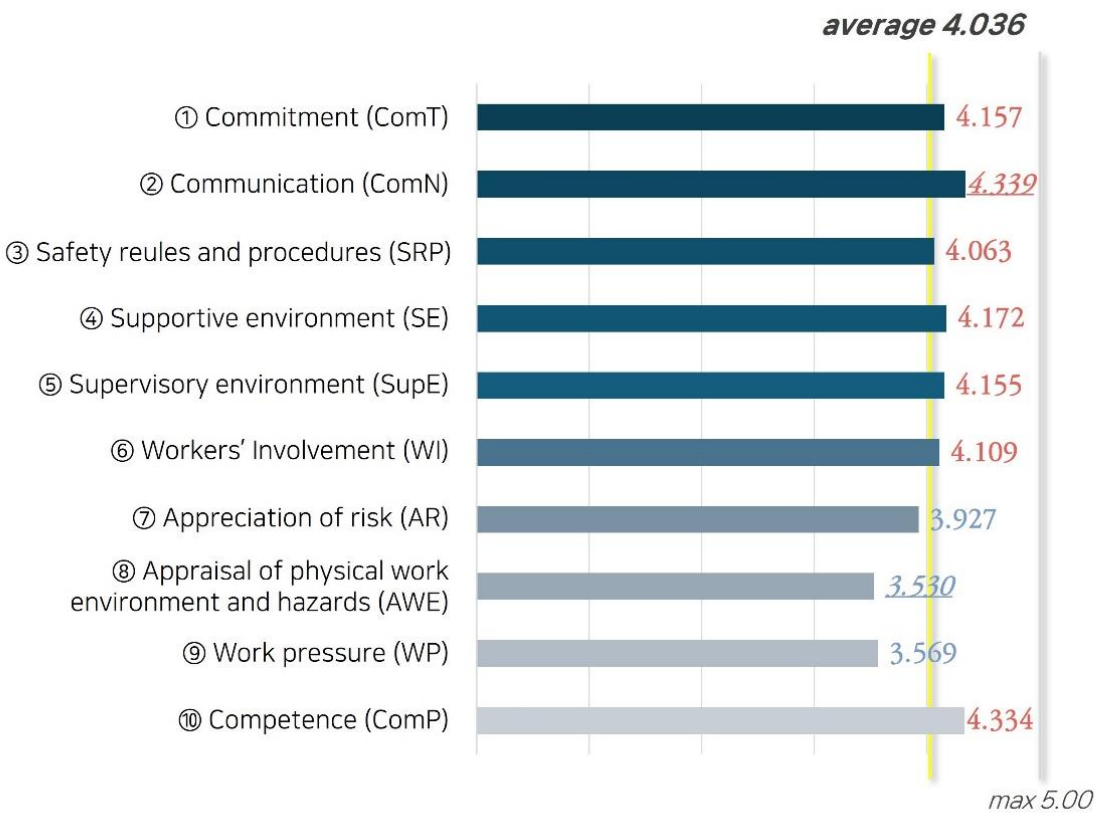

Figure 4.
Average scores by safety factor survey items.

The highest-scoring safety factor is "Communication within the organization" (4.339), with the lowest-scoring being "Appraisal of physical work environment and hazards" (3.530).

4.2. Bivariate Correlation Analysis

Bivariate correlation analysis is a statistical method used to determine and evaluate the relationship between two variables, examining their correlation's direction and strength [34]. This analysis expresses results through the correlation coefficient and p-value.

The correlation coefficient quantitatively characterizes the relationship between two variables, with the Pearson correlation coefficient (r) being the most prevalent.

The value of the correlation coefficient ranges between -1 and 1, with the following implications:

- r = 1: Perfect positive correlation (when one variable increases, the other variable also increases)
- r = −1: Perfect negative correlation (when one variable increases, the other variable decreases)
- r = 0: No correlation (no linear connection exists between the two variables)

The formula for calculating the Pearson correlation coefficient is presented in Equation 1:

$$r = \frac{\sum(X_i - \bar{X})(Y_i - \bar{y})}{\sqrt{\Sigma(X_i - \bar{X})^2 \Sigma(Y_i - \bar{Y})^2}} \quad (1)$$

$X_i$and $Y_i$are the individual observed values of X and Y, respectively, while $\bar{X}$ and $\bar{Y}$ are the corresponding means X and Y. To evaluate the significance of the derived correlation coefficient, a p-value is calculated using the specified formula. This p-value represents the probability of observing the calculated statistic, or a more extreme one, under the assumption that the null hypothesis holds true. In this study, we rejected the null hypothesis and accepted the alternative hypothesis when the p-value was below 0.05. Hence, the null hypothesis (H0) and the alternative hypothesis (H1) were established as depicted as below:

Null Hypothesis (H0): There is no correlation between the safety culture on the construction site and the safety factors (IV)

Alternative Hypothesis (H1): There is a correlation between the safety culture on the construction site and the safety factors (IV)

The null hypothesis (H0) and the alternative hypothesis (H1) are determined by the following conditions:

If (Probability of p-value ≥ 0.050), the iv removed

If (Probability of p-value < 0.050), the iv selected

A bivariate correlation analysis was conducted between independent and dependent variables, categorized by job role, and the results are shown in Table 3. The analysis revealed that safety factor variables with an r-value greater than zero and a p-value < 0.05 are positively correlated. The relevant independent variables are described below. For workers, variables such as "Communication within the organization (ComN)," "Supportive Environment for Safety-related Work (SE)," "Workers' Involvement (WI)," and "Competence (ComP)" were associated with the safety climate. For skilled workers, "Communication within the organization (ComN)," "Workers' Involvement (WI)," and "Competence (ComP)" showed significant correlations. Lastly, for managers, "Commitment (ComT)," "Communication within the organization (ComN)," "Appraisal of Work Environment Hazards (AWE)," and "Competence (ComP)" were found to be correlated with the safety climate.

Table 3.
Bivariate Correlation Analysis between Independent and Dependent Variables.

		ComT	ComN	SRP	SE	SupE	WI	AR	AWE	WP	ComP
Worker	Pearson Correlation (r-value)	0.032	0.519*	0.413	0.546*	0.206	0.628*	0.466	0.304	0.026	0.631*
	Significance Probability (Two-tailed) (p-value)	0.909	0.047	0.126	0.035	0.46	0.012	0.08	0.271	0.927	0.012
Skilled Worker	Pearson Correlation (r-value)	0.185	0.478*	0.136	0.297	0.284	0.389*	0.122	0.246	0.231	0.534**
	Significance Probability (Two-tailed) (p-value)	0.356	0.012	0.5	0.132	0.151	0.045	0.546	0.215	0.246	0.004
Manager	Pearson Correlation (r-value)	0.505*	0.486*	0.317	0.399	0.473	0.303	0.392	0.572 *	0.408	0.622**
	Significance Probability (Two-tailed) (p-value)	0.039	0.048	0.216	0.113	0.055	0.238	0.120	0.016	0.104	0.008

4.3. Multiple Regression Analysis

Multiple regression analysis was employed to assess the impact of various factors on the dependent variable. This statistical method enables simultaneous consideration of multiple independent variables, enhancing the accuracy of explanations for complex phenomena [34, 35]. The multiple regression analysis was conducted on safety factors with a p-value < 0.05 derived from the bivariate correlation analysis of survey data. Initially, the ANOVA results of the multiple regression analysis are displayed in Table 4.

Table 4.
ANOVA for Multiple Regression Analysis of Workers.

Safety Factor	R^2	F-value (sig.)	Unstandardized coefficient (b)	Standardized coefficient (β)	T-value	Sig.
ComN	0.269	4.792 (0.047)	0.992	0.519	0.519	0.047
SE	0.299	5.532 (0.035)	1.160	0.546	2.352	0.035
WI	0.394	8.460 (0.012)	1.381	0.628	2.909	0.012
ComP	0.398	8.609 (0.012)	1.032	0.631	2.934	0.012

Note: *DV: Safety climate in the workplace.

Table 5 illustrates the ANOVA results of the multiple regression analysis for skilled workers. Despite the significance of WI (Workers' Involvement) for skilled workers based on the p-value, the R^2 value of 0.151 signifies a low explanatory power, suggesting the model needs refinement. Nonetheless, as this study is an early-stage examination of the correlation between safety awareness and factors, WI has been retained for data analysis.

Table 5.
ANOVA for Multiple Regression Analysis of Skilled Workers.

Safety Factor	R^2	F-value (sig.)	Unstandardized coefficient (b)	Standardized coefficient (β)	T-value	Sig.
ComN	0.228	7.384 (0.012)	0.855	0.478	2.717	0.012
WI	0.151	4.456 (0.045)	0.806	0.389	2.111	0.045
ComP	0.285	9.965 (0.004)	1.011	0.534	3.157	0.004

Note: *DV : Safety climate in the workplace.

Table 6 depicts the ANOVA resulting from the multiple regression analysis of survey responses from managers.

Table 6.
ANOVA for Multiple Regression Analysis of Managers.

Safety Factor	R^2	F-value (sig.)	Unstandardized coefficient (b)	Standardized coefficient (β)	T-value	Sig.
ComT	0.255	5.130 (0.039)	2.834	0.505	2.265	0.039
ComN	0.236	4.637 (0.048)	0.992	0.486	2.153	0.048
AWE	0.327	7.284 (0.016)	3.008	0.572	2.699	0.016
ComP	0.386	9.449 (0.008)	3.303	0.622	3.074	0.008

Note: *DV: Safety climate in the workplace.

5. Proposed Directions for Improving Workers' Safety Awareness

5.1. Proposed Directions for Improving Safety Awareness Across All Job Roles

"Communication within the organization" and "Competence" were positively correlated with the safety climate for all categories of workers. To enhance safety awareness, the responses to detailed items for each safety factor were analyzed, leading to the identification of the bottom three items for each factor, as outlined in Table 7 and Table 8. For "Communication within the organization," it is necessary to effectively communicate safety issues, develop safety actions based on field employee feedback, and initiate campaigns promoting safe work practices. In terms of "Competence," recommended improvements include conducting pre-training for safe task execution, acquainting workers with safety regulations, and increasing their competency to recognize potential hazards.

Table 7.
Average and Standard Deviation of the Bottom 3 Items for "Communication within the Organization (ComN)" among All Responses.

Num	Questions	Mean	S.D
Q12	Listens to and takes action based on feedback from field employees.	4.254	0.900
Q08	Clearly communicates safety issues at all organizational levels.	4.271	1.387
Q14	Carries out campaigns to promote safe work practices.	4.288	0.828

Table 8.
Average and Standard Deviation of the Bottom 3 Items for "Competence (ComP)" among All Responses.

Num	Questions	Mean	S.D
Q66	I fully understand the current laws related to safety rules.	4.237	0.851
Q64	I have received sufficient training to perform tasks safely.	4.271	0.954
Q68	I can identify potential hazardous situations.	4.305	0.670

5.2. Proposed Directions for Improving Safety Awareness for Workers/Skilled Workers

It was found that "Workers' Involvement" correlates with the safety climate in the workplace for both workers and skilled workers. The analysis of responses to detailed items for each safety factor is detailed in Table 9. The bottom three items for "Workers' Involvement" suggest that enhancing worker participation requires reporting safety incidents and potential hazards, actively participating in accident investigations when requested, and conducting job safety analyses.

Table 9.
Average and Standard Deviation of the Bottom 3 Items for "Workers' Involvement (WI)" among Workers/Skilled Workers.

Num	Questions	Mean	S.D.
Q41	I actively participate in accident investigations.	3.786	1.440
Q38	I report safety incidents and potential hazards.	4.214	0.976
Q42	I contribute to job safety analysis when accident investigations are requested.	4.214	0.813

5.3. Proposed Directions for Improving Safety Awareness for Managers

For managers, it was found that both "Commitment" and "Appraisal of Work Environment Hazards" exhibit significant positive correlations with the safety climate. Therefore, based on the analysis of the bottom three items for "Commitment," we recommend implementing preventive safety measures before accidents occur, encouraging on-site employees to maintain safe work practices, and enforcing disciplinary actions for non-compliance (refer to Table 10). Moreover, improvements in safety awareness could be realized by examining factors contributing to workplace accidents, assuring conditions for safe work performance, and assessing site arrangement plans for potential improvements in safety (refer to Table 11).

Table 10.
Average and Standard Deviation of the Bottom 3 Items for "Commitment (ComT)" among Managers.

Num	Questions	Mean	S.D
Q07	I discipline on-site employees who work unsafely.	3.353	1.081
Q05	I take preventive safety measures before accidents occur.	3.647	1.328
Q06	I encourage on-site employees who work safely.	4.000	0.967

Table 11.
Average and Standard Deviation of the Bottom 3 Items for "Appraisal of Work Environment Hazards (AWE)" among Managers.

Num	Questions	Mean	S.D
Q52	There are no factors in the workplace that could contribute to accidents.	2.529	1.333
Q53	The workplace is prepared with conditions that allow for safe work performance.	3.118	0.899
Q51	Improper site layout planning is unacceptable in the industry.	3.765	1.11

6. Discussion and Conclusion

The construction industry in South Korea continues to explore institutional and technological strategies to mitigate chronic safety accidents, yet these problems persist. Small-scale construction sites, in particular, struggle with adopting new systems and recruiting safety managers, underscoring the urgency for feasible solutions. This study focuses on analyzing safety factors explicitly linked to the small-scale site safety climate, a shift from prior research on general construction sites. It identifies low-scoring items and suggests corresponding improvements.

This study conducted a survey targeting 59 workers employed at small construction sites, with questions designed to assess safety factors and the onsite safety climate. The independent variables were identified as ten safety factors, while the dependent variable was defined as the current safety climate at the site. The alternative hypothesis proposed a correlation between the safety climate and safety factors at small-scale construction sites, contrary to the null hypothesis. The null hypothesis was rejected, and the alternative hypothesis was accepted when the p-value was less than 0.05. Through bivariate correlation analysis, safety factors with a p-value below 0.05 were classified by job category. As depicted in Table 4, the primary influencing factors for workers included "Communication within the organization," "Supportive Environment for Safety-related Work," "Workers' Involvement," and "Competence." For skilled workers, "Communication within the organization," "Workers' Involvement," and "Competence" were directly related to the safety climate, while for managers, the factors were "Commitment," "Communication within the organization," "Appraisal of Work Environment Hazards," and "Competence." The multiple regression analysis revealed that the R^2 value for "Workers' Involvement" among skilled workers was low, indicating insufficient explanatory power of the model. Future studies will aim to improve this by identifying additional influencing variables or collecting more responses.

The proposed improvement measures were categorized into three groups: 1) workers across all job roles (workers, skilled workers, managers), 2) on-site workers and skilled workers, and 3) managers and supervisors. Common factors for each classification were identified, and the bottom three items with low scores were derived from the detailed responses. For all workers, safety factors positively correlated with the workplace safety climate included "Communication within the organization" and "Competence." An analysis of the bottom three items for "Communication within the organization" highlighted the need to clearly communicate safety issues within the organization, propose safety actions based on feedback from field employees, and actively promote campaigns that encourage safe working practices. Furthermore, for "Competence," it was deemed necessary to conduct pre-training for safe task execution, familiarize workers with safety regulations, and enhance their ability to identify potential hazards.

In the worker/skilled worker category, "Workers' Involvement" was identified as influencing the safety climate at the site. To encourage worker participation, it is essential to report safety incidents and potential hazards, actively participate in accident investigations when requested, and conduct job safety analyses.

Lastly, the manager category demonstrated a correlation between "Commitment" and "Appraisal of Work Environment Hazards" with the safety climate, and the results were examined accordingly. From the analysis of the bottom three items for "Commitment," it was determined that preventive safety measures should be implemented before accidents occur, on-site employee safety should be promoted, and disciplinary actions should be intensified in cases of unsafe behaviors. Concerning "Appraisal of Work Environment Hazards," the analysis suggested that safety awareness could be enhanced by monitoring potential accident factors at the workplace, ensuring conditions for safe work, and avoiding improper site layout planning. The variances in safety factors between the worker/skilled worker group and the manager group likely stem from differences in job role responsibilities.

These insights provide crucial evidence for shaping safety education and training programs in small construction companies. Moreover, by recognizing varying safety awareness focus tendencies among workers, skilled workers, and managers, this study recommends the formulation of customized safety management strategies tailored to each job role, thereby advancing cost-effective accident prevention. This contribution is expected to be highly beneficial in practical terms.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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