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# A Conceptual Model of Multi-Spectra Perceptions for Enhancing the Safety Climate in Construction Workplaces

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**Abstract:** Construction safety climates can reflect organizational safety behavior and commitment, employees' safety perceptions and attitudes, and the supervisory and support environments. Maintaining a healthy safety climate can help prevent workers from fatal accidents and illnesses. To enhance the safety climate and, consequently, improve safety performance at a construction site, it is very important to analyze the elements that affect the safety climate and are significant for different types of construction work organizations. Therefore, the main goal of this study was to develop a multi-spectra perception model to investigate which factors were considered critical from four key perspectives: managers, superintendents, skilled laborers, and general helpers. To achieve this goal, a survey questionnaire was conducted to collect empirical data from one commercial building construction project. Based on a stepwise regression analysis, it was revealed that the most significant factors enhancing the safety climate are: from the managers' perspective, a combination of improvement in the support environment and reduction in work pressure; for superintendents and skilled laborers, increasing worker competence; and for general laborers, increasing worker involvement. This research contributes to a better understanding of the significant factors and provides a measure for each important role in enhancing the safety climate at a job site.

## 1. Introduction

The construction industry continues to be one of the most dangerous sectors across all industries. According to the most recent survey conducted by the U.S. Bureau of Labor Statistics (BLS), 5250 work-related fatalities were reported in 2018 [1]. Of these, 1008 (19.2%) occurred in construction-related sectors [1]. This high rate of fatal accidents in construction work zones results in significant costs related to recovering from accidents and injuries [2,3]. The Midwest Economic Policy Institute reported that the average cost from fatal accidents related to construction as an occupation was approximately $5.0 billion per year [3]. To combat this problem, the construction industry has tried to improve the safety climate and culture at the job site, following four different approaches: (1) investing in safety inspections in accordance with the Occupational Safety and Health Association (OSHA) rules; (2) increasing the prevailing wages of construction workers; (3) establishing a clear ordinance that those contractors participating in bids must ensure safety standards; (4) and avoiding political issues that cause strikes by construction unions [3].

However, those approaches enforced by legislation cannot fundamentally reduce construction fatalities, accidents, and injuries because they overlook the intrinsic and unique features of the construction work environment.

The contractor is responsible for cultivating a safe worksite and providing for construction workers by ensuring that hazards are eliminated or minimized [4]. This can be done effectively in an optimistic and positive safety climate at the job site [5]. In this sense, many recent studies have contributed to quantifying safety climates based on safety indicators and an evaluation of the effects of each indicator on the greater climate [6–9]. These studies have suggested recommendations for cultivating a positive safety climate and improving safety performance at construction projects. Unfortunately, despite the numerous efforts to enhance construction safety, the construction industry continues to suffer poor safety performance and a high rate of fatalities, accidents, and injuries. To address this challenge, some research has focused on certain organizational aspects at the construction worksite such as relationships between supervisors and workers [10,11], because construction safety management can be regarded as a means of social communication in this area [12]. According to these studies, the behavior of the supervisor is significant and affects the behavior of construction workers [10,12,13]. One recent study quantified and compared the safety climates and behaviors of construction workers and supervisors in order to explore their effects on safety performance [14]. That effort helped to explain how social interactions on construction job sites can improve safety performance.

The Center for Construction Research and Training (CPWR) and the National Institute for Occupational Safety and Health (NIOSH) defined the safety culture and climate for the construction industry and identified key factors affecting it and barriers hindering its improvement, in order to bridge the gap between research and practice regarding construction safety [15]. The CPWR documented key factors and subset components that can be measured in a safety climate analysis [15]. According to these reports, it is critical to interact across all levels of an organization at the construction site [15]. Mohamed (2002) proposed a safety climate model based on ten hypotheses: commitment, communication, safety rules and procedures, support environment, supervisory environment, worker involvement, personal appreciation, appraisal of the work environment, work pressure, competence, and safe work behavior [8].

Previous studies have mainly focused on modeling or measuring the safety climate but ignored finding the relationships between multiple roles at job site and their perspectives regarding the critical factors influencing the safety climate. Therefore, the main goal of this study, as an empirical study, is to investigate how the different roles in the construction workspace have different perspectives regarding the safety climate, as well as providing the comprehensive discussion to enhance the safety climate based on the finding. The conceptual and theoretical model will be developed based on statistical analysis to describe their multi-spectra perspectives in enhancing construction safety climate. To achieve the goal, this study categorized four different levels at the construction job site for investigating their different perspectives about safety climate: project management and administration, superintendents, skilled labor, and general workforce labor. Thus, this work provides a deeper investigation of these four different perspectives and significant factors affecting the enhancement of safety climates.

Section 2 will provide extensive information and reviews of previous studies in the construction safety climate and demonstrate the main goal and scope of this study based on the review. Section 3 mainly describes the research methodology including survey questionnaire, recruiting samples, the demonstration of samples, and description of job sites. Section 4 includes the information about the statistical analysis and procedures and findings of data analysis, as well as the description of the multi-spectra perception model. Lastly, Section 5 will comprehensively discuss implications, the threat of validity and limitations, and future studies based on the results.

## 2. Literature Review

The concept of the safety climate has been described as workers' perceptions regarding job site conditions, environment, and safety [16]. The safety climate can be considered a subset of the safety culture of the worksite because the climate is reflected and cultivated by a safe culture at a well-arranged job site [17,18].

In recent decades, there have been numerous studies on the safety climate, exploring and investigating the relationship between safety climate and job performance, the traumatic record of fatal accidents, and negative social perceptions of the construction environment. They explored and investigated the relationships between the safety climate, behavior, and performance [5–9,19–23]. The main group of contributions identified leading factors affecting the safety climate at a job site. For example, safety behavior related to workers' actions in accordance with a safety program or procedure have a positive relationship with an effective safety climate at the job site [10,13].

Another group of studies measured and assessed the safety climate based on certain identified factors [6,7,9]. Such work has contributed to a better understanding of the impact of the safety climate on safety performance [24,25]. The following sections describe the: (1) concept of construction job site safety climate and the leading indicators affecting it (Section 2.1); (2) interactions among different organizational levels at a job site (Section 2.2); and (3) the problem statement based on the information synthesized in current research (Section 2.3).

### 2.1. Safety Climate at Construction Job Site

For the construction industry, in particular, Mohamed (2002) proposed a conceptual model of the construction safety climate based on 10 different determinants in the context of safety management practices at the job site [8]. The 10 determinants identified were: (1) commitment, (2) communication, (3) safety procedures, (4) support environment, (5) supervisory environment, (6) workers' involvement, (7) personal appreciation of risk, (8) appraisal of job site and hazards, (9) work pressure, and (10) competence. Choudhry et al. (2009) addressed two main factors affecting construction safety performance—management commitment and inappropriate safety procedures—and used them to measure the safety climate [6]. Glendon and Litherland (2001) analyzed six factors influencing safety climate and performance at road construction sites. That study identified communication, safety procedures, work pressure, personal protective equipment, relationships, and safety rules as important elements [26]. Chen et al. (2017) developed a safety climate resilience model to predict safety performance at the construction job site. In this model, the authors identified seven indicators affecting safety performance, including commitment, supervisors' safety perceptions, coworkers' perceptions, safety concern reporting, education, anticipation, and awareness of the job site situation [19]. From the contractor's perspective, this study emphasized that commitment from management on the individual level was critical to improving safety performance, and an awareness of safety features was the most important element when cultivating an enhanced safety climate at construction worksites [5,19]. Likewise, a high-level safety climate is important for onsite managers, engineers, and workers [9,10,27].

To maintain a better safety climate on site, project engineers, safety managers, and superintendents must coordinate to inspect safety-related features, based on the overall safety management program, including procedures and regulations in accordance with OSHA [4,28]. To do so, field inspections to secure safety are conducted by the owner, field manager, and superintendent. These individuals discuss outcomes based on the data collected during such inspections and document their findings and suggest corrective action to address any issues threatening safety. However, there are still concerns regarding safety at the job site because of a lack of communication between the different levels of the organization involved in the safety management program, such as field management and superintendents.

### 2.2. Interaction of Different Organizations in Construction Safety Climate

A construction project requires significant human resources and management input throughout a project's life cycle, and specifically during the construction phase [29,30]. Hence, it is necessary for there to be social communication and interactions between different levels of the organization [12]. In addition, when executing a safety management program during the construction, field management is responsible for cultivating a high-level safety climate and delivering a safe job site to workers [10,14]. Many studies have explored the interaction between supervisors and workers in the work environment. Fang et al. (2015) analyzed the impact of the supervisor on workers' safety behavior in construction projects supervisors' behavior as having a critical impact on workers' conduct because the supervisor usually has the most frequent contact with workers [10]. Another recent study analyzed the effects of the safety climate and behavior on safety performance, documenting that there are obvious differences in the perceptions of supervisors and workers [14]. This study documented the obvious and different perceptions of safety climate between supervisors and workers. Supervisors tended to follow safety compliance but had more stress than workers did at construction worksites [10,13,14].

Some research expanded upon the organizational scope of supervisors and workers to incorporate company managers [21,26,27]. Hon et al. (2014) compared safety climates based on the occurrence of injuries among managers, supervisors, and workers in the repair and maintenance worksite environment [21]. Workers' positive attitudes were found to be an important predictor of injury occurrence, and managers with a deeper commitment to safety were more effective at improving safety performance.

Glendon and Litherland (2001) focused on a subset of construction labor, construction workers and maintenance crew in the road construction domain [26]. The researchers argued that construction crews had more frequent interactions with their supervisors than did regular maintenance workers; however, maintenance crews tended to comply with safety rules and procedures more often than did construction workers. It is likely that different types of workers at a construction worksite have a wide variety of perspectives on the safety climate. Skilled labor requires assistance by and support from general laborers and helpers [31]. Generally speaking, skilled labor has substantial training in special trade jobs [32]. In contrast, general labor tends to have less experience than skilled labor and thus tends to assist skilled laborers [31,32]. In this sense, the two groups likely have different perspectives on and insights into the construction safety climate. Therefore, this study has attempted to categorize the two groups at the labor level: specialized labor and general labor.

### 2.3. Departure of the Problem and Aims of the Study

The current state of knowledge on the topic of construction safety climates has documented certain common factors appearing in various studies. Some research has analyzed the safety climate according to two specific workgroups, supervisor and workers [10,11,14]. It is clear that an effective safety climate at the job site will enhance safety performance [6,24,33,34], and supervisors' commitment, which in turn will have a positive impact on workers' safety [10,13,27]. Such research has contributed to a better understanding of how each indicator affects the safety climate and documented the impact of the safety climate on safety performance. This study departs from previous research on this topic by focusing on the interactions among multiple perceptions in construction field operations (rather than simply the worker–supervisor dichotomy), such as construction and safety management, superintendents, specialty laborers, and general laborers. To identify the different perceptions regarding safety climate enhancement, this study distributed a questionnaire survey and collected the social perceptions of these different groups in a controlled environment. Based on a statistical analysis, this research developed a multi-spectra perception (MsP) model across a variety of perspectives, identifying these different perspectives regarding the enhancement of the construction safety climate and enriching the current state of knowledge and practice of construction safety.

## 3. Research Methodology

The safety climate is a construct that captures employees' perceptions of the role that safety plays in an organization [16]. It can be useful as a measure of the attitudes regarding safety in a particular work atmosphere. It is also important to periodically assess the safety climate to prevent workers from fatal accidents resulting from low safety morale [5,11]. More specifically, the present study investigates the range of perceptions from different groups regarding the safety climate at the construction workplace. Figure 1 illustrates the overall research method.
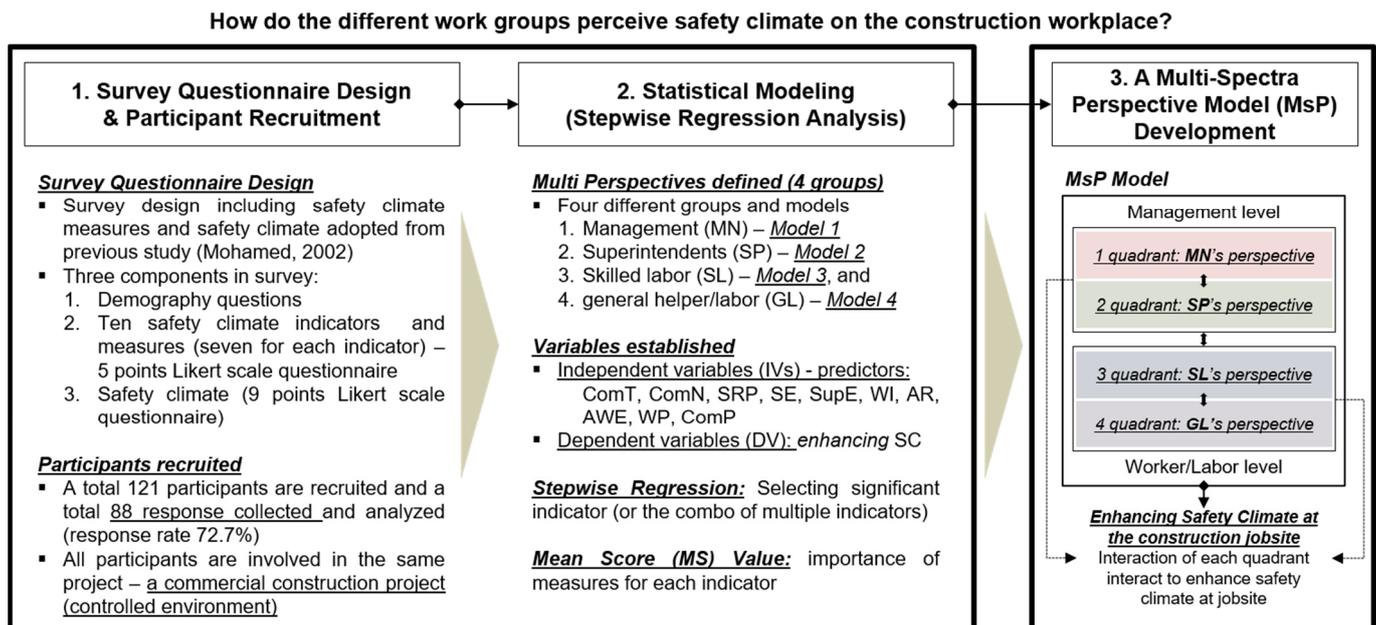


**Figure 1.** Overall research method.

### 3.1. Scope of Different Perspectives

This section describes the dimensions of the different perspectives at the construction job site and variables affecting the safety climate, based on a previous study. Four different dimensions are defined here: managers (e.g., construction or safety supervisors), construction superintendents, skilled labor (e.g., carpenters or electricians), and general laborers and helpers. For example, managers include the safety and construction project managers responsible for a site's operational control needed to complete and deliver a project. Specifically, superintendents are in charge of supervising the daily work scope as a specific part of a project task [35]. They have different roles and management perceptions, and they are responsible for coordinating all sources in the construction project, such as material, labor, and equipment [36]. For laborers, skilled labor includes any employee with a specialty job needed to complete a part of a task, while general labor includes workers who assist skilled laborers [31,32]. Figure 2 illustrates the scope of the different roles and perceptions in a construction work environment.
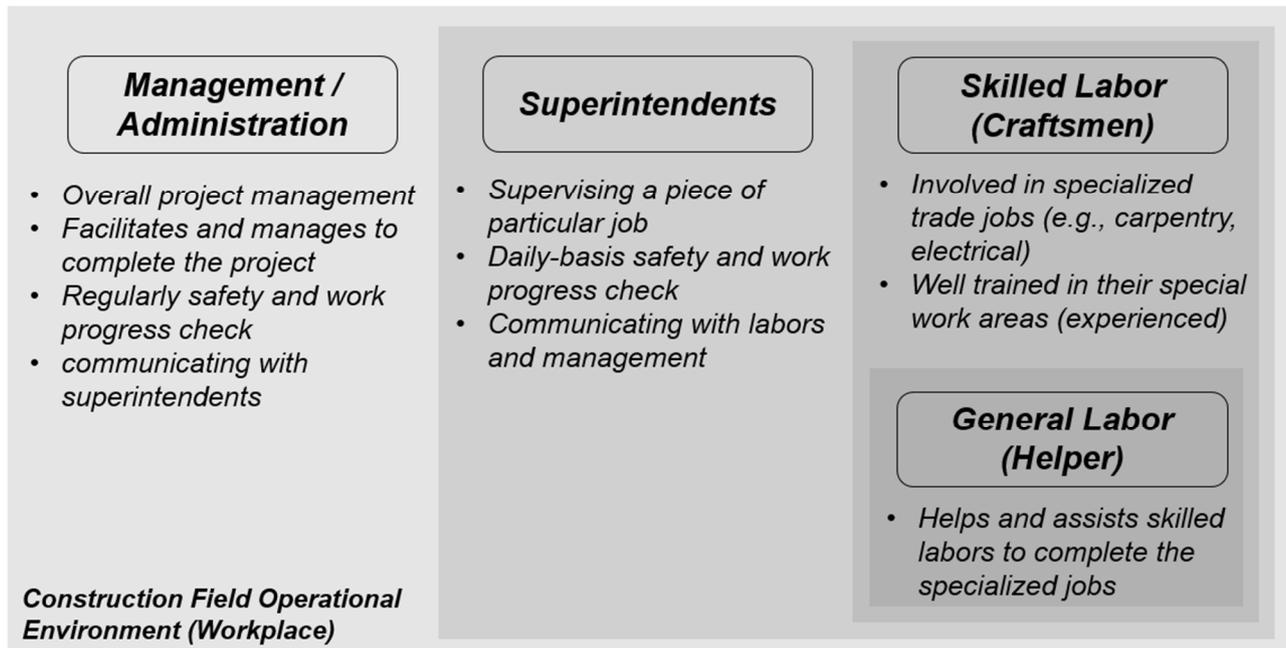
**Figure 2.** Scope of the different perceptions at the construction worksite.

*3.2. Survey Questionnaire and Participants*

This study employed a survey questionnaire to collect empirical data from the construction industry. The questions were developed by referencing the determinants identified in a previous study [8]. Based on this research, a total of ten different variables impacting the safety climate were documented: commitment, communication, safety rules and procedures, support environment, supervisory environment, workers' involvement, personal appreciation of risk, appraisal of the work environment and hazards, work pressure, and competence [8]. This questionnaire contains three elements about demographics, ten indicators affecting the safety climate, and the safety climate measure. For the demographics description, participants were asked their age, gender, years of experience in construction, and job classification. Mohamed (2002) documented seven sub-statements for each safety climate indicator and 10 sub-statements measuring the safety climate [8]. Thus, a total 80 questions were asked to quantify the safety climate indicators and measure the safety climate. The questions regarding indicators influencing the safety climate employed a five-point Likert scale (1 = strongly disagree or not effective, 3 = neither disagree/not effective nor agree/effective, and 5 = strongly agree or effective). For the measure of safety climate, the participants also indicated the safety at their current workplace (the same job site) based on a nine-point Likert scale (9 = very strong endorsement). To identify the statistical relationship between the indicator and safety climate, the means score (MS) of the seven sub-questions for each indicator was computed. Based on the MS, a statistical analysis was conducted to document the independent variable (IV) most significant to the dependent variable (DV), which was safety climate. Table 1 includes a description of each indicator and an acronym for each variable.

**Table 1.** Description of Variables (Applied from Mohamed, 2002 [8]).

| Type of Variables | Variable Descriptions [1] | Acronym |
|---|---|---|
| Independent Variables (IV) | Commitment ($x1$) | ComT |
| | Communication ($x2$) | ComN |
| | Safety rules and procedures ($x3$) | SRP |
| | Supportive Environment ($x4$) | SE |
| | Supervisory Environment ($x5$) | SupE |
| | Workers' Involvement ($x6$) | WI |
| | Appreciation of Risk ($x7$) | AR |
| | Appraisal of Physical Work Environment and Hazards ($x8$) | AWE |
| | Work Pressure ($x9$) | WP |
| | Competence ($x10$) | ComP |
| Dependent Variable (DV) | Safety Climate | SC |

[1] Variables refer to Mohamed (2002).

A total 121 participants, all industry professionals from construction job sites, were asked to measure each indicator and the safety climate. All participants were recruited from the same construction job site and company because it was important to obtain perceptions from the same physical work environment and culture. A commercial construction project in the greater Atlanta area was employed (see Figure 3). Among the total, 88 respondents (72.70%) were selected after filtering out 33 inapplicable questionnaires. A total of 29 management-level personnel (32.95%), 16 superintendents (18.18%), 24 skilled laborers (27.27%), and 19 general helpers or laborers (21.60%) were classified. The average experience in the construction industry was 11.2 years, and the average experience in the current safety climate at the present company was 4.7 years across all job classifications. Specifically, skilled labor had the largest average number of years of experience in the construction industry and with the current company (12.5 years and 5.1 years, respectively). Table 2 describes the demographics of the survey respondents.

**Table 2.** Demographic of Survey Participants.

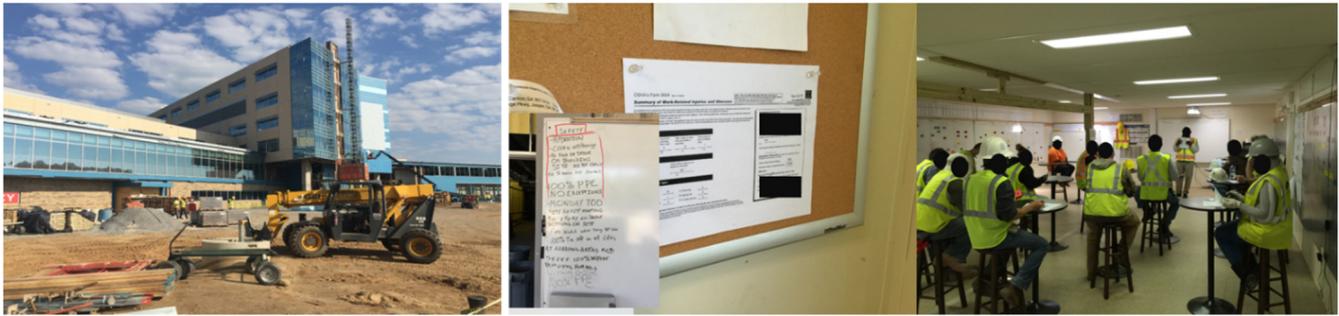| Job Professions | Number of Participants | Ave. Experience in Construction (Years) | Ave. Experience in Current Company (Years) |
|---|---|---|---|
| Management (MN) | 29 (33.0%) | 8.7 | 3.0 |
| Superintendent (SP) | 16 (18.2%) | 7.9 | 4.1 |
| Skilled labor (SL) | 24 (27.3%) | 12.5 | 5.1 |
| General labor/helper (GL) | 19 (21.5%) | 5.1 | 2.1 |
| Total | 88 | 11.2 | 4.7 |

**Figure 3.** Construction workplace environment for survey questionnaire data collection (taken by Authors—Dr. Sungjin Kim and Dr. Javier Irizarry).

## 4. Statistical Analysis and Modeling

Based on the established hypothesis, this study analyzed various perspectives from different job professions on the safety climate at a construction site. Each participant was asked about their perceptions as they related to the study variables. Based on the responses, this work developed a stepwise regression model for each organization on the construction project. Section 4.1 explains the stepwise regression analysis and procedures used to enhance the safety climate, as identified in the present study.

### 4.1. Stepwise Regression Analysis

A stepwise regression analysis was employed to quantify the weighted impact of each variable. A stepwise regression is an iterative process in which the correlation of independent variables (IVs) with the dependent variable (DV) is assessed. During the running of the model, independent variables with the highest correlation were entered into the regression equation at each iteration. The regression analysis ended when all variables were selected or the correlation between the remaining IVs and DV was considered insignificant. All variables in the stepwise regression model were checked for significance if they were below a specific tolerance level. If insignificant variables were found, they were removed from the model. The test was adjusted for the significant variables selected in the regression model.

This study had a set of predictors (IVs) to test the significance of one DV. To find the subset of IVs that was most realistic, this research included all IVs in the model via stepwise regression [37,38]. This model decreased irrelevant predictors and achieved the computation of more precise coefficients and predicted values. By using the stepwise regression, the data analysis process struck a balance between the simplicity of selecting effective IVs and fit of the data to the model. In this study, all IVs entered into the regression model were deemed significant at a correlation coefficient of 0.05. The probability of the *F*-value was used as a criterion for selecting and removing the IVs affecting the DV during the development of each regression model, as follows:

$$\text{if(Probability of } F\_value \leq 0.050\text{), then IV selected} \tag{1}$$

$$\text{if(Probability of } F\_value \geq 0.100\text{), then IV removed} \tag{2}$$

### 4.2. Results

Based on the stepwise regression analysis, the correlations among IVs and DV were collected. The scope of this study was to analyze the indicators (IVs) and safety climate (DV) for different groups at the construction job site. Therefore, the values of the Pearson correlations (*r*-values) among IVs were ignored. The significance between each IV and DV was computed at a confidence level of 0.05. Table 3 describes *r*-value and associated *p*-value of each IV. The color blocked in the table indicates that IV was significant to DV with the associated *r*-value. For example, SE had a very significant relationship with SC, with a 0.696 correlation coefficient from the MN perspective. Conversely, WI was very

significant to SC, with a 0.674 correlation coefficient from the GL perspective. ComP was a critical indicator, enhancing the safety climate from all the organizational perspectives in the construction work task environment.

**Table 3.** Pearson Correlation (*r*-value) and Significance of IVs (*p*-value) by Group.

| Group \ IV | ComT | ComN | SRP | SE | SupE | WI | AR | AWE | WP | ComP |
|---|---|---|---|---|---|---|---|---|---|---|
| MN | 0.631 | 0.559 | 0.287 | 0.696 | 0.569 | 0.589 | 0.146 | −0.095 | −0.503 | 0.534 |
| | * 0.000 | * 0.001 | 0.066 | * 0.000 | 0.001 | * 0.000 | 0.226 | 0.311 | * 0.003 | * 0.001 |
| SP | 0.574 | 0.520 | 0.215 | 0.424 | 0.508 | 0.256 | 0.038 | −0.187 | −0.363 | 0.667 |
| | * 0.010 | * 0.020 | 0.211 | 0.051 | * 0.022 | 0.169 | 0.444 | 0.244 | 0.087 | * 0.002 |
| SL | 0.114 | 0.437 | 0.500 | 0.234 | 0.239 | 0.240 | 0.118 | 0.223 | −0.198 | 0.516 |
| | 0.298 | * 0.016 | * 0.006 | 0.135 | 0.130 | 0.129 | 0.292 | 0.148 | 0.177 | * 0.005 |
| GL | 0.178 | 0.562 | 0.260 | 0.598 | 0.212 | 674 | 0.510 | 0.448 | −0.151 | 0.646 |
| | 0.233 | * 0.006 | 0.141 | * 0.003 | 0.192 | * 0.001 | * 0.013 | * 0.027 | 0.268 | * 0.001 |

DV: Safety Climate (SC) * IVs are significant at the confidence level of 0.05.

Next, four stepwise regression models were designed across the four perspectives. Individual IVs were selected or excluded based on the criteria defined in Equations (1) and (2). For Model 1, three IVs (i.e., SRP, SE, and WP) were initially entered at the first step; SRP was removed in the next step. Therefore, only two IVs (i.e., SE and WP) were selected for Model 1. The combination of SE and WP were significant to SC. AWE and ComP were included in In Model 2. Based on the information criteria, one IV was finally selected, ComP, as affecting the DV. Model 3 selected SRP and ComP in the first step and removed SRP in the next step. Model 4 only selected WI through the stepwise regression analysis. Table 4 reports the results of the stepwise regression models.

**Table 4.** Stepwise Regression Models.

| Regression Models | $R^2$ | *F*-Value (sig) | Final Selected Effects | | | | |
|---|---|---|---|---|---|---|---|
| | | | IVs * | Unstandardized Coefficient Beta | Standardized Coefficient Beta | *t*-Value | sig |
| Model 1 (MN) | 0.558 | 16.403 (0.000) | SE | 1.672 | 0.592 | 4.236 | 0.000 |
| | | | WP | −0.709 | −0.290 | −2.077 | 0.048 |
| Model 2 (SP) | 0.445 | 11.242 (0.005) | ComP | 3.579 | 0.667 | 3.353 | 0.005 |
| Model 3 (SL) | 0.267 | 7.995 (0.010) | Comp | 0.939 | 0.332 | 2.828 | 0.010 |
| Model 4 (GL) | 0.455 | 14.176 (0.002) | WI | 1.313 | 0.674 | 3.765 | 0.020 |

DV: Safety Climate (SC) * Predictors (IV): SE and WP in Model 1, ComP in Model 2 and 3, and WI in Model 3.

### 4.2.1. Model 1—Management Perspective (MN)

The first regression, Model 1, indicated that management on the construction worksite had ideas regarding enhancing the safety climate. Two IVs (i.e., SE and WP) were the final variables selected as affecting the safety climate from the perspective of managers (e.g., construction managers, safety managers). According to Table 4, this model had $R^2$ value of 0.558, indicating that 55.8% of the variance in safety climate could be predicted from SE and WP. This model yielded *F*-value (F = 16.403), and the *p*-value associated was computed as 0.000, meaning that IV could reliably predict DV. The combination of SE and WP was very significant to predicting enhancement of the safety climate. Specifically, based on the

unstandardized coefficient beta value and constant computed, the safety climate from the perspective of management (Model 1) could be predicted through Equation (3), as follows:

$$SC(model\ 1):\ 39.86 + 1.672 \times (x4) + (-0.709) \times (x9) \tag{3}$$

Each unstandardized coefficient beta of each IV indicated the relationship between the IV and DV. Assuming the quantified values for the IVs and DV increasing one point for SE, the score for SC was predicted to be higher by 1.672 points, if holding another variable (i.e., WP) constant. Since Model 1 included two IVs (i.e., SE and WP), the score for SC was determined by combining the values for SE and WP and holding constant values. By standardizing the IV, the magnitude of the coefficient could be compared based on the absolute value of the standardized coefficient beta. In Model 1, SE (0.592) had a more significant effect on SC than WP (0.290). For each IV in Model 1, the coefficients for SE (1.672) and WP ($-0.709$) were statistically significantly important because their *p*-values were 0.000 and 0.048, respectively, which are smaller than 0.05. From the management perspective, the most important factor affecting the enhancement of the safety climate was cultivating a supportive job site environment (SE). Reducing work pressure (WP) at the job site was another factor important to delivering an enhanced safety climate at the construction worksite. Table 5 shows the measurements of each effective predictor and their MS-values in Model 1. The most important measures were SE03 (*MS*-value = 4.586 out of 5.000) and WP01 (*MS*-value = 3.138) for each IV selected for the stepwise regression analysis.

**Table 5.** Measurements of Selected Indicators in Model 1 (Adopted from Mohamed, 2002 [8]).

| IVs | | Measurement [1] | *MS*-Value (max = 5.000) | S.D. |
|---|---|---|---|---|
| SE | ▪ | SE01: Not blaming each other for unsafe behavior | 3.391 | 0.753 |
| | ▪ | SE02: Communication ensuring safe work for one another | 4.241 | 0.689 |
| | ▪ | SE03: Clear goal development for maintaining a safe job site | 4.586 | 0.568 |
| | ▪ | SE04: Supporting each other in performing jobs safely | 4.517 | 0.574 |
| | ▪ | SE05: No work in risky or hazardous conditions | 4.310 | 0.604 |
| | ▪ | SE06: Maintenance of good working relationships | 4.448 | 0.736 |
| | ▪ | SE07: Reasonable workload balance | 3.966 | 0.823 |
| WP | ▪ | WP01: Working under a great deal of tension (pressure) | 3.138 | 0.953 |
| | ▪ | WP02: Not enough time to perform jobs safely | 2.138 | 0.639 |
| | ▪ | WP03: Safety requirements for production's sake | 1.690 | 0.761 |
| | ▪ | WP04: In conflict with some safety measures | 2.241 | 0.951 |
| | ▪ | WP05: Shortcuts at the expense of safety | 1.586 | 0.628 |
| | ▪ | WP06: Toleration of minor unsafe behaviors | 2.172 | 0.966 |
| | ▪ | WP07: Unacceptable to delay periodic inspections | 3.138 | 1.529 |

[1] Variables refer to Mohamed (2002).

However, Model 1 was composed of a combination of SE and WP (as combined IVs) that helped to reliably predict DV, according to Equation (3). Based on the seven measurements for each IV, a total of 49 combinations ($SE_\alpha WP_\beta$, where $1 \leq \alpha \leq 7, 1 \leq \beta \leq 7$) between SE and WP were developed; the combination that had the most significant impact on SC in this model was then explored. Based on Equation (3), it was possible to calculate the predicted value of SC based on *MS*-value of each measurement. Table 6 lists the measured predicted SE values in Model 1. Among them, seven combinations (e.g., $SE_3 WP_3$, $SE_3 WP_4$) were

higher than 46.000, as shown in the orange block. They were relatively more important in terms of the impact on SC. The values in the blue color are located between 45.000 and 46.000 (e.g., $SE_1WP_3$, $SE_2WP_2$). If the value was less than 45.000, it is indicated as a yellow block (e.g., $SE_1WP_1$, $SE_2WP_1$), meaning that they were relatively less important to SC from the management perspective.

**Table 6.** Predicted SE Values from Combined SE and WP Measurements in Model 1.

| Measures | SE01 | SE02 | SE03 | SE04 | SE05 | SE06 | SE07 |
|---|---|---|---|---|---|---|---|
| WP01 | 44.208 | 44.727 | 45.303 | 45.188 | 44.842 | 45.073 | 44.266 |
| WP02 | 44.917 | 45.436 | 46.012 | 45.897 | 45.551 | 45.782 | 44.975 |
| WP03 | 45.235 | 45.754 | 46.330 | 46.215 | 45.869 | 46.100 | 45.292 |
| WP04 | 44.844 | 45.362 | 45.939 | 45.824 | 45.478 | 45.708 | 44.901 |
| WP05 | 45.308 | 45.827 | 46.404 | 46.288 | 45.942 | 46.173 | 45.366 |
| WP06 | 44.892 | 45.411 | 45.988 | 45.873 | 45.527 | 45.757 | 44.950 |
| WP07 | 44.208 | 44.727 | 45.303 | 45.188 | 44.842 | 45.073 | 44.266 |

4.2.2. Model 2—Superintendent Perspective (SP)

As seen in Table 4, Model 2 demonstrated the perspective of superintendents regarding the safety climate at the construction worksite. As a result of the stepwise regression, only one IV (i.e., ComP) was entered into the model with $R^2$ value (0.445). With the $F$-value (11.242) and associated $p$-value (0.005), the IV was a reliable predictor for the DV in Model 2. Based on the parameter estimates computed, Model 2 predicted the SC based on the linear relationship with ComP described in Equation (4), as follows:

$$SC(model\ 2): -39.031 + 3.579 \times (x10) \tag{4}$$

The coefficient for ComP (3.579) was statistically significant because its $p$-value was 0.0005, which is smaller than 0.05. From the superintendents' perspective, the most important factor affecting enhancement of the safety climate was competence at the job site (i.e., ComP). Superintendents considered worker competence to be the most important factor for enhancing the safety climate. In Model 2, the most important measurement affecting SC was ComP07 ($MS$-value: 4.625). Table 7 shows the importance of the measurement of ComP in Model 2.

**Table 7.** Importance of ComP Measurement in Model 2 (Adopted from Mohamed, 2002 [8]).

| ComP Measurements in Model 2 [1] | $MS$-Value (max = 5.000) | S.D. |
|---|---|---|
| ▪ ComP01: Received training adequate to perform job safely | 4.313 | 1.1014 |
| ▪ ComP02: Made aware of relevant safety procedures through training | 4.563 | 0.629 |
| ▪ ComP03: Fully understand relevant legislation | 4.125 | 0.806 |
| ▪ ComP04: Capable of avoiding workplace hazards | 4.375 | 0.500 |
| ▪ ComP05: Capable of identifying potentially hazardous situations | 4.375 | 0.500 |
| ▪ ComP06: Proactive in removing workplace safety hazards | 4.438 | 0.629 |
| ▪ ComP07: Uses protective equipment | 4.625 | 0.500 |

[1] Variables refer to Mohamed (2002).

### 4.2.3. Model 3—Skilled Labor Perspective (SL)

Model 3 shows results similar to those of Model 2. One IV (i.e., ComP) was entered into the model with $R^2$ value (0.267). Compared with the $R^2$ value of Model 2, Model 3 indicated a larger variance (i.e., was less stable) in terms of the safety climate predicted by ComP, the same IV as in Model 2. Therefore, Model 3 showed a lower *F*-value (7.995) and a higher associated *p*-value (0.010). However, IV was still significant for predicting the DV in Model 3. Based on the unstandardized parameter value, it was possible to predict SC under a linear relationship with ComP, as shown in Equation (5), as follows:

$$SC(model\ 3): 51.941 + 0.939 \times (x10) \tag{5}$$

The coefficient of ComP (0.939) was statistically significant to SC because its *p*-value was 0.010, which is smaller than 0.05. From the skilled labor perspective, it was revealed that the same factor was critical to enhancing the safety climate. The most important measurement affecting SC in Model 3 was Comp07 (*MS*-value: 4.667), the same as in Model 2. However, the other ComP measurements in Models 2 and 3 had different results regarding importance. Therefore, superintendents and skilled laborers still had slightly different perspectives on enhancing the safety climate. Table 8 lists the importance of each ComP measurement from the skilled laborer perspective.

**Table 8.** Importance of ComP Measurements in Model 3 (Adopted from Mohamed, 2002 [8]).

| ComP Measurements in Model 3 [1] | *MS*-Value (max = 5.000) | S.D. |
|---|---|---|
| ■ ComP01: Received training adequate to perform job safely | 4.292 | 0.859 |
| ■ ComP02: Made aware of relevant safety procedures through training | 4.208 | 0.833 |
| ■ ComP03: Fully understand relevant legislation | 4.292 | 0.690 |
| ■ ComP04: Capable of avoiding workplace hazards | 4.292 | 0.690 |
| ■ ComP05: Capable of identifying potentially hazardous situations | 4.208 | 0.721 |
| ■ ComP06: Proactive in removing workplace safety hazards | 4.417 | 0.654 |
| ■ ComP07: Uses protective equipment | 4.667 | 0.482 |

[1] Variables refer to Mohamed (2002).

### 4.2.4. Model 4—General Labor or Helper (GL)

From the stepwise regression analysis, WI was selected as the only one IV affecting SC in Model 4 from the general laborers' or helpers' perspective. Based on the value computed, Equation (6) was defined as predicting the DV (i.e., SC) based on the IV (i.e., WI), as follows:

$$SC(model\ 4): 42.645 + 0.1.313 \times (x6) \tag{6}$$

In Model 4, the *F*-value was computed as 14.176 with *p*-value of 0.002. In this sense, WI could reliably predict SC in this model. The coefficient (1.313) was statistically significant because its *p*-value of 0.020 is less than 0.050. Workers' involvement in the environment was linearly related to enhancing the safety climate. General laborers or workers considered their involvement to be very important to improving the safety climate in the construction task environment. From the general helper's perspective, the most important measurements were WI04 and WI05, with *MS*-value of 4.316 (as shown in Table 9).

**Table 9.** Importance of WI Measurements in Model 4 (adopted from Mohamed, 2002 [8]).

| WI Measurements in Model 4 [1] | *MS*-Value (max = 5.000) | S.D. |
|---|---|---|
| ▪ WI01: Achieving a high level of safety performance | 4.263 | 1.098 |
| ▪ WI02: Active role in identifying site hazards | 4.211 | 1.134 |
| ▪ WI03: Reporting accidents, incidents, and hazardous situations | 4.211 | 1.134 |
| ▪ WI04: Participating in safety planning/compliance with safety policy | 4.316 | 0.885 |
| ▪ WI05: Responsible for reflecting upon safety practices | 4.316 | 0.885 |
| ▪ WI06: Not involved in accident investigations | 3.053 | 1.545 |
| ▪ WI07: Contributing to job safety analysis | 4.211 | 0.855 |

[1] Variables refer to Mohamed (2002).

### 4.3. Multi-Spectra Perception Model

Based on the stepwise regression analysis, the present research successfully identified the combination of IVs most significant to achieving a high-level safety climate at the construction job site. A remarkable aspect of this study is its documentation of each model per the different perspectives within the job site organization: management, superintendents, skilled laborers, and general laborers. This research developed an MsP model to enhance the safety climate in the construction work environment. The MsP model consisted of quadrants indicating the four different perspectives (see Figure 4). It was found that there were common variables affecting the safety climate (i.e., ComN and ComP), based on the *r*-value. Two of the three perspectives had a common sense of what variables affected the safety climate.
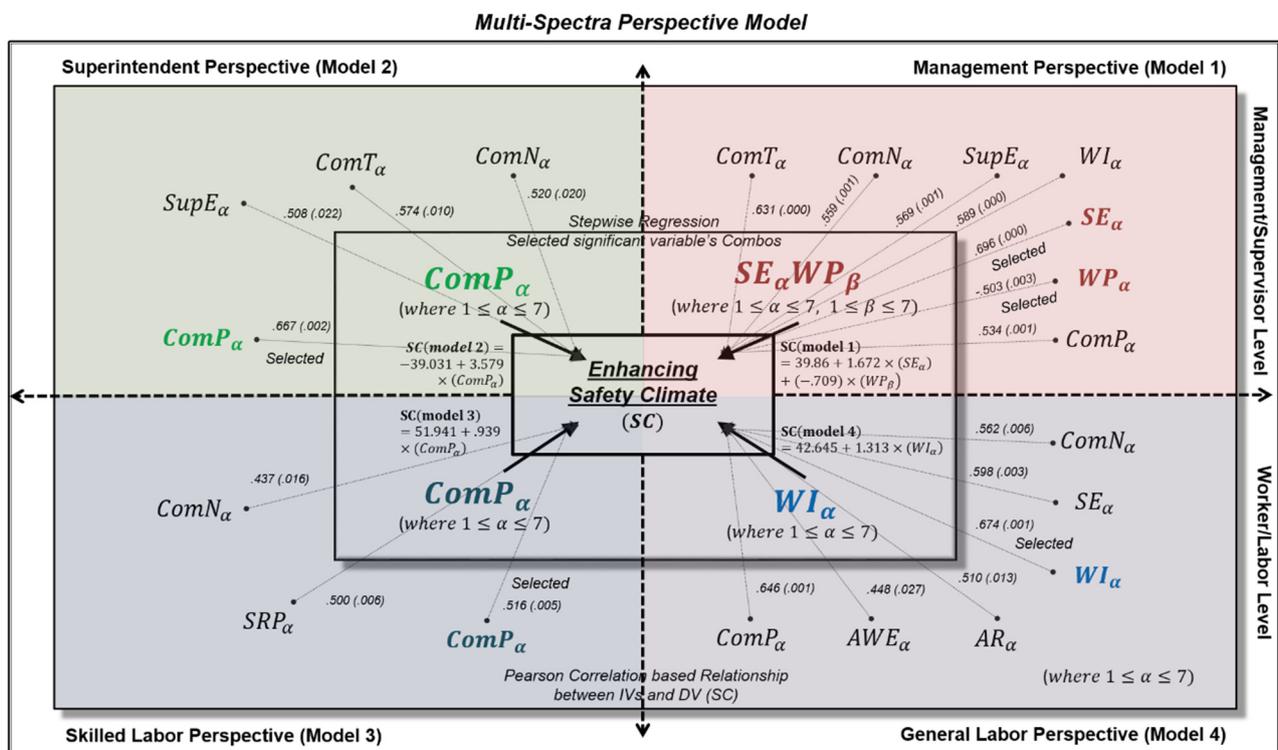


**Figure 4.** Multi-spectra perspective model.

However, it seems that the groups had different perceptions on the significance of combined variables influencing safety. The first quadrant indicates the perspective of

management, including the safety and construction managers in charge of overall project management and completing a project on time. They considered many individual variables as enhancing the construction safety climate. Based on the stepwise regression, they tended to consider the combined variable of SE and WP ($SE_\alpha WP_\beta$) as the most significant in terms of impact. The second quadrant describes the perspectives of superintendents at the job site. These individuals are responsible for daily inspection and management of specific onsite tasks. They also regularly do their own safety inspections. Their perspective was similar to that of management and skilled labor; however, they focused on ComP for the safety climate.

Skilled laborers (i.e., the third quadrant) considered ComP to be the most significant factor affecting the safety climate. These individuals generally have significant work experience and training in their specialties. Therefore, it was also important to explore how they perceived worksite safety. Finally, general laborers and helpers are very important because they are essential to completing skilled laborers' tasks at the job site. However, they may not have the experience and training that skilled laborers do. In addition, their perceptions regarding the safety climate may affect the overall safety in the construction work environment, and those perceptions were quite different from those of the other groups. They considered WI to have the most critical impact on the safety climate.

## 5. Discussion

This section provides a comprehensive overview of the four perspectives on enhancing the safety climate at construction worksites. In this section, all variables are described in detail to provide a better understanding of their implications. Section 5.1 includes a summary of the findings of the study. Section 5.2 comprehensively documents the theoretical and practical implications of the findings. This study employed a survey-based instrument to quantify and evaluate the indicators of the safety climate in the construction work environment. Section 5.3 lists potential threats to this work's validity and the limitations of this study.

### 5.1. Summary of Findings

This study was designed to investigate how individuals with different job classifications perceive factors affecting improvement of the safety climate at their worksite. Thus, this research employed a survey questionnaire to collect the opinions of four different and important groups of construction professionals: management, superintendents, skilled labor, and general labor; all individuals queried worked at the same project site. A stepwise regression analysis documented the most important factor combinations for each perspective; an MsP model was also developed (see Figure 4). Each perspective was found to have different perceptions of how best to enhance the safety climate at their construction job site. On the whole, four noteworthy findings can be summarized, as follows.

- First, as individuals responsible for overall project management, managers tended to consider factors different from those of other respondents. Management considered individual safety climate indicators such as commitment, communication, the support and supervisory environment, workers' involvement, work pressure, and competence. The most critical indicator was the combination of support environment and work pressure. Work pressure had a negative relationship with the safety climate, and the support environment had a significant positive relationship with the safety climate. The combination of the two had the most significant effect on enhancing the safety climate from the perspective of management personnel. Based on the specific measures outlined in Table 5 and their importance described in Table 6, it can be seen that all groups at the site wanted to establish a goal of maintaining a safe workplace as a priority, but were pressured to: (1) perform tasks in a short period of time, (2) complete safety requirements for production's sake, and (3) take shortcuts at the expense of safety. In addition, managers thought improving the support environment would assist with performing tasks safely, as well as receiving less pressure to complete the

work at the expense of safety. They also wanted to focus on improving the working relationships among groups by reducing the pressure to complete work at the expense of safety. In summary, managers were most focused on reducing the requirements and cost related to safety, as well as providing a supportive environment to enhance the safety climate.

- Superintendents had attitudes similar to those of managers. As the supervisory level, they highlighted communication and commitment, providing an enhanced supervisory environment, and workers' competence as essential to improving the safety climate at the job site. Superintendents believed increasing worker competence was the most important indicator. Among the seven measures evaluated here, the top three related to increasing worker competence were: (1) using protective equipment (*MS*-value = 4.625), (2) increasing awareness of relevant safety procedures through training (4.563), and (3) encouraging being proactive in removing safety hazards from the workplace (4.438). From the superintendents' perspective, it was essential to address how to efficiently improve workers' behaviors in accordance with safety procedures, as well as their ability to prevent onsite accidents, in order to enhance the safety climate.

- Third, skilled laborers had slightly different perceptions from those of superintendents with regards to individual safety climate factors. Based on their significant training and experience in special trades for which they are responsible, their primary considerations were communication, safety rules and procedures, and workers' competence. Surprisingly, they did share one impression with superintendents in what they considered the most significant factors affecting the safety climate. At both the supervisor and worker levels, all respondents emphasized worker competence as critical. Two measures were commonly highlighted as a priority affecting workers' competence: (1) using protective equipment (*MS*-value = 4.677) and (2) being proactive in eliminating potential hazards (*MS*-value = 4.417). Though the groups had different duties related to the construction project, they tended to manage the project itself or special trade jobs; hence, they were likely to be aware of the importance of worker competence and its direct impact on improving the safety climate.

- Fourth, general helpers considered various factors directly related to their safety and the likelihood of fatalities. Based on the correlation coefficient of each factor, laborers considered communication with management, managers' support, appreciation of risk, appraisal of the work environment and possible hazards, workers' involvement in safety (including skilled labor), and competence to be essential. Among these factors, they most often highlighted the importance of their involvement in the safety climate. They felt that they best understood the importance of involvement in construction safety, underscoring the necessity of their participation in developing safety plans complying with general safety policy (*MS*-value = 4.316). Establishment of a safety plan and program generally involves the participation of management. Laborers tend to be active participants in the overall safety management program, enhancing the safety climate and performance at the worksite.

### 5.2. Theoretical and Practical Implications

The findings of the present study significantly strengthen and broaden the current state of the literature related to the construction safety climate. Recent studies have documented safety climate indicators and the relationships among them, including climate, behavior, and performance [6,7,17,24]. Recent work has also addressed the social aspects at particular construction job sites because of their unique organizational and social cultures [12]. Thus, researchers have described the current safety culture, its level of maturity, and the interrelationship between supervisors and workers [5,10,14,25]. The impact of supervisors is significant to workers' safety behavior, and they have important effects on establishing a safe workplace for one another.

However, the construction environment is composed of multiple job classifications, such as managers, superintendents, skilled laborers, and general helpers. They have different responsibilities and perspectives on cultivating a safe workplace during the construction phase. Therefore, this research established a pipeline for linking multiple individual perspectives regarding enhancement of the construction safety climate, ultimately improving safety management and reducing work-related fatalities. Four root questions gleaned from the previous literature were asked for the present research: (1) How did respondents perceive the safety climate at the job site? (2) Which safety factors were most significant to enhancing the safety climate for different workgroups? (3) Among the documented factors, which were most critical, both individually and in combination? and (4) How could participants best interact to enhance the safety climate onsite?

In answering these questions, this study provides a substantial contribution to the construction industry. The main contribution is enriching the group-level safety climate based on the MsP model. Multiple interactions among these groups are critical to enhancing the safety climate because their different perspectives consider various safety climate factors and measures of improvement to safety. Although respondents were at different organizational levels, some had very similar perspectives on their current safety climate. For example, superintendents are regarded as being at supervisor-level, yet believed worker competence to be the most important factor affecting the safety climate; skilled laborers felt similarly. This study offers a profound understanding of the multiple perspectives (i.e., managers, superintendents, skilled laborers, and general helpers) across two different organizational levels (i.e., management and workers). Based on the MsP model developed, it was revealed that social and organizational interactions across multiple occupations were considered critical to safety in the construction work environment. This study will support additional research describing how construction professionals can interact with one another to enhance the safety climate and general behavior (at both the group and individual levels), ultimately improving safety performance in the construction industry.

In practice, this frontline study will enrich current safety management and planning procedures. The most significant measures and factors have been documented for each job profession at the construction site, based on the empirical links between the theoretical models and practical views. In turn, practitioners can now compensate for defects in the current safety management process. Managers should encourage maintaining goals (SE03), a supportive environment that allows for jobs to be performed safely (SE04), and good relationships between workers and supervisors (SE06). However, this might impose work pressure on both skilled and general workers if the safety planning and management program continues in the current form (WP02, WP03, and WP05). Superintendents and skilled laborers have very similar perspectives; for example, both would consider it critical to using protective equipment at the job site (ComP07). At the management level, superintendents tend to encourage worker awareness and familiarity with safety procedures (ComP02). In contrast, skilled laborers (at the worker level) preferred to consider the ability to proactively recognize and eliminate safety hazards as essential to enhancing safety (ComP06).

The results of the stepwise regression analysis emphasized that general labor would prefer to participate in the design and development of safety planning procedures and programs (WI04). Recommended future practices include: (1) encouraging workers' participation in safety program development, in order to reflect their experience and practice and (2) investing in safety training to enhance workers' and managers' situational awareness to increase their chance of identifying and eliminating safety hazards. These approaches will help to increase competence and relieve work pressure for workers, consequently enhancing safety and task performance at the job site. The findings of this study provide a better understanding and greater insight to construction project and safety practitioners, contributing to an enhancement of the safety climate. Also, this study can serve as a guideline for those seeking to develop more reliable and efficient safety planning programs in coordination with all levels of the work organization and safety training program professionals.

*5.3. Threats to Validity and Limitations*

The main goal of this empirical study was to develop an MsP model for four different perspectives related to the enhancement of the safety climate on a construction worksite. To develop this model, this study employed a questionnaire survey administered to industry professionals and a stepwise regression analysis based on the respondents. During the data collection and analysis process, this work considered data and its validity in order to prevent potential threats to the reliability and trustworthiness of this research. Each group has less than 30 participants (a relatively low number). The numbers were different for the four groups. This might affect confidence in the experiment design, a potential threat to internal validity [39,40]. To address this concern, all participants were randomly recruited at the construction job site to avoid a sampling bias. Another concern was the threat to the external validity of this study because the survey responses were from a single commercial construction project managed by one general contractor. This might affect the generalizability of the findings (i.e., the external validity) because the safety climate might be quite different at other construction job sites. Also, they might be subjective and relying on their behavior in the workplace. However, this study can still provide the overview of different perspectives per job occupation related to the safety climate in a current project environment under controlled conditions (i.e., the same work atmosphere and job site for all respondents) since the construction projects might have a common fundamental understanding of key work groups (i.e., managers, superintendents, and skilled and general workers), as well as safety management programs. Therefore, the findings of this study make a substantial contribution to the current literature and general construction industry by providing a better understanding of how to enhance the overall safety climate.

*5.4. Future Research*

This study evaluated the most significant factors for four workgroups, including management, superintendents, skilled labor, and general workers through the survey questionnaire with construction professionals, and proposed a conceptual model empirically explaining which factors are more critical to enhance the safety climate for each different groups in the construction project. Based on the MsP model proposed, this study successfully tested which factors are significant to enhance the safety climate and which are not. It is currently undetermined whether social and psychological interactions between different groups are necessary to enhance safety, based on the documented factors.

Future research should investigate the direction of the interaction between two or multiple groups via objective approaches such as statistical analysis and simulation. Since all are important factors affecting the safety climate across groups, it is possible to formulize the relationships among these variables and measures. To strengthen the generalizability of the findings, further studies on this topic may be able to recruit a larger number of survey respondents from different groups (e.g., general contractors, sub-contractors, and labor) from different types of construction projects (e.g., road, bridge, airport, residential, and commercial projects). This can increase the level of confidence in the validity of multi-perspectives to the construction safety climate. In addition, further studies might be able to design a new research method to observe the behaviors of the different groups to enhance safety climate by considering the significant factors identified in this study, in order to validate the conceptual model in a real environment. Though the findings of future work may yield conclusions different from the current study, this work is important in that it provides an overview of the various perspectives on how best to enhance the construction safety climate.

## 6. Conclusions

The safety climate at organizations or companies has a direct impact on overall safety performance and productivity because its immense impact is critical to overall project success. The current body of research has made substantial contributions to the

safety climate at construction workplaces; however thus far there has been a gap in how different job groups (i.e., managers, superintendents, skilled laborers, and general helpers) perceive the current safety climate, as represented by practitioners in the construction work environment. This is an important topic because these individuals have different responsibilities and scopes for completing a project successfully and safely. Therefore, this research scientifically identified and quantified critical factors and measures that have a significant impact on the overall safety climate from those four perspectives. A survey questionnaire was employed to collect construction professionals' perceptions, and a stepwise regression analysis was conducted to weigh the impacts of certain variables.

Based on the regression results, this works documented correlations among 10 determinants of the safety climate and the most significant factors or combinations of factors identified by these different groups. As a result, this study proposed an MsP model for enhancing the safety climate at construction worksites, providing an overview of significant factors affecting the safety climate from multiple perspectives. Management was found to have a wide range of considerations when managing safety at the job site. A combined factor of enhancing the support environment and reducing work pressure was considered the top priority. Specifically, maintaining good work relationships across workgroups and enacting clear safety goals in order to provide a more supportive environment were considered as primary, because these were perceived as necessary to decreasing the pressure to finish tasks in a short period of time.

Superintendents and skilled labors considered increasing workers' competence as the most significant factor in enhancing the safety climate. They emphasized the importance of using protective equipment properly and the ability to proactively identify and remove potential hazards in the workplace. General helpers hoped to have a deeper involvement and greater participation in safety management programs and planning the development process, as well as a more substantial contribution to safety practices and analysis at the job site. This study makes a substantial contribution to both the practice and knowledge related to developing and improving safety management program on construction job sites, as well as continuous improvement in construction safety.

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