Impact of Job Stressors and Stress on the Safety Behavior and Accidents of Construction Workers

Mei-Yung Leung[1]; Qi Liang[2]; and Paul Olomolaiye[3]

Abstract: Construction workers (CWs) are usually exposed to various job-related hazards while working on construction sites, especially when there is a lack of appropriate equipment, working without support, or being forced to work quickly. All these can induce serious stress and lead to dangerous situations at work. Hence, to prevent CWs from injury, this study sets out to investigate the relationships between job stressors, stress, safety behavior, and accidents. A survey of CWs was carried out using statistical tools to analyze the data. Five job stressors, two different types of stress, and safety behavior among CWs were identified using factor analysis. The results of the correlation and regression analyses showed that (1) physical stress is predicted by job certainty, co-worker support, and safety equipment, while psychological stress is predicted by both supervisor support and job certainty; (2) supervisor support and physical stress predict safety behavior; and (3) the risk of accidents can be reduced by safety behavior, whereas a high level of job control increases it. Finally, several recommendations are made, including on-the-job training, stress-reduction programs, and appropriate employment policies, to enhance safety behavior and decrease the number of accidents on construction sites. This paper provides empirical support to and extends some accident-causation theories, and sets a base for further study regarding stress management for Hong Kong's construction participants working in Mainland China. **DOI: 10.1061/(ASCE)ME.1943-5479.0000373.**

Introduction

Construction workers (CWs) are groups of skilled and unskilled workforce employed in the construction industry and input physical efforts for performing actual construction work (Hoonakker and Duivenbooden 2010). They usually work on the front line, so their performance directly influences project success in terms of quality, duration, cost, and safety (Gouett et al. 2011; Oberlender 2014). CWs are often hired on a project-to-project basis and may spend only a few months, weeks, or days on any single site (e.g., Cheng et al. 2005; Alterman et al. 2013). In general, their working environment is very poor (e.g., extreme temperature, excessive noise, and inappropriate lighting) and almost always involves various job-related hazards such as working with heavy equipment, working at height, and exposure to chemical production (Jones and Saad 2003; Loosemore et al. 2003; Xiang et al. 2014). Therefore, a construction site is still one of the most dangerous workplaces, with a large amount of injuries and accidents (Hallowell 2012; Liao et al. 2013; Teo et al. 2005). In fact, construction industry accounts for 25.2% (3,160 of 12,547) of the total industrial accident, and 82.7% (24/29) of the total industrial fatal rate in Hong Kong in 2012 (Labour Department 2013). In the same year, there were 806 fatal accidents in the U.S. construction industry, comprising 17.5% of the total industrial fatal accidents (Bureau of Labor Statistics 2012).

[1]Associate Professor, Dept. of Architecture and Civil Engineering, City Univ. of Hong Kong, Tat Chee Ave., Kowloon Tong, Hong Kong (corresponding author). E-mail: bcmei@cityu.edu.hk

[2]Ph.D. Candidate, Dept. of Architecture and Civil Engineering, City Univ. of Hong Kong, Tat Chee Ave., Kowloon Tong, Hong Kong. E-mail: qiliang3-c@my.cityu.edu.hk

[3]Professor, Faculty of Environment and Technology, Univ. of the West of England, Frenchay Campus, Coldharbour Ln., Bristol BS16 1QY, U.K. E-mail: Paul.Olomolaiye@uwe.ac.uk

Note. This manuscript was submitted on June 13, 2014; approved on March 3, 2015; published online on April 15, 2015. Discussion period open until September 15, 2015; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Management in Engineering***, © ASCE, ISSN 0742-597X/04015019(10)/$25.00.

Many theories have been proposed to explain the mechanism through which accident happened, including the domino theory (Heinrich 1931), human error theory (Choudhry and Fang 2008), epidemiological theory (Goetsch 2009), system theory (Gatti et al. 2013), etc. One of these theories, adjustment-stress theory, has postulated that stressors in working environment increase individuals' vulnerability to accident (Kerr 1950; Rojas 2009). Because of the detrimental working environment, construction work is regarded as one of the most stressful occupations (International Labour Organization 1992; Peterson and Zwerling 1998). Studies show that various stressors in the construction industry can induce stress for CWs, while the stress can lead to accidents (Loosemore and Waters 2004; Leung et al. 2010, 2012).

However, there has so far been very limited examination of the relationship between job stressors, stress, safety behavior, and accidents. To prevent injury to CWs, it is important to investigate how job stressors and stress influence the risk of accidents on construction sites.

Job Stressors

A stressor was created to distinguish stress stimulus from response, which refers to a threatening or challenging event that can result in stress (Lazarus 1976; Selye 1956). Stressors in working environment are defined as *job stressors* (Brockman 2014; Nixon et al. 2011). Because of the special characteristics of the job, such as working at height, working in crowded places, and operating complicated plant and equipment, CWs are often placed in dangerous situations (e.g., falling from height, being struck by falling materials, being trapped in machinery) (Choudhry and Fang 2008). In fact, working in such an environment also induces great stress for CWs [Chartered Institute of Building (CIOB) 2006; Djebarni 1996]. Although previous studies have identified various job stressors in the construction industry (CIOB 2006; Leung et al. 2005; Ng et al. 2005), there are some stressors unique to CWs and may cause stress as well as accidents to CWs.

Safety equipment, such as safety helmets and gloves to protect the head and hands from injury, plays an important role in protecting the health and safety of CWs in the workplace (Eakin 1992). However, working with insufficient safety equipment not only causes accidents (Toole 2002), but also places CWs under stress as they have to constantly worry about their own safety while working (Leung et al. 2010).

CWs on a construction project usually need support from supervisor to finish tasks efficiently and overcome operational difficulties such as dealing with seepage through exterior walls. Such support can reduce their stress levels (Mayo et al. 2012) and also their accident rates (Iverson and Erwin 1997). In practice, CWs normally work as a team and therefore need support from each other; for example, a chainman will assist the land surveyor to measure building location, and laborers help bricklayers mix mortar and deliver bricks (Farr and Mangin 2007; Mitropoulos and Memarian 2012). *Co-worker support* refers to work-related assistance given from co-workers to carry out tasks (Susskind et al. 2000). Poor co-worker support usually leads to work stress and burnout, or even unsafe behaviors (Blau 1981; Choudhry and Fang 2008; Jayaratne and Chess 1984).

Job control refers to the belief of individuals in their ability to exert some influence over the working environment in order to make it more rewarding and less threatening (Carayon and Zijlstra 1999; Karasek 1979). In practice, CWs need to manage and control many tasks by themselves. However, lack of job control among CWs is more prevalent than other working population (Boschman et al. 2013), and it can lead to both psychological and physical stress of CWs (Cheng et al. 2005), and lead to injury or near misses (Goldenhar et al. 2003; Suraji et al. 2001). CWs are always engaged in short-term tasks on-site on a weekly or daily basis, and have little *job certainty* (Choudhry and Fang 2008). This is known to affect their confidence and ability to work, leading ultimately to stress at work and even injuries, particularly on-site (Abbe et al. 2011; Roney and Cooper 1997).

Stress

Stress is an inevitable part of human experience and is not limited to any particular profession (Ng et al. 2005). CWs usually suffer from a lot of different types of stress, including physical and psychological (Meliá and Becerril 2007; Merlino et al. 2003). *Physical stress* can induce biological reactions in response to a stressful situation by releasing hormones to support the fight-or-flight response (Henry 1992; Leung et al. 2012). It may lead to problems such as sleep disorders, headaches, and skin problems (McEwen and Lasley 2002; Mellner et al. 2005; Sapolsky 1998), while CWs under physical stress may even be more prone to accidents (Abbe et al. 2011).

Psychological stress refers to a severely traumatizing experience, which can induce anxiety, sadness, anger, and/or tension in the workplace (Lazarus 1993; Lehrer 2006). Individuals suffering from psychological stress are often emotionally drained and their ability to undertake their duties is diminished as a result (Goliszek 1992). This may affect performance and decrease the likelihood that they will carry out safety behavior (Seo 2005).

Safety Behavior and Accidents

Safety behavior is defined as the individuals' behaviors to promote health and safety of their own and the working environment (Burke et al. 2002). CWs are always required to carry out *safety behavior* on-site. An individual performing such safety behavior should not only avoid taking any risks or shortcuts, but must also comply with safety rules and procedures during the process (Hsu et al. 2008; Marchand et al. 1998). It is widely recognized that the majority of accidents are caused by failure to carry out *safety behavior* (Choudhry and Fang 2008; Mearns et al. 2001). This is often cited as one of the most important causes of accidents (Haslam et al. 2005; Landeweerd et al. 1990).

Accidents are serious events. They include both reported and unreported incidents and near misses that are actual dangerous events, which have fortunately ended without injury (Neal and Griffin 2006; Probst and Brubaker 2001). Although unsafe behavior is the most significant factor, accidents at work can also be caused by job-related stressors such as low job control, lack of support from supervisor or co-workers, uncertainty about information (Abbe et al. 2011; Sherry 1991). Stress levels of CWs influence their adoption of safety behavior and, in turn, the risk of injury or accidents (Iverson and Erwin 1997; Schuler 1980).

By contrast, accidents have many negative effects such as fines and loss of productive time. The impact of an accident may subsequently affect CWs during normal working operations, and cause them to experience more stress in dealing with the tasks which follow (Davies and Tomasin 1996). In other words, experiencing or witnessing accidents is itself one type of stressors for CWs (Health and Safety Executive 2007).

Conceptual Model

In this study, it was hypothesized that job stressors influence accidents among CWs through stress and safety behavior, directly or indirectly. The conceptual model consists of job stressors (safety equipment, supervisor support, co-worker support, job certainty, and job control), stresses (physical and psychological), safety behavior, and accidents (Fig. 1).

Research Method

To investigate the complicated relationships between job stressors, stress, safety behavior, and accidents among CWs, a questionnaire was designed and disseminated among CWs in Hong Kong. Because of the low educational levels of most CWs (Chan and Chan 2011), the questionnaire was written in both Chinese (the mother tongue of Hong Kong CWs) and English. As well as collecting personal information, the survey included items measuring job stressors (Goldenhar et al. 2003; Leung et al. 2005, 2010), stress (Gmelch 1982; Greenberg 2003; Leung et al. 2008, 2012), and safety behavior (Mearns et al. 2001). To prevent the response acquiescence that is common in questionnaire survey, both favorable and unfavorable statements were included in this questionnaire survey (Goodwin 2010; Podsakoff et al. 2003).

All responses were measured using a 7-point Likert-type scale ranging from 1 (strongly disagree/never) to 7 (strongly agree/always) (Maslach and Jackson 1996). For the measurement of accident, the interval scale was used to record the number of accidents that respondents had experienced in the 2 years before the survey (i.e., 1 = 0, 2 = 1, 3 = 2, 4 = 3, and 5 = 4 or above). A shorter reference period is preferable because it enables more accurate data to be collected (Landen and Hendrick 1995). Statistical analyses, including factor analysis, reliability analysis, Pearson's correlation analysis, and stepwise multiple linear regression analysis, were then carried out on the data.

Because this study aims to investigate the stressors, stress, and safety behavior of CWs with different work trades, purposive sampling was adopted to control the quality of the data collection

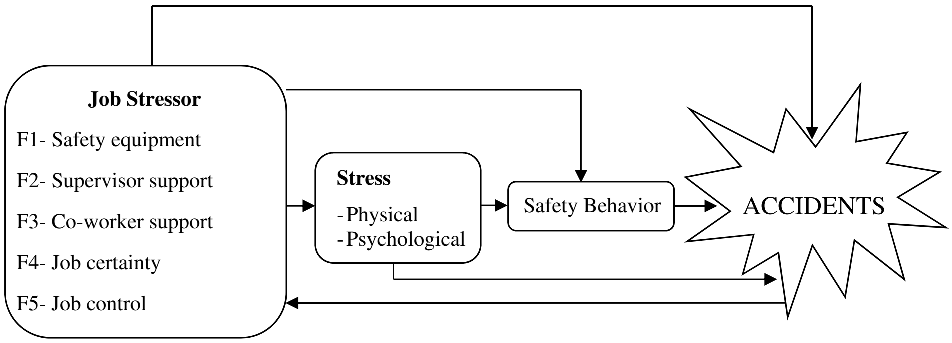

Fig. 1. Conceptual model of stressors–stress–safety behavior–accidents for CWs

(Cooper and Schindler 2006; Patton 1990). A total of 500 surveys were distributed to CWs in Hong Kong through personal contact, company delivery, and the governmental vocation training institutions. All the CWs in this study were skilled workers in the construction industry, with the following three specific inclusion criteria: (1) being qualified in a specific trade (such as brick mason, pipe layer, plumber, carpenter, excavator, and bricklayer); (2) currently working in the mainstream construction industry (that is, for a main contractor, subcontractor, or supplier firm); and (3) having experience of accident.

Of the 500 surveys distributed, 166 CWs returned completed surveys, giving a response rate of 33.2%. The majority of respondents were aged 40–49 (42%), with 28%, 19%, and 11% being aged over 50, 31–40, and 21–30 years, respectively. Half of the respondents (55%) had amassed over 20 years of experience in the construction industry, with 38% having 11–20 years of experience, and 16% with 1–10 years. Over 96% of respondents had not received a certificate-level college education.

Results

Factor Analysis

The job stressors, stress, and safety behavior scales consisted of 24 items in total. To identify the main categories of the 24 items, psychometrically sound items, and avoid factors with indeterminacy, a principal components analysis with varimax rotation (eigenvalue: 1 cutoff) has been adopted (Pallant 2011; Stevens 1996). The results of varimax and oblimin rotation were found to be similar with each other in this study. Because the former one is easier to be interpreted, the result of the varimax rotation has been reported in the following analysis (Tabachnick and Fidell 2007). Because of the limited sample size (166), variables with a factor loading of lower than 0.6 were removed (Hair et al. 2010). The reliability coefficient was measured using Cronbach's alpha and all alpha values were higher than 0.5, and thus considered reliable (Hair et al. 1998).

With a sample size of 166, the item-sample ratios of stressors, stress, and safety behavior were 11:1, 27:1, and 55:1, which meets the sample-size requirements for factor analysis (Nunnally 1978). The items of stressors, stress, and safety behavior were separately subjected to factor analysis, and are generally loaded onto the predicted factors, including safety equipment (F1), supervisor support (F2), co-worker support (F3), job certainty (F4), and job control (F5), which explained 84.76% of variance; physical stress (S1) and psychological stress (S2), which explained 69.71% of variance; and safety behavior (SB), which explained 61.42% of variance (Table 1). Item 15, with a factor loading of below 0.6, was deleted, causing the Cronbach's alpha of job control (F5) to increase from 0.362 to 0.550.

Pearson's Correlation Analysis

A Pearson's correlation analysis was then conducted to investigate the relationships between job stressors, stress, safety behavior, and accidents for the CWs in this study (Table 2). The results showed the following interrelationships: *co-worker support* (F3) was significantly related to all other stressors including *safety equipment* (F1: 0.194; $P < 0.05$), *supervisor support* (F2: −0.184; $P < 0.05$), *job certainty* (F4: −0.198; $P < 0.05$), and *job control* (F5: 0.258; $P < 0.01$). *Job control* (F5) was significantly correlated with *safety equipment* (F1: 0.368; $P < 0.01$) and *supervisor support* (F2: −0.179; $P < 0.05$).

By contrast, *physical stress* (S1) significantly correlated with *safety equipment* (F1: −0.219; $P < 0.01$), *co-worker support* (F3: −0.173; $P < 0.05$), and *job certainty* (F4: −0.156; $P < 0.05$). *Psychological stress* was significantly correlated with *supervisor support* (F2: 0.233; $P < 0.01$) and job certainty (F4: −0.235; $P < 0.01$). *Safety behavior* (SB) had a significant relationship with *safety equipment* (F1: 0.159; $P < 0.05$), *supervisor support* (F2: 0.157; $P < 0.05$), and *physical stress* (S1: −0.164; $P < 0.05$), whereas the *accidents* factor (Acc) was significantly correlated with *job control* (F5: 0.247; $P < 0.01$) and *safety behavior* (SB: −0.271; $P < 0.01$).

Regression Analysis

Multiple linear regression analysis with stepwise method was used to further investigate the interrelationships among stressors, stress, safety behavior, and accidents. It is a sophisticated statistical technique allowing for the prediction of a single dependent variable (e.g., accidents) from a group of independent variables (e.g., stressors, stress, and safety behavior). The assumptions for multiple regression analysis, including multicollinearity, outliers, and normality, were checked by inspecting variance inflation factor (VIF), Mahalanobis distance, and normal probability plot of the regression standardized residuals, respectively. The statistical results show that the VIF value for independent variables are within 1–10, which indicates no violation to multicollinearity (Mayo et al. 2012); the Mahalanobis value are within the required critical value (i.e., 26.13 for eight independent variables; e.g., Tabachnick and Fidell 2007); and the normal probability plot (P–P) of the regression standardized residual shows as a reasonable straight diagonal line from bottom left to top right, which suggests no major deviations from normality for dependent variables (i.e., accident; Pallant 2011). Two models were elaborated for the two types of stress (Models 1 and 2; Table 3). In Model 1, *physical stress*

Table 1. Scale Items, Factor Loadings, and Alpha Coefficients for Job Stressors, Stress and Safety Behavior

Factors	Nature	Item	Description	Factor loading	Alpha (α)
Job stressors					
F1: safety equipment	+	1	Safety equipment is regularly maintained	0.933	0.904
F1: safety equipment	+	2	Safety equipment is regularly checked	0.931	0.904
F1: safety equipment	+	3	Safety equipment is in good condition	0.850	0.904
F2: supervisor support	+	4	My immediate supervisor contributes an extra effort to make my work life easier	0.940	0.903
F2: supervisor support	+	5	My immediate supervisor contributes an extra effort to make my work life safer	0.914	0.903
F2: supervisor support	+	6	My immediate supervisor can be relied upon to help when a difficult situation arises at work	0.859	0.903
F3: co-worker support	+	7	My co-workers contribute an extra effort to make my work life easier	0.944	0.931
F3: co-worker support	+	8	My co-workers contribute an extra effort to make my work life safer	0.911	0.931
F3: co-worker support	+	9	My co-workers can be relied upon to help when a difficult situation arises at work	0.908	0.931
F4: job certainty	+	10	If I lost my job, I would know how to find another job to maintain my income	0.940	0.906
F4: job certainty	+	11	I am certain about the future of my job	0.912	0.906
F4: job certainty	+	12	If I lost my job, I would certainly know how to support myself	0.878	0.906
F5: job control	+	13	I can control how fast I work	0.875	0.550
F5: job control	+	14	I can control the provision of proper personal protective equipment that I need from the contractor	0.698	0.550
F5: job control	+	15[a]	I can control the types of tasks assigned to do during a workday	0.307	0.550
Stress					
S1: physical	+	16	I have insomnia or trouble sleeping	0.834	0.866
S1: physical	+	17	I usually get headaches	0.751	0.866
S1: physical	+	18	I have dermatitis	0.736	0.866
S2: psychological	+	19	I have often felt angry in the workplace due to issues relating to my job	0.905	0.671
S2: psychological	+	20	I have often felt sad in the workplace due to issues relating to my job	0.887	0.671
S2: psychological	+	21	I have often felt tense in the workplace due to issues relating to my job	0.866	0.671
Safety behavior					
SB: safety behavior	—	22	I bend the rules to achieve targets	0.897	0.676
SB: safety behavior	—	23	I ignore safety regulations to get the job done	0.831	0.676
SB: safety behavior	—	24	I take shortcuts that involve little or no risk	0.629	0.676

Note: All items measured using a 7-point scale ranging from 1 (strong disagree/never) to 7 (strongly agree/always).
[a]With factor loadings under 0.60 deleted from further data analysis.

Table 2. Correlation Coefficients between Stressors, Stress, Safety Behavior, and Accidents

Factors	F1	F2	F3	F4	F5	S1	S2	SB	Acc
F1: safety equipment	1	—	—	—	—	—	—	—	—
F2: supervisor support	−0.072	1	—	—	—	—	—	—	—
F3: co-worker support	0.194[a]	−0.184[a]	1	—	—	—	—	—	—
F4: job certainty	−0.036	−0.108	−0.198[a]	1	—	—	—	—	—
F5: job control	0.368[b]	−0.179[a]	0.258[b]	−0.096	1	—	—	—	—
S1: physical stress	−0.219[b]	0.133	−0.173[a]	−0.156[a]	−0.131	1	—	—	—
S2: psychological stress	−0.089	0.233[b]	−0.021	−0.235[b]	−0.097	0.151	1	—	—
SB: safety behavior	0.159[a]	0.157[a]	0.099	−0.149	−0.077	−0.164[a]	−0.012	1	—
Acc: accidents	0.038	−0.136	0.072	−0.111	0.247[b]	0.011	−0.078	−0.271[b]	1

[a]Correlation significant at the 0.05 level (two tailed).
[b]Correlation significant at the 0.01 level (two tailed).

was negatively predicted by *safety equipment* (F1), *co-worker support* (F3), and *job certainty* (F4). Model 2 showed that *psychological stress* was predicted positively by *supervisor support* (F2) but negatively by *job certainty* (F4).

To predict the safety behavior of CWs on-site, Model 3 was developed using the independent variables of the five stressors and the two types of stress. This model showed that safety behavior (SB) was positively predicted by *supervisor support* (F2), but negatively

J. Manage. Eng.

Table 3. Regression Model for Stressors, Stress, Safety Behavior, and Accidents

Model	Dependent variable	Independent variable	*B*	SE	Significant	VIF	*R*	R^2	ANOVA *F*	ANOVA Significant
1	Physical stress	Stressors, SB, Acc								
		Constant	4.432	0.387	0.000	—	0.321	0.103	6.176	0.001
		F1: safety equipment	−0.163	0.065	0.013	1.039	—	—	—	—
		F4: job certainty	−0.114	0.044	0.010	1.041	—	—	—	—
		F3: co-worker support	−0.120	0.053	0.025	1.080	—	—	—	—
2	Psychological stress	Stressors, SB, acc								
		Constant	5.611	0.305	0.000	—	0.314	0.099	8.585	0.000
		F4: job certainty	−0.129	0.046	0.006	1.012	—	—	—	—
		F2: supervisor support	0.151	0.055	0.007	1.012	—	—	—	—
3	Safety behavior	Stressors, stresses								
		Constant	5.800	0.579	0.000	—	0.292	0.085	4.856	0.003
		S1: physical stress	−0.259	0.096	0.007	1.039	—	—	—	—
		F2: supervisor support	0.140	0.065	0.033	1.026	—	—	—	—
		F4: job certainty	−0.116	0.055	0.037	1.033	—	—	—	—
4	Accidents	Stressors, stresses, SB								
		Constant	0.808	0.291	0.006	—	0.350	0.123	10.985	0.000
		SB: safety behavior	−0.203	0.060	0.001	1.006	—	—	—	—
		F5: job control	0.174	0.058	0.003	1.006	—	—	—	—
5	Safety equipment	Stressors, Acc								
		Constant	1.905	0.207	0.000	—	0.368	0.136	25.763	0.000
		F5: job control	0.345	0.068	0.000	1.000	—	—	—	—
6	Co-worker support	Stressors, Acc								
		Constant	5.678	0.471	0.000	—	0.351	0.124	7.612	0.000
		F5: job control	0.244	0.088	0.006	1.048	—	—	—	—
		F4: job certainty	−0.166	0.063	0.009	1.026	—	—	—	—
		F2: supervisor support	−0.168	0.076	0.028	1.051	—	—	—	—
7	Job control	Stressors, Acc								
		Constant	2.478	0.421	0.000	—	0.468	0.219	15.119	0.000
		F1: safety equipment	0.348	0.076	0.000	1.040	—	—	—	—
		Acc: accident	0.279	0.089	0.002	1.006	—	—	—	—
		F3: co-worker support	0.153	0.061	0.013	1.044	—	—	—	—

Note: Acc = accidents; SB = safety behavior; SE = standard error.

predicted by *job certainty* (F4) and *physical stress* (S1). *Safety behavior* (SB) and *job control* (F5) could predict *accidents* (Acc) among all the stressors, stress, and safety behavior in Model 4.

To investigate the interrelationships among the five stressors, two types of stress, safety behavior, and accident, Models 5, 6, and 7 were also developed. In general, *job control* (F5) positively predicted *safety equipment* (F1) and was itself positively predicted by *safety equipment* (F1), *co-worker support (F3)*, and *accidents* (Acc). *Co-worker support* (F3) was positively predicted by *job control* (F5), and negatively predicted by *supervisor support* (F2) and *job certainty* (F4).

Discussion

Based on the correlation analysis and regression models illustrated in Tables 2 and 3, a comprehensive stressor–stress–safety behavior–accidents model for CWs in Hong Kong was developed (Fig. 2). Fig. 2 shows that safety behavior predicted accidents, whereas safety behavior was predicted by physical stress and supervisor support. Physical stress was predicted by various stressors including job certainty, co-worker support, and safety equipment, and psychological stress by supervisor support and job certainty. Finally, accidents could be directly predicted by job control and also influence stressors through job control in subsequent tasks.

Supervisor Support and Job Certainty Predict Psychological Stress

One interesting finding from this study is that psychological stress was positively predicted by *supervisor support*. Such support may create enhanced expectations and put pressure on CWs to respond with hard work and good performance, perhaps even leading them to perceive themselves as incompetent if a task is not completed properly (Blaine et al. 1995). Hence, a supervisor may actually be a source of stress to subordinates (Beehr et al. 2003), and induce psychological stress in the form of distress, tension, and sadness. By contrast, *job certainty* negatively predicted psychological stress. It is not uncommon for CWs to be employed on a casual or temporary basis (that is, to have a low level of job certainty), and therefore, they will constantly worry about their future employment, which could easily increase psychological stress (Goldenhar et al. 2003).

Safety Equipment, Co-Worker Support, and Job Certainty Predict Physical Stress

The negative relationship between safety equipment and physical stress was confirmed by both the correlation and regression analyses, consistent with previous studies (Leung et al. 2012). *Safety equipment* is one of the most important and practical means of protecting employees from accidents (Ahlgren et al. 1983). Equipping CWs with appropriate safety equipment can also, to some extent, stimulate their awareness of safety and prevent them from allowing

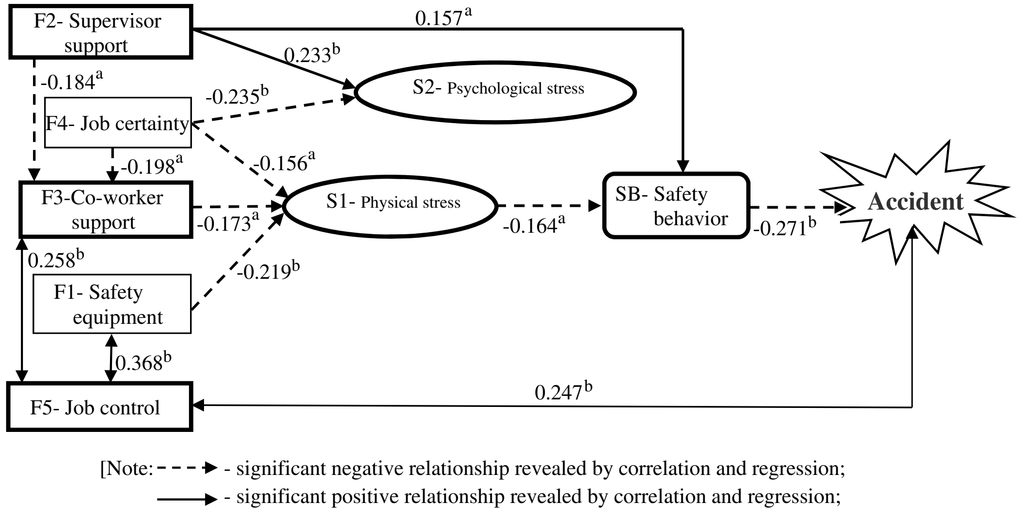

Fig. 2. A stressor–stress–safety behavior–accidents model for CWs in Hong Kong (a indicates significance at 0.05 level; b indicates significance at 0.01 level)

stressful situations to develop at work. It may therefore reduce their risk of physical stress as well. To complete complicated tasks, CWs must cooperate with their workmates, such as lending a hand to move plaster or bricks or pointing out hazards around the workplace. CWs who have *support from their co-workers* can therefore carry out their work with more efficiency and will be less likely to suffer from physical stress than those with less co-worker support (Babin and Boles 1996; Choudhry and Fang 2008). In addition, CWs who constantly worry about their future employment are exposed to long-term stress as a result. Lack of *job certainty* may induce a permanent physiological adjustment for responding stressors; that is, physical stress (Ferrie et al. 1998; Mak and Mueller 2000).

Supervisor Support and Physical Stress Predict Safety Behavior

Safety behaviors are measured and regulated by rules and instructions from supervisors (Mearns et al. 2001). If there is *poor support from the supervisor*, his/her leadership behavior will be questioned by CWs (Xin and Pelled 2003). Consequently, the workers may tend to ignore his/her instructions and even flout safety rules and work in their preferred manner. CWs carry out most of their work using their bodies as well as their minds. When they suffer physical stress symptoms such as headaches, they are likely to feel uncomfortable and unable to engage fully with their work (Kidd et al. 1996). In such circumstances, they are more likely to neglect safety compliance and precautions, and may even exhibit unsafe behaviors such as taking shortcuts to get their work done as quickly as possible to alleviate their physical symptoms (Low et al. 1996; Murray et al. 1997). This may explain why *physical stress* had a negative linear relationship with safety behavior.

Safety Behavior Predicts Accidents

CWs carrying out *safety behavior* such as obeying rules and regulations and wearing protective clothing have a lower risk of *accidents* associated with unsafe practices (Clarke 2006). By contrast, if CWs behave unsafely, they may carry out tasks while neglecting safety issues by means such as taking shortcuts or even bending the rules to complete their work. This increases their accident risk and may result in injury (Yee 2000). For instance, a CW who forgets to wear a safety helmet may be struck by falling tools or materials (Davies and Tomasin 1996).

Job Control Directly Affects and Is Affected by Accidents

Interestingly, this study also shows that *accidents* on construction sites can positively predict *job control*. This may be because CWs who have already experienced an accident are more aware of their own role in improving safety and so pay more attention to their work and ensure they maintain control of the situation to prevent another one (Turner et al. 2012). Furthermore, the more accidents occur on a construction site, the less likely it is that the construction company will push CWs to work hurriedly and refuse to provide them with appropriate protective equipment.

By contrast, the *job control* of CWs can be a direct stimulus of *accidents*, which provides empirical evidence to support the proposed accident-causation theories (Kerr 1950). Workers with greater job control can make decisions, such as how fast they work and whether to use personal protective equipment in some more dangerous tasks. However, this may lead them to perceive themselves as being in control of the risks around them and hence to pay insufficient attention to external hazards (Harrell 1990; Weyman and Kelly 1999), making accidents more likely (Goldenhar et al. 2003).

Recommendations

Practical Recommendations

As shown in this paper, the stressors of supervisor support, co-worker support, safety equipment, and job certainty can indirectly (through physical stress and safety behavior) affect the accident rate, whereas job control directly predicts it. In addition, safety behavior also reduces the risk of accidents. Particular attention should be paid to these important factors, especially safety behavior.

Supervisor support can affect accidents through the mechanisms of co-worker support, physical stress, and safety behavior. It is suggested that project managers offer proper support to CWs in handling these specific job stressors, as inappropriate supervisor support may exacerbate their stress levels (Mayo et al. 2012).

Establishing hometown associations, which are informal organization created by migrants from same area for arranging social gatherings, exchanging various experiences, and providing necessary assistances, is a good way to develop informal relationships and improve communication, which could help to enhance mutual understanding among supervisors and CWs (Canales et al. 2009). This would support managers to understand what is causing stress for CWs and provide support as appropriate. In addition, *supervisors should assign co-workers to work together in relevant teams*, such as structural steel erector and structural steel welder, so that they can support each other and mutually encourage the observance of safety behavior during the task.

To enhance job security and provide opportunities for CWs in current or anticipated projects, construction companies are encouraged to design construction programs *to offer consistent long-term rather than daily employment*. It is expected that the resulting improvement in job security and certainty would reduce stress of CWs and facilitate the effective performance of safety behavior, thereby reducing the risk of injury due to accidents.

If they are not suffering from physical stress, CWs can find it easier to focus on their work and their safety. Therefore, construction organizations should provide CWs with *stress-reduction interventions such as guided imagery, relaxation exercises*, *exercise of Tai Chi*, to help reduce physical stress and its symptoms (Moraska et al. 2010; Steven and Gwen 1997).

However, as shown in this study, giving CWs too much job control also leads to accidents. Hence, CWs *should not be overconfident, even though their tasks may be daily routine jobs*. *Regular-on-the-job training* may be necessary to review working procedures and update knowledge and skills in the use of personal protective equipment.

Moreover, construction companies can also motivate and support CWs to work more safely. Apart from the employment of a safety officer and updated on-site training (Langford et al. 2000), it is also suggested that companies should conduct regular tests on CWs. Those who cannot pass the test even after being trained should not be allowed to work on-site, in order to ensure that all CWs understand and observe the safety regulations relevant to their jobs.

Further Research

While this study has given rise to some important findings, it does have some limitations. The relatively small sample size and the use of self-reporting measures may affect the generalizability and reliability of the results and undermine the validity of the data (Hufnagel and Conca 1994; Tinsley and Brown 2000). However, several factors reduce this risk. First, all the measurement scales used in the survey were adopted following an extensive literature review. Second, all CWs in this study were skilled artisans (such as concreters, carpenters, excavators, and bricklayers) and most had more than 5 years' experience of working in the construction industry. Third, all respondents had previously experienced accidents on-site. Fourth, the Cronbach's alphas for all factors were greater than 0.5, which demonstrates the reliability of the measures used (Hair et al. 1998).

With sufficient sample size (Hair et al. 2010), several regression models were developed based on the five job stressors, two types of stress, safety behavior, and accidents. However, structural equation modeling for developing and testing an integrated model of all the variables cannot be applied in this study, due to the constant argument on sample-size requirement (Westland 2010). Nevertheless, the study provides a basis for a large-scale survey to develop an integrated stressor–stress–safety behavior–accidents model for preventing injuries and accidents among CWs.

Furthermore, the complicated interrelationships among job stressors, stress, safety behavior, and accidents were explored by multiple regression analysis. The results still revealed significant relationships among these stressors, stress, safety behaviors, and accidents, although the value of R^2 is relatively small. Getting small to medium R^2 is not uncommon in construction-management and psychological behavioral studies (Goldenhar et al. 1998; Turner et al. 2005). In fact, both low R^2 value with significant P value and high R^2 value with significant P value reflect more or less the same significant relationship between predictors and dependent variables, although the precise level of the latter one is higher (Frost 2014). The relatively low R^2 value may result from the common method bias in questionnaire survey that can deflate the relationships between independent and dependent variables (Podsakoff et al. 2003). To improve the precise level of the prediction, it is recommended to include more other factors that are believed to contribute to dependent variable (e.g., accident) in the complicated environment of a construction site (Wooldridge 2011). Hence, it is strongly recommended that future studies consider additional dimensions of safety behavior to develop a more comprehensive regression model based on the results of this study.

No mediating effect on the relationship among stressors, stress, safety behavior, and accidents has been found through correlation and multiple regression analyses (Holmbeck 1997; Kim et al. 2001), which enhances the current understanding of how these factors interact for CWs working on-site. Because all the data were generated by CWs themselves, the results can help to predict the current situation of every CW in Hong Kong. Case studies could also be conducted to check and verify the survey findings (Kirkman et al. 2002). Hence, it is also recommended that the results shall be further inspected and verified by undertaking several industrial case studies.

Conclusion

CWs usually work in complicated physical environments amid various hazards such as poorly maintained equipment and unsafe machinery. This directly influences their stress levels and safety behavior and, ultimately, their risk of being involved in accidents. In view of this situation, this study was conducted with a view to investigating the root cause of the high accident rate in the construction industry from a stress-management perspective.

The study has adopted scientific research methodology, including logic research design and statistical analyses, to identify the complicated relationships between five job stressors (safety equipment, supervisor support, co-worker support, job certainty, and job control), two types of stress (physical and psychological), safety behavior, and accidents. The results have shown that job certainty and co-worker support, as well as safety equipment, can minimize physical stress of CWs, whereas their psychological stress will be reduced by high levels of job certainty but increased by supervisor support. Safety behavior among CWs will be hampered by physical stress, and enhanced when appropriate supervisor support is provided. The risk of accidents can also be reduced when CWs carry out safety behavior. However, the study has also shown that a high level of job control increases this risk.

To decrease the number of accidents on construction sites, several recommendations have been proposed, to encourage supervisors offering proper support to CWs, to assign tasks according to the actual ability of each CW, and to provide enhanced job security and certainty by designing long-term construction programs.

Finally, it is recommended that the results be further inspected and verified by means of industry-based case studies. The current study provides empirical evidence to and expands some classical accident-causation theories in the context of construction industry. In accordance to the unique working environment, the influence of significant stressors for CWs was identified, and their influence on both physical and psychological stress, safety behavior, and accident had been explained, which enhances current understanding of stress management and accident prevention in construction industry. At present, research results are also applicable in industrial practices to improve occupational health and safety in construction industry.

Acknowledgments

The work described in this paper was fully supported by the Strategy Research Grant project (Project No. CityU 7002742).

References

Abbe, O. O., Harvey, C. M., Ikuma, L. H., and Aghazadeh, F. (2011). "Modeling the relationship between occupational stressors, psychosocial/physical symptoms and injuries in the construction industry." *Int. J. Ind. Ergon.*, 41(2), 106–117.

Ahlgren, A., Jarl, T., and Oja, M. (1983). "Personal safety equipment and rescuing in disabling occupational accidents." *J. Occup. Accid.*, 5(1), 9–16.

Alterman, T., Luckhaupt, S. E., Dahlhamer, J. M., Ward, B. W., and Calvert, G. M. (2013). "Job insecurity, work-family imbalance, and hostile work environment: Prevalence data from the 2010 national health interview survey." *Am. J. Ind. Med.*, 56(6), 660–669.

Babin, B. J., and Boles, J. S. (1996). "The effects of perceived co-worker involvement and supervisor support on service provider role stress, performance and job satisfaction." *J. Retailing*, 72(1), 57–75.

Beehr, T. A., Farmer, S., Glazer, S., Gudanowski, D., and Nair, V. (2003). "The enigma of social support and occupational stress: Source congruence and gender role effects." *J. Occup. Health Psychol.*, 8(3), 220–231.

Blaine, B., Crocker, J., and Major, B. (1995). "The unintended negative consequences of sympathy for the stigmatized." *J. Appl. Soc. Psychol.*, 25(10), 889–905.

Blau, G. (1981). "An empirical investigation of job stress, social support, service length, and job strain." *Organ. Behav. Hum. Perform.*, 27(2), 279–302.

Boschman, J. S., Van Der Molen, H. F., Sluiter, J. K., and Frings-Dresen, M. H. W. (2013). "Psychosocial work environment and mental health among construction workers." *Appl. Ergon.*, 44(5), 748–755.

Brockman, J. L. (2014). "Interpersonal conflict in construction: Cost, cause and consequence." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000805, 04013050.

Bureau of Labor Statistics. (2012). "Fatal occupational injuries by industry and event or exposure."⟨http://www.bls.gov/iif/oshwc/cfoi/cfch0011.pdf⟩ (Aug. 20, 2014).

Burke, M. J., Sarpy, S. A., Tesluk, P. E., and Smith-Crowe, K. (2002). "General safety performance: A test of a grounded theoretical model." *Pers. Psychol.*, 55(2), 429–457.

Canales, A. R., et al. (2009). "Exploring training needs and development of construction language courses for American supervisors and Hispanic craft workers." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2009)135:5(387), 387–396.

Carayon, P., and Zijlstra, F. (1999). "Relationship between job control, work pressure and strain: Studies in the USA and in the Netherlands." *Work Stress*, 13(1), 32–48.

Chan, K. L., and Chan, A. (2011). "Understanding industrial safety signs: Implications for occupational safety management." *Ind. Manage. Data Syst.*, 111(9), 1481–1510.

Cheng, Y., Chen, C. W., Chen, C. J., and Chiang, T. L. (2005). "Job insecurity and its association with health among employees in the Taiwanese general population." *Soc. Sci. Med.*, 61(1), 41–52.

Choudhry, R. M., and Fang, D. (2008). "Why operatives engage in unsafe work behavior: Investigating factors on construction sites." *Saf. Sci.*, 46(4), 566–584.

CIOB (Chartered Institute of Building). (2006). "Occupational stress in the construction industry." Berkshire, U.K.

Clarke, S. (2006). "The relationship between safety climate and safety performance: A meta-analytic review." *J. Occup. Health Psychol.*, 11(4), 315–327.

Cooper, D. R., and Schindler, P. S. (2006). *Business research methods*, 9th Ed., McGraw-Hill, New York.

Davies, V. J., and Tomasin, K. (1996). *Construction safety handbook*, ASCE, Reston, VA.

Djebarni, R. (1996). "The impact of stress in site management effectiveness." *Constr. Manage. Econ.*, 14(4), 281–293.

Eakin, J. M. (1992). "Leaving it up to the workers: Sociological perspective on the management of health and safety in small workplaces." *Int. J. Health Serv.*, 22(4), 689–704.

Farr, J. M., and Mangin, P. (2007). *The enhanced occupational outlook handbook*, 6th Ed., JIST Publishing, St. Paul, MN.

Ferrie, J. E., Shipley, M. J., Marmot, M. G., Stansfeld, S., and Smith, G. D. (1998). "The health effects of major organisational change and job insecurity." *Soc. Sci. Med.*, 46(2), 243–254.

Frost, J. (2014). "How to interpret a regression model with low R-squared and low P value." ⟨http://blog.minitab.com/blog/adventures-in-statistics/how-to-interpret-a-regression-model-with-low-r-squared-and-low-p-values⟩ (Dec. 16, 2014).

Gatti, U., Migliaccio, G., Bogus, S. M., Priyadarshini, S., and Scharrer, A. (2013). "Using workforce's physiological strain monitoring to enhance social sustainability of construction." *J. Archit. Eng.*, 10.1061/(ASCE)AE.1943-5568.0000110, 179–185.

Gmelch, W. H. (1982). *Beyond stress to effective management*, Wiley, New York.

Goetsch, D. L. (2009). *Construction safety and the OSHA standards*, Prentice Hall, Boston.

Goldenhar, L. M., Swanson, N. G., Hurrell, J. J., Ruder, A., and Deddens, J. (1998). "Stressors and adverse outcomes for female construction workers." *J. Occup. Health Psychol.*, 3(1), 19–32.

Goldenhar, L. M., Williams, L. J., and Swanson, N. G. (2003). "Modelling relationships between job stressors and injury and near-miss outcomes for construction labourers." *Work Stress*, 17(3), 218–240.

Goliszek, A. (1992). *60 second stress management*, New Horizon, London.

Goodwin, C. J. (2010). *Research in psychology: Methods and design*, 6th Ed., Wiley, Hoboken, NJ.

Gouett, M. C., Haas, C. T., Goodrum, P. M., and Caldas, C. H. (2011). "Activity analysis for direct-work rate improvement in construction." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000375, 1117–1124.

Greenberg, J. S. (2003). *Comprehensive stress management*, 8th Ed., McGraw-Hill, New York.

Hair, J. F. J., Anderson, R. E., Tatham, R. L., and Black, W. C. (1998). *Multivariate data analysis*, 5th Ed., Prentice Hall, Upper Saddle River, NJ.

Hair, J. F. J., Black, W. C., Babin, B. J., and Anderson, R. E. (2010). *Multivariate data analysis*, 7th Ed., Prentice-Hall, Upper Saddle River, NJ.

Hallowell, M. R. (2012). "Safety-knowledge management in American construction organizations." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000067, 203–211.

Harrell, W. A. (1990). "Perceived risk of occupational injury: Control over pace of work and blue-collar versus white-collar work." *Percept. Mot. Skills*, 70(3II), 1351–1359.

Haslam, R. A., et al. (2005). "Contributing factors in construction accidents." *Appl. Ergon.*, 36(4), 401–415.

Health and Safety Executive. (2007). "An analysis of the prevalence and distribution of stress in the construction industry." *Rep. No.RR518*, Health and Safety Laboratory, Derbyshire, U.K.

Heinrich, H. W. (1931). *Industrial accident prevention*, McGraw-Hill, New York.

Henry, J. P. (1992). "Biological basis of the stress response." *Integr. Physiol. Behav. Sci.*, 27(1), 66–83.
Holmbeck, G. N. (1997). "Toward terminological, conceptual, and statistical clarity in the study of mediators and moderators: Examples from the child-clinical and pediatric psychology literatures." *J. Consult. Clin. Psychol.*, 65(4), 599–610.
Hoonakker, P., and Duivenbooden, C. V. (2010). "Monitoring working conditions and health of older workers in Dutch construction industry." *Am. J. Ind. Med.*, 53(6), 641–653.
Hsu, S. H., Lee, C. C., Wu, M. C., and Takano, K. (2008). "A cross-cultural study of organizational factors on safety: Japanese vs. Taiwanese oil refinery plants." *Accid. Anal. Prev.*, 40(1), 24–34.
Hufnagel, E. M., and Conca, C. (1994). "User response data: The potential for errors and biases." *Inf. Syst. Res.*, 5(1), 48–73.
International Labour Organization. (1992). "Preventing stress at work." *Conditions of work digest*, V. Di Martino, ed., Geneva.
Iverson, R. D., and Erwin, P. J. (1997). "Predicting occupational injury: The role of affectivity." *J. Occup. Organ. Psychol.*, 70(2), 113–128.
Jayaratne, S., and Chess, W. A. (1984). "The effects of emotional support on perceived job stress and strain." *J. Appl. Behav. Sci.*, 20(2), 141–153.
Jones, M., and Saad, M. (2003). *Managing innovation in construction*, Thomas Telford.
Karasek, R. A. (1979). "Job demands, job decision latitude, and mental strain: Implications for job redesign." *Adm. Sci. Q.*, 24(2), 285–308.
Kerr, W. (1950). "Accident proneness of factory departments." *J. Appl. Psychol.*, 34(3), 167–170.
Kidd, P., Scharf, T., and Veazie, M. (1996). "Linking stress and injury in the farming environment: A secondary analysis of qualitative data." *Health Educ. Behav.*, 23(2), 224–237.
Kim, J., Kaye, J., and Wright, L. K. (2001). "Moderating and mediating effects in causal models." *Issues Ment. Health Nurs.*, 22(1), 63–75.
Kirkman, G. S., Cornelius, P., Sachs, J., and Schwab, K. (2002). *Global Information Technology Rep., 2001–2002*, Oxford University Press, New York.
Labour Department. (2013). "Occupational safety and health statistics bulletin." ⟨http://www.labour.gov.hk/eng/osh/pdf/archive/bulletin/Bulletin2012.pdf⟩ (Dec. 15, 2013).
Landen, D. D., and Hendrick, S. (1995). "Effect of recall and reporting of work injuries." *Public Health Rep.*, 110(3), 350–354.
Landeweerd, J. A., Urlings, I. J., De Jong, A. H., Nijhuis, F. J., and Bouter, L. M. (1990). "Risk taking tendency among construction workers." *J. Occup. Accid.*, 11(3), 183–196.
Langford, D., Rowlinson, S., and Sawacha, E. (2000). "Safety behaviour and safety management: Its influence on the attitudes of workers in the UK construction industry." *Eng. Constr. Archit. Manage.*, 7(2), 133–140.
Lazarus, R. S. (1976). *Patterns of adjustment*, McGraw-Hill, New York.
Lazarus, R. S. (1993). "From psychological stress to the emotions: A history of changing outlooks." *Annu. Rev. Psychol.*, 44(1), 1–22.
Lehrer, P. (2006). "Anger, stress, dysregulation produces wear and tear on the lung." *Thorax*, 61(10), 833–834.
Leung, M. Y., Chan, I. Y. S., and Yu, J. (2012). "Preventing construction worker injury incidents through the management of personal stress and organizational stressors." *Accid. Anal. Prev.*, 48, 156–166.
Leung, M. Y., Chan, Y. S., and Olomolaiye, P. (2008). "Impact of stress on the performance of construction project managers." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2008)134:8(644), 644–652.
Leung, M. Y., Chan, Y. S., and Yuen, K. W. (2010). "Impacts of stressors and stress on the injury incidents of construction workers in Hong Kong." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000216, 1093–1103.
Leung, M. Y., Ng, S. T., Skitmore, M., and Cheung, S. O. (2005). "Critical stressors influencing construction estimators in Hong Kong." *Constr. Manage. Econ.*, 23(1), 33–44.
Liao, P.-C., Lei, G., Xue, J. W., and Fang, D. P. (2013). "Influence of person-organizational fit on construction safety climate." *J. Manage. Eng.*, 10.1061/(ASCE)ME.1943-5479.0000257, 04014049.
Loosemore, M., Dainty, A., and Lingard, H. (2003). *Human resource management in construction projects: Strategic and operational aspects*, Taylor and Francis, London.
Loosemore, M., and Waters, T. (2004). "Gender differences in occupational stress among professionals in the construction industry." *J. Manage. Eng.*, 10.1061/(ASCE)0742-597X(2004)20:3(126), 126–132.
Low, J. M., Griffith, G. R., and Alston, C. L. (1996). "Australian farm work injuries: Incidence, diversity and personal risk factors." *Aust. J. Rural Health*, 4(3), 179–189.
Mak, A., and Mueller, J. (2000). "Job insecurity, coping resources and personality dispositions in occupational strain." *Work Stress*, 14(4), 312–328.
Marchand, A., Simard, M., Carpentier-Roy, M. C., and Ouellet, F. (1998). "From a unidimensional to a bidimensional concept and measurement of workers' safety behavior." *Scand. J. Work Environ. Health*, 24(4), 293–299.
Maslach, C., and Jackson, S. E. (1996). *Maslach burnout inventory: Human services survey*, Consulting Psychologists Press, Palo Alto, CA.
Mayo, M., Sanchez, J. I., Pastor, J. C., and Rodriguez, A. (2012). "Supervisor and coworker support: A source congruence approach to buffering role conflict and physical stressors." *Int. J. Hum. Resour. Manage.*, 23(18), 3872–3889.
McEwen, B. S., and Lasley, E. N. (2002). *The end of stress as we know it*, Joseph Henry Press, Washington, DC.
Mearns, K., Flin, R., Gordon, R., and Fleming, M. (2001). "Human and organizational factors in offshore safety." *Work Stress*, 15(2), 144–160.
Meliá, J. L., and Becerril, M. (2007). "Psychosocial sources of stress and burnout in the construction sector: A structural equation model." *Psicothema*, 19(4), 679–686.
Mellner, C., Krantz, G., and Lundberg, U. (2005). "Medically unexplained symptoms in women as related to physiological stress responses." *Stress Health*, 21(1), 45–52.
Merlino, L. A., Rosecrance, J. C., Anton, D., and Cook, T. M. (2003). "Symptoms of musculoskeletal disorders among apprentice construction workers." *Appl. Occup. Environ. Hyg.*, 18(1), 57–64.
Mitropoulos, P., and Memarian, B. (2012). "Team processes and safety workers: Cognitive, affective, and behavioural processes of construction crews." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)CO.1943-7862.0000527, 1181–1191.
Moraska, A., Pollini, R. A., Boulanger, K., Brooks, M. Z., and Teitlebaum, L. (2010). "Physiological adjustments to stress measures following massage therapy: A review of the literature." *J. Evidence-Based Complementary Altern. Med.*, 7(4), 409–418.
Murray, M., Fitzpatrick, D., and O'Connell, C. (1997). "Fishermen's blues: Factors related to accidents and safety among Newfoundland fishermen." *Work Stress*, 11(3), 292–297.
Neal, A., and Griffin, M. A. (2006). "A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels." *J. Appl. Psychol.*, 91(4), 946–953.
Ng, S. T., Skitmore, R. M., and Leung, T. K. (2005). "Manageability of stress among construction project participants." *Eng. Constr. Archit. Manage.*, 12(3), 264–282.
Nixon, A. E., Mazzola, J. J., Bauer, J., Krueger, J. R., and Spector, P. E. (2011). "Can work make you sick? A meta-analysis of the relationships between job stressors and physical symptoms." *Work Stress*, 25(1), 1–22.
Nunnally, J. C. (1978). *Psychometric theory*, 2nd Ed., McGraw-Hill, New York.
Oberlender, G. D. (2014). *Project management for engineering and construction*, McGraw-Hill Education, New York.
Pallant, J. (2011). *SPSS survival manual: A step by step guide to data analysis using SPSS*, 4th Ed., Allen and Unwin, Crows Nest, NSW, Australia.
Patton, M. Q. (1990). *Qualitative evaluation and research methods*, Sage, Newbury Park, CA.
Peterson, J. S., and Zwerling, C. (1998). "Comparison of health outcomes among older construction and blue-collar employees in the United States." *Am. J. Ind. Med.*, 34(3), 280–287.
Podsakoff, P. M., MacKenzie, S. B., Lee, J.-Y., and Podsakoff, N. P. (2003). "Common method biases in behavioral research: A critical review of the literature and recommended remedies." *J. Appl. Psychol.*, 88(5), 879–903.

Probst, T. M., and Brubaker, T. L. (2001). "The effects of job insecurity on employee safety outcomes: Cross-sectional and longitudinal explorations." *J. Occup. Health Psychol.*, 6(2), 139–159.

Rojas, E. M. (2009). *Construction project management: A practical guide for building and electrical contractors*, J Ross Publishing, Fort Lauderdale, FL.

Roney, A., and Cooper, C. (1997). *Professionals on workplace stress: The essential facts*, Wiley, Chichester, U.K.

Sapolsky, R. (1998). *Why zebras don't get ulcers: An updated guide to stress, stress-related disease and coping*, W. H. Freeman and Co, New York.

Schuler, R. S. (1980). "Definition and conceptualization of stress in organizations." *Organ. Behav. Hum. Perform.*, 25(2), 184–215.

Selye, H. (1956). *The stress of life*, McGraw Hill, New York.

Seo, D. C. (2005). "An explicative model of unsafe work behavior." *Saf. Sci.*, 43(3), 187–211.

Sherry, P. (1991). "Person-environment fit and accident prediction." *J. Bus. Psychol.*, 5(3), 411–416.

Steven, H. C., and Gwen, E. J. (1997). "Massage therapy as a workplace intervention for reduction of stress." *Percept. Mot. Skills*, 84(1), 157–158.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences*, 3rd Ed., Lawrence Erlbaum, Mahwah, NJ.

Suraji, A., Duff, A. R., and Peckitt, S. J. (2001). "Development of causal model of construction accident causation." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2001)127:4(337), 337–344.

Susskind, A. M., Borchgrevink, C. P., Kacmar, K. M., and Brymer, R. A. (2000). "Customer service employees' behavioral intentions and attitudes: An examination of construct validity and a path model." *Int. J. Hosp. Manage.*, 19(1), 53–77.

Tabachnick, B. G., and Fidell, L. S. (2007). *Using multivariate statistics*, 5th Ed., Pearson Education, Boston.

Teo, E. A. L., Ling, F. Y. Y., and Chong, A. F. W. (2005). "Framework for project managers to manage construction safety." *Int. J. Proj. Manage.*, 23(4), 329–341.

Tinsley, H. E., and Brown, S. D. (2000). *Handbook of applied multivariate statistics and mathematical modeling*, Academic Press, San Diego.

Toole, T. M. (2002). "Construction site safety roles." *J. Constr. Eng. Manage.*, 10.1061/(ASCE)0733-9364(2002)128:3(203), 203–210.

Turner, N., Chmiel, N., and Walls, M. (2005). "Railing for safety: Job demands, job control, and safety citizenship role definition." *J. Occup. Health Psychol.*, 10(4), 504–512.

Turner, N., Stride, C. B., Carter, A. J., McCaughey, D., and Carroll, A. E. (2012). "Job demands-control-support model and employee safety performance." *Accid. Anal. Prev.*, 45, 811–817.

Westland, J. C. (2010). "Lower bounds on sample size in structural equation modeling." *Electron. Commer. Res. Appl.*, 9(6), 476–487.

Weyman, A., and Kelly, C. (1999). "Risk perception and communication: A review of the literature." *Rep. No. CRR 248*, Health and Safety Laboratory, Norwich.

Wooldridge, J. M. (2011). *Solutions manual and supplementary materials for econometric analysis of cross section and panel data*, 2nd Ed., MIT Press, Cambridge, MA.

Xiang, J., Bi, P., Pisaniello, D., and Hansen, A. (2014). "Health impacts of workplace heat exposure: An epidemiological review." *Ind. Health*, 52(2), 91–101.

Xin, K. R., and Pelled, L. H. (2003). "Supervisor-subordinate conflict and perceptions of leadership behavior: A field study." *Leadersh. Q.*, 14(1), 25–40.

Yee, W. C. (2000). "Safety risk management in construction worksites." *Risk Manage. Insur. Rev.*, 3(2), 251–264.