Comparative Study on the Perception of Construction Safety Risks in China and Australia

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Abstract: Safety is a major concern in the construction industry because fatalities and injuries from construction work bring great losses to individuals, organizations, and societies as a whole. This paper aims to understand how construction personnel perceive safety risks in China as compared with those in Australia. Postal questionnaire surveys were used to collect data on safety risk perceptions from the two nations. The safety risk factors were assessed using a risk significance index based on the likelihood of occurrences and the impacts on safety performance. The survey results revealed that in China the main perception of safety risks came from human-and/or procedure-related issues, with "low/no safety education" paramount, followed by "inadequate fire prevention and electrical prevention procedures," etc. In contrast, the major safety risks perceived in Australia were related to the environment and physical site conditions with "contamination of land, water and air" ranked first, followed by "unforeseen excavation of soil," etc. To minimize construction safety risks in China, this paper suggests that the government should develop collective legislation and safety protection procedures, and enforce safety education and training to all site participants. Risks related to environmental and site conditions were generally realized by the Australia construction industry, which were not highly acknowledged in China. This may also bring imminent attention in this regard to the Chinese government.

DOI: 10.1061/(ASCE)CO.1943-7862.0000019

CE Database subject headings: Risk management; Construction management; Safety; Labor relations; Compensation; China; Australia.

Introduction

China, home of more than 1.3 billion people, over the past 20 years has become the fastest growing economy in the world at an average grass domestic product increase rate of 9% per annum. Although this has triggered and been accompanied by a continuously booming construction market, construction safety has become a major concern due to tremendous losses caused by workplace injuries (Fang et al. 2000). From 2002 to 2006, the number of workers in the Chinese construction industry has been continuously increasing and reached 28.37 million at the end of 2006, with an average increase rate of 6.5% per annum (CCIA 2007). It is conservatively estimated that 3,000 construction workers are killed in work-related accidents per annum (Huang et al. 2000), and 1,174 deaths were related to construction accidents in 2003 as per the report by the Ministry of Construction, P.R. China. The Chinese government claimed the use of illegal and unsafe operations during construction was the driving factor of the high deaths toll. Similar situation existed in the Australian construction industry with its incidence rate of 28.6 per 1,000 employees in 2003–2004, which was almost twice of the overall industry average of 16.4 per 1,000 employees. It also experienced a high fatality rate of 4.7 fatalities per 100,000 employees in 2004–2005, which was almost twice the rate for the national average for all industries of 2.5 fatalities per 100,000 employees (ASCC 2006).

This paper aims to investigate and compare the perceptions of major safety risk factors in the Chinese and Australian construction industries. It will identify the major construction safety risk factors in China and Australia, and then analyze the reasons for and the resultant implications of the differences. This may underpin future improvement and learning from each other in safety risk management for both nations.

Past Research Related to Construction Safety Risks

Construction sites exhibit unique hazardous features, such as crowded sites, operating at height and outdoors, and extensive use of heavy machines and equipment. Studies have been under taken to identify factors affecting construction site safety and explore the risk-prone activities, which included safety hazard identification (Tam et al. 2004; Carter and Smith 2006), construction safety culture (Fang et al. 2006; Choudhry et al. 2007), safety management activities and performance (Mohamed 1999), and management's commitment in construction safety (Huang and Hinze 2006; Abudayyeh et al. 2006). Huang et al. (2000) explored the losses in construction accidents and pointed out that contractors in China paid less attention to safety because they did not realize the potential resultant losses.

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Note. This manuscript was submitted on June 10, 2008; approved on November 11, 2008; published online on March 27, 2009. Discussion period open until December 1, 2009; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Construction Engineering and Management***, Vol. 135, No. 7, July 1, 2009. ©ASCE, ISSN 0733-9364/2009/7-620–627/$25.00.

Table 1. Typical Safety Risk Factors with Construction Activities (Adapted from Tam et al. 2004)

Factors affecting site safety	Relative important index
Poor safety awareness of firm's top leaders	0.93
Lack of training	0.90
Poor safety awareness of project managers	0.89
Reluctance to input resources for safety	0.86
Reckless operations	0.86
Lack of certified skill labor	0.84
Poor equipment	0.82
Lack of first aid measures	0.81
Lack of rigorous enforcement of safety regulations	0.74
Lack of organizational commitment	0.71
Low education level of workers	0.68
Poor safety conscientiousness of workers	0.65
Lack of personal protective equipment	0.62
Ineffective operation of safety regulation	0.59
Lack of technical guidance	0.55
Lack of strict operational procedures	0.55
Lack of experienced project managers	0.54
Shortfall of safety regulations	0.53
Lack of protection in materials transportation	0.53
Lack of protection in material storage	0.51
Lack of teamwork spirits	0.50
Excessive overtime work for labor	0.49
Shortage of safety management manual	0.48
Lack of innovation technology	0.43
Poor information flow	0.40

Tam et al. (2004) explored the risk-prone activities on construction sites, and highlighted factors affecting construction site safety. Adapted from Tam et al. (2004), Table 1 shows the identified risks ranked in descending order. The study indicated that the behaviors of contractors on safety management were of grave concern, including the lack of provision of personal protection equipment, regular safety meetings, and safety training. It also revealed that the low level of education was a driving factor of safety accidents in China. As stated in the study, "one of the characteristics of the Chinese construction industry is the existence of large number of peasant workers, who received little education and are unskilled, untrained, and inexperienced." The study also proposed that the government should play a more critical role in stricter legal enforcement and organizing safety training programs.

Carter and Smith (2006) investigated the current levels of safety hazard identification on three U.K. construction projects and found that they were far from ideal. The research disclosed at least two types of barriers existing to improved levels of hazard identification, i.e., knowledge and information barriers and processes such as "subjective nature of hazard identification and risk assessment," and procedure barriers such as "lack of standardized approach."

Larsson and Field (2002) explored the perceived probability of serious accidents on construction sites. The respondents were asked to choose the most probable serious site accidents that may result in fatalities. The results showed that "falling from height" was considered most risky (92%). Other accidents in descending order of perceived probability were "hit by falling materials" (85%), "collapse of earthwork" (72%), "use of heavy machine" (60%), and "electrocution" (55%). The major construction safety risk factors obtained from the *China Statistical Yearbook on Construction* (NBS 2000, 2005 2006, 2007, 2008) are listed in Table 2. These results are comparable with the ones identified by Larsson and Field (2002). The trend shows that the factors resulting in construction fatalities have been the same safety risks since 1999 and the percentages of each contribution nearly unchanged. This indicates that construction safety risks were not effectively managed in China.

A conceptual model examining construction safety culture was developed by Choudhry et al. (2007). The construction safety culture model incorporated the presence of interactive relationships between psychological and perceptional, environmental and situational, and behavioral constructs, and offered a triangulated method of measurement, thus allowing for a multilevel analysis of construction safety culture. The triangular model is consistent with Fang et al.'s (2006) finding that statically significant relationships were found between safety climate and personal characteristics and behaviors.

Mohamed (1999) investigated the effectiveness of safety management activities as currently adopted by Australian contracting organizations through a safety management survey conducted in Queensland, Australia. A safety management index reflecting the intensity of level of safety management activities was developed to provide a means whereby individual organizations could be assessed and graded on their safety management commitment and attitude. No strong positive correlations were found between the

Table 2. Trend of Fatalities and Safety Risks in the Chinese Construction Industry

	Fatalities (person)				
Category of accidents	1999	2004	2005	2006	2007
Falling from height	524 (48)	703 (53)	543 (46)	430 (41)	460 (45)
Electrocution	124 (11)	95 (7)	78 (7)	65 (6)	67 (7)
Hit by falling materials	116 (11)	140 (11)	141 (12)	134 (13)	117 (12)
Collapse of earthwork	148 (13)	191 (14)	222 (19)	216 (21)	206 (20)
Use of heavy machine	71 (6)	89 (7)	70 (6)	62 (5)	49 (5)
Lifting of weights	45 (4)	41 (3)	66 (6)	92 (9)	65 (6)
Other[a]	69 (7)	65 (5)	73 (6)	49 (5)	48 (5)
Total	1097 (100)	1324 (100)	1193 (100)	1048 (100)	1012 (100)

Note: Figures in parentheses indicate the percentage of the total.

[a]This category includes toxic and suffocation, use of motor, fire and explosions, flood, etc. Sources: *China Statistical Yearbook on Construction* (NBS 2000, 2005, 2006, 2007, 2008).

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safety management commitment and any of the safety performance and proactiveness variables. Mohamed suggested a need to change the safety culture, i.e., redesigning how organizations view and approach safety management activities. The process of on-site hazard detection and management, in particular, needs to be thoroughly analyzed in terms of its basic activities, i.e., planning, detection, action, and feedback to employees with a view to examine how these four activities interact with each other. This should, in turn, lead to a more effective way to detect and manage hazards.

Huang and Hinze (2006) interviewed the owners of large construction projects and scrutinized the relationship between the project safety performance and the owner's influence, with focus on project characteristics, selection of safe contractors, contractual safety requirements, and the owner's participation in safety management during a project execution. It was concluded that owners could positively influence project safety performance. Abudayyeh et al. (2006) studied the correlation between management's commitment to safety and the frequency of construction-related injuries and illnesses. They affirmed that safety managers and teams could improve safety management programs by focusing more on engineering improvements to equipment, methods, and materials and changing human behaviors positively through education and training. A clear commitment from management to construction safety could be materialized and demonstrated by having a "safety budget," "safety management position," "communication skills," "safety culture," "empowerment," "continuous monitoring and improvement," and "involvement."

As Fang et al. (2004) pointed out, although plenty of effort has been placed on examining construction safety issues, no appropriate tools are available in China for evaluating safety performance. An effective identification and assessment of safety risks is an important ingredient for improving safety management in China.

Research Methodology

The research methodology selected for this safety risk investigation comprised a comprehensive literature review, a survey to the Chinese and Australian construction industries, a statistical analysis of the survey data, and exploration of safety risk management in Australia and China.

Survey Questionnaire Design

The survey questionnaire was designed to assess the perspectives which respondents held on various construction safety risk factors in China and Australia. Through literature reviews (as noted earlier) and understanding the problems, 50 questions reflecting safety risk factors were identified and classified into five aspects: ten questions related to legal and regulatory issues, seven related to safety education and training, six related to employee-related issues, ten related to technical issues, eight describing organizational management issues, and the last nine questions related to environmental- and site-condition-related issues.

Data Analysis Method

The survey includes two groups of data—the likelihood of occurrence of each risk and its level of consequences. The risk significant index developed by Zou et al. (2007) and Shen et al. (2001) was used. The four-point scales for the likelihood α (very likely,

Table 3. Construction Safety Risk Assessment Matrix

	Likelihood			
Consequence/impact	Very likely (0.9)	Likely (0.6)	Unlikely (0.3)	Highly unlikely (0.1)
Fatality (1.0)	*0.90(H)*	*0.60(H)*	*0.30(M)*	0.10(L)
Major injuries (0.7)	*0.63(H)*	*0.42(M)*	0.21(M)	0.07(L)
Minor injuries (0.3)	*0.27(M)*	0.18(M)	0.09(L)	0.03(L)
Negligible injuries (0.1)	0.09(L)	0.06(L)	0.03(L)	0.01(L)

Note: H=high; M=medium; and L=low.

likely, unlikely, and highly unlikely) and the consequence (impact) β (fatality, major injury, minor injury, negligible injury) were converted into numerical scales. The matrix presented in Table 3 shows the converted numerical values and the calculation of the risk significance index. The significance score for each risk assessed by each respondent can be calculated through Eq. (1), which is similar to the one developed by Zou et al. (2007) and Shen et al. (2001)

$$r_{ij} = \alpha_{ij}\beta_{ij} \tag{1}$$

where r_{ij}=significance score assessed by respondent j for the impact of risk i, i=ordinal number of risk, $i \in (1,m)$; m=total number of risks; j=ordinal number of valid feedback to risk i, $j \in (1,n)$; n=total number of valid feedbacks to risk i; α_{ij} =likelihood of occurrence of risk i, assessed by respondent j; and β_{ij}=level of consequence of risk i, assessed by respondent j.

The average significance score for each risk can be calculated through Eq. (2). This average score is called the risk significance index score and can be used to rank among all risks

$$R_i = \frac{\sum_{j=1}^{n} r_{ij}}{n} = \frac{1}{n}\sum_{j=1}^{n} \alpha_{ij}\beta_{ij} \tag{2}$$

where R_i^k=significance index score for risk i.

It should be noted that the method for calculating the risk significance index score may overlook the extreme risks with a very low level of likelihood of occurrence but a very high level of consequence, which should be taken into account in the risk management practice.

The likelihood of occurrence was indicated by the values from the lowest figure of 0.1 (where the safety risk would be highly unlikely to happen), to 0.3 (unlikely), to 0.6 (likely), to 0.9 a (representing very likely to be the most critical risk level). The consequence of the safety risks resulting in an injury was shown with similar but slightly adjusted figures, with 0.1 representing negligible injuries, 0.3 minor injuries, 0.7 major injuries, and 1.0 fatality. The reason for the slight difference where death is represented by a whole figure is because of the severity of the impact. According to AS/NZS 4360 (2004), the figures italicized in Table 3 represent high or major risk factors; the lowest value from the group of high risk factors is 0.27. Hence, only the safety risk factors with a significant index score of 0.27 and above are discussed in the following.

Data Collection

A total of 290 survey questionnaires were sent out in 2005 to selected construction projects/sites, 170 distributed in Beijing, P.R. China and 120 in Sydney, Australia. From the 127 responses received from China, 59 were invalid due to reasons such as being incomplete, damaged, inappropriate. In Australia, 65 re-

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Table 4. Comparison of Education Level of Respondents

Education level	China (%)	Australia (%)
Master or above	1	7
Undergraduate	7	37
High school	18	49
Junior high school	51	7
Primary school	22	0
Other	1	0
Total	100	100

sponses were returned with 24 invalid responses. This left 68 and 41 valid survey returns from both nations for further analysis.

Survey Results and Discussion

The respondents' education background is summarized in Table 4. The risk significance index scores in Table 5 have been ranked from the highest to the lowest.

Respondents' Education Level and Industrial Experience

Table 4 shows the comparison of the level of education of the respondents in China and Australia. It shows that 73% of China's construction workforce did not complete high school; this is significantly different when compared to Australia, where only 7% did not complete high school. The Chinese construction industry had an average low level of education, whereas in Australia the majority of its workforce received high school education or above. As a result, Chinese construction workers might have difficulty in understanding their responsibilities, rights, and the necessity of safety protection. They were not competent enough to maintain their safety rights and protect their benefits when working on construction sites. This would be one of the areas that needs to be built upon and improved for a proactive construction safety plan in China.

The respondents were practitioners in the construction industry. Respondents from both nations had almost equal lengths of experience in the construction industry, Chinese respondents had an average of 14 years of experience and Australian counterparts had an average of 15 years of experience. With respect to construction safety management, Australian respondents had an average of 11 years of experience, whereas Chinese respondents only had around 7 years of experience. It is astonishing that approximately a quarter of Chinese people had less than 2 years experience in construction safety management.

Table 5 presents and compares the significant index scores of construction safety risk factors in China and Australia. The implications of the results are discussed in the following.

Discussion

Legal and Regulatory Issues

The results from China show that "inadequate fire and electrical prevention procedures" (0.43) is ranked as the highest risk followed by "lack of poor crisis preparedness (emergency plan)" (0.42), which are higher than those from the Australia survey results of 0.34 and 0.26, respectively. Kartam et al. (2000) described the "main concern of a contractor is how to save money and reduce costs. Safety is usually considered a waste of money

Table 5. Significant Index Scores of Safety Risk Factors in China and Australia

Safety risk factors	China (C)	Australia (A)	C–A
Legal and regulatory issues			
Inadequate fire and electrical prevention procedures	0.43	0.34	0.09
Lack of poor crisis preparedness (emergency plans)	0.42	0.26	0.15
Inadequate safety programs	0.40	0.30	0.10
Ignoring labor safety insurance	0.32	0.19	0.13
Lack of union enforcement of safety	0.28	0.19	0.09
Not following safety checklist	0.27	0.20	0.07
Inappropriate signage	0.26	0.20	0.06
Poor site induction	0.20	0.16	0.04
Noncompliance with regulation or code of practice	0.17	0.22	0.05
Inadequate license and certification	0.15	0.21	0.06
Education- and training-related issues			
Low/no safety educations/training	0.46	0.24	0.22
Poor trade knowledge	0.29	0.35	0.06
Unavailability of professional guidance/management	0.28	0.18	0.10
Low level of formal education	0.27	0.38	0.11
Poor experience of handling material and operating equipment	0.26	0.22	0.04
No or little on-site training	0.20	0.34	0.14
Unavailability of sufficient amounts of skilled labor	0.15	0.19	0.04
Employee-related issues			
Personal stupidity	0.28	0.32	0.04
Low expectations in safety operation	0.27	0.18	0.09
Intimidation/racism/discrimination	0.20	0.16	0.04
Cultural background and personal quality differences	0.17	0.15	0.02
Personality conflicts between participants	0.17	0.13	0.04
Site welfare and facilities	0.16	0.16	0.00
Technical issues			
Hazardous materials	0.41	0.31	0.10
Damaged equipment/inappropriate positioning of equipment	0.36	0.37	0.01
Poor precautions on working from height	0.35	0.47	0.12
Poor electrical safety	0.26	0.42	0.16
Illegal operations	0.26	0.38	0.12
Inadequate safety precautions (safety harness)	0.24	0.39	0.15
Using substandard materials and equipment	0.23	0.29	0.06
Unauthorized patent technique adopted (patent liability)	0.23	0.17	0.06
Unavailability of construction materials/equipment	0.21	0.16	0.05
Clients reliance upon incomplete or inaccurate cost estimate	0.15	0.17	0.02
Organizational-management-related issues			
Low hazard awareness from upper management	0.40	0.36	0.04
Inadequate project planning	0.32	0.26	0.06

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Table 5. (*Continued.*)

Safety risk factors	China (C)	Australia (A)	C–A
Lack of management involvement in safety programs	0.29	0.23	0.06
Lack of control from safety officer/coordinator	0.28	0.35	0.07
Inexperienced management team	0.22	0.40	0.18
Inappropriate or inefficient project delivery system (communication channel)	0.18	0.26	0.08
Lack of coordination between project participants	0.15	0.23	0.08
Communication barrier due to different languages	0.12	0.35	0.23
Environmental- and site-condition-related issues			
Natural forces (earthquake, Tsunami, flood)	0.37	0.34	0.03
Unforeseen ground conditions	0.29	0.51	0.22
Severe weather (storms, snow)	0.29	0.37	0.08
Geographical hazards (unstable soil)	0.28	0.40	0.12
Serious noise pollution caused by construction	0.24	0.34	0.10
Contamination of land, water and air	0.22	0.64	0.42
Ecological damage	0.22	0.27	0.05
Environmental sustainability	0.22	0.18	0.04
Asbestos contamination	0.21	0.44	0.23

by most contractors since they may be unaware of the effectiveness of safety prevention programs in reducing costs and increasing productivity." Thus, "inadequate safety programs" is ranked third and "not following safety checklist" ranked sixth. Although safety programs and safety checklists are emphasized to minimize potential hazards and dangers, it is up to the employers and employees to pay attention and follow these systems to maximize its functions. The Australia survey results show "inadequate safety programs" is scored 0.30, lower than the score in China; however, it is still classified as a high risk. On the other hand, "not following safety checklist" in Australia is below the high risk margin. The remaining high risk factors for China include "ignoring labor safety insurance" and "lack of union safety" with significance scores of 0.32 and 0.28. In comparison, the Australian construction industry only recognized them as medium risks.

Education- and Training-Related Issues

Respondents in China ranked both "low/no safety education/training" and "low level of formal education" as high risks, ranked first and fourth, respectively. In fact, the percentage of construction workers in China being trained in safety is very low. Statistics reveal that only 3% of workers have been trained and certified, 7% trained under short-term programs, whereas 90% received no training at all (Zhang 2001). In contrast, the Australian construction industry did not regard "low/no safety education/training" as important. In Australia, all site participants need to receive safety training and obtain a green card (safety induction card), equal to an 8 h safety education course targeted to increase safety knowledge and skills, before they can commence their work on-site. This may provide some ideas for the Chinese government to develop a similar admittance policy to raise site workers' safety consciousness, knowledge, and skills. The Australian surveys indicated "low level of formal education" in general terms is a high risk factor as well. Further, "poor trade knowledge" is highlighted as a major risk leading to safety issues in both countries.

Employee-Related Issues

"Personal stupidity" is ranked first in both China and Australia with significance scores of 0.28 and 0.32. "Personal stupidity" can be classified into many situations such as people not understanding or following simple instructions, performing dangerous maneuvers, where they know they are taking a risk of injuring themselves, taking short cuts (wrong way) and ignoring the long way (right way). This is consistent with the findings of Tam et al. (2004) that reckless operation is one of the top risks in the construction industry. In reality, reckless operations largely occur during building demolition according to the *China Statistical Yearbook of Construction*. The number of fatalities resulting from reckless operations was 46 (4.19%) of the overall fatalities in 1999.

Technical Issues

"Hazardous building materials" was ranked first by the Chinese respondents with a significance score of 0.41, and the Australian respondents also ranked it as a high risk with a score of 0.31. Not understanding material safety and its potential influences, handling hazardous materials without care, disturbing its internal membranes and causing them to spill out and contaminate surrounding area, etc., abound on the construction sites. Damage to the brain, nerve systems, and permanent damage to the human body are just some of the well-recognized impacts.

"Damaged equipment/inappropriate positioning of equipment" was ranked second by the Chinese construction industry with a significance score of 0.36, which is almost identical to the result from the Australian construction industry. In 1999, 95 fatalities (8.66%) resulted from the problems of construction equipment in China. Construction equipment was well considered to be one of the weakest links in the China construction industry. As there were no plant-hiring services offered in China, the construction firms had to purchase their own construction equipment. Most equipment was not fully utilized, which placed a heavy financial burden on firms. Although around 30% of construction equipment is old and obsolete, it is still being used because most state-owned firms lack money to replace it (Chen 1997).

"Poor working from height precautions" has a significance score of 0.35 in China compared to a significance score of 0.47 in Australia. The *China Statistical Yearbook on Construction* (NBS 2000) reported that 50% of construction accidents in 1999 were related to falling from height, which is obviously higher than other accidents. With respect to fatalities, 524 construction workers (48%) lost their life due to falling from height. Thus, the Australian construction industry saw working from heights to be highly risky and paid as enormous amount of attention to working from height precautions. Workcover NSW Codes of Practice Section on "Safe Working at Height" Guide 2004 edition deals with risk management, control measures, and checklist to help manage this issue.

"Poor electrical safety" was ranked fourth in China with a significance score of 0.26, whereas the Australian construction industry scored it as high as 0.42. Electrocutions resulted in the second most fatalities in 1999 as per the *China Statistical Yearbook on Construction* (NBS 2000).

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Organizational-Management-Related Issues

"Low hazard awareness from upper management," "lack of management involvement in safety programs," and "inadequate project planning" were ranked within the top three in China with significance scores of 0.40, 0.32, and 0.29, respectively, compared with the Australian results of 0.36, 0.26, and 0.23, respectively. It indicates that leaders play a very important role in construction safety management and project planning may influence the safety performance in a construction project. The top management sets up appropriate safety management by defining the safety policy and allocating resources, and their attitude affects the result of cultivating a good safety culture (Seppala 1995). However, as contractors have to finish the work within a specific period of time, at an agreed price, and at a certain standard of workmanship, they tend to focus on these immediate problems and give priorities to these objectives. Only after archiving them will they give some consideration to safety (Tam et al. 2001).

The Australian respondents ranked "inexperienced management team" as the highest risk in the management section. From the Australian survey results, 6 of the 41 respondents were managers and of those 6 managers, 4 had over 15 years of experience in the construction industry and 2 have 10–15 years of experience. Respondents with such long management experience still reflected that they were inexperienced in safety management, which indicates that extreme emphasis placed on construction safety in Australia. This is further substantiated by recognizing "lack of control from safety officers/coordinators" as a high risk in the Australian Construction Industry. Mohamed (1999) found a similar answer to this issue: "more than 46% of the respondents rate their policy towards rewarding safety officers with excellent safety records as poor or fair. Only 25% of respondents felt that their policy towards appointing appropriate safety personnel is excellent."

Environmental- and Site-Condition-Related Issues

The Australian respondents perceived the "contamination of land, water and air" as the highest risk of all safety risk factors, with a significance index score of 0.64. China, on the other hand, does not regard this issue as important, thus a score of 0.22. Contamination of air may cause long-term damage to the brain nerve system and respiratory, system and land contamination may result in poison and injury. WorkCover NSW (2005) has set out specific guidelines to assess the risk of contamination. However, it is a fact that China's recent booming economy development has led to significant pollution and environmental damage. The relative low score in this regard from China discloses that the environmental issue has not been well recognized in China, which has strategic concerns from the government and industries. Another major concern from Australia is "unforeseen ground conditions," which received more moderate recognition from the Chinese respondents. This result may deserve further research.

In comparison, China's number one ranking is "natural forces (earthquake, tsunami, and flood)" with a significance score of 0.37. Earthquakes and floods, though large or small, do happen yearly in China. After each encounter the result is devastating, thus respondents in china have ranked it as a high risk factor.

Major Differences between China and Australia

Major differences in safety risk recognition exist between the two nations. Analyzing the differences will help the nations develop a better safety management system for the future. As per the data in the fourth column (C–A) in Table 5, the factors with over 0.10 score differences are discussed in the following.

Legal and Regulatory Issues

"Lack of poor crisis preparedness (emergency plans)" was found to be the biggest difference between the two nations in this section, with a significant index score difference of 0.15. It shows that the Chinese found the need for emergency planning very important, whereas the Australian saw it as less important. This might be due to the Australian respondents' relatively longer experience in construction safety management and as a result, they could foresee the crisis more competently and make appropriate preparation. Comparatively, more accidents and emergencies occur in the Chinese construction industry than in Australia, and this could be the reason leading to this major difference.

"Ignoring labor safety insurances" was scored the second highest difference at 0.13, with the Chinese seeing it as more risky than Australians. In Australia, it is illegal to work on a construction site without having the proper insurance, such as workers compensation and public liability. China has also developed regulations regarding insurance on construction sites; however, due to the lack of strict enforcement, such regulations have never been implemented well. Also, most labor forces and contractors come from rural and country areas and are generally less educated, and they do not realize the importance of purchasing insurance and/or are not willing to purchase insurance in order to reduce their labor cost.

Education- and Training-Related Issues

"Low/no safety education/training" was scored with the biggest differences in this section. As mentioned previously, Australia presents a higher level of safety education and training compared to China through regular site inductions, safety inductions (green card), and OH&S training. In China, construction workers live and work in a very poor conditions and they are often treated as third-class citizens.

"No or little onsite training" was found to have the second biggest difference between the two nations, with Australians being more conscious of this factor. This is an unexpected finding as site participants need to obtain green cards to be eligible to work on-site in Australia. This is not compulsory in China. This may deserve further research to determine what kind of on-site training is beneficial to construction site safety.

Employee-Related Issues

One risk factor is worth mentioning here, i.e., "low expectation in safety operation," with a score difference of 0.09. Due to culture and education background, the Chinese people, particularly those less educated and from rural areas, may see their work as a way of making a living and hence not expect workplace safety to be of great importance. However, the Australian people regard a safe and healthy workplace environment as a fundamental work right.

Technical Issues

Australian people's view on "poor electrical safety" is largely different than the Chinese people. The Australian government has imposed strict regulations in managing safety when operating electrical equipment and dealing with live wires. As per the survey result, Chinese respondents fail to see electrical safety as high risk even though electrocution is the second most deadly cause of

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accidents in China. Hence, this issue needs to be looked at in detail and discussed in the future planning of construction safety in China.

Another factor with a major difference is "inadequate safety precautions." The Australians had a higher level of awareness on the importance of safety precautions, compared to their counterparts in China. Implementing proactive safety actions can help minimize losses from injuries and fatalities. Accordingly, the Australian construction industry thought that more effort needs to be taken to better safety precautions. Given that Chinese labor forces are relatively less educated in terms of site skills and knowledge, Chinese safety policy makers should investigate how to improve construction safety proactively and in a more serious manner.

Organizational-Management-Related Issues

With respect to management-related issues, "communication barriers due to different languages" had the biggest difference. The Australian industry gave it a high rating as Australia is a multicultural nation and, as a result, the construction industry may present a language barrier. A large number of construction participants cannot communicate effectively because they may come from a non-English speaking background. In China, this problem is less likely as the majority of the labor forces is Chinese speaking.

The second major difference is the "inexperience of management teams." The Australians realized that it was a critical issue related to construction safety. The Chinese, on the other hand, felt that this risk factor was not so important, which might be due to the lack of appropriate attitude toward management among industry practitioners. Inexperienced management was also seen as an important factor leading to accidents in the research of Tam et al. (2004). Practitioners in China should pay more attention to the development of competent management teams and skills in industry, particularly in the area of construction safety management.

Environmental- and Site-Condition-Related Issues

"Contamination of land, water and air" had the paramount difference score among all the surveyed risk factors. It was highly regarded by the Australian industry practitioners. The much lower score does not mean contamination is not a concern in China. Rather, it reflects that the Australian construction industry cares more about the negative impacts of construction activities on their environment. The second major difference is "asbestos contamination." Asbestos was found to be one of the most seriously contaminative products on construction sites and causes millions to suffer from long-term brain damage and respiratory illnesses. In China, people are still not fully aware of the impact and dangers of working with these products. Policies are urgently needed in China to regulate the construction site environment and minimize the contamination and pollution cases.

Top Five Safety Risk Factors in China and Australia

Table 6 shows the top five safety risk factors in China and Australia. It appears that the Australian respondents were generally more cautious about physical safety risks than the Chinese respondents. It is noted that "low or no safety education/training," "inadequate safety programs," "lack of fire and electrical prevention procedures," "lack of poor crisis preparedness (emergency plans)," and "lack of upper management awareness" are all within the list raised by the Chinese respondents, whereas most risk factors faced by the Australians are related to site conditions and environments (rather than people). This indicates China should focus more on developing capability of its personnel such as safety knowledge and skills and standard operation and prevention procedures, to essentially improve construction safety performance. On the other hand, this also reflects that Australians have a relatively better way of managing human-related construction safety risks and now has its effort focused more on minimizing impacts of construction activities on the environment. This finding also coincides with the relatively substantial experience concerning construction safety management that Australian industry practitioners had compared to their Chinese counterparts, as highlighted earlier.

Table 6. Top Five Safety Risk Factors in China and Australia

Country	Safety risk factors	Significant index score
China	Low/no safety education/training	0.46
	Inadequate fire and electrical prevention procedures	0.43
	Lack of poor crisis preparedness (emergency plans)	0.42
	Hazardous materials	0.41
	Inadequate safety program	0.40
	Low hazard awareness from upper management	0.40
Australia	Contamination of land, water, and air	0.64
	Unforeseen ground conditions	0.51
	Poor precautions on working from height	0.47
	Asbestos contamination	0.44
	Poor electrical safety	0.42

Conclusions

Accidents leading to fatalities or serious injuries frequently occur in China and also exist in Australia. A comparison of industry practitioners' recognition of safety risk factors will help the individual, company, industry, and government pinpoint the risks and take appropriate solutions to minimize construction accidents. A survey-based comparison was carried out in China and Australia. It was found that the workforces in the Chinese construction industry are generally less educated in terms of safety knowledge and skills compared to their Australian counterparts. Although safety risks abound in both nations, the Australian construction industry has paid more attention to safety risks relating to "environmental aspects" and has rated these issues as the highest level of risk. However, the Chinese construction personnel felt that "legislation," "education and training," and "technical aspects" are more important.

The comparison of the top five construction safety risks also shows that safety education and regulations were more of a concern at the moment in China, whereas environment contamination and unforeseen site conditions were highly recognized in Australia. The Chinese government should support safety management more by establishing safety legislation and procedures, and providing safety training and proper legal framework with stringent enforcement. The workers must be educated/trained about safety regulations, procedures, and skills. The Australian safety green card system might be referred to by the Chinese government in developing a similar admittance policy for construction participants. On the other hand, the study also found that environment issues have not been recognized yet by the Chinese people. Ac-

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tually, the booming construction market along with the speedy development of the Chinese economy have resulted in a sacrifice of the environment in recent years. This may raise the government's attention to take actions and ensure sustainable construction and improve worker safety on construction sites.

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