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Determining safety climate factors in the repair, maintenance, minor alteration, and addition sector of Hong Kong

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Abstract: Accident record of the repair, maintenance, minor alteration, and addition (RMAA) sector has been alarmingly high; however, research in the RMAA sector remains limited. Unsafe behavior is considered one of the key causes of accidents. Thus, the organizational factors that influence individual safety behavior at work continue to be the focus of many studies. The safety climate, which reflects the true priority of safety in an organization, has drawn much attention. Safety climate measurement helps to identify areas for safety improvement. The current study aims to identify safety climate factors in the RMAA sector. A questionnaire survey was conducted in the RMAA sector in Hong Kong. Data were randomly split into the calibration, and the validation samples. RMAA safety climate factors were determined by exploratory factor analysis on the calibration sample. Three safety climate factors of the RMAA works were identified: (F1) *management commitment to OHS and employee involvement*; (F2) *applicability of safety rules and work practices*; and (F3) *responsibility for health and safety*. Confirmatory factor analysis (CFA) was then conducted on the validation sample. The CFA model showed

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satisfactory goodness-of-fit, reliability, and validity. The suggested RMAA safety climate factors can be utilized by the construction industry practitioners in the developed economies to measure safety climate of their RMAA projects, thereby enhancing safety of RMAA works.

CE Database subject headings: Safety; Climates; Renovation; Maintenance.

Author keywords: Safety climate factors; Repair; Maintenance; Exploratory factor analysis; Confirmatory factor analysis.

Introduction

The construction industry has long been an accident-prone industry. Despite past significant improvements of construction safety in many developed countries, many of these countries have reached a plateau in safety improvement (Saurin et al. 2008). To strive for continuous safety improvement in the construction industry, the repair, maintenance, minor alteration, and addition (RMAA) sector having rising importance and worsening safety performance should be the new area of focus (Hon et al. 2010). In view of the growing concern for sustainability of existing building structures, the volume of RMAA works has continuously increased (Hon et al. 2011). RMAA works are becoming increasingly important to the construction industry, particularly in times of economic downturn when new construction projects are being halted (Hon et al. 2010). For example, the RMAA sector in the United States has been expanding after the credit crisis or economic downturn. According to the Bureau of Labour Statistics of the United States (2010), jobs for alteration, remodelling and maintenance works continue to rise in times of an economic downturn while new building works shrink. People opt to remodel existing buildings for resale or retrofit existing buildings to green buildings to reduce mounting energy expenses, hence an increase in alteration and addition works (Bureau of Labour Statistics 2010).

When the RMAA market expands, the intensity of associated safety problems also escalates. In particular, some tasks of RMAA works put workers at risk of electrical shock, burns, falls, cuts, and bruises. Statistics indicate that RMAA safety problems have been worsening in recent years. Statistics of the United States Department of Labour show that maintenance workers have higher injury rates than the national average for industrial workers (Bureau of Labour Statistics 2012).

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Statistics also indicate that the RMAA sector accounted for 49.3% of accidents in the construction industry of Hong Kong in 2010 (Legislative Council 2011a, b) when it contributed to only 45.0% of the construction volume in the same period (Census and Statistics Department 2011). Even more shockingly, 6 out of 9 fatalities in the construction industry in 2010 were from RMAA works, accounting for 66.7% of the overall fatality rate in the construction industry of Hong Kong (Legislative Council 2011a, b). Surprisingly, the RMAA sector has been overlooked, and literature discussing safety of RMAA works remains scarce.

Unsafe behavior is considered a key cause of accidents; however, there may be more distal underlying reasons for such accidents. Mullen (2004) argues that the majority of workplace accidents are attributed to unsafe work practices of employees rather than to unsafe working conditions. Rather than blaming the unsafe behavior of employees, Hofmann and Stetzer (1998) advocate that organizational factors may influence individual safety behavior at work (Griffin and Neal 2000). Researchers have attempted to investigate unsafe behavior by identifying inherent organizational factors. Safety climate, which reflects the true priority of safety in an organization, is an organizational factor that has drawn much attention. Safety climate, the current-state reflection of the underlying safety culture, highlights areas for safety improvement (Mearns et al. 2001, 2003). RMAA projects have distinct features from new construction projects. RMAA projects are often more difficult to control than new building works because of small project size and short duration of the RMAA projects (Hon et al. 2011). RMAA workers are tempted to accept unsafe behavior when they undertake minute work tasks (Cameron et al. 2007). Because the RMAA works involve different teams of labor and face different working environment from the new construction works, safety climate factors of the RMAA sector is

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believed to be different from that of the new construction works. Previous safety climate research findings on the new construction projects (e.g., Chan et al. 2005, Mohamed 2002) may not fully reflect the situation of the RMAA works. Since safety climate tends to be industry- and context-specific (Cooper and Philips 2004), an investigation of RMAA safety climate factors is needed.

The current paper draws on part of the findings of a larger scope safety research project on RMAA works in Hong Kong. It aims to identify the safety climate factors of the RMAA sector of the construction industry. Significance of this study lies on identifying safety climate factors for the RMAA sector, which can be a convenient tool for continuous safety evaluation of the project team and a leading indicator of safety performance of RMAA projects. Industry practitioners can assess safety climate of their RMAA projects in respect of these factors.

Safety Climate Factors

The perception of employees on the organizational policies, procedures, and practices related to safety comprises the safety climate (Griffin and Neal 2000). Safety climate, which can be gauged easily and periodically with the help of predetermined questionnaire survey, is considered a leading indicator of organizational safety. Safety climate helps to identify potential pitfalls in organizational management that may lead to serious accidents (Zohar 2010).

Zohar (1980) identified eight dimensions of safety climate: perceived importance of safety training programs, perceived management attitudes toward safety, perceived effects of safe conduct on promotion, perceived level of risk at the workplace, perceived effects of workplace

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on safety, perceived status of the safety officer, perceived effects of safe conduct on social status, and perceived status of safety committee. Brown and Holmes (1986) tested the factor structure of a shortened version of Zohar's (1980) measures using confirmatory factor analysis, and have identified three factors: management concern, management action, and physical risk. In conducting a study of safety climate factors in two different organizations using similar questions, Coyle et al. (1995) have identified seven factors for one organization and six factors for another organization; however, the factor structures in both organizations differ from the factor structures identified in the previous studies. Thus, Coyle et al. (1995) concluded that the factor structure of safety climate has been unstable.

Cox and Flin (1998) suggested that factor structure is industry specific. For example, Cox and Cox (1991) have developed a questionnaire consisting of 18 items to measure the safety climate of industrial gas companies. Their study has identified five factors: personal skepticism, individual responsibility, safeness of the work environment, effectiveness of arrangements for safety, and personal immunity. Based on the questionnaire developed by Cox and Cox (1991), Cheyne et al. (1998) conducted a safety climate study in the manufacturing sector, and have identified five safety climate factors: safety management, communication, individual responsibility, safety standards and goals, and personal involvement. Except for individual responsibility, the results of Cheyne et al. (1998) differ from that of Cox and Cox (1991). As noted by Cooper and Phillips (2004), each structure is unique to each population under consideration, and factors developed in one industry cannot be generalized to other industries. A priori prediction of factor structure is not possible. Despite the instability of safety climate factor structure, the review done by Flin et al. (2000) on 18 scales of safety climate from different industries showed that there are five most frequently-occurring dimensions which are related to management/ supervision, the safety system, risk, work pressure and competence.

In the context of the construction industry, a number of notable safety climate studies have been conducted (e.g. Dedobbeleer and Béland 1991; Glendon and Litherland 2001; Mohamed 2002; Siu et al. 2004; Fang et al. 2006; Choudhry et al. 2009; Lingard et al. 2009, 2010, 2011; Zhou et al. 2011). For the comparison of safety climate factors in the construction industry, only six of these studies directly related to derivation of safety climate factors were selected (Dedobbeleer and Béland 1991; Glendon and Litherland 2001; Mohamed 2002; Fang et al. 2006; Choudhry et al. 2009; Zhou et al. 2011). Safety climate factors of these studies were tabulated in Table 1. The two earliest studies listed in Table 1 were conducted by psychology researchers. The studies of Dedobbeleer and Béland (1991) and Glendon and Litherland (2001) were conducted in the construction industry by using safety climate questionnaires originally developed for other industries. The remaining three studies were conducted by researchers in the construction industry. Mohamed (2002) may be one of the earliest researchers in construction to measure construction safety climate. The studies of Fang et al. (2006), Choudhry et al. (2009), and Zhou et al. (2011) are closely related studies contributing to the recent development of safety climate research in the construction industry.

Based on 71 questions of the safety climate questionnaire developed by HSE (2001) and 16 items covering 14 safety management elements complied by the Hong Kong government, Fang et al. (2006) empirically tested the 87-item questionnaire with data from construction sites in Hong Kong, yielding ten key factors. Choudhry et al. (2009) conducted a follow-up study,

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greatly reducing the number of items in the questionnaire to 22 and the number of factors to two. Zhou et al. (2011) also conducted a closely related study in China in 2004 and 2007 using a shortened version of the questionnaire of Fang et al. (2006), thereby deriving a four-factor structure of construction safety climate and further reducing the questionnaire to 24 items.

Comparing the number of occurrence of construction safety climate factors with similar semantic meanings in Table 1, it was found that management commitment to safety, safety rules and procedures, and workers' involvement in safety are the three most common construction safety climate factors. These three factors are believed to be key safety climate factors in the construction industry because they appear in studies involving construction projects of different sizes and nature conducted in different time and places.

(Insert Table 1 here)

Research methods

Questionnaire design

Safety climate research has been predominantly carried out with the help of a survey questionnaire because a questionnaire is an effective instrument to gauge people's perceptions and the information can be used to reveal intercorrelations of their perceptions (Spector 1994). Hence, a quantitative research approach using a survey questionnaire for data collection was adopted in this study. The questionnaire consisted of 38 questions adopted from the Safety

Climate Index (SCI) survey of the Occupational Safety and Health Council (OSHC) of Hong Kong which measures safety climate behavior of workers.

There are a number of measurement scales of safety climate available in the literature (Davies et al. 2001). After evaluation, the SCI survey items of the OSHC were selected for a number of reasons. The SCI survey tool originating from HSE (2001) was shortened and modified to suit the local context of the construction industry of Hong Kong. Validity and practicality of the tool have been proven in the prior research of the OSHC with local government works departments, private property developers and major contractors. It was designed and presented in English and Chinese. The Chinese version was provided to potential respondents, especially the frontline workers.

Participants and procedures

Sampling of the questionnaire is important because it affects generalization of the findings. A sampling frame was set to enlist key stakeholders in the RMAA sector to participate in this study: the private property management companies; the maintenance sections of quasi-government developers and their subcontractors; the RMAA section of general contractors; and the small RMAA contractors, building services contractors and trade unions.

To ensure the research endeavors actually met the industry's needs and concerns, an advisory group of 13 members was formed. A pilot questionnaire was reviewed by the advisory group members. The advisory group members were experienced senior managers with responsibilities for safety in the Hong Kong government, quasi-government organizations and the private sector, respectively. Some experts also served on the board of the construction safety committee of the Hong Kong government.

The survey was administered between April and August in 2009. A number of private property management companies, maintenance section of quasi-government developers and their subcontractors, RMAA project team of general contractors, small RMAA contractors, building services contractors, and trade unions in Hong Kong participated in this study. For companies or organizations that were willing to administer the questionnaire in their respective RMAA project sites, their managerial or supervisory staff members were briefed to ensure that they were familiar with the questionnaire. To enhance the quality of the responses, 14 trained student helpers assisted the RMAA workers to complete the questionnaire.

In total, 814 completed questionnaires were returned. Although 30 questionnaires distributed to a trade union were uncollectible, all other distributed questionnaires were promptly returned. The response rate was 96.3%. After the deletion of outliers and imputation of missing values, 662 completed questionnaires were deemed valid for analysis. Among the respondents, 60.0% were frontline workers (N = 397), 19.8% were supervisor (N = 131), 19.5% were managers (N = 129) and the remaining 0.6% (N = 5) did not disclose their job position.

Data analysis

Data were randomly split in the statistical package SPSS 18.0 (SPSS Inc., Chicago, IL, USA) into the calibration sample and the validation sample for data analyses. First, the calibration sample data were analysed with exploratory factor analysis (EFA) in SPSS 18.0. EFA helps to reduce the number of variables into a smaller number of factors (Hair et al. 2010). The extraction method Principal Component Analysis (PCA) was selected. As a rule of thumb to access significance of factor loadings, factor loadings of 0.3 to 0.4 are minimally accepted (Hair et al. 2010). Variables with factor loadings below 0.4 were eliminated (Hair et al. 2010). To determine the number of factors to be extracted, Kaiser's criterion, scree test, and Horn's parallel analysis were considered. Horn's parallel analysis has been recognized as the most accurate method to determine the number of factors to retain (Pallant 2007). Both Kaiser's criterion and scree test tend to overestimate the number of factors to retain (Pallant 2007). For factor rotation, Pallant (2007) recommends beginning with direct oblimin which is an oblique rotation method and then checking the degree of correlation between the factors. If the factors are not correlated, the result will resemble that of the orthogonal rotation method. Tabachnick and Fidell (2007) suggest that oblique rotation should be selected if factor correlations exceed 0.32. Because the factors of safety climate are likely to be correlated with one another, this study selected direct oblimin as the method of rotation. Cronbach's alpha was calculated to check for the internal consistency and reliability of each factor.

Factors derived from EFA were then validated by confirmatory factor analysis on the validation sample in LISREL 8.80 (Jöreskog and Sörbom 2006). Common goodness-of-fit indexes, such as the ratio between chi-square and degrees of freedom (χ^2/df), root mean square error of approximation (RMSEA), Comparative Fit Index (CFI), and Non-normed fit index (NNFI) were

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utilized to assess the model (Diamantopoulos and Siguaw, 2000). Because the data were non-normally distributed, Satorra-Bentler scaled chi-square was selected. Satorra-Bentler is an adjusted chi-square statistic which attempts to correct for the bias introduced when data are markedly non-normal in distribution (Satorra and Bentler 2001). As a rule, the model fits the data when the χ^2/df is less than 2, the RMSEA is less than 0.05, the CFI and NNFI are greater than 0.95 (Diamantopoulos and Siguaw 2000).

Aside from overall model fitness, internal reliability and validity of the model has to be assessed. To assess the reliability of the CFA, construct reliability (CR) index was calculated. CR value over 0.7 suggests good reliability (Hair et al. 2010). To assess the discriminant validity of the CFA, average variance extracted (AVE) was calculated. Ideally, AVE of a factor should be greater than its squared correlations with other factors. However, if 95 % confidence interval of factor correlation does not pass the value of 1, that pair of factor still has discriminant reliability (Torkzadeh et al. 2003). Overall flow of the data analysis is depicted in Fig. 1.

(Insert Fig. 1 here)

Analysis results

EFA results

The 38 items of the SCI were subjected to EFA with the extraction method PCA. Prior to performing PCA, the suitability of data for factor analysis was assessed. The Kaiser-Meyer-

Olkin (KMO) value was 0.903, indicating superb sampling adequacy (Field 2009). Barlett's Test of Sphericity produced an approximation of $\chi^2 = 2496.544$ ($df = 231$, $p < 0.001$), indicating that the correlations between variables to be sufficiently large for PCA. The inspection of the correlation matrix revealed the presence of numerous coefficients of 0.3 and above. The factor loading cut-off was fixed at 0.4. In total, 16 items were removed. The communalities of all variables were all above 0.33. The ratio between 331 cases of the calibration data set and 22 selected variables was 15:1.

PCA revealed the presence of four components with eigenvalues exceeding 1. However, an inspection of the scree plot (Fig. 2) and the Horn's parallel analysis both supported three components (Table 2). Because the Horn's parallel analysis is considered the most accurate method to determine the number of factors to be extracted (Pallant 2007), the three-component solution which encapsulated 22 variables was selected. The three-components explained a total variance of 48.20%. Components one to three explained 31.78%, 8.76% and 7.65% of the variance, respectively. This result is comparable to that of Choudhry et al. (2009) which yielded a two-component factor structure explaining 43.9% of total variance.

(Insert Fig. 2 & Table 2 here)

Direct oblimin rotation was performed to enhance factor interpretability. Factor pattern and structure matrix results are shown in Table 3. Tabachnick and Fidell (2007) suggest that oblique rotation (e.g., direct oblimin) instead of orthogonal rotation (e.g., varimax) should be selected if factor correlation exceeds 0.32. Table 4 shows that the factor correlation between F1 and F2 was

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0.351 (i.e., > 0.32), justifying the selection of direct oblimin rotation instead of varimax rotation (Pallant 2007). Values of Cronbach's alpha ranged from 0.67 to 0.87 (Table 4), which are above the minimum cut-off value 0.6 suggested by Hair et al. (2010).

(Insert Table 3 & Table 4 here)

The three factors generated are listed as follows:

- **F1 – Management commitment to OHS and employee involvement**

  This factor consisted of 12 variables. Variables B8, 21, 15, 16, 30, 28, and 34 were more related to management commitment to OHS whereas B19, 38, 13, 9, and 3 were more related to employee involvement in OHS.

- **F2 – Applicability of safety rules and work practices**

  Six variables were included in this factor. Most of the variables were related to the practicality and enforcement of health and safety procedures (B32, 20, 11, and 35) and work execution practices (B29, and 17).

- **F3 –Responsibility for health and safety**

  This factor was comprised of four variables that described both the employee and organization perception of health and safety responsibility. The variables B10 and B26 were reversed statements explicitly reflecting whether the employees perceive health and safety as part of their responsibilities in the working environment. The variables B37 and B14 were about whether the organization takes up its responsibility for providing a safe working environment.

Hypothesized CFA model

To confirm the three-factor structure of the RMAA safety climate (RMAASC) derived from EFA, CFA was conducted on the validation sample. The hypothesized model is shown in Fig. 3. The observed variables, comprising the 22 SCI questions, are shown in regular boxes whereas the latent factors are shown in ellipses. The model hypothesized that RMAASC accounted for the relations of three factors: (F1) *management commitment to OHS and employee involvement*; (F2) *applicability of safety rules and work practices*; and (F3) *responsibility for health and safety*. The model hypothesized a second-order safety climate factor structure in line with the literature (e.g., Zhou et al., 2011). Hence, both the measurement and structural models are involved. The measurement model consists of the hypothesized relationship among 22 variables and the three first-order factors (F1, F2, and F3) were tested. The structural model focused on the relationship between the three first-order latent factors (F1, F2, and F3) and the second-order latent factor RMAASC.

(Insert Fig. 3 here)

Empirically tested CFA model

The empirically tested CFA model of RMAA safety climate on the validation sample with standardized parameter estimates is shown in Fig. 4. Results show that the CFA model fits the

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data well. Satorra-Bentler χ^2 (206, $N = 331$) = 366.637, $p < 0.05$, $\chi^2/df = 1.780$, RMSEA = 0.049, CFI = 0.983, NNFI = 0.981.

(Insert Fig. 4 here)

All the paths from the observed variables to the latent factors were significant. Hair et al. (2010) recommend that standardized factor loading should be greater than 0.5. Except the path from B20 to F2, which marginally attained 0.5 (standardized path coefficient = 0.46), all standardized factor loadings were greater than 0.5.

In the first-order factor level, among the 12 observed variables in (F1) *management commitment to OHS and employee involvement*, the observed variable (B8) “The company really cares about the health and safety of the people who work here” had the strongest standardized path coefficient of 0.79. The strongest standardized path coefficient in (F2) *applicability of safety rules and practices* was (B35) “Supervisors sometimes turn a blind eye to people who are not observing the health and safety procedures” (standardized path coefficient = 0.75), whereas in (F3) *responsibility for health and safety*, it was (B14) “Little is done to prevent accidents until someone gets injured” (standardized path coefficient = 0.72). In the second-order factor level, RMAASC was the underlying latent variable encapsulating F1, F2, and F3. The standardized factor loadings between RMAASC and F1, RMAASC and F2, RMAASC and F3 were 0.78, 0.82, and 0.89, respectively.

Reliability measures the internal consistency of the latent factors. As shown in Table 5, three values of construct reliability (CR) were above the recommended level of 0.7 (Hair et al. 2010). All the factors achieved good internal consistency. Validity is the extent to which the indicators accurately measure what they are supposed to measure (Hair et al. 2010). Construct validity is the extent to which data exhibit evidence of convergent validity and discriminant validity. Convergent validity can be assessed via observable variables that load significantly on their respective latent factors (Anderson and Gerbing 1988). Fig. 3 shows that convergent validity was achieved because all the paths in the CFA model were significant. Results of the discriminant validity test in Table 5 show that the structure has dissimilar constructs for the three factors because all the pairs of 95% confidence interval of factor correlation do not pass through 1.

(Insert Table 5 here)

Discussions

This study has refined the predetermined seven factors of 38 questions in SCI into three factors of 22 questions for the safety climate measurement of RMAA projects. The results are believed to concisely reflect the key factors of RMAA safety climate. Notably, the RMAA safety climate of the current study and other safety climate studies (e.g., O'Toole 2002; Fang et al. 2006; Choudhry et al. 2009) could only explain less than 50% of the total variance. This may imply that safety climate is a multifaceted concept that cannot be grasped easily.

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RMAA safety climate factors identified in this study are: (F1) *management commitment to OHS and employee involvement*; (F2) *applicability of safety rules and work practices*; and (F3) *responsibility for health and safety*. F1 and F2 have been most commonly identified in the literature (Dedobbeleer and Béland 1991; Mohamed 2002; Fang et al. 2006; Choudhry et al. 2009; Zhou et al. 2011). *Management commitment to OHS and employee involvement* is an important factor because effective OHS management needs promotion from the top and support from the bottom. Applicable safety rules and work practices prevent potential hazards from endangering the RMAA workers.

For (F3) *responsibility for health and safety,* it has been identified in safety climate studies conducted in industrial gas production (Cox and Cox 1991), manufacturing (Cheyne et al. 1998), and offshore oil and gas production (Mearns et al. 1998). This is one of the dominant themes in safety climate factors identified by Clarke (2000). The study has succinctly revealed the factor of responsibility for safety and health, which may have been undermined or ubiquitously scattered across several factors in previous construction safety climate studies.

The three-factor structure of the RMAA safety climate revealed in the current study shares commonalities with other safety climate studies in construction and other industries. Despite the commonalities in factor labeling, subtle characteristics and peculiar challenges in the management of these safety climate factors in the context of RMAA works were noted.

As for management commitment to OHS and employee involvement, most RMAA contracting companies are small/medium-sized companies which may have inadequate awareness and resources for safety (Hon et al. 2010). RMAA worksites are usually scattered in various locations, making it particularly difficult for the management to carry out safety supervision, demonstrate commitment to OHS and enlist employee involvement (Hon et al. 2011).

For applicability of safety rules and practices, because most RMAA projects are small in scale and short in duration, some safety rules applicable to new construction works may not be applicable to RMAA works. For example, the law of Hong Kong requires construction projects with over 100 workers to employ a safety officer; however, this requirement usually does not apply to RMAA projects because they seldom employ more than 100 workers on site (Hon et al. 2011). RMAA works also face many ad hoc problems that differ from new construction works. For example, the risks involved in RMAA works undertaken at the external wall of an old building is different from that of a new building because concrete strength of their external walls are likely to be different. Although most construction companies have generic method statements for general building works, they cannot directly address the potential risks and problems in RMAA works (Hon et al. 2011). The challenge now is to design a set of safety rules and good practices for the common types of RMAA works.

As for the responsibility for health and safety, the sense of responsibility for health and safety of RMAA workers may be undermined by the working environments and the nature of tasks of the RMAA projects. RMAA workers working in occupied buildings and handling minute tasks may easily underestimate the importance of safety. RMAA projects undertaken by SMEs may not have a comprehensive safety system, or may be lacking in terms of transparency and communication. Workers can easily develop a mindset that takes safety for granted, or to care only when an accident actually occurs. This can lead to a subsequent negative impression on accident investigation.

Conclusions, Limitations and Recommendations

To conclude, three RMAA safety climate factors, which encapsulated 22 questions of SCI, were identified with EFA on the calibration sample, and then validated with CFA on the validation sample. The three identified factors were: (F1) *management commitment to OHS and employee involvement*; (F2) *applicability of safety rules and work practices*; and (F3) *responsibility for health and safety*. The CFA model had proven goodness-of-fit, reliability, and validity, thereby indicating that the three factors concisely represented the key factors of safety climate of RMAA works. It is acknowledged that the analysis and findings of this study are limited due to sample selection. The selected sample organizations may only represent a section of the RMAA sector in Hong Kong, and not the entire population. However, the findings of the current study shed light on managing safety climate of RMAA works, an area where empirical work is largely uncharted. Further research work should be conducted with a larger sample size to achieve more representative results.

To improve the perception of (F1) *management commitment to OHS and employee involvement*, a vision of nurturing a good safety culture in the workplace should be clearly laid down in the company policy. The company can demonstrate steadfast commitment to OHS by selecting RMAA subcontractors with good track records of safety performance; by implementing safety incentive schemes, such as pay for safety of subcontractors; by hiring licensed RMAA workers who have demonstrated previous professional expertise and safety competence; and by providing sufficient safety equipment for the RMAA workers (e.g., personal protective equipment). Employee involvement in OHS can be improved by raising the safety awareness of the RMAA workers.

To improve the perception of (F2) *applicability of safety rules and practices*, the current legislative control of the RMAA works needs to be reviewed. The company has the responsibility for laying down clear safe working procedures and guidance for the RMAA workers to follow. Government or OHS consultant bodies are advised to provide relevant safety training in handling multiple tasks for the specific trades of RMAA works. Designers or architects are advised to consider maintenance safety in their designs. Unlike new works, the execution procedures of RMAA works are constrained by the original building design. Many accidents could be prevented if maintenance safety is taken into account in the design stage. Simple features such as roof top access and anchor points can be effective in alleviating risks of RMAA works done at heights. Technological innovations can also contribute to the eradication of dangerous work practices, such as, the rapid demountable platform promoted by the Construction Industry Institute of Hong Kong (CII-HK) (Cheung and Chan 2011), which replaces the traditional bamboo truss out scaffolding that has been the cause of many deaths.

To improve the perception of (F3) *responsibility for health and safety*, raising the safety awareness of RMAA workers and helping to develop in them a sense of responsibility and ownership for safety are important. Undoubtedly, construction activities are high risk; however, risks are something that can be managed (Reason 1990). RMAA workers need to be equipped

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with better safety awareness so that they will know how to manage peculiar risks involved in RMAA works. Notably, management enforcement of safety affects the frontline workers' perception of safety. The enforcement of site safety indicates real company concern regarding safety. More attainable actions could include the improvement of site tidiness and housekeeping, strengthening of the site monitoring and safety supervision, and implementation of an award and penalty scheme. These seemingly simple actions could have profound effects. Government and OHS consultant bodies should put more effort in safety promotion and education towards the RMAA sector and the public, such as launching an RMAA works safety publicity campaign for better awareness.

Although the current study was conducted in Hong Kong, findings can be extrapolated to any other developed society with aging buildings or a surging RMAA sector. Although RMAA works in Hong Kong have some unique local practices, some generic practices of RMAA works in Hong Kong are likely to be applicable to other developed societies. As an international city, typical job characteristics and work environment of RMAA works in Hong Kong are similar to other developed societies, such as the United States. According to the Bureau of Labor Statistics (2012), RMAA workers in the United States often carry out many different tasks on a single day, at a large number of locations. They need to work inside a single building or be responsible for the maintenance of many buildings. They may work in hot or cold environments, in uncomfortable and cramped positions, or on ladders. Their work involves a lot of walking, climbing, and reaching. These challenges are also commonly encountered by RMAA workers in Hong Kong; Therefore, safety climate factors derived in Hong Kong would be relevant and of value to the United States as well.

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The current study has derived an RMAA safety climate measurement scale with proven construct reliability, validity, and predictability of safety performance. This scale can be employed in future research studies in the RMAA sector in other places. Practitioners in the RMAA sector can easily employ this three-factor RMAA safety climate to periodically gauge the safety climate of their own RMAA projects, which would act as a leading indicator of safety performance. Safety climate assessment of RMAA projects will contribute to nurturing a positive safety culture in the RMAA sector, and thus enhancing safety of the whole construction industry.

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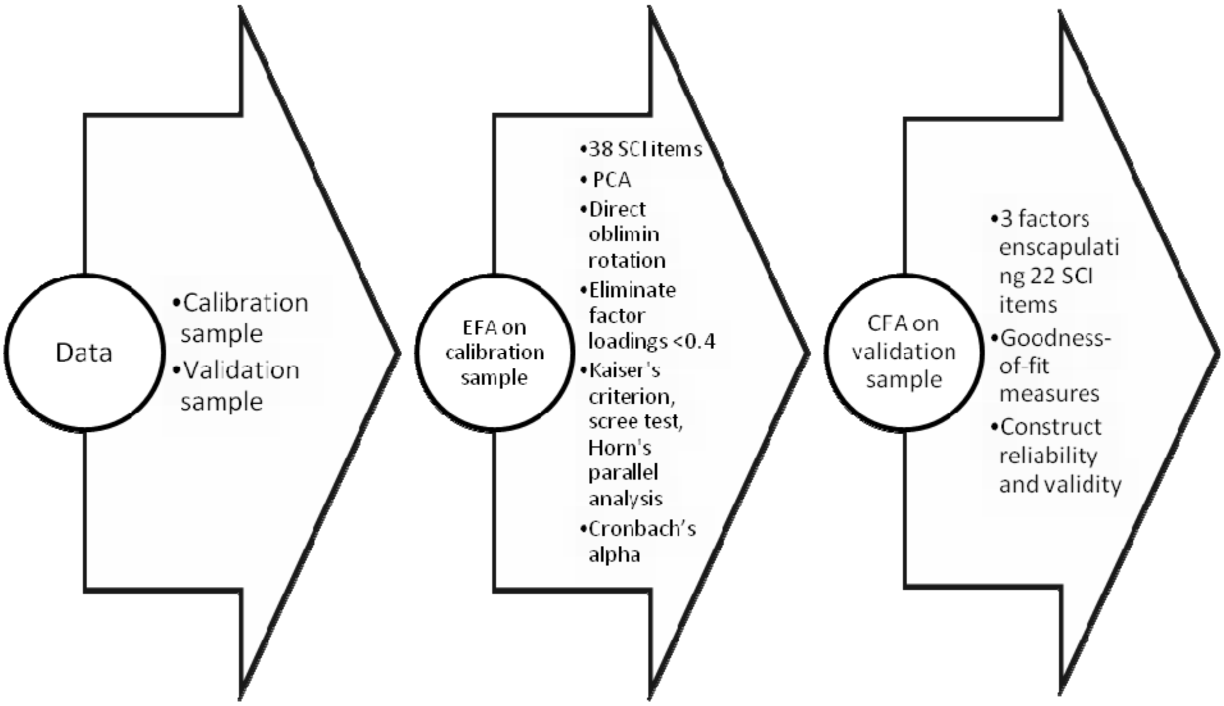

Fig. 1. Overall flow of the data analysis.

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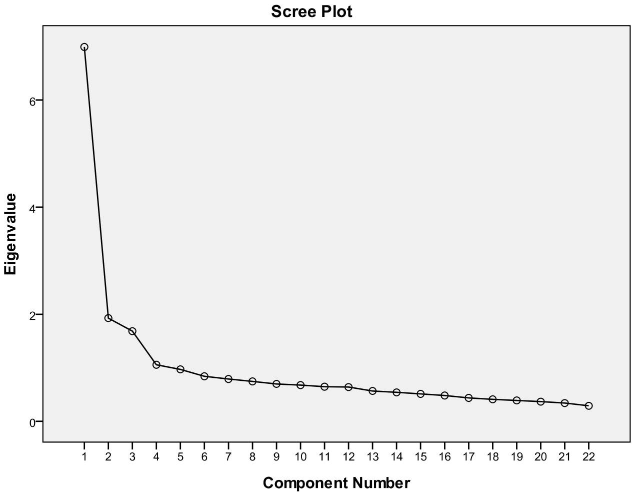

Fig. 2. Scree plot of EFA

Figure 3

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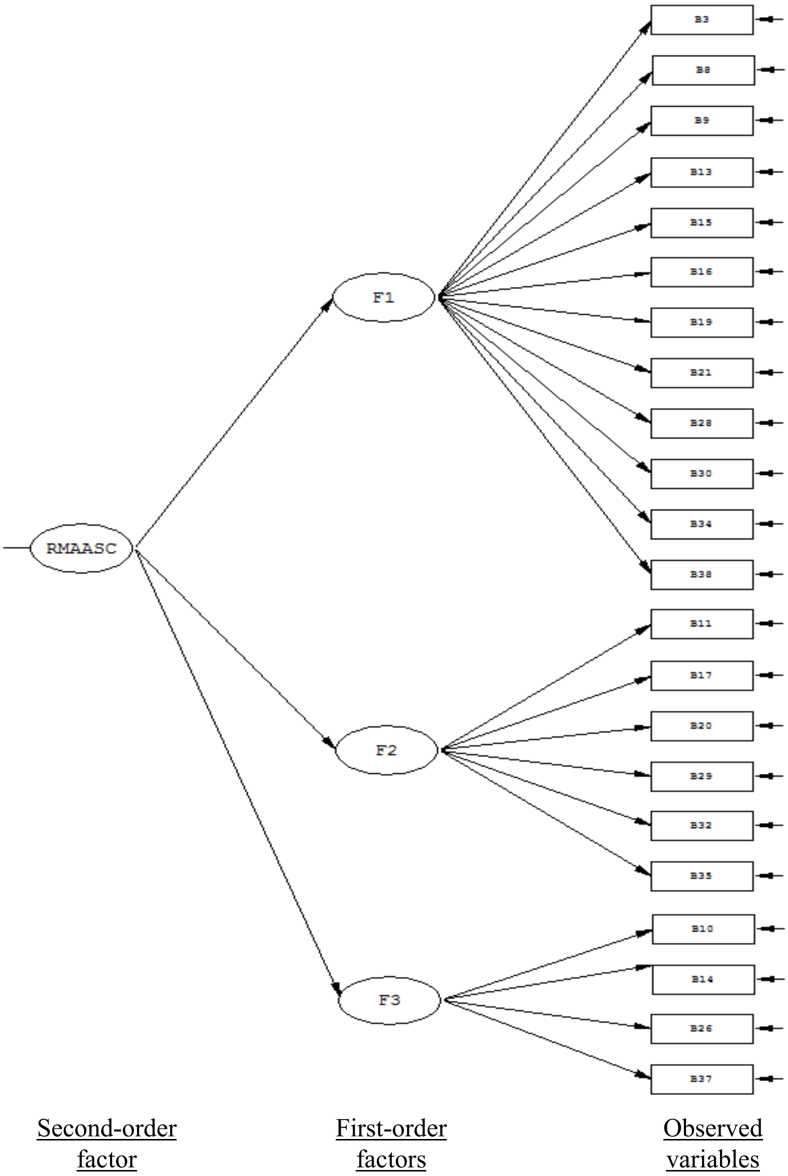

Fig. 3. Hypothesized CFA model of the RMAASC

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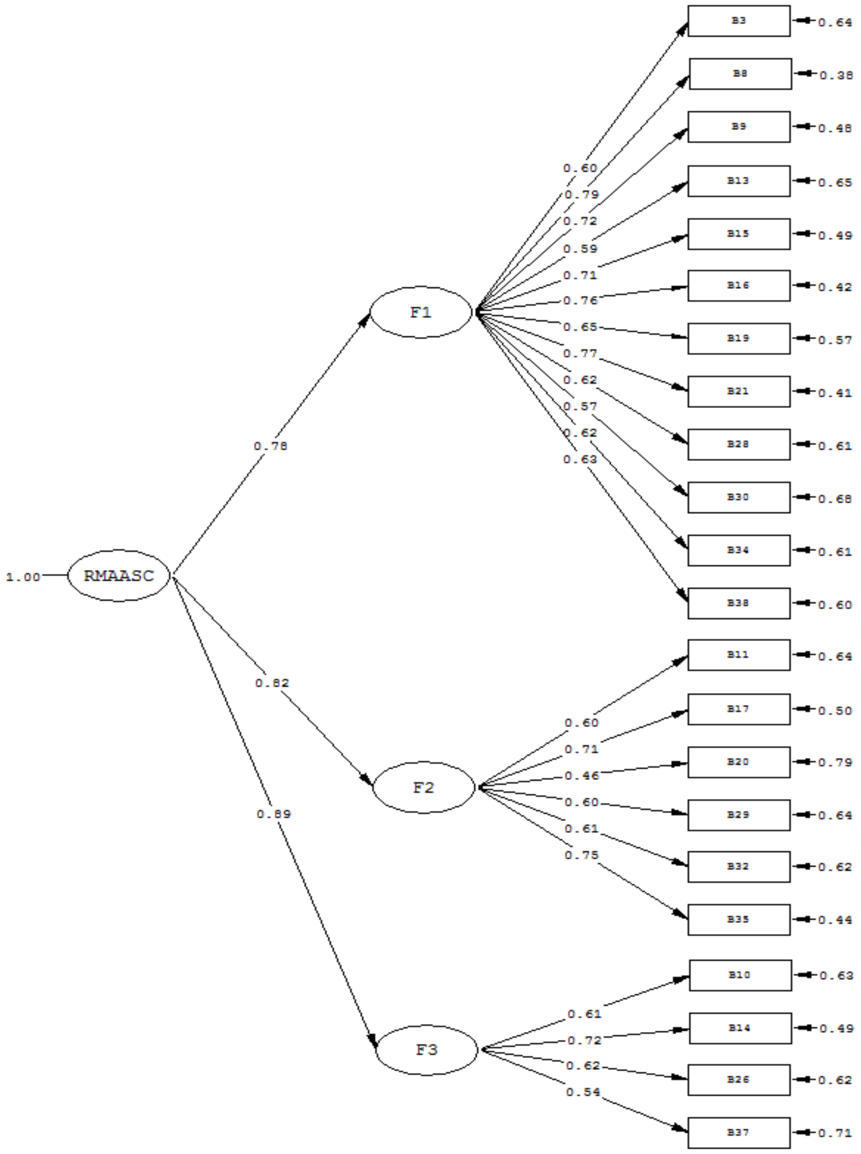

Fig. 4. RMAASC CFA model tested on the validation sample

Note: All the paths are significant at 0.05 significance level.

Table 1

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Table 1. A Review of Safety Climate Factors in Construction

	Management commitment	Workers' involvement	Safety rules and procedures	Safety resources	Communication and relationships	Safety attitude	Work pressure	Appraisal of risks and hazards	Competence	Risk taking behavior	Safety training	Supervisors' role/ workmates' influence
Dedobbeleer and Béland (1991)	√	√										
Glendon and Litherland (2001)			√	√	√		√					
Mohamed (2002)	√	√	√		√		√	√	√	√		
Fang et al. (2006)	√	√	√	√		√		√	√	√	√	√
Choudhry et al. (2009)	√	√	√									
Zhou et al. (2011)	√		√			√					√	√
Total number of occurrence	5	4	5	2	2	2	2	2	2	2	2	2

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Table 2. Comparison of the Eigenvalues from PCA and the Criterion Values from the Horn's Parallel Analysis

Component number	Actual eigenvalue from PCA	Criterion value from parallel analysis	Decision
1	6.992	1.490	Accept
2	1.928	1.409	Accept
3	1.684	1.343	Accept
4	1.056	1.291	Reject

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Table 3. Pattern and Structure Matrix for the PCA and Direct Oblimin Rotation of the Three-factor Solution of the RMAASC

	Item	Pattern coefficients			Structure coefficients			Communalities
		1	2	3	1	2	3	
	Factor 1 Management commitment to OHS and employee involvement *(Eigenvalue = 6.992; % of variance =31.782; cumulative % =31.782)*							
B8	The company really cares about the health and safety of the people who work here	**.755**	.002	.002	**.756**	.268	.193	.572
B21	There are good communications here between management and workers about health and safety issues	**.705**	.192	-.167	**.730**	.423	.031	.591
B15	The company encourages suggestions on how to improve health and safety	**.701**	.004	-.054	**.708**	.382	.064	.476
B19	I am clear about what my responsibilities are for health and safety	**.690**	-.275	.192	**.688**	.244	.124	.511
B38	I think management here does enough to follow up recommendations from safety inspection and accident investigation reports	**.685**	.154	-.126	**.686**	.304	.120	.536
B13	All the people who work in my team are fully committed to health and safety	**.675**	.073	-.058	**.685**	.381	.011	.478
B16	There is good preparedness for emergency here	**.672**	.163	-.176	**.657**	.202	.367	.521
B30	Accidents which happened here are always reported	**.647**	-.132	.128	**.642**	-.013	.339	.430
B9	Most of the job-specific safety trainings I received are effective	**.615**	-.035	.215	**.633**	.108	.278	.476
B3	I fully understand the health and safety risks associated	**.572**	-.140	.249	**.586**	.086	.380	.418
B28	Safety inspection here is helpful to improve the health and safety of workers	**.529**	.099	.020	**.569**	.287	.164	.332
B34	Staff are praised for working safely	**.473**	.241	-.131	**.525**	.394	.013	.342

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	Factor 2 Applicability of safety rules and work practices *(Eigenvalue = 1.928; % of variance =8.763; cumulative % =40.545)*							
B29	Some jobs here are difficult to do safely	-.093	**.735**	.147	.202	**.717**	.197	.537
B32	Not all the health and safety rules or procedures are strictly followed here	.081	**.682**	.031	.328	**.714**	.121	.518
B20	Some of the workforces pay little attention to health and safety	.042	**.621**	-.200	.490	**.676**	.270	.416
B11	Some health and safety rules or procedures are difficult to follow	.013	**.600**	.197	.274	**.624**	.261	.429
B35	Supervisors sometimes turn a blind eye to people who are not observing the health and safety procedures	.251	**.573**	.149	.210	**.615**	-.127	.551
B17	Sometimes it is necessary to take risks to get the job done	.222	**.487**	.284	.465	**.594**	.390	.503
	Factor 3 Responsibility for health and safety *(Eigenvalue = 1.684; % of variance =7.653; cumulative % =48.198)*							
B10	People are just unlucky when they suffer from an accident	-.042	.125	**.783**	.200	.189	**.785**	.630
B37	Accident investigations are mainly used to identify who should be blamed	.011	-.052	**.612**	.226	.275	**.624**	.374
B26	Work health and safety is not my concern	-.002	.215	**.602**	.148	.013	**.610**	.434
B14	Little is done to prevent accidents until someone gets injured	.311	.214	**.489**	.510	.372	**.589**	.526

Note: Major loadings for each item are shown in bold font.

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Table 4. Factor Correlation Matrix of the RMAASC (Cronbach's Alpha in Diagonal)

	Number of items in scale	1	2	3
(F1) Management commitment to OSH and employees' involvement	12	(.871)		
(F2) Appropriate safety rules and work practices	6	.351	(.762)	
(F3) Perception of risk and safety system	4	.253	.101	(.666)

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Table 5. Discriminant Validity, Squared Factor Correlation, Confidence Interval and the Composite Reliability of the First-order Factors of the RMAASC

	F1	F2	F3	CR[d]
F1	*0.454*[a]			0.913
F2	0.409[b] (0.572, 0.699)[c]	*0.395*		0.793
F3	0.483 (0.635, 0.747)	0.526 (0.671, 0.772)	*0.390*	0.717

Note: [a]Average variance extracted (AVE) along diagonal. [b]Squared factor correlation. [c]95% confidence interval of factor correlation. [d]CR = Construct reliability