Work at Height Fatalities in the Repair, Maintenance, Alteration, and Addition Works

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Abstract: Hong Kong's construction industry has shown significant improvement in safety performance since the turn of the century. The number of industrial accidents in the construction industry has decreased from 11,925 in 2000 to 3,833 in 2004, which is an encouraging drop of almost 68%. However, the category "fall of person from height" has always represented a large proportion of the industrial accidents, particularly fatal accidents. In 2004, fall of person from height represented just over 47% of the total number of fatal accidents in the construction industry. The statistics show that although the overall number of accidents has dropped immensely, the same does not apply for fall from height accidents. According to statistics provided by the Labor Dept. of the Hong Kong Special Administrative Region, there were a total of 22 fatal industrial accidents associated with fall of persons from height in repair, maintenance, alteration, and addition works during 2000–2004. When analyzing these case studies, 12 common factors were identified for analyzing these case studies and strategies were suggested to prevent recurrence of similar accidents in each case. The top five strategies were: (1) provide and maintain a safe system of work; (2) provide a suitable working platform; (3) (tier) provide safety information/training/instruction/supervision; (4) (tier) provide suitable fall arresting system/anchorage; and (5) maintain safe workplace.

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Introduction

The construction industry is one of the most hazardous industries. Although the accident rate in the construction industry in Hong Kong has decreased, the number of people injured, as well as killed, as a result of fall from height, especially in repair and maintenance works, has remained shockingly high. Readily available safety measures and techniques on the market have been found to be insufficient to reduce the number of fatalities as a result of fall from height. Hence, there has been a desperate cry to identify potential problems and more importantly to identify solutions to overcome these problems.

This paper was inspired by the publication of Beavers et al. (2006) on crane related fatalities in the construction industry, in which they examined crane related fatalities in the United States. In this paper, the writers present some major findings of a collaborative research study between the Construction Industry Institute–Hong Kong and The Hong Kong Polytechnic University, entitled "Construction Safety involving Working at Height for Residential Building Repair and Maintenance." The study aims at improving construction safety involved in working at height for residential building repair refitting and maintenance works. In addition, it sets out to identify situations where such works are necessary and to investigate the causes of any associated accidents and problems.

The analysis of case studies was one of the principal data collection techniques utilized in the collaborative research study to gain an in-depth understanding of the causes of fall accidents in repair and maintenance works. The case studies were analyzed for common failures, features, and problems. The cases selected were ones of fatal fall accidents in building repair and maintenance works only. It is hoped that by identifying the common causes, solutions would be sought so as to prevent fall accidents in future repair and maintenance works, especially fatal ones. The findings from the case studies will enable us to verify and triangulate the findings from the other sources of data collection used in the research study. The case studies will be analyzed collectively to validate findings.

Twenty-two fatal case histories in the repair, maintenance, al-

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teration, and addition (RMAA) sector were obtained from the Labor Department of the Hong Kong Special Administrative Region (HKSAR) for comparative analysis with a view to identifying the common causations and features of the mishaps, drawing analogy on the rationale and recommending the appropriate preventive measures for the industry.

Literature Review

Research on Falls from Height

Falls from height in construction projects have long been a major problem and the prevention of accidents involving falls from height remains a high priority for the construction industry (Glasgow Caledonian Univ. 2005). Previous researchers have conducted surveys on causes of fall accidents, types of fall precautionary measures and practical solutions to fall accidents. For instance, Huang and Hinze (2003) pointed out that the inadequate or inappropriate use of fall protection equipment and inoperative safety equipment can contribute to more than 30% of the falls. Moreover, Construction Worker Research Group (1998) examined the effects of human factors involved and found that the causes of accidents are attributed to the failure of an individual to act promptly to avoid it. More recently, Glasgow Caledonian University (2005) conducted a comprehensive study on fall prevention and arrest equipment available to the construction industry, including purlin trolley systems, safety decking, fall arrest mats, safety netting, cable and track-based fall arrest systems, and the use of fall arrest equipment when erecting, altering, and dismantling scaffold. Some practical solutions to reducing fall accidents at the workplace, such as the use of new technologies and techniques, an effective safety management system and the concerted efforts of construction personnel, have been suggested by previous researchers (Dalton 2002; Howell et al. 2002; Huang and Hinze 2003). However, most research focuses on general construction at large and the nature of repair and maintenance is less taken into consideration.

Combined Efforts of the Government and the Industry

Construction safety is not only the concern of researchers in the academic field; practitioners from the government and the industry have also put much effort in improving safety performance of working at height for RMAA works. The Accident Analysis and Information Division of the Labor Department (of the HKSAR) recently produced a report entitled "Accidents in the Construction Industry of Hong Kong (2000–2004)" to identify the category, trend and causes of fall of persons on building repair and maintenance works. The Labor Department (of the HKSAR) and the Occupational Safety and Health Council (of the HKSAR) have also produced many safety work guidelines related to fall prevention, fall identification, and fall minimization (Labor Dept. 2001a,b,c; 2002a,b, 2004; Occupational Safety and Health Council 2006). These documents have adapted international best practices and combined them with the local context to derive suitable guidelines for Hong Kong. With a view to tackling malpractice in the use of ladders, the Hong Kong Architectural Services Department (of the HKSAR) produced key notes on enhanced measure for safe use of ladders (Architectural Services Dept. 2005). Internationally, the Work at Height Regulations 2005 of the United Kingdom has just been in force in April 2005 for proper implementation of working at height. Some property management companies in Hong Kong have set out working at height guidelines, safety handbook, and working at height instructions for workers to follow (Henderson Land Group 2002, 2004, 2005; Synergis Management Services Limited 2002; Well Born Real Estate Management Limited 2002).

Fall from Height Regulations in the United States

The Occupational and Safety and Health Administration of the United States Labor Department, is an active and leading organization in the field of construction safety internationally (Occupation, Safety and Health Administration 2007a). In the United States there are several major regulations governing construction safety. The most relevant of these is "Part 1926 Safety and Health Regulations for Construction" (Occupation, Safety and Health Administration 2007b) which covers safety and health aspects generally on construction sites. Under this regulation there are two parts that cover fall from height safety, these are "1926 Subpart L - Scaffolds" and "1926 Subpart M—Fall Protection."

A small section regarding fall protection for scaffolding is covered in "1926 Subpart L—Scaffolds," whereas more detailed guidelines are included in "1926 Subpart M—Fall Protection," This section covers a wide range of safety issues regarding fall from height, including:

- 1926.500—Scope, application, and definitions applicable to this subpart.
- 1926.501—Duty to have fall protection.
- 1926.502—Fall protection systems criteria and practices.
- 1926.503—Training requirements.
- 1926 Subpart M App A—Determining Roof Widths—Non-mandatory Guidelines for Complying with 1926.501(b)(10).
- 1926 Subpart M App B—Guardrail Systems—Non-Mandatory Guidelines for Complying with 1926.502(b).
- 1926 Subpart M App C—Personal Fall Arrest Systems—Non-Mandatory Guidelines for Complying with 1926.502(d).
- 1926 Subpart M App D—Positioning Device Systems—Non-Mandatory Guidelines for Complying with 1926.502(e).
- 1926 Subpart M App E—Sample Fall Protection Plan—Non-Mandatory Guidelines for Complying with 1926.502(k).

It was found that under "1926.501—Duty to have fall protection" employees working at a height of 1.8 m or above should be protected from falling by guardrail systems, safety net systems, or personal fall arrest systems. This height requirement is similar to that for Hong Kong (as mentioned in the following section).

Review of Regulatory Framework in HKSAR Government

The Labor Department of the HKSAR Government has stipulated various ordinances, regulations, guidelines, and safety procedures for maintaining construction safety (HKSARG 1997a,b,c,d,e, 2000, 2003). Statutory provisions on the prevention of fall of person from height are set out mostly under the Factories & Industrial Undertakings (F&IU) Ordinance and its subsidiary regulations, as well as under the Occupational Safety and Health Ordinance. The main objective of the legislation is to ensure that workplaces on construction sites are safe and to safeguard the workers from exposure to hazards during construction. The most notable requirements regarding falling from height are explicitly stated in Part VA of the Construction Sites (Safety) Regulations (CAP 59I 2003), it also advises that preventing any person on site from falling from a height of 2 m would be impractical. In addi-

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tion to these regulations, the third schedule of the Construction Sites (Safety) Regulations lists all specific requirements and practices for performing work in construction sites.

The reviewed regulations (HKSARG 1997a,b,c,d,e, 2000, 2003) with regard to fall of person from height in Hong Kong also impose responsibilities on both employers and employees. Indeed, Sections 6A and 6B of the F&IU Ordinance enforce general duties on proprietors and employees of industrial undertakings. Section 6A states that employers should provide all necessary equipment to ensure that the works are safe and without risk to health. These provisions are not only binding for principal contractors, subcontractors who are employers and who have management or control of construction activities within the site are also regarded as proprietors and are therefore bound by Section 6A. Section 6B specifies that every employee should take reasonable care for the safety and health of himself and other persons; and to follow the duty and requirement given by the employers for securing health and safety.

Current Practice of Working at Height

In Hong Kong, residential building repair and maintenance works rely heavily on the use of bamboo truss-out scaffold that is supported by steel brackets. However, the current practice of erecting a temporary platform by way of a bamboo truss-out scaffold supported by steel brackets is considered as highly unreliable and a number of fatal accidents have occurred. To provide local contractors with a suitable anchor point, a temporary transportable anchor device was devised and manufactured in the United States and the United Kingdom. The Labor Department (of the HKSAR) and the Occupational Safety and Health Council (of the HKSAR) jointly launched such devices for use by maintenance contractors through a sponsorship scheme (Occupational Safety and Health Council and Labor Dept. 2005). In the private sector one of the largest property developers in Hong Kong produced a report to prevent accidents with bamboo truss-out scaffolds (So et al. 2005). Another leading scaffolding specialist has recently introduced a computerized climbing scaffold system to the local market (Wui Loong Scaffolding Works Company Limited 2005).

Background Information of the Case Studies

The fatal cases were investigated by Occupational Safety Officers of the Labor Department (of the HKSAR). The study reveals that investigation of fatal accidents remains a very complex and complicated process involving on-the-spot investigation and subsequent investigations, collection of evidence and information of the accident scene, examination of the equipment, evaluation of the probable causes and developing appropriate preventive measures. In-house legal advice had to be sought in most of the cases and in many of the cases, technical advice and assistance was also required for completion of the investigation. A brief summary of each case study is given in Table 1.

Table 1. Summary of Fatal Case Studies

Case number	Summary of accident
1	Lost balance and fell from an unauthorized structure erected on first floor when mixing cement
2	Fell off ladder when attempting to repair air conditioners
3	Fell out of window while looking out or climbed out to look
4	Hydraulic working platform collapsed when cleaning lamp casings
5	Unknown why fell from roof before cleaning chore
6	Fell while dismantling bamboo truss-out scaffold
7	Fell while erecting bamboo truss-out scaffold
8	Fell through unprotected opening with no suitable covering and guardrail
9	Fell from inadequately protected staircase
10	Fell from ladder during leveling work for electrical conduit installation
11	Fell while dismantling bamboo truss-out scaffold
12	Fell while bamboo scaffold for renovation works collapsed
13	Fell while dismantling bamboo truss-out scaffold
14	Fell from bamboo truss-out scaffold while dismantling a metal rack
15	Punched through corrugated plastic sheets of roof
16	Fell from canopy during inspection
17	Lost balance and fell from bamboo truss-out scaffold
18	Fell from window while replacing window gasket
19	Fell from unprotected canopy while cleaning
20	Fell from ladder when fixing water pipe
21	Fell from window sill while dismantling formwork
22	Fell over guardrails of suspended working platform

Research Methodology

The 22 cases under scrutiny all involved fatal fall from height accidents in RMAA work that occurred during 2000–2004. The 22 cases were confined to fatal accidents occurred to workers which were reported by the employers to the Labor Department. Each case was thoroughly studied individually. The cases were further analyzed by identifying 12 common factors believed to share a high degree of importance to the cause of these fatal accidents. Descriptive statistical analysis of the cases was carried out, and the findings are presented in this paper. It should be emphasized that the analyses presented hold limitations as they only represent a small sample size of 22 cases. It is not our intention to generalize the findings with these limited samples but rather we hope to identify some lessons learned through the scrutiny of these 22 cases. The factors studied included the following.

1. Date of accident—The date of the accident is important to observe for any changes that may occur in accident rates over different years, months and days. If a noticeable pattern or trend can be spotted there must be a reason for a certain period to be more prone to accidents and hence there could be a way to eliminate the trend.
2. Time of accident—The time of the accident is equally interesting to investigate. There are no similar studies in Hong Kong which looks at the time of when a fall from height accident occurs.
3. Age of worker—Accident statistics have shown that workers of a certain age group are more prone to accidents, and workers of another age group are more prone to fatal accidents (Labor Dept. 2000–2004). It is therefore worth studying the age group of workers that experience fatal fall from height accidents in repair and maintenance works, and as a result to see whether there is any relationship between the statistics.
4. Trade of worker—This factor will look at which trades are more prone to fall accidents in repair and maintenance

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works. Whether a worker needs to work at height is very much related to their occupation.

5. Length of experience—Previous studies (Chan et al. 2005) have shown that the safety attitude of workers is a determining factor contributing to accidents. Their length of experience in the industry can very much affect their attitude toward safety. Hence it is important to analyze whether experience is beneficial toward reducing accidents.
6. Height of fall—Wong et al. (2005) presented statistics that most fall accidents occurred below 2 m of height and that most fatal fall accidents occurred below 10 m. It is therefore of interest to see how the cases presented here are compared to previous statistics.
7. Place of fall—This factor studies whether there are any similarities among the accidents for place of fall.
8. Agent involved—Analysis of local statistical data has shown that certain agents are more likely to be involved in accidents (Labor Dept. 2000–2004; Wong et al. 2005). It is therefore of interest to see if the cases hold any similarities in agent involved.
9. Type of work performed—The type of work performed is an important factor affecting the likelihood of an accident (Labor Dept. 2000–2004). It is therefore important to identify these types of work and try to eliminate them as appropriate. If these types of work are really necessary but just high risk chores it is important to seek solutions via better safety management and work planning to reduce the accidents.
10. Unsafe condition/action—Unsafe conditions exposed and unsafe actions performed are often a result of human failure. Human failure is an area that can be prevented with proper precautions. It is therefore a great achievement to identify these failures and prevent them in future works.
11. Safety education and training—The local government has invested heavily in safety education and training. It is believed that increasing safety knowledge and training will decrease accidents. This section will look at the level of safety training the victims had received.
12. Use of safety equipment—The use of safety equipment could help prevent an accident from occurring. It is therefore important to investigate whether the contractor had provided the necessary safety equipment and taken adequate steps to ensure workers using the equipment and the worker had correctly used the equipment.

Results

Date of Accident

Previous analysis of accident data collected from the Labor Department (of the HKSAR) and the Architectural Services Department (of the HKSAR) (Chan et al. 2006) has shown that at a certain time of the year and week there is a higher probability of accidents across the construction industry. The sources showed that accidents as well as fall accidents were more common in the summer months. Statistics from the Architectural Services Department (of the HKSAR) also showed that Friday was more prone to fall accidents (Wong et al. 2005). Hence it is possible that this pattern also holds true for fatal fall accidents. In addition to looking at the month and day of the week, the year and day of the month were also studied.

Fig. 1 shows a comparison of the number of fatal accidents in new work, repair and maintenance work, and fall from height in repair and maintenance work for the years 2000–2004. The statistics show that the number of fatal accidents in both new work and repair and maintenance works have fallen immensely between 2000 and 2004 (17–11 for new work, 12–6 for RMAA). But unfortunately the numbers of fatal fall from height accidents in RMAA work remained at a relatively high level of 4.

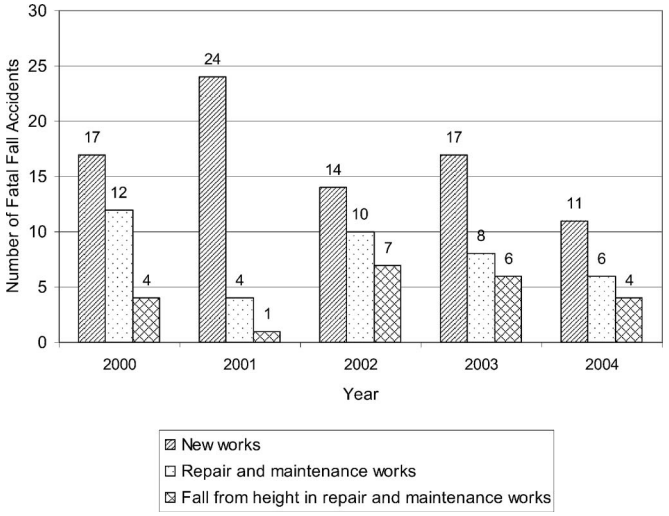

Fig. 1. Number of fatal fall accidents from 2000 to 2004

Other sources of accident statistics reported by Wong et al. (2005) showed that the summer months are more prone to accidents. The case studies showed that June experienced three fatal fall accidents, which are the highest in number, but the months February, September, and October also experienced three accidents from the years between 2000 and 2004. The comparison does not necessarily contradict the previous statistics, but instead a larger sample size would be more reliable as the information discussed in this paper is limited to only 22 cases.

Previous local studies have not looked at the day of the month to which accidents are more prone. The days of the month were split into six periods, and the aim is to compare which period experiences the highest number of accidents. The analysis showed that the period from 21 to 25 days experienced the highest number of accidents by far with seven cases, followed by four cases experienced by 1–5, 6–10, and 16–20 days. Days 26–31 experienced much fewer accidents as for many months there is no day 31 and for February no days 29–31. As the days 29–31 occur less often than the days 1–28 in a year, the possibility of accidents occurring on them would consequently be lower.

Previous analysis shows that Friday experienced the highest number of fall accidents in a week (Wong et al. 2005). This pattern also holds true for the 22 fatal cases discussed in this paper. Seven accidents among the twenty-two, almost one-2 third occurred on a Friday, next followed by four accidents which occurred on a Tuesday and Thursday.

Time of Accident

Similar to studying the date of the cases, the time of accident also indicates the hours of the day that are more prone to accidents. The analysis showed that most accidents occur in the afternoon. During the hours of 14:01–16:00, the number of accidents among the 22 cases was 7, followed by six experienced during the hours

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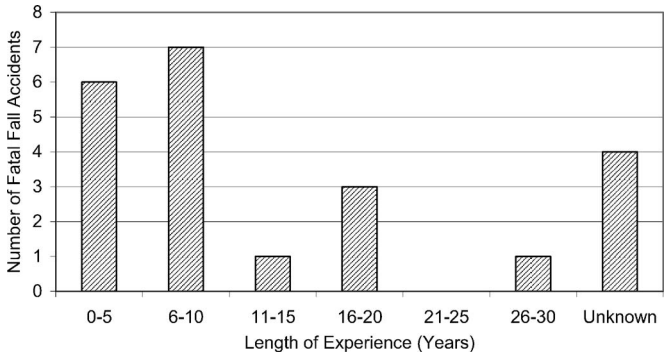

Fig. 2. Number of fatal fall accidents from 2000 to 2004 analyzed by the workers' length of experience in the construction industry

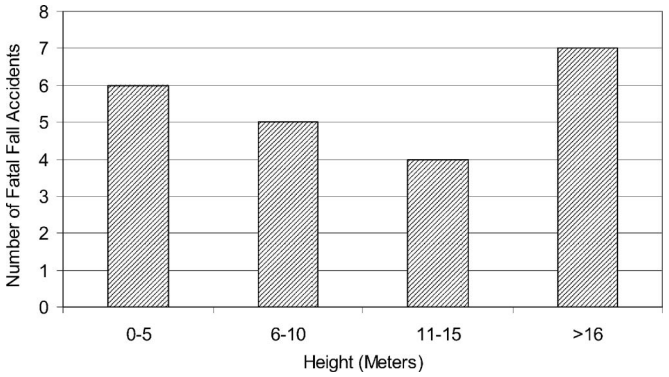

Fig. 3. Number of fatal fall accidents from 2000 to 2004 analyzed by height of fall

of 16:01–18:00. It is therefore logical to recommend that increasing safety inspection and monitoring by contractors in the afternoon would effectively reduce the accidents.

Age of Worker

Previous analysis showed that the highest number of fall accidents occur among workers in the age group of 40–44 (Wong et al. 2005). However, in terms of fatal accident for repair and maintenance work the age group 45–49 topped the rank. This pattern is comparable to the case studies studied in this paper. The findings show that workers aged 45–49 experienced the highest number of fatal fall accidents, totaling five cases from year 2000 to 2004. Next was followed by three accidents experienced by workers in the age groups 20–24, 25–29, and 30–34.

Trade of Worker

Analysis of the cases by the trade of the workers was difficult. This again was due to the small sample size available. It was found that the trade of the workers varied immensely, hence where the trade of the worker was not repeated in the 22 cases, it was counted as "other." Laborers, scaffolders, and electricians were among the trades that experienced the highest number of fatal fall accidents. The frequency of accidents was six, four, and three, respectively, for these trades, therefore special attention should be given to these occupations.

Length of Experience

The length of experience that a worker has is believed to be a determining factor toward their accident rate (Chi et al. 2005). The analysis shows that almost 60% of the accidents for these 22 cases occurred to workers with less than 10 years of experience in the industry (Fig. 2). The experience of 18% were unknown, hence only just over 20% of accidents occurred to workers with over 10 years of experience. However, it should be noted that accidents can happen with any length of experience. It is generally accepted that safety training and education is an effective means to prevent accidents (Chan et al. 2006). Proper and adequate safety training is important for all, particularly with the less experienced group.

Height of Fall

Wong et al. (2005) showed that the majority of fall accidents occurred below 2 m of height. Contradictory, the statistics, the 22 cases showed only 2 out of the 22 cases were below 2 m of height, which is a mere 9% (Fig. 3). The differences can be attributed to the fact that the statistics presented here are for fatal accidents arising from RMAA work only whereas the previous statistics were for all fall related (i.e., both fatal and nonfatal) accidents. The analysis also showed that the majority of fatal accidents occurred below 15 m of height, almost 70%. An increasing trend of more fatal accidents occurring at lower heights was observed. The percentage of accidents that occurred at heights 0–5 m, 6–10 m, and 11–15 m was 27, 22, and 18%, respectively. The statistics show an obvious downward trend of accidents as height increases. For accidents in the category "above 16 meters" these accidents actually occurred between 32 and 75 m of height. As mentioned previously in this paper much of the literature presents devices, technologies, and job procedures for preventing falls from height, but often these are for tall buildings. It is logical to assume that tall buildings require these solutions as a fall is more obvious. But statistics show that a fall could occur at any height and their damages could be equally devastating. One should not relax their vigilance when working at lower heights.

Place of Fall

The places of fall for the 22 cases were studied (Fig. 4) and the places were similar to those reported in previous literature (Labor Dept. 2000–2004; Wong et al. 2005). Bamboo scaffolds, including bamboo truss-out scaffolds, showed the highest danger with

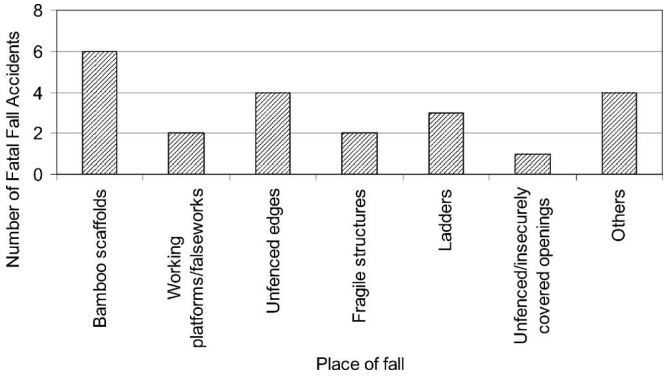

Fig. 4. Number of fatal fall accidents from 2000 to 2004 analyzed by place of fall

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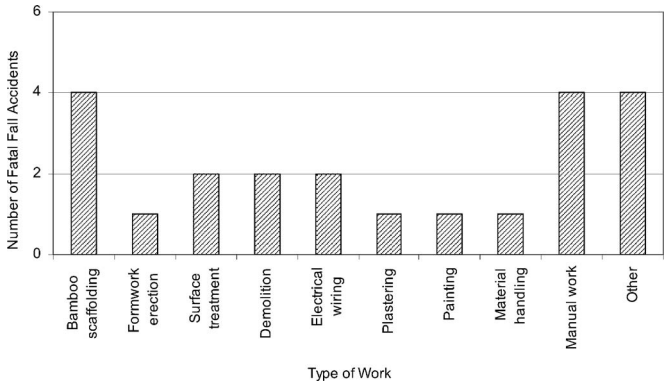

Fig. 5. Number of fatal fall accidents from 2000 to 2004 analyzed by type of work performed

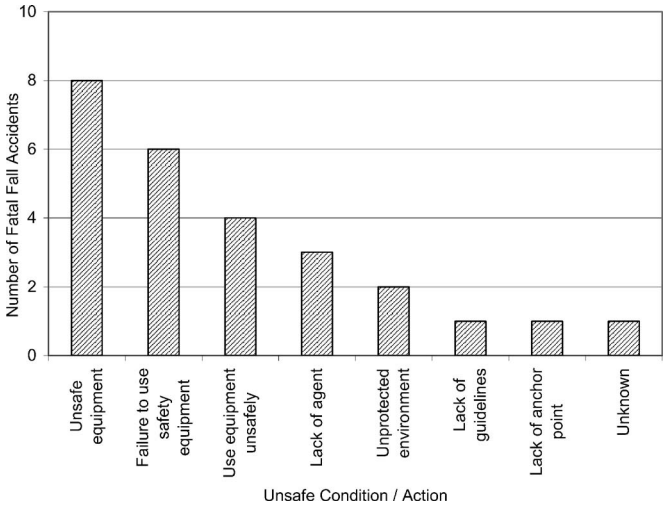

Fig. 6. Number of fatal fall accidents from 2000 to 2004 analyzed by unsafe condition/action

over 27% of accidents resulting from the use of them. Unfenced edges were next on the list of places of fall, which represented 18%. In addition, other places of fall included ladders, working platforms/falseworks, fragile structures, and unfenced/insecurely covered openings which are also commonly recorded places of fall.

Agent Involved

Among the 22 cases, bamboo scaffolds and ladders were the main agents involved. Six of the cases included bamboo scaffolds whereas three involved ladders. This trend is similar to the analysis of accident statistics reported by Chan et al. (2005).

Type of Work Performed

The findings showed that bamboo scaffolding and manual work each represented almost 20% of the fatal accidents that occurred in RMAA work from 2000 to 2004 (Fig. 5). Surface treatment, demolition, and electrical wiring each represented almost 10% among the types of work performed during the accidents. Other accidents also occurred while the work of formwork erection, plastering, painting, and material handling were performed. The top place of fall, agent involved, and type of work performed among the 22 cases has been bamboo scaffolding/scaffolds.

Unsafe Condition/Action

Toole (2002) identified that one of the root causes of construction accidents was unsafe site conditions. The case studies also showed that often an accident occurs as a result of an unsafe condition or action. For over 36% of these cases (Fig. 6), the occurrence of the fatal accident was attributable to the equipment provided by the contractor being unsafe. Provision of safe equipment and proper maintenance are essential in accident prevention. Failure to use safety equipment resulted in 27% of the accidents and represented the second top cause for unsafe condition/action. In third place was using the equipment unsafely which accounted for 18% of the accidents. Other unsafe conditions/actions included lack of agent, unprotected environment, lack of guidelines and lack of anchor point. The statistics show that the main causes of the accidents were all related to equipment.

Among those cases that failed to use safety equipment, half belonged to the age group of 20–24 years, and half had only 6–10 years of working experience. This has shown a clear trend that those who did not use safety equipment were younger workers with less experience in the construction industry. Also, it was noticed that the majority of those workers (five out of the six) either had no previous training or it was unknown whether they have had training before. These accidents therefore show an obvious relationship that there is less chance of fatal accidents occurring to workers who have had safety training.

Looking at the workers that used the equipment unsafely, no obvious relationship can be observed with their ages. But again half of those had only 6–10 years of working experience. Another observation was that, similar to the workers that failed to use safety equipment, only one worker (out of four) had previously had training. This finding reveals that workers with previous training were less likely to use equipment unsafely.

From the analysis, it is likely that workers between 20 and 24 years and workers with 6–10 years of working experience would be more prone to accidents caused due to unsafe conditions/actions. In addition, it was found that workers with previous training were less likely to experience fatal accidents.

Safety Education and Training

Since May 1, 2001, employers in Hong Kong are not allowed to employ a worker who has not been issued a "Green Card" or whose Green Card has expired under the F&IU Ordinance. As such, workers need to attend the mandatory safety training and obtain a Green Card before working on a construction site. Among the 22 cases studied in this paper, 5 of these occurred before the effective date of this mandatory requirement (Fig. 7). For the remaining 17 workers, it was only sure that 14 of these victims possessed a Green Card. For two of the victims it was unclear whether they had received any safety training. For one of the victims, investigations confirmed he did not receive any safety training at all. As discussed earlier, safety training and education is an effective means to prevent accidents. It is therefore important to ensure that all workers should fulfill this mandatory requirement before they are allowed to work in a construction site. Up to the end of 2004, the Labor Department has issued 58 summonses to employers for employing a worker who had not been issued a Green Card.

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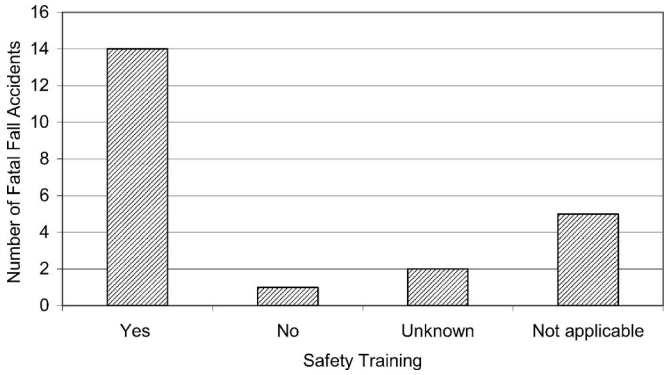

Fig. 7. Number of fatal fall accidents from 2000 to 2004 analyzed by safety training

Fig. 8. Number of fatal fall accidents from 2000 to 2004 analyzed by use of safety equipment

Use of Safety Equipment

The use of personal protection equipment is particularly important when all other safety precautions and measures do not work as planned. The 22 cases were investigated and it was found that in most of the cases (36%), safety belt/harness was not provided by the employer (Fig. 8). Nearly 22% of the deceased did not use the safety belt/harness provided. And only 32% of the deceased wore the safety belt/harness. Employers are under the legal duties to provide their employees with the necessary safety equipment and to take appropriate steps, such as exercising adequate supervision, in ensuring workers to make full and proper use of the safety equipment so provided.

Further investigation was undertaken for the 22% that did not use the safety belt/harness provided. It was found that these tended to be older workers. The average age of these workers was 44 years old and the eldest was 56 years old. No observations or patterns were realized from the experience and training of the deceased.

Recommendations to Prevent Recurrence of These Fatal Accidents

For each reported case, an after-event investigation would be conducted by the Labor Department to find out the causes of the incident, and to recommend actions for avoiding recurrence of similar incidents. Table 2 summarizes the recommendations made for each case and shows which recommendation occurs most frequently. The top five recommendations have been further tabulated in Table 3 to highlight their importance. The top recommendation was "provide and maintain a safe system of work" which occurred eleven times. In second place was "provide suitable working platform" which occurred ten times. The recommendations "provide safety information/training/instruction/supervision" and "provide suitable fall arresting system/anchorage" both occurred eight times. The last recommendation on the list was "maintain safe workplace" which occurred four times. Besides the top five recommendations, seven other recommendations were identified.

For analysis of accidents by the month and the day, both find-

Table 2. Preventive Measures Recommended for Each Case Study

	Case number																						
Preventive measures	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	Total
Provide and maintain a safe system of work	✓		✓	✓						✓	✓	✓	✓	✓				✓	✓		✓		**11**
Provide suitable working platform		✓		✓			✓		✓					✓	✓	✓	✓			✓	✓		**10**
Provide safety information/training/instruction/supervision			✓				✓		✓	✓	✓			✓				✓				✓	**8**
Provide suitable fall arresting system/anchorage						✓	✓				✓		✓	✓	✓						✓	✓	**8**
Maintain workplace safe	✓							✓								✓			✓				**4**
Provide suitable covering and guardrail	✓							✓														✓	**3**
Provide maintenance program				✓																			**1**
Provide suitable design by Code of Practice/professional engineer						✓						✓	✓										**3**
Provide and ensure use of ladder										✓													**1**
Provide communication between designers and operatives												✓											**1**
Implement agreed procedures/follow instructions																		✓				✓	**2**
Take adequate steps to prevent fall of persons																			✓				**1**
Total	**3**	**1**	**2**	**3**	**0**	**2**	**3**	**2**	**2**	**3**	**3**	**3**	**3**	**4**	**2**	**2**	**1**	**3**	**3**	**1**	**3**	**4**	

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Table 3. Top Five Recommendations

Rank	Top five recommendations	Frequency
1	Provide and maintain a safe system of work	11
2	Provide suitable working platform	10
3 (tier)	Provide safety information/training/ instruction/ supervision	8
3 (tier)	Provide suitable fall arresting system/anchorage	8
5	Maintain workplace safe	4

ings showed that accidents occurred toward the end of the period. For the analysis of the time of accident, it was found that accidents also occur toward the end of the day. To eliminate the increase of accidents during these times, extra monitoring and inspections should be carried out by the management to alert the workers. Laborers, scaffolders, and electricians were found to be the most susceptible occupations of the deceased workers. Adequate attention should be given on the system of work, necessary safety equipment and due supervision provided by employers to workers who need to work in these situations. The training course should also emphasize the need for and the correct usage of safety equipment. In addition, workers must be properly trained to handle the equipment they will use to ensure for safety.

It is important to note that of the 22 fatal industrial accidents, 4 (18.2%) involved bamboo truss-out scaffolds. The use of bamboo truss-out scaffolds was identified as a problematic area and the root cause of many fatal fall accidents in Hong Kong. The bamboo truss-out scaffold is a unique feature of Hong Kong hence there were no lessons that could be learned from overseas. There are many problems related to the procedure of installing and using the bamboo truss-out scaffold causing it to be unsafe. The lack of standards and requirements has caused the control of them to be difficult. Therefore there should be guidelines, standards and legal enforcement concerning the design, installation procedure and dismantle procedure of the bamboo truss-out scaffold, to ensure that it is safe to use.

The statistics also show that a number of the victims were not provided with any personal protection equipment and some did not wear the equipment properly. Similarly, the most unsafe condition/action was a result of the equipment being unsafe. It is necessary to provide proper and safe equipment and proper maintenance to ensure that it is safe for use. It should also be stressed that employers are legally liable to provide the necessary personal protection equipment to their employees and to provide adequate supervision to ensure that their employees put on this equipment properly. The importance of purchasing insurance for maintenance work regardless of size should be publicized in order to increase the awareness of the employers about their legal responsibilities on proper implementation of the repair work. Likewise, employees should work diligently to implement the safety instructions. Continuous training should be provided for workers to improve their safety attitude and hence reducing the occurrence of unsafe acts or procedures. Continuous training is also important to refresh workers on safety knowledge and also introduce them to new safety guidelines and refinements to previous practices. Monitoring and inspection should be increased to ensure that workers follow the rules. A mandatory licensing system should be introduced for workers performing minor work to ensure proper monitoring and inspection.

Conclusions

This paper summarizes the results of the analysis from the 22 fatal fall accident cases in Hong Kong occurring between 2000 and 2004, and highlights the areas of concern in relation to fall from height for future RMAA work. The statistics showed that workers belonging to the age group of 45–49 experience the most fatal accidents. This may be attributable to the fact that most of the workers engaged in RMAA work fall within the age group of 45–49. In these 22 cases all deceased workers, irrespective of occupation, fell to death from height.

The most common place of fall derived from the cases reinforced the findings from previous literature. The statistics also prove the importance for safety training and education. Although statistics showed that over 20% of accidents occurred to workers with over ten number of years of experience, accidents could occur at any years of working experience in the industry. Therefore regular safety training courses should be provided to workers with any years of experience. Workers often ignore safety precautions when working at low levels as fall from height is less obvious. But statistics show that accidents often occur not far from the ground and so safety precautions should not be neglected even for work at low levels. The same degree of seriousness should be adapted for all works at height. Failure to use safety equipment or to use safety equipment incorrectly, were also common unsafe conditions/actions observed. In fact, only a very low proportion of the victims had received any form of safety education or training. Hence there is an urgent need for increasing workers' safety training and education to ensure that they are fully aware of correct safe procedures for work and how to protect themselves by using correct personal protection equipment. Definitely, safety training and education courses for working at height in RMAA work would be of benefit to the industry.

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