Safety management in repair, maintenance, minor alteration and addition works: A knowledge management perspective

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Abstract: Safety of repair, maintenance, alteration and addition (RMAA) works has long been neglected because RMAA works are often minute and only last for a short period of time. With rising importance of the RMAA sector in many developed societies, safety of RMAA works has begun to draw attention. Many RMAA contracting companies are SMEs which do not have comprehensive safety management systems. Existing safety legislation and regulations for new construction sites are not fully applicable to RMAA works. Instead of relying on explicit and well established safety systems, tacit safety knowledge plays an extremely important role in RMAA projects. To improve safety of RMAA works, safety knowledge should be better managed. However, safety knowledge is difficult to capture in RMAA works. This study aims to examine safety management practices of RMAA contracting companies to see how safety knowledge of RMAA projects is managed. Findings show that RMAA contracting companies undertaking large scale RMAA projects have more initiatives of safety management. Safety management of small scale RMAA works relies heavily on the motivation of site supervisors and self-regulation of workers. Better tacit knowledge management improves safety performance. To enhance safety capability of RMAA contracting companies, a knowledge sharing culture should be cultivated. The government should provide assistance to SMEs to implement proper safety

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management practices in small-sized projects. Potentials of applying computer software technology in RMAA projects to capture, store, and retrieve safety information should be explored. Employees should be motivated to share safety knowledge by giving proper recognition to those who are willing to share.

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Introduction

Construction safety performance of many developed countries have been improving and gradually reached a plateau. The prevailing challenge of the industry is to find out ways for further safety improvement. Knowledge management is often regarded as a way to improve productivity and competitiveness (Javernick-Will 2012). By the same token, proper safety knowledge management may be one of the ways to improve construction companies' safety performance. Hallowell (2012) asserted that better safety knowledge management can improve the organization's capacity of adapting to changes, resulting in better safety performance. Hallowell (2012) found that high performing companies have distinguished abilities in managing implicit knowledge with formal processes. Safety knowledge of the construction industry is resourceful but has yet to be capitalized. Knowledge management studies relating to construction safety have been limited (Hallowell 2012). Many of them focus on lessons learned from large companies (e.g. Robinson et al. 2005; Carrillo and Chinowsky 2006) and their findings may not

be directly applicable to small and medium-sized enterprises (SMEs). Besides, many SMEs do not have formal knowledge management system. Safety knowledge management of SMEs in the construction industry is a rather uncharted-area.

Repair and maintenance, minor alteration and addition (RMAA) works are usually undertaken by SMEs. SMEs are defined by the Hong Kong Government as "any manufacturing business which employs fewer than 100 persons in Hong Kong, or any non-manufacturing business which employs fewer than 50 persons in Hong Kong" (Hong Kong Government, 2012a). Adopting the same classification system, RMAA contracting companies in Hong Kong employing fewer than 50 persons are classified as SMEs. Authoritative figure on the number of RMAA contracting companies in Hong Kong is not available in the public domain. According to recent information of the Hong Kong Government (2012b), there were over 14,300 Registered Minor Works Contractors in Hong Kong as at 31 March 2012. Minor Works Control System, which simplifies the application procedures of minor buildings works, was fully implemented on 31 December 2012. It requires RMAA works to be undertaken by Registered Minor Works Contractors. Thus, it can be inferred that more than 14,300 numbers of contractors are active in the RMAA sector.

The RMAA sector has been of rising importance in developed societies because of rising awareness of sustainability and aging buildings. For example, RMAA works in Hong Kong accounted for 45% of the construction market in 2010 (Hon and Chan 2013). The RMAA sector is expected to grow even further because the Hong Kong Government has recently launched a number of policies to improve safety of ageing buildings. Mandatory Building Inspection Scheme (MBIS) and Mandatory Window Inspection Scheme (MWIS) were both implemented on

30 June 2012. Under the MBIS scheme, the Buildings Department will select 2,000 private buildings aged 30 years or above (domestic buildings not exceeding three storeys are exempted) per year for building inspection and follow up with necessary repair and maintenance works. Subsequent inspections will be done every 10 years (Development Bureau, 2010). For MWIS, the Buildings Department will select about 5,800 private buildings aged 10 years or above every year for inspection and repair works (domestic buildings not exceeding three storeys are exempted). Subsequent window inspections will be done every five years (Development Bureau, 2010). To dovetail theses schemes, subsidies are available for building owners to apply for repair and maintenance of their buildings. All these measures will lead to an increase in the volume of RMAA works (Hon and Chan, 2013), which, in turn, will increase the magnitude of safety incidents in the RMAA sector.

Accidents occurring in RMAA works have been rising. For example, the RMAA sector accounted for 66.7% (six out of nine) fatal accidents in the construction industry of Hong Kong in 2010 (Hon and Chan 2013). Undoubtedly, safety of RMAA works deserves serious attention; however, it has long been undermined because RMAA projects are often small in scale and undertaken by SMEs (Hon et al. 2010). As Hinze and Gambatese (2006) advocated, safety research has been focused on large general construction and design firms, neglecting those small specialty contractors. Safety of specialty contractors, such as subcontractors undertaking RMAA works, should be better understood.

This study originates from a larger research initiative of safety climate of repair, maintenance, minor alteration, addition (RMAA) works in Hong Kong, a sector which consists of many SMEs.

Inspired by the work of Hallowell's (2012) safety knowledge management study of construction companies in the United States, this study focuses on examining safety management of the RMAA sector in Hong Kong from a knowledge management perspective. Safety knowledge in RMAA works is particularly difficult to maintain because of small project scale, short duration and dispersed locations of RMAA works (Hon et al. 2012). Most RMAA contracting companies are small and medium-sized which lack resources for proper safety management, not to mention safety knowledge management. This paper aims to analyze current safety management of the RMAA sector from a knowledge management perspective. The objective is to examine how safety knowledge is captured and reused in safety management system of RMAA contracting companies. Recommendations for improving safety management of RMAA works are offered. This paper will be useful to better manage safety knowledge of RMAA contracting companies and improve their safety capability.

Safety of the RMAA sector in Hong Kong

The RMAA sector has been identified by the Hong Kong Government as one of the key areas for safety improvement (Legislative Council, 2011). The Construction Industry Council, a statutory coordinating body for the construction industry of Hong Kong, has set up a Task Force on Work Safety of Repair, Maintenance, Alterations and Additions (RMAA) Sites to especially look into the ways for improving safety of RMAA works (Construction Industry Council, 2012). The RMAA sector has its own uniqueness rendering safety management of RMAA works different from new construction works. Thus, safety of RMAA works deserves separate research endeavors.

RMAA works are usually conducted in enclosed building structures which may not resemble construction sites. RMAA workers may easily underestimate the risks involved in conducting their tasks (Hon et al. 2010). Unlike new construction projects, working environment of RMAA projects varies, making it difficult to control potential risks and problems in RMAA works. For example, concrete strength of aged buildings is different from that of new buildings. External wall repair and maintenance works of aged buildings are different from that of new buildings because of different concrete strength of external wall. Instead of adopting standard practices, different method statements have to be designed to suit ad hoc situation of RMAA projects. Safety management faces a challenge to provide adequate instructions on undertaking the RMAA work safely (Hon et al. 2012).

Term contract nature of some RMAA projects makes safety supervision difficult because RMAA work tasks are widely scattered (Hon et al. 2012). Different subcontracting works of new construction projects are likely to be responsible by individual specialty subcontractors of a single trade; however, nature of RMAA works generally requires workers to have multi-skills to perform multi-tasks. Very often, RMAA tasks are not done by specialists of a single trade. RMAA workers may be endangered when performing tasks that they are not so familiar with (Hon et al. 2010).

A fatal case analysis revealing the root causes of accidents in RMAA works was done by Hon and Chan (2013). Hon and Chan (2013) analyzed 119 RMAA fatal cases occurred between

January 2000 and October 2011 in Hong Kong. Fall of person from height was the top killer of the RMAA sector, accounting for 72 (62%) of the 119 RMAA accidents in the aforesaid period. Three clusters of fall from height fatalities were identified, they were: 1) bamboo scaffolders aged between 25 and 34 who fell from external wall/facade in the beginning of weekdays; 2) miscellaneous workers aged between 45 and 54 who fell from other/unknown places in the end of weekdays; and 3) manual labour aged between 35 and 44 who fell at floor level/from floor openings in weekends. The main unsafe conditions leading to fatal falls were unsafe process and improper procedures whereas the main unsafe action leading to fatal falls was improper usage of safety belt. Young and inexperienced bamboo scaffolders were particularly susceptible to fatal falls.

Safety knowledge management of construction projects

Knowledge is an important asset of a company. Proper knowledge management helps the company to achieve efficiency and improves performance (Kululanga and McCaffer 2001). Knowledge management helps individuals to share their tacit knowledge and transforming tacit knowledge into explicit knowledge. According to Nonaka and Takeuchi (1995), there are four ways of turning explicit knowledge to tacit knowledge, they are socialization, externalization, combination and internalization (Fong and Chu 2006). Companies successfully capturing tacit knowledge of their employees will outperform other companies which have the same tacit knowledge but uncaptured and left idle (Chinowsky and Carrillo 2007).

Knowledge management in the construction industry involves management of project knowledge and knowledge management within individual firms (Kamara et al. 2002). Knowledge management within a project changes in context and content as the project progresses from design stage to construction stage. Knowledge management within a construction firm involves the ability to transfer knowledge across different projects. Very often, knowledge management initiatives are adopted without having given the label of knowledge management. As revealed by Kamara et al. (2002), initiatives of knowledge management of construction firms includes reassignment of people to different projects, the use of standards and practice guidelines, contractual arrangements, intranets, and specific activities such as post-project reviews. These are, however, organizational strategies but not necessarily dedicated strategies for knowledge management. It seems that knowledge management has not received enough attention in the construction industry, especially by the SMEs.

Safety knowledge is important to successful safety management and good safety performance (Hallowell 2012). Safety knowledge can be explicit or tacit. For explicit knowledge, it is knowledge that has been explicitly explained, recorded, or documented. In the construction industry, it can be accident records, safety legislation, regulations and guidelines (Hadikusumo and Rowlinson 2004). Accident records provide useful information for risk assessment. Analysing accident records in terms of frequency occurrence and degree of seriousness allow better allocation of safety resources. More attention and resources should be given to safety hazards with high occurrence frequency and serious consequences. Safety legislation, regulations and guidelines provide the minimum requirements of site safety. However, meeting these stipulated standards are not enough to maintain a safe working environment. Safety legislations

of Hong Kong are self-regulatory, that is, legislations only give a rough guideline leaving the flexibility for the companies to decide their own company safety practices.

Construction projects are complex and dynamic. Ad hoc events often occur. It is obvious that proper safety management of construction projects rely not on the basic safety legislation, regulations and guidelines but experience of the project team, which is tacit knowledge (Hadikusumo and Rowlinson 2004). In this way, tacit knowledge plays a decisive role in determining the safety performance. For tactic knowledge, it is knowledge that is intuitive and guided by experience. In the construction industry, safety hazard recognition based on the experience of safety engineers is an important source of tacit knowledge. Safety hazard recognition is indispensable to construction safety management (Carter and Smith 2006). If management cannot identify potential hazards, relevant training and measures cannot be provided accordingly (Hadikusumo and Rowlinson 2004). Large construction companies may have a comprehensive safety management system to properly capture, store and utilize tacit knowledge; however, this is often impossible for SMEs undertaking RMAA projects to imitate. The way that tacit knowledge is handled by SMEs needs further investigation.

Knowledge management processes basically include acquisition, storage, and transfer. Knowledge acquisition is “the process that involves imbibing information including making meaning of situations and other stimuli from the internal and external business environment” (Kululanga and McCaffer 2001). A construction company can acquire tacit knowledge internally through their staff, internal benchmarking studies and experience or externally through recruiting staff from innovative organizations, collaborating with others, attending conferences etc

(Kululanga and McCaffer 2001). According to Hadikusumo and Rowlinson (2004), there are two ways of capturing tacit safety knowledge from safety engineers or managers. The first one could be face-to-face discussions with method statements and drawings or visiting the site. The second one could be utilizing computer software systems such as DFSP tool (Hadikusumo and Rowlinson 2004) and ToolSHeD (Cooke et al. 2008) to capture safety information in a database.

Implementing knowledge management in a construction company faces many barriers. For example, resources invested in knowledge management of a project do not result in immediate benefit. Tacit knowledge is difficult to capture because construction projects are dispersed. There are also other barriers such as limit of time, high turnover rates, early retirement, lack of a knowledge management budget, low acceptance to new things, poor IT infrastructure, and others (Hallowell 2012). Construction companies are reluctant to invest in knowledge management and support initiatives because of lack of standard work processes, low profit margin and conservative culture (Carrillo and Chinowsky 2006).

To motivate people to share knowledge, some companies give monetary rewards to those who are willing to share knowledge. However, it was found that monetary returns may adversely affect people's intrinsic motivation to share knowledge. Javernick-Will (2012) revealed the power of social motivations for people to share knowledge in engineering and construction organizations. Javernick-Will's study found that people are willing to share knowledge due to reciprocity, conformity to corporate culture, mimicking the behavior of leaders, peer recognition, and honoring knowledge sharing commitments. For reciprocity, people feel obliged to share knowledge when the others have done so to them. If there is a corporate culture of sharing

knowledge, people working in that organization will also follow the norm to share knowledge. Leaders are often the role model of fellow team members. If leaders take the lead to share knowledge, fellow members will follow. People are motivated to share knowledge so as to gain peer recognition. When people are committed to share knowledge either verbally or in written form, they are motivated to honor their commitment. Javernick-Will (2012) proposed a number of management strategies to motivate employees to share knowledge, such as promoting people who engage in knowledge sharing, promoting norms of knowledge sharing, recognizing the behavior of sharing knowledge with peer-recognition awards, and encouraging employees to make commitment to knowledge sharing.

Research methods

RMAA contractors were targeted for interviews. Invitations were sent to 17 RMAA contractors on the approved contractors' list of a property management company in Hong Kong. Eight RMAA contracting companies responded favorably to the research interview request. Face-to-face interviews were conducted with senior management representatives of these eight companies between December 2008 and February 2009. Each interview lasted for approximately an hour. Each interview was tape-recorded and transcribed for later coding of data.

As shown in Table 1, the interviews A to C, D to F, and G to H represent views of RMAA contractors undertaking large-, medium-, and small-sized RMAA projects in Hong Kong respectively. Interviewees were requested to briefly describe safety management practice of their company and share their experience of managing RMAA projects with outstanding safety performance.

Table 1. Background of the interviewees.

No. of Interviews	Position of interviewees	Companies' project scale/ nature
A	Director	Around USD$ 1.3 million - USD$ 13 million
B	Project Safety Manager & Project Manager	Around USD$ 1.3 million - USD$ 13 million
C	Managing Director & Senior Manager	More than USD$ 13 million, term contract
D	Executive Director	Less than USD$ 2.6 million
E	Managing Director	Around USD$ 1.3 million
F	General Manager	Around USD$ 1.3 million
G	Senior Project Manager	Around USD$ 1,300- USD$ 260,000
H	Director	Around USD$ 1, 000 - USD$ 1.3 million

Qualitative interview data transcribed into narratives were coded by constant comparative method (Grove 1988; Ryan and Bernard 2000) in NVivo 8, software for qualitative data analysis. Interview data concerning safety management systems were analyzed in regard to processes of knowledge management. Data of common themes and similar semantic meanings were initially coded together as the same category. For example, the concepts of "guidelines" and "practice notes" that appeared in transcripts were coded in the same category. Each category was then compared with other categories continuously during the coding process for refinement until each presented a clear and distinct categorization.

Results and discussions

Safety management practices adopted by the interviewees were analyzed from a knowledge management perspective to see how safety knowledge is acquired, stored and transferred. Interview findings are summarized in Tables 2 to 4. As shown in Table 2, interviewees identified

10 initiatives to capture safety knowledge in RMAA contracting companies. Safety knowledge is acquired by most interviewed RMAA contracting companies through legislation and regulation, management site visit, regular safety meeting at management level, pre-project safety planning, and risk assessment. Management site visit is adopted by many small-sized RMAA contracting companies interviewed.

Legislation and regulation is the main source of acquiring explicit safety knowledge. Guidelines and practices are available from the Occupational Safety and Health Council and the Labour Department. RMAA contracting companies/units which are subsidiaries/sections of big contractors follow the safety practices of their parent companies and thus tend to have a more formal and established system of safety knowledge acquisition. For example, Interviewee A stated that:

> "There is standard safety practice, we follow [parent] company safety plan. We issue practice notes on working at height because RMAA works involve lots of working at height. Disciplinary actions will be taken if practice notes are violated, no matter by worker, subcontractor, site agent, foreman, or project manager. There will be verbal warning; written warning and the heaviest disciplinary action would be dismissal." (Interviewee A)

Company B has a department designated to undertake RMAA works. Similarly, interviewees representing company B expressed that RMAA works follows the same safety policy as for new works. Parent company of company F had a safety department consisting of 20 to 30 people. Two to three of them were assigned to oversee RMAA projects of company F.

Site visit of management is the major source of capturing tacit safety knowledge. Tacit knowledge is better captured in RMAA contracting firms which undertake large scale RMAA projects. For large projects, there is safety walk conducted by project manager (Interviewee F), safety officers will be stationed on site, and attend regular safety meetings. As for company C, interviewees stated that a number of initiatives were in place to analyze project information relating to ensure safety:

> "Project manager and resident safety officer will produce 3-month forecast to identify high hazard activities in detail. After identifying the activities, they will produce method statement, risk assessment, and then safety precaution measures and finally pre-work meeting. In the meeting, safety officer, project team and subcontractors will sit together to make clear how the work should be done. During implementation, there is monitoring; if deviated from the plan, they will fine tune the process." (Company C)

Safety practices for SMEs are very limited. Safety management of SMEs largely depends on the attitude of managerial staff. Safety is better managed if managerial staff visits the site frequently and uphold safety standards seriously. Interviewee E mentioned that "there is safety meeting, site safety plan and site risk assessment for individual project but their implementation depends very much on the site agent". For small RMAA contracting companies, safety depends on supervisors and the workers themselves. As revealed by interviewee H, "For large projects, supervisors will be placed on site to ensure safety. For very small project, workers largely depend on their self-regulation because safety supervisor only visits the site occasionally".

Regular safety meeting, pre-project safety planning and risk assessment can both capture explicit and tacit safety knowledge. These tactics help the project team to analyze the construction methods of RMAA works to be undertaken, identify potential safety hazards and plan coordination works. Coordination work is particularly important in RMAA works because RMAA works often affect the public and the neighborhood.

Table 2. Knowledge acquisition

Knowledge acquisition	A	B	C	D	E	F	G	H	Total
Legislation and regulation	X	X	X	X	X	X	X	X	8
Company safety plan/ practice notes	X					X			2
Regular safety meeting at management level			X	X		X			3
Accident analysis			X						1
Pre-project safety planning		X	X		X				3
Risk assessment		X	X		X				3
In-house case sharing	X								1
Safety workshop/meeting at site level	X				X				2
Management site visit				X		X	X	X	4
Good practices from new works				X					1

Referring to Table 3, safety knowledge storage initiatives are very limited and traditional. Safety plan and project safety plan are the two most common ways of keeping safety information. This indicates that safety knowledge has not been properly stored and managed. Only one interviewee can indicate other methods of keeping safety knowledge, such as near miss report, accident report and quarterly hazard forecast. RMAA projects of SMEs are so small in scale that interviewees did not mention any application of software systems to store safety knowledge.

Table 3. Knowledge storage

Knowledge storage	A	B	C	D	E	F	G	H	Total
Company safety plan	X	X	X	X	X	X	X	X	8
Project safety plan	X	X	X	X	X	X	X	X	8

Near miss report	X		1
Accident report		X	1
Quarterly hazard forecast		X	1

Regarding knowledge transfer (Table 4), eight initiatives were identified by the interviewees. Developing partnership with subcontractors, pre-work safety briefing with workers and safety department of parent company are the most common ways of transferring safety knowledge. Other ways include toolbox talk, safety training, newsletter/bulletin, safety notices and employ direct labour with good safety performance as gangers.

Knowledge can be transferred to the next project by having partnership with subcontractors. For example, Company G provides half-day safety training to subcontractors' workers to renew their green cards every three years free of charge. This can guarantee the quality of safety training. Valuable lessons learned from a project can be carried forward to the next by having a stable project team. Site supervision of subcontractors in RMAA projects is limited due to scattered location of RMAA projects and limited safety resources for small-sized projects. Hence, selection of subcontractors with good safety performance is important. Developing long-term working relationships with subcontractors with good safety performance is one of the recommended strategies to improve safety performance of RMAA works (Hon et al., 2011) According to interviewee C, subcontractors will be allowed to adjust their tender prices after the tender interview if they consider the safety standard is more stringent than what they have priced in their tender submissions. If accident happens, there will be a panel enquiry. The panel will urge the subcontractor to submit improvement plan to rectify unsafe conditions and practices.

354 **Table 4**. Knowledge transfer

Knowledge transfer	A	B	C	D	E	F	G	H	Total
Safety department of parent company	X			X		X			3
Toolbox talk			X						1
Safety training		X					X		2
Newsletter/bulletin			X						1
Safety notices							X		1
Pre-work safety briefing with workers	X	X			X				3
Direct labour as gangers		X							1
Partnership with subcontractor	X	X	X					X	4

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357 Although safety knowledge management is rather inadequate in most interviewed RMAA
358 contracting companies, most interviewees agreed that learning and innovation is important to
359 achieve good safety performance. As reflected by Interviewee A, learning and innovation is
360 crucial for a RMAA company to have outstanding safety performance. Interviewee A quoted an
361 example that in a project with outstanding safety performance, contractor based on its own
362 expertise and experience proposed an alternative method of construction which is much safer but
363 still achieving the same purpose of alternation and addition work. Interview C quoted an
364 example of innovation. Having analyzed previous injury record, the site staff thought of buying
365 small trucks to prevent injuries of workers when moving materials from one place to another.
366 These are good examples of safety knowledge transfer from project to project.

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368 In line with the findings of Kamara et al. (2002), most of the RMAA contracting companies do
369 not have formal knowledge management strategies to reuse safety knowledge captured in
370 different projects. Rather, they rely on the same organizational strategies to manipulate safety
371 knowledge in the industry. This study also echoes with Hallowell (2012) that companies
372 successfully turning tacit knowledge into explicit knowledge for utilization of the company tend

to have better safety performance. In general, RMAA contracting companies undertaking large scale RMAA projects have more initiatives to improve safety.

Legislation and regulations are basic explicit safety knowledge acquired by RMAA contracting companies. However, it is the responsibility of RMAA contracting companies to design their own safety management systems and company safety plans. Although RMAA works share some similarities with new works, RMAA works have their uniqueness such as multi-tasking, dispersed in location etc. Some of the existing safety legislation and regulations do not fit well with RMAA works. For example, only projects over 100 workers are legally required to employ a safety officer on site; however, a RMAA project seldom reaches this scale and is therefore not bounded by this legal requirement. Safety officers are often not employed in RMAA projects, instead safety supervisors are employed. Safety officers, who are fully designated to safety, have more knowledge and greater authority in upholding safety than safety supervisors who are usually site foremen or project engineers playing the dual role to run the project and uphold safety concurrently (Hon et al. 2010). Another example is that projects with contract sum less than HK$ 1,000,000 (US$ 128,000; at a rate US$1 = HK$7.8) are not required by law for the contractor to inform the Labour Department of Hong Kong. Thus, many small-scaled RMAA projects are exempted from this regulation, resulting in less surveillance of the government regulatory body to the RMAA works than to the new works (Hon et al. 2010)

Lessons learned and best practices of safety are carried forward to the next project if site supervisor proactively share the knowledge know-how. An experienced site supervisor/engineer has the ability to identify potential safety hazards that will occur in the projects. Nevertheless,

there are no formal strategies to capture the tacit knowledge possessed by site supervisors. This is especially the case for RMAA works. Site supervisors are not fully designated to take care of safety. They have to consider other aspects of the project. Due to tight project schedule, they simply cannot spend time and effort in sharing the tacit knowledge they have in mind. However, they are the people who possess abundant project safety knowledge to share.

Construction processes of new works are relatively well-planned; however, that of RMAA works are rather unforeseeable and ad hoc. Thus, tacit knowledge is extremely important in RMAA works. Undocumented building changes could be found in RMAA project sites, making the originally planned RMAA work dangerous to execute. For example, interviewee A recalled that site project staff of an alteration and addition project suggested a design change because construction method of the original design was unsafe. The project was an alteration and addition work in a shopping arcade to have a leveled slab for retailing. Interviewee A proposed a design change because the original plan was too dangerous. The first level of the shopping arcade was a cinema and the ground floor level was a market. The original plan was to take away the slab and lower the floor level. From the as-built drawings, there were double slabs but they did not exist in reality for some unknown reasons. That being the case, it would be very dangerous to execute the planned alteration and addition work and it would also affect the business of shops on the ground level. Proposals were finally made to raise the floor and use up the excessive headroom. The proposed design change not only resulted in ad hoc savings but also maintained safety of the end-users (shops and customers in the market) throughout the project.

RMAA contracting companies face severe competition. In order to survive, they need to develop into a learning organization which keeps on sharpening their competitive edge (Chinowsky and

Carrillo, 2007). Safety is one such priority areas that cannot be neglected. It is recommended that RMAA contracting companies should encourage project managers/site supervisors to carry out pre-project safety meeting and post-project review. Their experiences are valuable in identifying potential safety hazards and preventing injuries. However, according to the interviewees there are barriers of implementing safety practices such as frequent turnover of site staff and limited resources for safety. Safety knowledge is not captured because there is little time and resources for safety. Resources for safety often depend on the project size. Many RMAA works are small in scale and short in duration. Many companies hold the view that it is not realistic to invest in safety for such minute projects (Hon et al. 2012). Thus, safety management of RMAA projects is often inadequate. It is recommended that the government should provide assistance to RMAA contracting companies to implement proper safety management practices in small scale projects. Computer software technology has been used in new construction projects (Hadikusumo and Rowlinson, 2004) but it is seldom used in RMAA projects. It is recommended that user-friendly software/ databases should be introduced to RMAA works to store and maintain safety knowledge. As advocated by Javernick-Will (2012), management strategies should be designed to promote social motivation to share knowledge. As for RMAA companies, they should cultivate the safety knowledge sharing culture within and across project teams, recognize/award the employees who are willing to share their knowledge to deliver the project safely, identify potential safety hazards, and set up a mentorship system which assigns experienced workers as mentors to teach newcomers. These strategies may help people interact and enhance knowledge sharing.

Conclusions and recommendations

To conclude, this study has analyzed safety management practices of RMAA contracting companies in Hong Kong from a knowledge management perspective. Many RMAA contracting companies are SMEs and they do not have formal knowledge management system; however, there are initiatives in the safety management system to capture tacit knowledge and best practices. Safety knowledge management has the potential to enhance safety capability of construction companies. Since RMAA works rely more on people and workmanship than new construction works, RMAA works need to make use of tacit knowledge to better manage safety. From the findings of the structured interviews, safety knowledge of RMAA contracting companies not having been captured effectively will be lost when project finishes. As revealed by interviewees A to C, RMAA companies with a proper system to capture knowledge generated from previous projects and transfer to future projects tend to have better safety performance. Currently, most RMAA contracting companies do not have a formal mechanism to turn tacit knowledge into explicit knowledge. Thus, attitude of managerial staff and site supervisor play a crucial role in safety knowledge management. Although this study was conducted in Hong Kong, it is expected that findings of this study are applicable to other geographical locations with expanding RMAA sectors and provide insights to industry practitioners and researchers concerning about construction safety. Data collection of this study is limited by only eight interviews. For further research, investigations could be extended to a larger number of RMAA contractors and compare safety management practices with contractors undertaking new construction projects. Safety knowledge management has the potential of improving safety performance of RMAA contracting companies. Strategies should be formulated to motivate employees to share safety knowledge. Proper recognition should be given to those who are

willing to share knowledge, from managers, supervisors to workers. In the long run, RMAA contracting companies should target to develop into a learning organization which builds on learning and innovative culture.

Appendix. List of Abbreviations

RMAA	Repair, maintenance, minor alteration and addition
MBIS	Mandatory Building Inspection Scheme
MWIS	Mandatory Window Inspection Scheme
SMEs	Small and medium-sized enterprises

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