Manuscript No.**KSCE-D-18-02044**

Investigation of demographic factors in construction employees' safety perceptions

Yu Han[1], Ruoyu Jin[2,*], Hannah Wood[3], Tong Yang[4]

[1]Associate Professor, Faculty of Civil Engineering and Mechanics, Jiangsu University, 301 Xuefu Road, Zhenjiang, 212013, Jiangsu, China. Email: hanyu85@yeah.net
[2] Senior Lecturer, School of Environment and Technology, University of Brighton, Cockcroft Building 616, Brighton, BN24GJ, U.K. Email: R.Jin@brighton.ac.uk
[3]Senior Lecturer, School of Environment and Technology, University of Brighton, Cockcroft Building, Brighton, BN24GJ, UK. Email: hw35@brighton.ac.uk
[4]Senior Lecturer, Faculty of Science and Technology, Middlesex University, London, UK
The Burroughs, Hendon, London, NW44BT, UK. Phone: +44 (0)208 411 3427 Email:*t.yang@mdx.ac.uk*
*: Corresponding author

Abstract

This study focused on the effects of these demographic factors on construction employees' safety perceptions. It first initiated a theoretical framework illustrating the impacts of demographic factors (i.e., education level, gender, and age) on employee's perceptions towards pre-defined site hazards as well as their general safety perception. Then site questionnaire survey approach was adopted in nine construction jobsites in southeastern China followed by statistical analysis. The study revealed that construction employees' education level, although not affecting their perceptions towards safety hazards/accidents, could create differences in other general safety perceptions between management staff and workers. Gender differences were found in safety perceptions of hazard/accident scenes and general safety perceptions, indicating that gender issue in safety perceptions applied consistently crossing different industries. Employees between *37* and *46* years old tended to underestimate safety risks from commonly encountered hazards, suggesting the needs of continued safety refreshers for employees in the middle of their career. This study contributed to the body of knowledge in safety perceptions by investigating the effect of three major subgroup or demographic factors, including education level, gender, and age, which had not been sufficiently addressed in construction safety subculture or sub-climate.

Keywords: Construction safety; safety hazards; safety perception; demographic factors; subgroup analysis

1. Introduction

Construction is believed to be one of the riskiest industries in terms of the occurrence of incident and accident rates (Ho et al., 2000; Jin and Chen, 2013). These quantitative measurements are considered as being reactive evaluation criteria for safety performance. Besides these reactive indicators such as accident incidence rate (Iain et al., 2013), proactive measurements have also been developed to evaluate safety, such as hazard identification, behaviour-based safety, and safety climate/culture (Hofmann et al. 1995; Guldenmund 2000; Li et al., 2017). Safety culture and safety climate aid in improving safety performance (Choudhry et al. 2007b; Melia et al. 2008; Chen and Jin, 2013). The studies of safety culture and safety climate involve multiple subgroup issues (e.g., managers and workers) in human factors. Aiming to achieve more effective safety management, multiple studies (e.g., Clarke, 1998; Chen and Jin, 2013; Chen and Jin, 2015) have focused on the comparisons among subcultures and sub-climates for construction employees from different categories (e.g., trades).

More subgroup or demographic factors remain to be explored. For example, in general perspective crossing industries, males were believed to be more likely to take risks and females generally perceived a higher likelihood of negative outcomes or reported higher levels of risks (Davidson and Freudenburg, 1996; Harris et al., 2006). In the construction industry, female employees, as a minority group, might also have different perceptions and behaviors in safety. However, there have been limited research on the gender difference in safety perceptions on construction sites. Besides gender difference, other demographic or subgroup factors (e.g., employees' education background) have not been sufficiently investigated on their effects in safety perceptions.

China is one of the largest construction markets worldwide (MarketLine, 2014). The number of construction workers was estimated to be around *60* million, accounting for more than *20%* of the worker population in China (Zhang, 2017). The construction safety management in China is facing a series of challenges in terms of external and internal factors. Externally, there has been a lack of systematic management for safety risks (Sun et al., 2008). Internally, according to Zhang (2017), construction workers in China were typically professionally isolated within their own crew teams, which generally consisted of peers with personal relationships, for example, family members and friends. They may learn basic skills from their family members or friends without sufficient professional training and are likely to mimic unsafe behaviors from their peers (Zhang, 2017). More than half of Chinese construction workers had barely, or not finished middle school education (Zhang and Li, 2016), and the percentage of workers with skill qualifications or licenses is extremely low (Dong, 2014). Not only the laborers, but also site management personnel (e.g., crew foremen) in China's construction industry were also believed to have received insufficient education either in school or through professional training, according to the researchers' pilot study. These multiple issues are causing serious concerns on their safety behavior and safety performance including both workers and site management personnel. So far there are still limited studies addressing safety perceptions towards commonly encountered hazards and other general safety issues in the construction industry of developing countries such as China.

Construction site employees including workers and foremen played key roles in ensuring effective implementation of safety programs (Rowlinson et al., 2003; Chen and Jin, 2013). The similarities and differences in safety perceptions between management personnel and workers have been performed in some earlier studies (e.g., Chen and Jin, 2015; Han et al., 2018). Safety climate among workers have been investigated in the China context (e.g., Li et al., 2017). Communication in safety has been emphasized in improving the organizational safety climate (Liao et al., 2015). The communication issue also applies to site employees from different subgroups (e.g., employees with different levels of working experience) in order to form a joint-effort to ensure a safe work environment. Continuing these existing studies, this research aims to achieve these objectives: 1) to evaluate the overall perception towards eight pre-established safety hazard/accident scenes for employees working on China's construction sites; 2) to study their perceptions towards *12* safety questions (e.g., safety incentives); and 3) to conduct sub-sample analysis of site employees from different demographic groups (i.e., education level, gender, and age range). The research findings contribute to the body of knowledge in construction safety by considering a more comprehensive list of subgroup factors (e.g., employees' education). The human factor analysis within construction safety perception in the context of China could be expanded to other developing countries in the future.

2. Literature review

2.1.Safety hazards, risks, and perception towards risks

Multiple hazards and risks exist on construction jobsites, including falls, electrocution, struck-by, and caught-in or –between which are defined as Focus 4 Hazards by the Occupational Safety and Health Administration (OSHA, 2011). Risks negatively affect project performance such as cost (Sun et al., 2008). Hazard recognition and safety risk recognition are vital to improve safety performance (Namian et al., 2018). Risks are subjectively defined by individuals who may be impacted by psychological, social, institutional, and cultural factors, and survey instruments can be used to quantify and measure the individual responses to risks (Slovic, 1992). The psychometric paradigm has been the most influential model in risk perceptions, and the cognitive maps of hazards produced by the paradigm could describe how risks are perceived (Siegrist et al. 2005). Both qualitative and quantitative methods have been adopted in measuring and evaluating safety perceptions, such as historical information reviews and case studies (Wreathall, 1995), questionnaire survey (Mearns et al., 2003; Abbas et al., 2018), and jobsite experiment to workers (Namian et al., 2018).

2.2.Inter-relationships among safety perceptions, safety climate and safety culture

The workplace safety perception forms part of safety climate, which focuses on workers' perception of the role of safety and their attitudes towards safety (Cox and Flin, 1998; National Occupational Research Agenda or NORA, 2008). The impact of safety climate on safety performance has been well identified (Lingard et al., 2011; Newaz et al., 2018). Safety culture could be measured by safety commitment, safety incentives for safe performance, safety accountability and dedication, as well as disincentives for unsafe behaviors (Molenaar et al., 2009). It reflects the attitudes, beliefs, perceptions, and values that employees share in relation to safety (Cox and Cox, 1991). Safety culture involves employees' behavioral aspects (Choudhry et al., 2007a), and it further impacts safety performance (Choudhry et al., 2009). Safety culture and safety climate are both multi-level depending on whether employees are holding a management position (Grote and Kunzler, 2000; Chen and Jin, 2012). The interaction and communication among employees from different safety subcultures (e.g., managers and workers) were believed to play an important role in safety management (Clarke, 1998; Chen and Jin, 2013). Chen and Jin (2013) further indicated that safety climate/culture could vary between management-based employees and workers.

2.3.Demographic and subgroup factors in construction safety perceptions

Studies of demographic factor effects in risk perception have been carried out in multiple fields. These demographic factors could contribute to human errors, which were identified by Liao et al. (2018) as causes of construction accidents. Some of these demographic factors may be applicable crossing countries. For example, women and men differ in their perceptions of risks (Gustafson, 1998). Males are more likely to behave in a risky way and be distracted when performing work (Barr et al., 2015). Some other demographic factors may be specific in one country or region, such as cultural and language barriers of immigration or ethnic minority workers (Chan et al., 2017; Lin et al. 2018). Multiple other subgroup factors could affect construction employees' safety perceptions. For example, general contractors' workers were proved with a better safety perception compared to subcontractor workers, and older workers tended to have a better safety attitudes and perception than younger employees (Chen and Jin, 2015). The same contractor's employees located in different regions or branches might also vary in their safety perceptions (Chen et al., 2013). Other subgroup or demographic factors in construction safety management include job professions and levels (Zohar, 1980; Dedobbeleer and Béland, 1991), experience (Chen and Jin, 2013), and Trades (Liao et al., 2017). Employees from different positions and job duties further formed the sub-culture in construction safety (NORA, 2008), such as executive culture, engineering culture, and operators' culture (Schein, 1996).

3. Methodology

To study the effect of demographic factors in employees' safety perceptions, research was undertaken through construction jobsite visits, questionnaire surveys to site employees, and follow-up data analyses. Site employees covering multiple positions (i.e., both management and workers) were recruited in the survey sample. Fig.1 illustrate the theoretical background of this study.

<Insert Fig.1 here>

Construction site employees' perceptions form safety climate and culture (Cox and Flin, 1998). Several subgroup factors, such as building trades (Chen and Jin, 2015) and site experience (Han et al., 2018) had been conducted of their impacts on subgroup construction employees' perceptions towards hazards or general safety climate. Continued from these prior studies, this research focused on other demographic factors (i.e., education level, gender, and age) by studying their effects on employees' safety perceptions towards the danger of commonly encountered site hazards as well as general safety perceptions. According to Fig.1, employees' perceptions of the danger or severity of hazard could be affected not only by their own demographic factors, but also the features (i.e., the occurrence, severity, and visibility) of the hazard. This study started by investigating how the features of a given hazard affected employees' perceptions towards its danger or severity level. Afterwards, the demographic subgroups' perceptions towards both the hazard danger level and their general safety perceptions were studied.

3.1.Initiation of questionnaire survey

The site questionnaire survey consisted of two main Likert-scale questions. The first category of question was comprised of eight different safety hazard/accident scenes illustratedinFig.2.

<Insert Fig.2 here>

The rationale of selecting these eight image-based safety hazard/accident scenes was provided in Han et al. (2018). These scenes were tagged using a combination of three different categories according to their chance of occurrence, severity if they occur, and ease of being noticed on-site. These eight different scenes were pre-defined based on these three categories as shown in Table 1.

<Insert Table 1>

Categories of these scenes were defined based on data released by Division of Safety Supervision (2017), where safety statistics such as number of accidents, fatalities, severe injuries, and percentages accounting for total accidents were summarized according to safety accidents reported from 2014 to 2017 in China. For example, falling from working on scaffolding (e.g., H6) was defined with higher occurrence, and structural collapse (e.g., H4) was perceived highly severe but with lower occurrence. Site employees were asked of their perceptions towards each of these eight safety scenes. A numerical option ranging from *1* to *5* was assigned in each scene with *1* meaning that the given scene was not dangerous at all, *2* being "not very dangerous", *3* showing a neutral attitude, *4* indicating the given scene was dangerous, *5* indicating "very dangerous".

A second type of Likert-scale question consisting of *12* extended generalsafety perceptions-related statements were designed in the questionnaire as described in Table 2. These *12* statements describe employees' safety commitment, safety incentives, safety accountability, and dedication, which were defined by Molenaar et al. (2009) to form part of safety culture. Site employees were asked to rank these *12* statements according to how well each statement described themselves, from *1* being "strong disagree" to *5* meaning "strong agree".

<Insert Table 2 here>

The initial questionnaire was tested through a pilot study on four local jobsites in Jiangsu China during April and May of 2016. Both the eight safety hazard/accidentscenes and the*12*extended safety perception-related statements were displayed to site employees. Their feedback was collected and addressed to ensure that all these image-based scenes and text-based statements were easily understood correctlyby potential survey participants.

3.2.Site investigation

Following the pilot study with the finalized questionnaire, the research team conducted the survey on-siteduring May and August in 2016. Consistent to the random and un-biased sampling procedure suggested by Li et al. (2018), a total of nine different jobsites in south-eastern regions of China were visited for the site questionnaire survey. These nine jobsites were all based on reinforced concrete high-rise complex (mixed commercial and residential) building construction, which was a typical building construction sector in China. Site employees were guided to refer these eight hazard scenes to the general site conditions in the eastern China. Questionnaire survey was coordinated by site managers. All potential participants, including site management personnel (e.g., crew leader) and workers from different trades, were first explained of the purpose of the site survey and they could either refuse to continue with the survey or fill the questionnaire with the best of their knowledge. All questionnaire surveys were conducted anonymously to protect participants' personal information. To gain the background information in the questionnaire, survey participantswere asked of their demographic information, including their education level, age range, and gender.

3.3.Statistical analysis

Mean and standard deviation, as two basic statistical measurements, were used to summarize the Likert-scale survey data. The Relative Importance Index (*RII*) was used to rank the perceptions of employees towards safety hazard/accident scenes and other general safety questions. *RII*was calculated following the same equation adopted by Tam (2009) and Eadie et al. (2013). Ranging from *0* to *1*, a higher *RII* value shows that it is considered more significant.

Besides the *RII*analysis, Cronbach's Alpha analysis (Cronbach, 1951) was performed to test the internal consistency of site employees' perceptions towards the eight safety hazard/accident scenes and extended safety related questions. The Cronbach's Alpha value ranges from *0* to *1*, and a higher value would indicate a higher degree of consistency of employees' perceptions among these Likert-scale items. Generally a Cronbach's Alpha value above *0.700* would be considered acceptable (DeVellis, 2003), inferring that a site employee who selects a numerical Likert-scale score for one item is likely to assign a similar score to others in the same section (i.e., safety scene or general safety perception). Besides the overall Cronbach's Alpha value, individual values were also computed for each item within the same section (i.e., safety scene or general safety perception). An individual value lower than the overall value means that the internal consistency would be reduced without the given individual item, indicating that this item contributes positively to the overall consistency. Otherwise, an individual value higher than the overall value indicates that employees view in this given item more differently as they would normally do to other items.

Following the overall sample analysis, the whole sample was categorized into subgroups according to their demographic factors (i.e., education level, gender, and age range). The education levels included middle school, high school, and bachelor degree, etc. Research hypotheses were proposed prior to the subgroup analysis, specifically:

- Education level did not affect construction employees' perceptions towards the given site hazard scenes;
- Education level did not affect employees' perceptions towards the general safety perceptions;
- Construction employees' perceptions towards the given site hazard scenes were not affected by their gender;
- Construction employees' general safety perceptions were not affected by their gender;
- Construction employees' perceptions towards the given site hazard scenes were not affected by their age;
- Construction employees' general safety perceptions were not affected by their age.

Further statistical methods were adopted for subgroup analysis to test these null hypotheses, for example, the two-sample *t*-test and one-way Analysis of Variance (ANOVA). Parametric methods (e.g., ANOVA and two-sample *t*-test) have been utilized in existing studies in the field of construction engineering and management (e.g., Tam, 2009; Jin et al., 2017) when Likert-scale items were involved. Carifio and Perla (2008) and Norman (2010) displayed the robustness of parametric methods in being applied in survey samples that were either small-sized or not normally distributed.Examples of small sample sizes in parametric methods include subgroup size at 4 in Tam (2009)'s study and highly skewed non-normal distributions with subsample sizes as small as 4 in Pearson (1931)' case. Compared to earlier studies conducted in construction safety or other research themes in construction management (e.g., Tam et al., 2009; Jin et al., 2017; Li et al., 2017), the sample size at *155* in this study was considered fair. ANOVA aims to test whether employees from different education levels or age ranges had similar perceptions of the given safety scene or extended safety related item. Based on the null hypothesis that they held consistent opinions on the given item, a F value and the corresponding p value were computed to test the null hypothesis. Similar to ANOVA, the two-sample t-test was adopted to compare the mean values between male and female employees for each Likert-scale item. Using the similar null hypothesis and the same level of significance, a t value and the corresponding p value were computed to test the null hypothesis. Based on the level of significance at *5%* for both ANOVA and two-sample t-test, a p value below *0.05* would decline the null hypothesis and instead suggest that employees from different subgroups held inconsistent perceptions.

4. **Results and findings**

A total of *155* valid responses from *176* questionnaires were received by the end of site survey. Research findings from the site survey and data analysis are divided into sections of background information of the survey sample, overall sample analysis, and subgroup analysis by dividing employees according to their education level, gender, and age range.Fig.3displays the distribution of the overall sample's background information.

4.1.Employees' background information

<Insert Fig.3 here>

According to Fig.3, the employee sample had a generally even distribution of their education levels among middle school or below, high school, community college, and bachelor (i.e., four-year undergraduate study). Male employees accounted for the majority (i.e., *85%*) of the survey sample. Nearly half of the site employees fell into the age group between *25* and *36* years old, with the remaining identifying inage groups (i.e., from *18* to *24* years old, *37* to *46* years old, and *47* to *56* years old) had generally even share of the survey sample. A further breakdown of building trades or job position of the overall sample is provided in Fig.4.

<Insert Fig.4 here>

4.2.Overall sample analysis

The overall sample analyses presented in Table 3 involves multiple statistical measurements, including the mean and standard deviation (Std), *RII* with associated rankings, item-total correlation (ITC), and Cronbach's Alpha values.

<Insert Table 3 here>

The overall Cronbach's Alpha value at *0.8977*can be considered good and nearly excellent internal consistency according to George and Mallery (2003). Generally, an employee who chose one Likert-scale score to one safety scene would be likely to select a similar score to others, except H8, which is the lowest-ranked item in Table 3. The ITC measures the correlation between the given item and the remaining items. The lower ITC for H8 also indicates that employees' perceptions of H8 is more different as theirs towards other items. Struck-by causing hand injuries, which belongs to the category of high frequency, low severity, and being easily noticed, received the mean score at *3.000* meaning "neutral". According to Han et al. (2018), frequently occurring accidents would make employees perceive a lower degree of its severity, and also cause a higher perception variation measured by Std. In comparison, H1, which is categorized as lower frequency, high severity, and being easily noticed was perceived as most severe. The lower occurrence of a safety accident tends to catch more attention from employees, causing them to perceive a higher degree of severity (Han et al., 2018).

Following the similar approach of the overall sample analysis in Table 3, the analysis of general safety perception questions is summarized in Table 4.

<Insert Table 4 here>

The overall Cronbach's Alpha value is significantly lower compared to that in the section of safety hazard/accident scenes. The value close to *0.700*, the boundary between being acceptable and questionable, indicates that there is a relatively low internal consistency. Employees tended to have more varied views on these extended *12* safety perception related questions. ITC values are low for most items listed in Table 4, meaning that employees' perceptions towards these general safety perception questions vary to a larger degree compared to their perceptions towards safety scenes. Both these top two-ranked items (i.e., Q1 and Q3) and bottom two-ranked items had low ITC (i.e., Q11 and Q12) with the remaining items. Generally, employees held strong beliefs that they were capable of identifying safety hazards on jobsites, and remembering safety hazard/accident scenes that they witnessed or viewed through safety training. In contrast, they strongly disagreed that they would risk to complete jobs. They held a neutral view on whether they would often follow their own way which might be unsafe to completework. It is also noticed that these lower-ranked items generally received a higher variation of views among employees, who would perceive the higher-ranked items with less variation.

4.3.Subgroup analysis for site employees from different education background

The subgroup analysis for employees divided by their education levels was assisted by ANOVA. Table 5 demonstrates the subgroup analysis.

<Insert Table 5 here>

No significant subgroup differences were found among employees with different education levels. It was suggested that these main safety hazards or accidents could be consistently perceived by all site employees regardless of their education background. However, those with only middle school education or below might view safety scenes with a larger variation, compared to their peers who had received more education. Further subgroup analysis was conducted for the *12* safety perception questions. Table 6 displays the comparative analysis.

<Insert Table 6 here>

More subgroup differences were found in perceiving general safety perception-related questions (i.e., Q8, Q11, and Q12). Employees who have received more education (i.e., high school or above) tended to agree more with the effect of incentives in their safety behavior, especially those who had completed studies from community college or university. According to Feng et al. (2017), compared to workers who generally had received less education, management personnel tended to perceive safety with higher importance as safety performance would matter to their career promotion and incentive for finishing a project in a safe way. Since those with higher education levels were more likely to be in management positions, they also agreed more that incentives were one of the motivations to behave safely. In comparison, workers' main motivation came from finishing work in a fast and efficient way, with less emphasis on safety (Feng et al., 2017). The largest variation came from Q11. It was surprising to discover that those with a degree from community college were more likely to take risks, with the average score at *3.400*, between "neutral" and "agree". Differing from those who had finished community college education, the other three subgroups, all strongly disagree that they would work at the risk of safety. Overall, those from higher education levels (i.e., community college or university) held more confirmatory views on these general safety perception-related questions.

4.4.Subgroup analysis of survey participants between male and female employees

Male and female employees were tested of their perceptions towards safety scenes and other general safety questions. Table 7 and Table 8 show the statistical analyses involving the two-sample *t*-test.

<Insert Table 7 here>

All safety scenes were perceived by females with a higher degree of severity. On average, female employees considered all eight safety scenes to be significantly more dangerous. Some individual significant differences were found between male and female employees: 1) females perceived a higher degree of danger to H1 representing lower occurrence, high severity, and being easily noticed; 2) they also considered a higher danger of the scene which is with lower occurrence, low severity, and not being easily noticed; 3) they also believed more that scenes belonging to the category of high occurrence, high severity, and being easily noticed are highly dangerous.

<Insert Table 8 here>

Two significant differences were found from Table 8 regarding male and female employees' general safety perceptions. Female employees strongly believed that they would firmly remember the safety hazards or accidents through witnessing them or via safety training. However, male employees had a higher level of confidence that they would be able to evaluate correctly the severity of an identified hazard.

4.5.Subgroup analysis for site employees from different age groups

Employees were further grouped according to their age ranges as shown in Table 9 and Table 10 adopting ANOVA. Some significant differences can be found in both safety scenes and general safety perception questions.

<Insert Table 9 here>

Employees from *37* to *46* years old perceived the overall eight scenes with significantly lower degree of severity, especially in H1 and H5, both of which fell into the category of lower occurrence. Employees between *37* and *46* years old were generally in their mid-career stage defined by Han et al. (2018). According to Han et al. (2018), compared to employees in their early career stage and senior employees, mid-career employees tended to be more over-optimistic of completing jobs without safety risks by perceiving the same safety hazards/accidents with lower severity levels. The findings from Table 9 supported the conclusion drawn from Han et al. (2018). The Std listed in Table 9 indicated that compared to other age groups, employees between *37* and *46* years old also had a higher variation among their opinions.

<Insert Table 10 here>

Table 10 suggests that there were two general safety perception-related statements that were viewed differently by employees from multiple age groups. Employees from *37* to *46* years old and from *18* to *24* years old delivered less confirmatory answers that they would be able to concentrate on the safety hazard without being distracted. These two age groups also happened to be less confident that they were capable of reasoning or linking the existing hazards to other similar scenes. The variations among each age group in viewing these *12* general safety perception-related questions all turned out to be small.

5. Discussions

Despite of the information technology development (Kim et al., 2014) in assisting safety management, the human factors in construction safety can never de downplayed. Targeting the effects of demographic factors in safety perceptions, this study adopted a site questionnaire survey approach to construction employees followed by multiple statistical analyses. Using the *155* valid responses collected from south-eastern region of China as the survey population, employees were divided into subgroups according to their education level, gender, and age range. Two main Likert-scale questions were asked related to safety hazard/accident scenes and extended general safety perceptions. Generally survey participants were evenly distributed in terms of their education levels, including middle school or below, high school, community college, and four-year bachelor. The majority (i.e., *85%*) of them were males, and almost of them came from the age group of between*25* and *36* years old.

The statistical analysis in this study started from the overall sample. Higher internal consistency was found among the eight safety hazard/accident scenes. The Cronbach's Alpha value close to *0.900* showed a nearly excellent internal consistency, meaning that an employee who chose one numerical Likert-scale score for one safety scene was likely to assign a similar score to the remaining scenes, except H8 (struck-by causing hand injuries), which was categorized as high frequency, low severity, and being easily noticed. Safety hazard/accident with lower occurrence is more likely to be perceived with higher severity, and higher occurrence and less severe accidents would cause a higher variation among employees' perceptions (Han et al., 2018). The overall sample analysis towards the *12* general safety perception questions were perceived with lower internal consistency. Employees tended to vary on their opinions of these questions, especially the top-ranked and bottom-ranked questions. For example, they had higher confidence level that they were capable of identifying site hazards and remembering them well. They would be less likely to take risks to complete jobs and held a more neutral view of being likely to complete jobs in their own way with less consideration of safety.

The overall sample's perceptions of safety hazard/accident scenes and general safety perception-related questions were then studied by dividing employees into subgroups according to their education level, gender, and age ranges. Those who had received more school education tended to be more motivated by incentives to behave safely. The rationale behind that could be that these more-educated employees were mostly in management positions, and safety played a more important role in their performance evaluation and career. In contrast from management staff, workers might emphasize less on safety with more motivation coming from finishing a job on-time (Feng et al., 2017). Although those with different education levels had consistent judgements on the severity level of the eight different safety scenes, when it came to general safety perceptions, the education level might play some significant roles. Managers, who have generally received more education, tend to view safety as a more important issue.They may complete site jobs at a slower pace to guarantee safety, but workers are prone to finish jobs in a faster way for their own benefits (Feng et al., 2017). This would make the communication (Clark, 1998) between management personnel and workers a more significantly important issue.

Females generally perceived a higher degree of danger from all of the eight safety hazard/accident scenes, especially those belonging to the category of high severity. This finding in the context of construction industry, is consistent with the study of Harries et al. (2006) who found that women were more likely to perceive negative consequences associated with risky choices. Although females held more confirmatory views that they would remember safety hazards or accidents for which they have witnessed or learned through training, males had a higher confidence level that they could correctly tell the severity of an identified hazard. The differences between males and females could be added to the theoretical models proposed by Gustafson (1998) regarding gender differences in risk perceptions, leading to further discussions on gender difference in safety management. For example, men's higher confidence in their own safety capability is a two-edged issue, which could result in more unsafe behaviors or even more incidents/accidents due to over-confidence or carelessness.

Employees between *37* and *46* years old were found to perceive the eight safety hazard/accident scenes with significantly lower severity, especially these with lower occurrence. This could be due to the fact that these employees, who were more likely to be in the middle of their career, tended to underestimate safety risks compared to the younger or entry-level employees. Gaining certain experience could actually lead to over-confidence of employees in their capacity to identify and handle safety risks. Senior employees who were in the later years of a construction career, might be less ambitious and less likely to take risks (Han et al., 2018). It is suggested that periodic safety orientation or education would be necessary to refresh mid-career employees' safety awareness and accountability. The need for refreshing their safety accountability could also be indicated by the fact that they held a larger variation in viewing the severity of safety hazard/accident scenes. When responding to the safety general safety perception related questions, employees from *37* to *46* years old, together with their youngest peers from *18* to *24* years old, believed they were more likely to be distracted from concentrating on observing safety hazards. They were also less likely to reason the existing site hazards with other similar scenes. Though similarly in responding to these two general safety perception related questions, the rationale behind them could be different for these two age groups. The younger employees' being more easily distracted and less likely to reason hazards could be due to their lack of experience. But the similar perceptions in employees from *37* to *46* years old could be because they had multiple tasks to handle, and were less motivated to link the current hazards to their previously seen scenes.

According to Dijksterhuis and Bargh (2001), perceptionshave a direct impact on human behaviors. The perception-based study in this research could lead to future studies in safety behavior and safety performance, for example, the comparison of unsafe behaviors and safety accident rates among different subgroups. The safety findings generated from construction sites might be applicable in other industries (e.g., manufacturing), and safety research beyond the construction industry (e.g., Harries et al., 2006; Barr et al., 2015) could serve as references for construction safety. Based on the findings of this subgroup site employees' perceptions divided by demographic factors, future studies could also compare the perceptions of employees' with the empirical data from safety records (e.g., Division of Safety Supervision, 2017). Based on the comparison, further decisions on safety training can be made, as safety training might not only be applied to site manager (Hare and Cameron, 2011) or overall worker sample (Chen and Jin, 2013), but also site employees from different demographic subgroups (e.g., gender).

6. Conclusion

In order to gain a more comprehensive view of construction employees' perceptions towards commonly encountered site safety hazards and their general safety perceptions, this study adopted a site survey-based approach to collect perception-based data on China's construction sites in the southeastern region. Based on the random sampling approach, survey responses from the selected jobsites could represent the overall site employee sample in the southeastern region of China. The southeastern region of China is the most economically active area in the country, with migration construction employees from all over the country.The overall sample analysis revealed that hazards/accidents with lower occurrence would cause employees to view them with a higher level of severity. Higher occurrence of accidents would lead to a larger variation of employees' perceptions of the severity. It was inferred that employees' judgement of certain hazards/accidents would be affected by the nature of them in terms of frequency of occurrence, degree of severity, and ease of being noticed on-site. Besides the overall sample analysis in safety hazard perceptions and general safety perceptions, this study introduced and investigated three major subgroup factors in how they affected construction employees' safety perceptions based on six pre-defined research hypotheses.

Education level, although not affecting employees' perceptions of hazard/accident scenes, could play a more vital role in influencing the site safety perceptions, and ultimately safety performance. In the context of China's construction industry, education level is highly correlated to employees' job position, as management positions generallyrequire a higher educational degree diploma. Eventually the school education that an employee has received would affect their position levels on-site. The subgroup analysis for employees from different education levels would be linked to the scenario between management personnel and workers. The communication and coordination between these two types of employees for better safety management would become more important.

Consistent with the studies of gender difference from other industries, the subgroup analysis within construction safety perceptions also revealed similar results. Females were more likely to perceive a higher level of danger from the given safety hazard/accident scenes. Male construction employees were more confident of their capability to detect site hazards. On the other hand, it could mean that males were more likely to be risk takers. The study of gender difference between the construction industry and others could serve as references for each other.

Construction employees between *37*and *46* years old tended to underestimate the danger or severity associated with certain safety hazards, and they perceived themselves less likely to focus on observing safety hazards without being distracted. It was suggested that periodic safety training be implemented to employees in their mid-career, because gaining more experience and over-confidence of their own capacity in handling safety issues might lead to more risky behaviors. Employees in their early age and their mid-career might need to pay more attention on site safety hazards and associated risks, either due to less professional experience or the need of refreshing and updating their safety knowledge.

This research contributed to the knowledge of safety culture and safety climate by introducing a more comprehensive list of subgroup or demographic factors (i.e., age, gender, and education) in affecting construction employees' perceptions. Future research would extend the current site survey to computer-based simulation and analysis of workers' sensitivity in identifying site hazards. This would allow the comparison between human perception and computer simulation. The current study was limited to southeastern China's construction industry. Potentially, findings from this research (e.g., gender difference) could be expanded to the study of safety perception in other regions of China and other developing countries (e.g., Vietnam).

Acknowledgement

This research is supported by the National Natural Science Foundation of China (Grant No. 51408266), MOE (Ministry of Education in China) Project of Humanities and Social Sciences (Grant No.14YJCZH047), Foundation of Jiangsu University (Grant No. 14JDG012), and Writing Retreat Fund provided by University of Brighton.

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Table 1. The combination of categorization of the eight safety hazard/accident scenes on-site

Category	**H1**	**H2**	**H3**	**H4**	**H5**	**H6**	**H7**	**H8**
Chance of occurrence	Lower	High	High	Lower	Lower	High	Lower	High
Severity	High	High	Low	High	Low	High	Low	Low
Ease of being noticed	Easily noticed	Not easily noticed	Not easily noticed	Not easily noticed	Not easily noticed	Easily noticed	Easily noticed	Easily noticed

Table 2. General safety perception questions

Question	Description
Q1	Surrounding where I work on-site, I am generally able to identify all obvious safety hazards.
Q2	I am able to focus on observing an identified safety hazard, without being distracted by noise or other irrelevant things.
Q3	I remember very well of these safety hazard scenes which have been displayed in safety orientation or which I saw on-site
Q4	Upon identifying safety hazards on-site, I am usually able to reason or link it to a similar scene
Q5	I can usually tell correctly the severity of an identified safety hazard
Q6	When in danger, I can immediately tell the consequences and take corresponding actions
Q7	When in danger, I can decide what to do immediately without hesitancies
Q8	I want to receive incentives for being working in a safety manner. Therefore, I am always careful when working on-site
Q9	When in danger, I always trust myself and believe that I am able to handle it.
Q10	In handling safety issues, I usually achieve what I expect by following the way that I think should work out.
Q11	I have not been in an accident for many years of my career. Therefore, I should be fine by taking some risks.
Q12	Sometimes I have planned what to do to behave safely, but ultimately I behave in the way that I am used to, although my own way might be risky.

Table 3. Overall sample analysis in perceiving the severity of the eight safety scenes (overall Cronbach's Alpha = *0.8977*)

Safety scene	**Mean**	**Std[1]**	***RII***	**Ranking**	**Item-total Correlation**	**Cronbach's Alpha**
H1	4.608	0.829	0.922	1	0.6051	0.8895
H2	4.176	1.176	0.835	4	0.8049	0.8726
H3	3.601	1.279	0.720	7	0.7424	0.8788
H4	4.392	1.015	0.878	3	0.7207	0.8819
H5	4.033	1.178	0.807	5	0.7829	0.8748
H6	4.549	1.006	0.910	2	0.5554	0.8953
H7	3.654	1.149	0.731	6	0.6895	0.8839
H8	3.000	1.386	0.600	8	**0.5700**	**0.8990**

[1]Std stands for standard deviation. The same rule applies to follow-up tables of subgroup analyses.

Table 4. Overall sample analysis of general safety perceptions in agreeing with the given statements (overall Cronbach's Alpha = *0.7052*)

Question	**Mean**	**Std**	***RII***	**Ranking**	**Item-total Correlation**	**Cronbach's Alpha**
Q1	4.755	0.683	0.951	2	0.2234	0.7010
Q2	4.074	1.289	0.815	7	0.3867	0.6796
Q3	4.851	0.586	0.970	1	0.2205	0.7018
Q4	4.638	0.866	0.928	3	0.3190	0.6913
Q5	4.223	1.184	0.845	6	0.3094	0.6907
Q6	4.457	0.991	0.891	4	0.4557	0.6747
Q7	4.415	1.092	0.883	5	0.2740	0.6951
Q8	3.266	1.755	0.653	10	0.4536	0.6678
Q9	3.734	1.504	0.747	8	0.6105	0.6384
Q10	3.596	1.668	0.719	9	0.3878	0.6804
Q11	1.681	1.370	0.336	12	0.2566	0.6995
Q12	3.053	1.527	0.611	11	**0.2255**	**0.7073**

Table 5. ANOVA results for subgroup analysis for site employees from different education background responding to the eight safety scenes

Safety Hazard scenes	**Middle school or below**		**High school**		**Community college**		**Bachelor**		**Statistical comparison**	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	*F* value	*p* value
H1	4.356	1.111	4.714	0.713	4.667	0.702	4.745	0.628	2.05	0.110
H2	3.889	1.449	4.321	1.020	4.167	1.129	4.373	0.979	1.52	0.212
H3	3.311	1.564	3.964	1.170	3.542	1.318	3.686	1.010	1.62	0.188
H4	4.178	1.029	4.429	0.997	4.417	0.974	4.490	1.065	0.80	0.493
H5	3.800	1.290	4.179	1.278	3.958	1.122	4.118	1.070	0.81	0.490
H6	4.578	0.941	4.286	1.301	4.583	1.018	4.627	0.916	0.74	0.532
H7	3.600	1.338	3.536	1.138	3.625	1.096	3.706	1.045	0.14	0.934
H8	2.933	1.558	2.857	1.297	3.042	1.334	3.059	1.302	0.16	0.923
Average	3.831	1.020	3.781	0.583	4.000	0.858	4.100	0.735	1.13	0.341

Table 6. ANOVA results for subgroup analysis for site employees from different education background responding to general safety perception questions

Question	**Middle school or below**		**High school**		**Community college**		**Bachelor**		**Statistical comparison**	
	Mean	Std[1]	Mean	Std[1]	Mean	Std[1]	Mean	Std[1]	*F* value	*p* value
Q1	4.892	0.459	4.737	0.806	4.600	0.828	4.727	0.703	0.79	0.503
Q2	3.784	1.272	4.000	1.599	4.600	0.828	4.318	1.211	1.78	0.157
Q3	4.865	0.585	4.737	0.806	4.867	0.516	5.000	0.000	0.76	0.520
Q4	4.514	0.961	4.684	1.003	4.467	0.915	5.000	0.000	1.84	0.146
Q5	4.162	1.236	4.316	1.250	4.200	1.265	4.318	1.041	0.11	0.952
Q6	4.378	1.089	4.474	1.073	4.467	0.915	4.636	0.790	0.31	0.819
Q7	4.351	1.230	4.526	0.964	4.333	1.234	4.545	0.858	0.22	0.875
Q8	2.568	1.741	3.421	1.677	4.000	1.558	3.818	1.680	**3.90**	**0.011***
Q9	3.459	1.592	3.368	1.707	4.000	1.363	4.364	1.093	2.30	0.083
Q10	3.108	1.776	3.526	1.837	4.400	1.056	3.955	1.495	2.68	0.052
Q11	1.324	0.973	1.158	0.501	3.400	1.844	1.500	1.225	**13.84**	**0.000***
Q12	3.000	1.581	2.421	1.710	3.733	1.100	3.227	1.412	2.25	0.088
Average	3.706	0.581	3.781	0.583	4.256	0.696	4.117	0.468	**4.47**	**0.006***

[1]Std stands for standard deviation. The same rule applies to follow-up tables of subgroup analysis.

[2]A *p* value lower than 0.05 indicates the significant difference among employees from different education levels

Table 7. Two-sample *t*-test results for subgroup analysis between male and female site employees responding to the eight safety scenes

Safety Hazard scenes	**Males**		**Females**		**Statistical comparison**	
	Mean	Std	Mean	Std	*t*value	*p* value
H1	4.573	0.877	4.826	0.388	**-2.28**	**0.026***
H2	4.110	1.220	4.478	0.790	-1.89	0.065
H3	3.540	1.340	3.870	0.869	-1.52	0.136
H4	4.310	1.080	4.739	0.541	**-2.95**	**0.005***
H5	3.960	1.220	4.348	0.832	-1.90	0.065
H6	4.450	1.090	4.957	0.209	**-4.84**	**0.000***
H7	3.590	1.160	3.960	1.020	-1.56	0.128
H8	3.010	1.410	3.090	1.310	-0.26	0.793
Average	3.942	0.916	4.283	0.441	**-2.79**	**0.007***

*: A *p* value lower than 0.05 indicates significant differences between male and female employees towards the given scene

Table 8. Two-sample *t*-test results for subgroup analysis for site employees between males and females responding to general safety perception-related questions

Question	**Males**		**Females**		**Statistical comparison**	
	Mean	Std	Mean	Std	*t* value	*p* value
Q1	4.793	0.613	4.290	1.250	1.06	0.330
Q2	4.130	1.260	3.430	1.620	1.11	0.308
Q3	4.839	0.608	5.000	0.000	**-2.45**	**0.016***
Q4	4.632	0.878	4.714	0.756	-0.27	0.793
Q5	4.360	1.070	2.570	1.400	**3.30**	**0.016***
Q6	4.529	0.926	3.570	1.400	1.78	0.125
Q7	4.440	1.100	4.140	1.070	0.70	0.507
Q8	3.260	1.770	3.290	1.700	-0.03	0.976
Q9	3.770	1.490	3.290	1.700	0.73	0.493
Q10	3.630	1.660	3.140	1.860	0.67	0.526
Q11	1.700	1.410	1.429	0.787	0.82	0.435
Q12	3.000	1.540	3.710	1.250	-1.42	0.198
Average	3.923	0.614	3.548	0.516	1.83	0.110

*A *p* value lower than 0.05 indicates the significant difference between male and female employees

Table 9. ANOVA results for site employees from different age groups responding to the eight safety scenes

Safety Hazard scenes	**18 to 24 years old**		**25 to 36 years old**		**37 to 46 years old**		**46-56 years old**		**Statistical comparison**	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	*F* value	*p* value
H1	4.583	0.830	4.711	0.629	4.286	1.152	4.842	0.688	**2.77**	**0.044***
H2	4.000	1.251	4.263	1.012	3.800	1.451	4.632	0.955	2.54	0.059
H3	3.750	1.327	3.474	1.077	3.371	1.536	4.211	1.316	2.23	0.088
H4	4.417	1.060	4.461	0.901	4.029	1.294	4.579	0.838	1.79	0.152
H5	4.250	0.944	3.987	1.137	3.600	1.376	4.632	0.895	**3.73**	**0.013***
H6	4.500	1.142	4.553	0.929	4.314	1.323	4.842	0.375	1.13	0.340
H7	3.833	1.007	3.618	1.131	3.429	1.267	4.000	1.106	1.26	0.292
H8	3.292	1.334	2.868	1.350	2.857	1.458	3.579	1.427	1.81	0.148
Average	4.078	0.808	3.992	0.746	3.711	1.115	4.414	0.756	**2.90**	**0.037***

*A *p* value lower than 0.05 indicates the significant difference among employees from different age ranges

Table 10. ANOVA results for site employees from different age groups responding to general safety perception questions

Question	**18 to 24 years old**		**25 to 36 years old**		**37 to 46 years old**		**46-56 years old**		**Statistical comparison**	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	*F* value	*p* value
Q1	4.333	0.985	4.850	0.534	4.769	0.652	4.800	0.775	1.84	0.146
Q2	3.917	1.165	4.425	1.059	3.462	1.476	4.400	1.298	**3.59**	**0.017***
Q3	4.833	0.577	4.950	0.316	4.731	0.778	5.000	0.000	1.33	0.270
Q4	4.167	1.337	4.900	0.441	4.231	1.107	5.000	0.000	**5.99**	**0.001***
Q5	4.333	0.985	4.300	1.137	4.154	1.287	4.133	1.356	0.14	0.935
Q6	4.500	0.905	4.600	0.810	4.269	1.185	4.467	1.125	0.59	0.624
Q7	4.333	0.985	4.450	1.108	4.308	1.225	4.733	0.704	0.54	0.654
Q8	3.167	1.749	3.575	1.693	3.846	1.848	3.133	1.767	0.95	0.422
Q9	3.500	1.446	3.925	1.366	3.769	1.478	3.267	1.944	0.79	0.503
Q10	3.917	1.621	3.625	1.659	3.500	1.631	3.467	1.959	0.20	0.894
Q11	2.167	1.467	1.875	1.556	1.346	1.093	1.400	1.121	1.51	0.217
Q12	2.917	1.505	3.450	1.431	2.846	1.434	2.333	1.718	2.31	0.082
Average	3.840	0.625	4.077	0.579	3.686	0.617	3.844	0.618	2.33	0.079

*A *p* value lower than 0.05 indicates the significant difference among employees from different age ranges

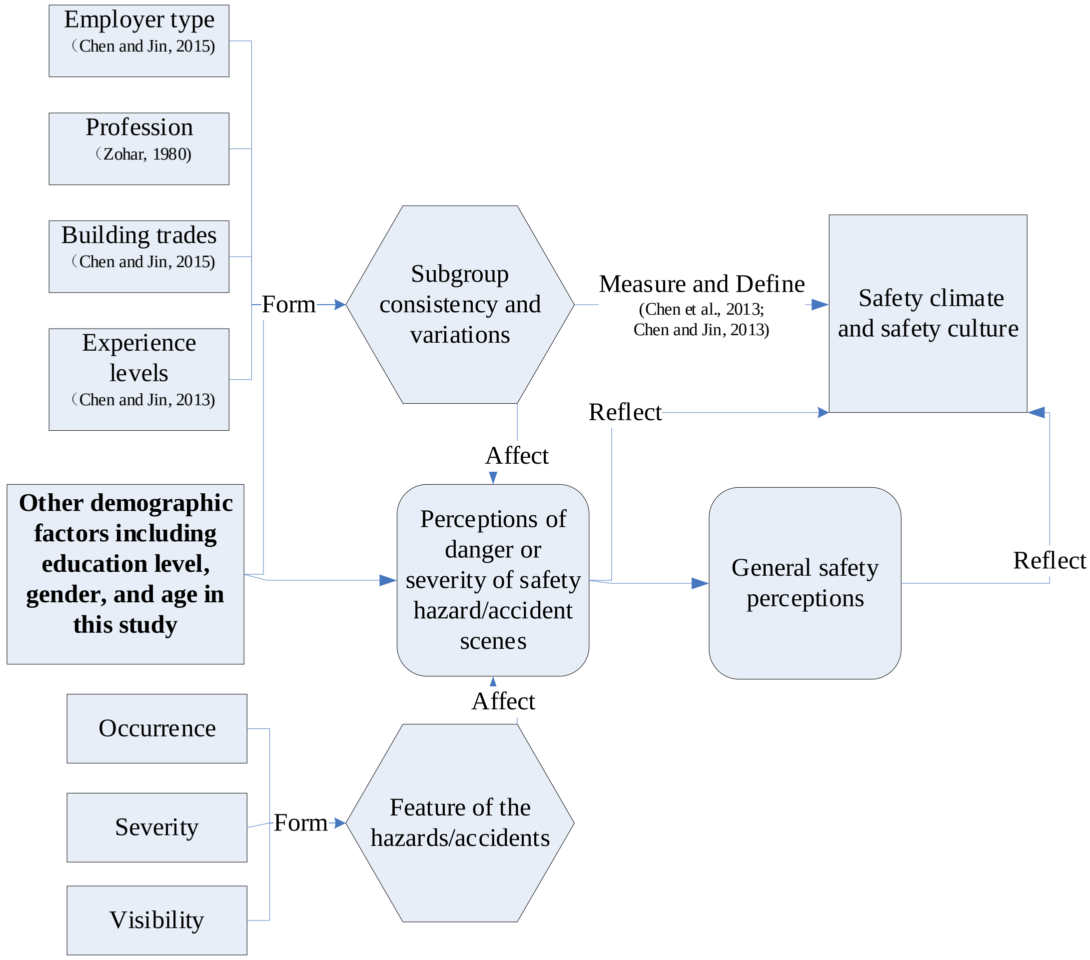
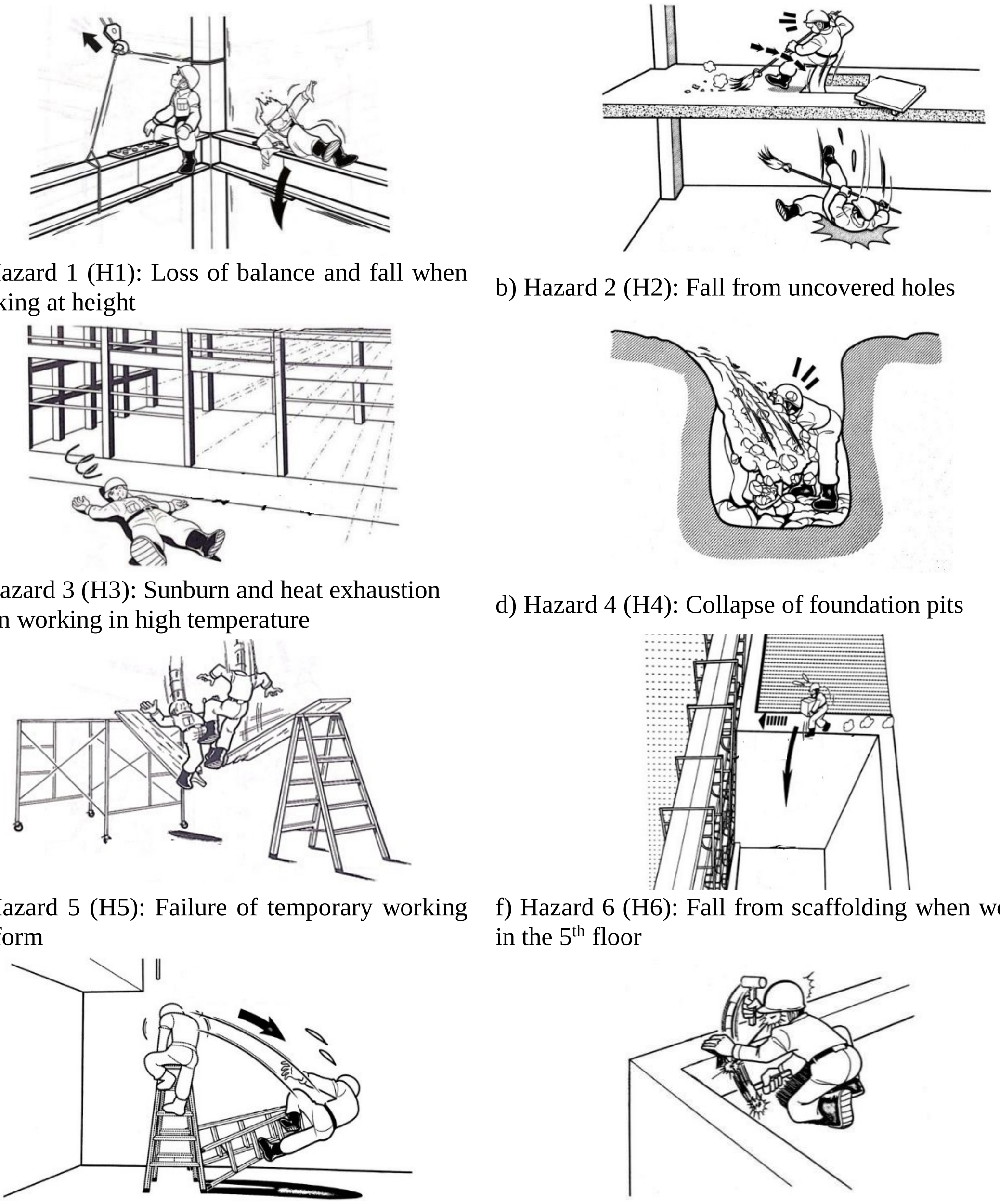


Fig.1. Theoretical background of the demographic factors' effects on safety perceptions in the context of safety climate and safety culture



a) Hazard 1 (H1): Loss of balance and fall when working at height

b) Hazard 2 (H2): Fall from uncovered holes

c) Hazard 3 (H3): Sunburn and heat exhaustion when working in high temperature

d) Hazard 4 (H4): Collapse of foundation pits

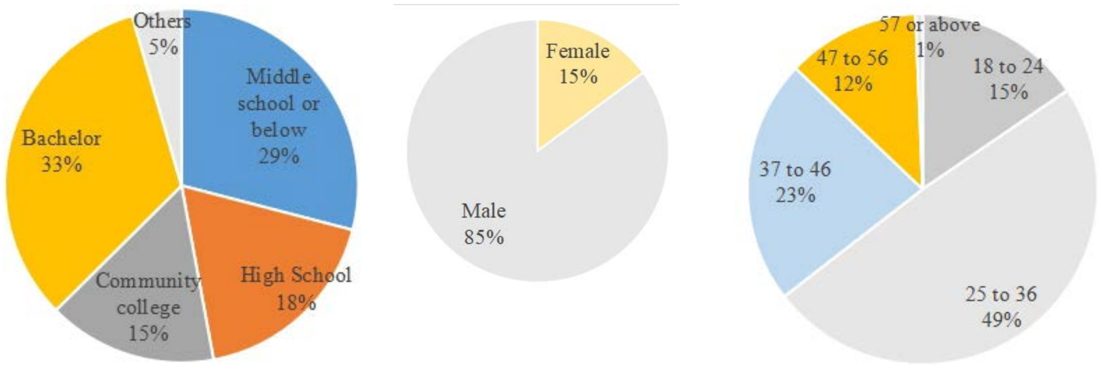
e) Hazard 5 (H5): Failure of temporary working platform

f) Hazard 6 (H6): Fall from scaffolding when working in the 5th floor

g) Hazard 7 (H7): Fall from unstable ladder

h) Hazard 8 (H8): Struck-by causing hand injury

Fig.2. Eight site hazard/accident scenes in the questionnaire survey (Images of safety hazards/accidents adapted from Zhang, 2009 and Han et al., 2018)



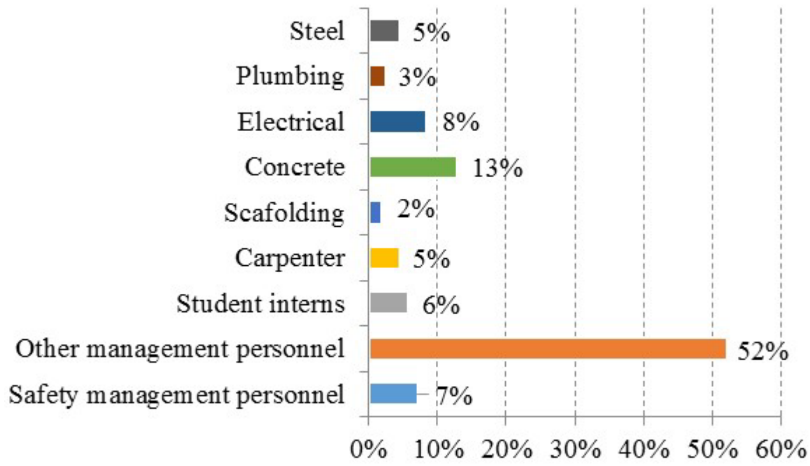
a) Percentages of survey participants from different education levels

b) Percentages of respondents from different genders

c) Percentages of respondents from differentageranges

Note: other education levels included respondents in their summer internship as part of theiracademic degree curriculum, or who had completed a master’s degree or above.

Fig.3. Background information of survey respondents



Note: other management personnel mainly referred to the crew leader, foremen, or the construction team leader.

Fig.4. Percentages of the overall survey sample divided by workers' trades or management personnel's position.