Survey of management practices enhancing labor productivity in multi-storey building construction projects

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Abstract

Purpose – The purpose of this paper is to identify and prioritize management practices that have the potential to improve labor productivity in multi-storey building construction projects.
Design/methodology/approach – The study adopted two-phase mixed-methods research design and 58 project managers, contract administrators and project coordinators were involved in the survey. During Phase I, qualitative data were collected from 19 experts using interviews and the management practices that could enhance labor productivity in multi-storey building construction projects were identified. In Phase II, quantitative data were collected from 39 contractors involved in the delivery of multi-storey building projects by using questionnaires. The data were analyzed to prioritize the practices identified in Phase I.
Findings – Well-defined scope of work, safety and health policy, safety and health plan, hazard analysis, long-lead materials identification, safe work method statement, and toolbox safety meetings are the top seven practices that have the potential to improve labor productivity in multi-storey building projects.
Originality/value – The research identifies the management practices that can be implemented to enhance labor productivity in multi-storey building construction projects in the context of Australia. Being the first study in the Australian context, the findings can be used as benchmark for international comparison.

Keywords Australia, Labour productivity, Construction management practices, Multi-storey building projects

Paper type Research paper

Introduction

The construction industry is a significant contributor to the economy of a country. In Australia, the industry comprised 8.29 percent of the annual gross value added in the year 2015 (Australian Bureau of Statistics, 2016a). Despite its significance, the productivity growth of the industry is low. According to the Australian Productivity Commission (2015) report, in the year 2013-14, the labor productivity growth for the total economy was 1.4 percent whereas the labor productivity growth in the construction industry was −1.0 percent. The report also indicated that multifactor productivity in construction industry declined but only marginally. Thus, the labor productivity growth rate was low when compared to muti-factor productivity. Multifactor productivity is measured as output per unit of combined inputs of labor and capital, while labor productivity is measured as output per unit of labor input in "hours worked" (Productivity Commission, 2013). Previous researchers in Australian context reported the loss of productivity due to management-related problems. Hughes and Thorpe (2014) identified rework, lack of materials and overcrowding as some of the major productivity deterrents. However, knowing the management practices that could enhance productivity could reduce the negative effects of the loss of productivity such as project delay, liquidated damage, and reduction in profit margins of contractors. Improvement in the project level productivity can enhance the industry level productivity because the output and input used for computing the industry level productivity are obtained from the projects. In most construction productivity studies conducted at the project level, the term productivity and labor productivity are used interchangeably. El-Gohary and Aziz (2013) explained that in

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construction, productivity usually refers to labor productivity. In this research, the term productivity refers to the labor productivity at the construction project level.

Previous studies indicated various drivers of productivity growth. Australian Productivity Commission (2013) suggested that the use of advanced technology and the change in the management practices could improve productivity. However, a study conducted by Organization for Economic Co-operation and Development (2001) showed that technological change does not necessarily translate into productivity growth. Rojas and Aramvareekul (2003) concluded that enhancing productivity in construction projects is a management issue and the use of new technologies may be helpful but not sufficient. Hence, this research focuses on the management practices that could improve productivity in multi-storey building projects. A review of the literature shows that construction management (CM) practices that have the potential to improve labor productivity in construction projects could be categorized into construction materials management practices namely long-lead materials identification, materials procurement and delivery plans, and inspection and test plans (Caldas *et al.*, 2014); preconstruction phase management practices including buildability review, short interval plans, and the scope of works (Lam *et al.*, 2006); management practices related to construction methods comprising integrated schedule and machinery positioning strategy (Gurmu *et al.*, 2016b; Nasir *et al.*, 2015); construction equipment and tools management practices such as procurement plans for machinery and maintenance of equipment (CII, 2013a); human resource management practices such as crew composition, skill assessment, training, and career development plans (Hewage *et al.*, 2011); health and safety practices including housekeeping, task safety analysis and toolbox meetings (CII, 2013b; Gurmu *et al.*, 2016a).

Previous studies identified the management practices that could improve productivity in infrastructure and industrial construction projects in North America. However, it is possible that none of these practices are appropriate for improving productivity in multi-storey building projects. Also, management practices and their effectiveness would depend on the context such as differences in the resources supply chain within the local market, project type and local regulatory requirements (Bloom and Van Reenen, 2010). Thus, management practices for improving productivity might vary from country to country and across project types. For instance, the use of control system for tool delay is found to be one of the practices that could enhance productivity in industrial projects but the practice is not applicable to improve productivity in infrastructure projects (Caldas *et al.*, 2014). Similarly, construction equipment utility requirement is identified as the practice that could increase productivity in infrastructure projects but not for industrial projects (Nasir *et al.*, 2015).Thus, multi-storey building projects would have different CM practices that could enhance their productivity. Moreover, there is little or no research conducted on what these practices might be and which of them are most significant in the context of multi-storey building projects in Australia. It is theoretically useful to understand which practices are similar and which are different and why. The findings should facilitate international comparison as well as sectoral comparison and provide useful information to companies seeking construction works in Australia. Accordingly, the objective of this research is to identify and prioritize the management practices that have the potential to improve productivity in multi-storey building construction projects in the context of Victoria state, Australia.

Literature review

In Australia, the construction projects can be broadly classified into two: engineering and building. This research focuses on productivity improvement in building construction projects because a significant level of activity occurs in this sector. In June 2016, the values of works done in the Australian building and engineering sectors are 54 and 46 percent, respectively (Australian Bureau of Statistics, 2016b). Building construction projects can be

classified based on the number of storeys. According to Australian Government (2006), a multi-storey building has a rise in storeys of more than three. This research investigates productivity improvement in multi-storey building construction projects as their construction processes are more complex due to the involvement of complex engineering services. The South Australian Department for Communities and Social Inclusion (2016) apartment design guideline states that apartments having two, three, and four storeys are simple to construct whereas towers over four storeys have more complex design and construction systems.

In Victoria state, Australia, most multi-storey building construction projects are managed by a single principal contractor that employs several subcontractors. Principal contractor is a person conducting a business that commissions the subcontractors' work and is authorized to manage, control, and coordinate the construction work at the workplace (Australian Government, 2011) whereas a subcontractor is a person conducting a business that enters into a contract with a principal contractor to undertake specified construction work. In this study, principal contractors are contacted during Phase II of the research as they are responsible for the delivery of multi-storey building projects.

Construction materials management practices

Procurement plan for construction materials and identification of long-lead (critical) materials can be some of the materials management practices that could enhance productivity in multi-storey building projects. Arditi (1985) mentioned the importance of materials procurement plan as the potential area for productivity improvement in the US construction projects. Caldas *et al.* (2014) indicated that preparation of materials procurement plan could enhance productivity in industrial projects. Abdul Kadir *et al.* (2005) recommended that to enhance productivity, the project management team should plan ahead to ensure that the critical materials are identified, procured and available on site every time.

Formation of materials procurement team, controlling the status of materials and maintenance of the received materials could also be considered among the potential materials management practices that could enhance productivity in multi-storey building projects. Nasir (2013) concluded that forming materials procurement team; keeping track of the quantity of the utilized materials and identifying the remaining materials; and preservation of the received materials on construction sites are the practices that have the potential to improve productivity in infrastructure projects. Caldas *et al.* (2014) identified that materials status database and preservation of construction materials are the best practices for increasing productivity in industrial projects in North America.

The use of materials tracking technology, preparation of materials delivery schedule, the availability of materials inspection process and formation of materials inspection team could be some of the potential areas where multi-storey building projects' productivity can be gained. Grau *et al.* (2009) assessed the positive impact of materials tracking technologies on crafts' productivity and quantified the impact of automating, identifying and localizing engineered components on productivity in industrial projects. Nasir *et al.* (2010) confirmed that the implementation of on-site materials tracking technology on industrial projects such as refineries and power plants can increase productivity. Arditi (1985) mentioned that materials delivery plan and schedule are among the potential areas for productivity improvement in construction projects in the USA. Bell and Stukhart (1987) identified materials planning as one of the most critical materials management systems. El-Gohary and Aziz (2014) indicated the importance of materials delivery plan in improving construction projects' productivity in Egypt. Makulsawatudom *et al.* (2004) suggested that careful inspection of construction materials could be one of the potential areas where productivity can be improved in the construction projects in Thailand.

Construction equipment and tools management practices

Procurement plan, preventive maintenance and performance analysis of the construction equipment can be some of the equipment management practices that have the potential to enhance productivity in multi-storey building projects. According to Prasertrungruang and Hadikusumo (2007), good equipment acquisition strategy is one of the success factors in construction projects. Stewart (2002) recommended the preparation of equipment procurement plan to reduce productivity loss due to the shortage of equipment on construction projects. Wireman (2005) described that equipment maintenance has the potential to increase the profitability of contractors by increasing the availability of equipment and by reducing the number of unexpected breakdowns or service interruptions. Crespo Márquez and Sánchez Herguedas (2004) described that good record keeping during the operation of equipment helps contractors to analyze the performance of the machinery and to take corrective actions.

The use of tracking technologies such as bar codes and radio frequency identification (RFID), development of tools and consumables management strategy, and regular maintenance of tools can be some of the tools management practices that could enhance productivity in multi-storey building projects. Goodrum *et al.* (2006) explained the significance of tools availability for productivity improvement and developed a tool tracking and inventory system which is capable of storing operation and maintenance data using RFID tags. Morse (1990) found that authorizing the tool manager to purchase some tools is one of the efficient tool management systems. Preparation of tools and consumables management strategy is recommended as the potential area for productivity improvement in industrial projects (Caldas *et al.*, 2014). Conducting onsite tool maintenance is found to be one of the best practices for improving productivity in infrastructure projects (Nasir, 2013).

Management practices related to construction methods

The use of integrated schedule and adopting different working hours strategies could be among significant practices that could increase the productivity of multi-storey building projects. Arditi and Mochtar (1996) indicated that the combination of cost and schedule control is one of the critical success factors in completing construction projects on time. Hanna *et al.* (2008) found that shift schedule is effective as compared to overtime and overmanning in reducing the project duration. The authors opined that the use of shift schedule reduces physical fatigue and site congestion that could occur if overtime and overmanning practices are implemented.

The use of appropriate project schedule controlling techniques for different activities and preparation of dynamic site layout plan could improve productivity in multi-storey building projects. The controlling techniques include the methods used to measure the work progress, to analyze the data, to report the status and to take corrective actions. Some of the techniques of measurement include units completed, incremental milestone, start/finish, and manager or supervisor judgment (CII, 1990; Attalla, 1997). Dynamic site layout is a sequence of layouts each of which is used for a discrete time interval or for a certain project phase and together covering the entire duration of a construction project (Tommelein and Zouein, 1993).

Construction machinery positioning strategy, project start-up and project completion plans might also be important practices that could enhance productivity in multi-storey building projects. Zhang *et al.* (1999) developed a computer model to optimize the location of a group of tower cranes. Kerzner (2010) proposed project kick-off meetings as one of the best practices that should be included in the project start-up process. Nasir (2013) found that project start-up plan, project completion plan, and innovations and new technologies are some of the best practices that could enhance productivity in infrastructure projects.

Preconstruction phase management practices

The use of short interval plans, assignment of a dedicated planner and preparation of manageable construction work packages could be some of the practices that could increase

productivity in multi-storey building projects. Short interval planning denotes the production planning having a time frame which usually spans between two to six weeks in which activities are broken down into the level of operations (Hamzeh *et al.*, 2008). Waly *et al.* (1999) suggested that short interval plans can increase productivity by reducing the nonproductive hours due to waiting for the resources. CII (2013b) identified the employment of committed planners as the potential areas for improving the productivity in infrastructure projects. Nasir (2013) verified that the implementation of the practice construction work package can enhance productivity in infrastructure projects in North America.

Well-defined scope of works, selection of appropriate construction contract types, use of software in preparing the construction work packages and development of 3D models could improve productivity in multi-storey building projects. Defining the scope refers to the development of a common understanding as to what to include or exclude from a certain work package (Turbit, 2005). Liao (2008) concluded that industrial projects with better scope definition also have better productivity. Arditi and Mochtar (1996) suggested that CM contracting is the preferred delivery method to increase productivity in Indonesian construction projects. Rojas and Aramvareekul (2003) recommended the enhanced use of IT systems in construction projects as one potential area for productivity improvement.

Conducting buildability review, adjustment of the utility lines and identification of the local regulatory requirements could also enhance productivity in multi-storey building projects. Poh and Chen (1998) confirmed the positive relationship between productivity and buildability. The authors investigated the buildability of 37 building projects in Singapore and found that projects with higher buildability reviews have also higher productivity. CII (2013b) identified that utility alignment and regulatory requirement are the best practices that can increase productivity in infrastructure projects.

Human resource management practices

The amount and timeliness of remuneration, incentive schemes, non-financial incentives, organizing social activities and preparing the career development plans for construction workers can be some of the human resource management practices that could increase productivity in multi-storey building projects. Kazaz and Ulubeyli (2007) found that incentive payments, adequacy of the workers' payment as compared to others who are working on similar projects, and making payment on time are the most important factors that increase workers' motivation. Luthans (2000) concluded that recognition is one of the most effective leadership tools that improve the performance of employees. Hewage *et al.* (2011) concluded that the construction productivity cannot be improved by not only working hard and fast but also by developing the social skills of workers.

Employees training, crew composition, maintaining the stability of a project's organizational structure, and specifying the duties and responsibilities of construction workers clearly might be important practices that have the potential to improve productivity in multi-storey building projects. Wang *et al.* (2010) found that training for craftsmen can increase productivity by 5 percent, decrease absenteeism by 2.5 percent and turnover by 10 percent. Liberda *et al.* (2003) identified crew composition and team spirit as the critical practices influencing productivity. Caldas *et al.* (2014) identified that maintaining the stability of organizational structure can enhance construction projects' productivity.

Conducting exit interviews, skill assessment and evaluation, and retention plan for experienced personnel can also increase productivity in multi-storey building projects. Kazaz and Ulubeyli (2007) suggested that conducting regular interviews and understanding problems of the construction workers are some of the socio-psychological factors that influence the productivity of construction projects. Exit interviews, and skill assessment and evaluation are found to be the best practices for increasing productivity in

infrastructure projects (CII, 2013b). Hong *et al.* (2012) concluded that employee empowerment, training and development, appraisal system and compensation are the principal factors for employee retention.

Safety and health practices

Preparation of safety and health policy, as well as safety and health plan could enhance productivity in multi-storey building projects. Safety and health policy is a written statement which shows the commitment of a construction company's management and workers to health and safety and aims to reduce the risks to the safety and health of construction workers, visitors, and others who might be affected during the construction process (Worksafe Tasmania, 2016). Sawacha *et al.* (1999) found that organizational policy on safety is the most dominant factors that influence the safety performance of construction projects in the UK. Workplace health and safety plan is a written plan that sets out the arrangements for managing the site health and safety matters (Safe Work Australia, 2011). Accordingly, the plan includes project-specific specific safety and health rules and the procedures to be followed in receiving, assessing, monitoring and reviewing the safe work method statements (SWMSs).

Preparation of SWMS for high-risk construction activities, conducting hazard analyses for activities with no SWMS, providing safety and health training, toolbox safety meetings, regular housekeeping, and alcohol and substance abuse testing programs could positively influence productivity in multi-storey building projects. Nasir *et al.* (2015) found that hazard analysis, and drugs and alcohol testing programs are the two practices that can improve productivity in infrastructure projects. Jergeas (2009) suggested that safety training can play a significant role to improve productivity in oil and gas projects in Canada. Toolbox safety meeting is found to be the best practice that can increase productivity in industrial projects (CII, 2013a). Hinze and Wilson (2000) indicated that conducting alcohol and substance abuse programs is one of the mechanisms to achieve zero accidents in construction projects.

Research methodology

This study uses exploratory sequential mixed methods research design involving a combination of qualitative and quantitative data in two phases. Mixed research designs have been classified into three categories: convergent parallel, explanatory sequential and exploratory sequential (Creswell, 2013). In convergent parallel mixed methods, the researcher collects both qualitative and quantitative data, analyses them separately, and then compares the results to see if the findings confirm or disconfirm each other. Explanatory sequential mixed methods involve a two-phase project in which the researcher collects quantitative data in the first phase, analyses the results, and then uses the results to plan or build on to the second qualitative phase. In exploratory sequential mixed methods, the researcher first begins by exploring with qualitative data and then uses the findings in a second quantitative phase. The qualitative phase may be used to build an instrument that best fits the sample under study, to identify appropriate instruments to use in the follow-up quantitative phase or to specify variables that need to go into a follow-up quantitative study (Creswell, 2013). In this research, the exploratory sequential mixed methods are used because CM practices identified by previous studies might not be applicable to the Victorian construction industry and there could be other practices that are specific to local industry. Thus, exploratory study is conducted first by collecting and analyzing qualitative data obtained from interviews during the first phase. To prioritize the practices and to generalize the findings, quantitative data are collected and analyzed during Phase II of the research.

Data collection and analysis techniques

The objective of the study is "to identify and prioritize the management practices that have the potential to improve productivity in multi-storey building construction projects in the context of Victoria state, Australia." In order to address this objective, data relating to the management practices were collected in Phase 1 using interviews. Nineteen professionals who have experience in delivering multi-storey building projects in Victoria state were interviewed. They have a 5-40 years' work experience and have been working as general manager, construction manager, project manager, project coordinator, project engineer, site engineer, contract administrator, supervisor, and cost manager. The experts were selected based on their experience in working for subcontractors and principal contractors that are involved in the construction of multi-storey building projects in Victoria state, Australia. A snowballing technique was used to select the participants for the interviews. In this technique, some experienced building construction experts were contacted first and the researcher asked them to nominate other experienced professionals who can participate in the interviews. The semi-structured interview questions comprise lists of CM practices that have the potential to improve productivity in construction projects. For each proposed practice, the questions include: Does this practice exist? How is it practiced by local contractors? Does this practice improve productivity in multi-storey building construction projects? What other practices enhance productivity in multi-storey building construction projects? How do you measure productivity in multi-storey building projects? Each interview lasted for an average of 1.5 hours. The interviews were conducted until the data analysis reached a saturation point. Saturation refers to the point where similar reasons for accepting or rejecting a particular practice were given by the participants.

The analysis of the qualitative data was conducted in three concurrent steps: data reduction, data display, and conclusion (Rose *et al.*, 2015). Data reduction is a form of analysis that sharpens, sorts, focuses, discards, and organizes data in a way that final conclusions can be drawn (Miles and Huberman, 1994). Writing summaries, coding, and making clusters are common methods used in data reduction process. The latter two methods are more suitable when the research is entirely inductive in nature. In this study, writing summary was used as a technique to reduce the transcribed interviews. The reduced data were displayed using matrices, graphs, charts and networks. In this research, matrix technique was used as it is suitable to display the summaries of the responses in matrix boxes. Once the data are displayed, the conclusion is drawn by either noticing the patterns of similarities and differences between categories and/or processes, clustering, making contrasts and comparisons and noting relations between concepts (Rose *et al.*, 2015). During the analysis, the audiotaped interviews were first transcribed and a matrix was prepared in Excel spreadsheet to match the responses of an expert and the CM practices. A summary of each interview result was written in a matrix box and conclusion was drawn for each practice. Similar iterative procedures were used for all the interview results. The similarity between the successive summaries was observed to find saturation point. After analyzing the outcome of the 15th interview, similar explanations for the CM practices that have the potential to improve productivity in multi-storey building projects were observed. Although the saturation point was reached at the 15th interviewee, more interviews were conducted until the 19th participant for the sake of validating the saturation point. Finally, the output of the first phase was used as input to the second phase which comprised quantitative data collection and analysis. The CM practices that were described as suitable to improve productivity in multi-storey building projects by the participants were included in the list for the industry-wide survey.

Quantitative data were collected using interview questionnaire survey whereby the survey was self-administered. Respondents were asked the questions face-to-face and requested to write their answers (Fowler and Cosenza, 2009). The approach can increase the

response rate and in this study it allowed the researchers to clarify issues during the survey. The questionnaire consists of a list of CM practices identified during Phase I and the respondents were asked to rate the relative importance of the practices in enhancing productivity in multi-storey building projects. A response scale of 1-5 was used in order to achieve optimum reliability and validity (Jamieson, 2004; Lozano *et al.*, 2008). In the rating, 1 = not important; 2 = slightly important, 3 = somewhat important, 4 = very important, and 5 = extremely important.

Principal contractors involved in Phase II of this research were selected from the registry of the Victorian Department of Treasury and Finance. The Department maintains a list of contractors that are pre-qualified to provide different construction activities (Department of Treasury and Finance, 2015). They have been assessed against a range of management, technical and financial pre-qualification criteria to ensure they meet the high standards required of government suppliers. According to the department's requirement, firms applying for pre-qualification must demonstrate that they have the management capability, qualifications, expertise, experience, technical, and financial capacity to deliver construction projects successfully. Accordingly, 39 principal contractors on the list having experience in constructing multi-storey building projects were selected and all of them participated in the survey. The persons directly responsible for the construction of a multi-storey building project by these companies were contacted and were the respondents. They were construction directors, operation managers, construction managers, project managers, project coordinators, and site managers. The letters explaining the objectives of the research and the benefits of participating in the research were sent to the respondents via e-mail and in person. The researchers then sent follow-up emails and phone calls requesting the participation and setting suitable time and places for the interviews. The results of the study can be generalized because the sample size of 39 represents all potential contractors that have the capability to execute multi-storey building projects. Thus, the sample size is adequate to enable a valid conclusion to be drawn.

Data analysis, findings and discussion

In Table I, the summary of the interview results for the CM practices that could enhance productivity in multi-storey building projects is presented. For the sake of brevity, all the interview results are not included in the table.

Identification of construction materials management practices enhancing productivity in multi-storey building projects

Six construction materials management practices are identified. These are procurement plans for materials, long-lead materials identification, materials status database, materials delivery schedule, material inspection process, and materials inspection team. However, the practices materials' procurement team, on-site materials tracking technology, and post-receipt preservation and maintenance of materials are not applicable to improve the productivity of multi-storey building projects in the context of Victoria state, Australia.

The interview participants explained that in most multi-storey building projects in Victoria, materials' procurement plan, which is based on the main construction program, is developed by the principal contractor and provided to the subcontractors. Some interviewees described that after collecting information such as the location of the manufacturers (overseas/local), the time it takes to manufacture materials and the duration of the delivery of materials, the contractors prepare the procurement plan.

The interviewees explained that identification of long-lead items and preparation of the package leading program or a program that is prepared to suit the long-lead items is essential to enhance productivity. Some participants described that requesting tenderers to submit

Management Practices Category	Elements	Summary	Conclusion
Construction materials	Long-lead materials identification	"Usually, the long lead materials are façade, tiles, and services such as lifts, generators, boilers; all these key primary elements have long lead times. These items are identified earlier and tabulated. The approximate lead times for these materials are also estimated; for example, tiles from Italy, 8 weeks. In general, most items imported from overseas are categorized as long lead materials"	Applicable
	On-site materials tracking technology	"Materials are not stored on site; they are delivered when required, and tracking technologies are insignificant. When materials are brought to a building construction site, they are placed in a location that is very close to where they will be installed"	Not applicable
Construction equipment and tools	Construction equipment productivity analysis	"Slow-speed hoist cost less money but it takes longer time, and high-speed hoist lifts materials quickly and saves construction time. For high-rise building, it is recommended to use two high-speed hoists side by side to increase productivity. The time the crane took to place concrete panels or other items is recorded to analyze its productivity. Thus, the practice is essential"	Applicable
	Tools management strategy	"As most of the works which involve tools are done by sub-contractors who bring their own tools, tools management strategy is not important for productivity improvement"	Not applicable
Preconstruction phase	Well-defined scope of works	"The scope of works is prepared before tendering phase and there is a section called scope of works in the contract document, for instance, the facade has its own scope of work, the structure has its own scope of works, finishing and fittings have the scope of works sections. The well-defined scope of works has reference to the drawings and specification, and it is prepared based on the previous scope of works developed for similar projects. There are templates of the scope of works which is used to prepare a site-specific scope of works"	Applicable
Construction methods	Construction machinery positioning strategy	"We sit down and work through a site layout details. It is interrelated with many things such as traffic control plan; access points; the way materials could easily get into the site; the size or the footprint of the job; crane types and number requirements; and the location of the cranes and other issues. We locate cranes for the maximum flexibility; we position them to get as much coverage as we can. Thus, integrating and developing a strategy for positioning cranes is critical for productivity"	Applicable
Human resource management	Skill assessment and evaluation	"Most principal contractors assess the competency of their subcontractors. The subcontractors should have the proper training to do a specific task. For instance, scaffolding work should be done by licensed scaffolder; workers should have dogging and rigging licenses before starting cranes related	Applicable

(*continued*)

Table I.
Summary of the interview results

Management Practices		Summary	Conclusion
Category	Elements		
		job; workers should also have safety and health induction cards to demonstrate their competencies"	
Safety and health	Safety and health policy	"Many contractors have safety and health policy at company and project levels. Some of them have accredited workplace health (WHS) management systems. The project specific policies are clearly displayed on sites, and workers are informed during the induction process. Some principal contractors also provide copies of their safety policies to their subcontractors"	Applicable

Table I.

quotations for materials including the source and lead times is essential to identify the critical materials easily. Preparing the material status database is also found to have a positive impact on productivity. The respondents explained that the principal contractor gets a report from the subcontractors about their progress and the project manager reviews the subcontractors' progress reports and prepare the material status report for each work package.

On-site materials tracking technology is found to be insignificant practice for enhancing productivity in multi-storey building projects. The interview participants described that as most building materials are not stored on building project sites due to the shortage of storage spaces, the use of tracking technology is not applicable. They explained that all materials are not brought to a building site and stored on the site; the materials are delivered when they are needed and placed close to their installation areas. "The practice of post-receipt preservation and maintenance is not considered as a good practice for improving multi-storey building projects productivity." The interviewees explained that as most building materials are not stored on site, the implementation of the practice is not recommended.

Identification of equipment and tools management practices enhancing productivity in multi-storey building projects

Construction equipment procurement plan, construction equipment productivity analysis, and construction equipment maintenance are found to be the three construction equipment management practices that have the potential to improve productivity in multi-storey building projects. The interview results revealed that preparing plan for either leasing or hiring of construction equipment has a positive impact on productivity. Some interviewees explained that cranes and hoists are the most frequently used equipment in multi-storey building projects and lack of proper procurement procedures could negatively influence productivity. Other respondents explained that a subcontractor involved in structure works provide crane and the principal contractor negotiate on how the crane is used by other subcontractors. Principal contractors can also identify any equipment required for execution of a particular task and include in the subcontract agreement.

According to the interviews, the productivity of a crane is analyzed by considering its speed in lifting materials and the source of power. For instance, since electric crane does not make noise, contractors can start their works early in the morning without disturbing neighbors. However, if it is a diesel crane, they could not start early as the crane's engine is noisy. The contractors should start work as per the permission provided to them by the city council. Cranes that have fast speed and capable of lifting maximum weight to be lifted at a particular multi-storey building project are preferred. For a mobile crane, weather conditions are also considered. Contractors need to look at weather forecasts before bringing the crane to the site or signing an agreement with the crane hiring company.

Identification of management practices related to construction methods

Ten management practices that are related to construction methods and enhancing the productivity of multi-storey building projects are identified. These include integrated schedule, work schedule strategies, schedule control, dynamic site layout plan, traffic control plan, site security plan, machinery positioning strategy, project start-up plan, project completion plan, and innovations and new technologies.

Construction schedule that integrates work, materials' procurement and delivery, machinery, subcontractors, financial and other schedules has a positive impact on the productivity of multi-storey building projects. The interviewees explained that if work schedule is integrated with material and machinery schedules then the project teams are aware of when a particular activity is done, what type of machinery should be hired, how much material and manpower should be deployed, and also track the delivery of materials. Developing suitable working hours strategies are found to be an essential practice that can increase productivity. There are working hour restrictions imposed by various city councils in Victoria and contractors are required to develop a strategy to reduce project delays. The participants explained that most contractors use the calendar prepared by Construction, Forestry, Mining, and Energy Union (CFMEU), which is typically 36 working hours per week. They schedule to work either four, five or six days per week and sign contracts with their subcontractors accordingly. Some respondents explained that on Saturdays, they reduce the working hours to 50 percent as the productivity of the workers could decrease.

The use of dynamic site layout plan is found to be an essential practice. Some interviewees described that the site plan is constantly changing for the sake of productivity. They explained that the gates in and out of the building site, for instance, might be changed depending on the construction phases. They suggested that the gates should be planned to allow easy movement of trucks and workers. The respondents also recommended that it is good practice to have two gates for a building project during earthworks. Construction machinery positioning strategy is found to be a practice that positively influences productivity in multi-storey building projects. According to the interviews, the critical machine for these projects is a tower crane and its location is planned by considering the maximum weight to be lifted, distance from the street from which materials are lifted, the area of a building under construction and distance from existing buildings.

Identification of preconstruction phase management practices enhancing productivity in multi-storey building projects

The interview results revealed ten preconstruction phase management practices that have positive impacts on the productivity of multi-storey building projects. These comprise well-defined scope of works, short interval plan, buildability review, construction work packages, regulatory requirement, contract types, use of software in planning work packages, utilities alignment, dedicated planner, and model development.

Well-defined scope of works is found to be one of the significant practices. Some participants described that if uncertainties in the scope of works are reduced, the productivity of building projects increase as subcontractors are confident on what they do and when they do a certain activity. They explained that defining the scope of works involves clarifying in words what each subcontractor needs to do. Preparation of short interval plan has also a positive impact on productivity. The interviewees described that the plan clearly shows the daily activities together with the resource requirements. Some respondents explained that the short period look-ahead programs help to focus the job at hand.

Buildability review is also found to be an essential practice to enhance productivity in multi-storey building projects. Some interviewees suggested the procedures that could facilitate the review of drawings before issuing to a site. They described that when a

consultant issues a drawing, the document controller receives and hangs the drawings using colored (red) sticks. Project coordinators, design manager, project manager, and services managers review the drawings on the sticks and send back for revision to the consultant. The respondents recommended that drawings should be reviewed by the project team for compliance with the design brief, for any scope changes which has a major impact on cost, and for the purpose of constructability.

The practice of preparing manageable construction work packages is found to be one of the factors which positively influence the productivity of multi-storey building projects. The interviewees explained that building projects' work packages are developed by considering the skill and financial capacity of the local subcontractors. The project team breaks down the building works to suit the capacity of subcontractors, to get a reasonable price for the work packages, and to increase productivity. Some respondents described that the principal contractors do not want to break a project into very small packages that do not worth subcontractors to tender. They suggested that bigger packages provide an incentive for subcontractors to work faster.

Identification of human resource management practices enhancing productivity in multi-storey building projects

In all, 11 human resource management practices that have the potential to enhance productivity in multi-storey building projects are identified. These include clear delegation of responsibility, stability of organizational structure, crew composition, retention plan for experienced personnel, employees training, skill assessment and evaluation, career development, financial incentive programs, social activities, non-financial incentive programs, and exit interviews.

Clear delegation of responsibility is found to be one of the practices that could enhance productivity in multi-storey building projects. The interviewees suggested that the responsibility of employees should be clarified at the beginning of a project. However, as the project progresses, people's role could change and the changes are notified through team meetings. Some participants explained that the roles and responsibilities of each employee are emailed to all members of the project team. Other respondents indicated that conducting a meeting to clarify employees' roles and responsibilities prior to starting a project is essential.

Maintaining stability of the organizational structure of a multi-storey building project also enhances productivity. The interviewees suggested that an employee who is a member of the original project team should not leave the job if the stability of the organizational structure is to be maintained. Some interviewees explained that employees who are working on a project starting from its commencement date have better project information. Retention plan for experienced personnel is also found to be an essential practice that should be implemented to improve productivity in multi-storey building projects. The interviewees described that experienced workers in construction are highly valued as they have knowledge about construction methods, codes, standards and relevant regulations. The respondents explained there are several regulatory changes in the building industry which could affect productivity and knowledge about these issues is crucial. Some interviewees suggested internal promotion as a mechanism to retain experienced construction personnel. According to the interviews, internal promotion helps to reduce the cost of recruitment and to retain knowledge which helps contractors to be competitive.

Identification of safety and health practices enhancing productivity in multi-storey building projects

Safety and health policy, safety and health plan, hazard analysis, SWMS, toolbox safety meetings, housekeeping, and safety and health training are among the seven safety

and health practices that have the potential to enhance productivity in multi-storey building projects. The practice drugs and alcohol testing program is considered to be inapplicable.

Safety and health plan is one of the crucial safety and health practices that influence productivity in multi-storey building projects. The interviewees explained that some contractors focus on engineering controls than on administrative controls to reduce accidents. The respondents described that the administrative controlling method lists the items that should be checked prior to executing the work and the engineering controlling method involves load calculations and recommend the materials to be used to ensure the safety of the workers. According to the interviews, in some building projects, there are rewards for employees who achieved zero accident. Other respondents stated that in some building projects, contractors plan not to exceed a specified value of lost-time injury frequency rate (LTIFR). The LTIFR is computed for the previous projects and used as a benchmark to prepare target LTIFR for new projects. The lost-time injury is any occurrence which results in a permanent disability, fatality, and/or time lost from work of one day or shift or more, and LTIFR is the number of occurrences of injury in a specified period for each one million hours worked (Worksafe Australia, 1990).

The implementation of SWMS is also one of the critical safety and health practices. The interviewees explained that SWMS is prepared by conducting safety analysis for any task that is classified under high-risk construction works. Accordingly, to prepare the SWMS, the activities involved and the procedures for execution of the task are outlined; potential hazards are identified; mechanisms for minimizing or eliminating the risks are proposed; and a person who monitors the compliance with the SWMS is assigned. Some interviewees described that, on some projects, SWMS can also be prepared by subcontractors and approved by a principal contractor. Other respondents stated that safety audit, every six months or every year, is conducted in the presence of a safety representative from a principal contractor's head office.

Relative importance of the CM practices

The questionnaires collected during Phase II were analyzed to assign weights to the CM practices identified in the interviews and to rank them accordingly. Relative importance index (RII) and mean value can be used for ranking purpose. According to Lam *et al.* (2007), both methods produce similar rankings but RII method is used to derive relative indices within the range of 0-1 which makes the relative comparisons of different variables easy. Holt (1997) explained that many researchers in CM prefer RII as the relative comparison of variables whose indices less than or equal to one is easier to perceive. This research adopted RII technique as it is suitable for ranking purpose. The following equation was used for RII computation (El-Gohary and Aziz, 2013):

$$\mathrm{RII} = \frac{5(n5)+4(n4)+3(n3)+2(n2)+n1}{5(n5+n4+n3+n2+n1)} \quad (1)$$

The number of respondents who selected 1 for "not important," 2 for "slightly important," 3 for "somewhat important," 4 for "very important," and 5 for "extremely important" practice to improve productivity in multi-storey building projects are shown as n_1, n_2, n_3, n_4, and n_5, respectively.

The relative importance indices of the CM practices are indicated in Table II. Accordingly, well-defined scope of works with RII of 0.96 is found to be the most significant practice that has the potential to enhance productivity in multi-storey building projects. Safety and health policy (RII = 0.95) is ranked second, safety and health plan (RII = 0.92) and hazard analysis (RII = 0.92) are both ranked third. All the safety and health related

Construction management practices	RII	Rank	Category
Well-defined scope of work	0.959	1	Preconstruction phase
Safety and health policy	0.949	2	Safety and health
Safety and health plan	0.923	3	Safety and health
Hazards analysis	0.923	3	Safety and health
Long-lead materials identification	0.918	5	Materials management
Safe work method statement	0.913	6	Safety and health
Toolbox safety meetings	0.908	7	Safety and health
Housekeeping	0.887	8	Safety and health
Safety and health training	0.887	8	Safety and health
Short interval plan	0.877	10	Preconstruction phase
Buildability review	0.877	10	Preconstruction phase
Construction work packages	0.856	12	Preconstruction phase
Traffic control plan	0.851	13	Construction methods
Project start-up plan	0.851	13	Construction methods
Regulatory requirement	0.851	13	Preconstruction phase
Procurement plans for materials	0.846	16	Materials management
Clear delegation of responsibility	0.836	17	Human resource management
Project completion plan	0.826	18	Construction methods
Machinery positioning strategy	0.821	19	Construction methods
Dynamic site layout plan	0.815	20	Construction methods
Stability of organizational structure	0.815	20	Human resource management
Construction equipment maintenance	0.790	22	Equipment management
Contract types	0.774	23	Preconstruction phase
Schedule control	0.769	24	Construction methods
Crew composition	0.769	24	Human resource management
Use of software in planning work packages	0.764	26	Preconstruction phase
Retention plan for experienced personnel	0.764	26	Human resource management
Utilities alignment	0.759	28	Preconstruction phase
Materials delivery schedule	0.749	29	Materials management
Employees training	0.749	29	Human resource management
Skill assessment and evaluation	0.738	31	Human resource management
Work schedule strategies	0.733	32	Construction methods
Site security plan	0.733	32	Construction methods
Career development	0.708	34	Human resource management
Material inspection process	0.697	35	Materials management
Procurement plan for construction equipment	0.692	36	Equipment management
Financial incentive programs	0.672	37	Human resource management
Social activities	0.672	37	Human resource management
Materials status database	0.662	39	Materials management
Integrated schedules	0.656	40	Construction methods
Non-financial incentive programs	0.651	41	Human resource management
Innovations and new technologies	0.636	42	Construction methods
Dedicated planner	0.610	43	Preconstruction phase
Construction equipment productivity analysis	0.605	44	Equipment management
Exit interviews	0.574	45	Human resource management
Materials inspection team	0.569	46	Materials management
Model development	0.538	47	Preconstruction phase

Table II.
The relative importance index of the construction management practices

practices are ranked with the within the top ten which imply that safety and health practices are more important in improving productivity in multi-storey building projects. To check the difference in the weights of the CM practices, Friedman test is conducted since the data do not fulfill the assumption of the parametric test (normality). Accordingly, a Friedman test for all practices indicates a p-value less than 0.001. The finding implies that there are significant differences among the weights of some of the practices.

The Friedman test for the top seven practices shows a p-value of $0.16 > 0.05$. This indicates that the practices well-defined scope of work, safety and health policy, safety and health plan, hazard analysis, long-lead materials identification, SWMS and toolbox safety meetings are equally important to improve productivity in multi-storey building projects. The finding suggests that these seven practices should be implemented jointly to enhance productivity.

The average weight for safety and health practices = 0.91, for preconstruction phase management practices = 0.79, for management practices related to construction methods = 0.77, for construction materials management practices = 0.74, for human resource management practices = 0.72, and for construction equipment management practices = 0.70. Accordingly, the safety and health practices are ranked first, preconstruction phase management practices are ranked second, management practices related to construction methods are ranked third, construction materials management practices are ranked fourth, human resource management practices are ranked fifth, and construction equipment management practices are ranked sixth. The finding indicates that implementation of safety and health practices is crucial to increase productivity in multi-storey building projects in the context of Victoria, Australia. Construction equipment management practices are found to be less important for enhancing productivity in multi-storey building projects. This could be due to the nature of building projects as compared to other engineering projects (industrial and infrastructure projects). They are the least equipment intensive and the implementation of equipment management-related practices are found to be less significant for increasing their productivity.

The finding shows that all safety and health practices are included in the top ten. This could be due to the presence of several occupational safety and health regulations at both state and national levels which oblige contractors to implement safety and health practices. Failure to comply with these regulations results in financial penalty and suspension of the construction work which is one of the causes for the loss of productivity. For instance, Work and Health Safety Regulations 2011 Section 6.5 article 316 and 317 explain the requirement of safety training and associated penalty ($18,000 AUD) for non-compliance. Section 6.3 Article 299 and 300 of the regulation also stipulate the obligations of a contractor to prepare SWMS and the penalty associated with non-compliance ($30,000 AUD). In Victoria, the Occupational Health and Safety Regulations 2007 article 5.1.20 and 5.1.22 oblige contractors to ensure that their employees are trained and specify fines up to 500 penalty units. Thus, contractors operating in Victoria state, Australia, give priority for the implementation of safety and health practices.

The presence of strong CFMEU could also oblige the implementation of the safety and health practices. The construction work could be suspended if a building site is not safe. The employees elect the health and safety representatives (HSRs) who have the power to issue Provisional Improvement Notice (PIN) and to cease work when there are urgent issues that are immediate threats to the health and safety of any person (CFMEU, 2016). According to article 60 of the Occupational Health and Safety Act 2004, the HSR's can issue the PIN to the contractor to remedy any contravention of the provisions of the act. Failure to comply with the PIN can result in 2,500 penalty units. Furthermore, article 74 of the act authorizes the HSRs to direct the suspension of the construction work if the work involves an immediate threat to the health or safety of any employee. Hence, contractors involved in the construction of multi-storey building projects in Victoria state, Australia, give priority to the implementation of safety and health practices.

Conclusion

In total, 47 CM practices that have the potential to improve productivity in multi-storey building projects are identified and prioritized. Well-defined scope of work, safety and health policy, safety and health plan, hazard analysis, long-lead materials identification,

task safety analysis and toolbox safety meetings are found to be the top seven practices. The finding indicates that the seven practices are equally significant, and they should be jointly implemented to enhance productivity in multi-storey building projects. The finding of this study also revealed that safety and health related practices are the most significant practices. However, construction equipment management practices are the least important management practices for enhancing productivity in multi-storey building projects. Future researchers can investigate the correlation between labor productivity and the management practices in multi-storey building projects in other contexts. Furthermore, the association between activity level productivity and the management practices can be studied.

This study has practical implications for contractors in Australia and other countries. Contractors involved in the delivery of multi-storey building projects in Victoria state, Australia, can implement the identified CM practices to improve productivity in their projects. Contractors in other countries can also implement the identified practices to enhance the productivity of their multi-storey building projects. However, as the practices could vary from country to country, validation is required to adapt to any local context.

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