Engineering, Construction and Architectural Management

Number 2

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Planning and controlling design in engineered-to-order prefabricated building systems

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Abstract

Purpose – The purpose of this paper is to propose a model for planning and controlling the design process in companies that design, manufacture and assemble prefabricated engineer-to-order (ETO) building systems. This model was devised as an adaptation of the Last Planner® System for ETO multiple-project environments.

Design/methodology/approach – Design science research, also known as prescriptive research, was the methodological approach adopted in this research. An empirical study was carried out at the design department of a leading steel fabricator from Brazil, in which the proposed model was implemented in six different design teams.

Findings – The main benefits of the proposed model were shielding design work from variability, encouraging collaborative planning, creating opportunities for learning, increasing process transparency, and flexibility according to project status. Two main factors affected the effectiveness of the implementation process: commitment and leadership of design managers, and training on design management and project planning and control core concepts and practices.

Research limitations/implications – Some limitations were identified in the implementation process: similarly to some previous studies (Ballard, 2002; Codinhoto and Formoso, 2005), the success of constraint analysis was still limited; some of the metrics produced (e.g. ABI, causes of planning failures) have not been fully used for process improvement; and systematic feedback about project status was not properly implemented and tested.

Originality/value – The main contributions of this study in relation to traditional design planning and control practices are related to the use of two levels of look-ahead planning, the introduction of a decoupling point between conceptual and detail design, the proposition of new metrics for the Last Planner® System, and understanding the potential role of visual management to support planning and control.

Keywords Engineer-to-order, Design process, Last planner system, Planning and control, Design teams, Prefabricated building systems

Introduction

Despite the importance of the design process for the success of construction projects, it is widely recognized that not enough attention is given to design planning and control in this industry (Choo et al., 2004; Tribelsky and Sacks, 2010; El Reifi and Emmitt, 2013). Design plans are often limited to a list of design deliverables, produced at the beginning of design process (Choo et al., 2004). The ineffectiveness of design planning and control results in poor coordination between disciplines, unbalanced resource allocation, insufficient information available to complete design tasks and delays in the delivery of design information to
downstream processes, among other problems (Koskela et al., 2002; Ballard, 2002; Tribelsky and Sacks, 2010).

Indeed, design planning and control is often carried out informally (Tzortzopulos et al., 2001; Koskela et al., 2002). This is partly due to the fact that traditional construction planning techniques, such as work breakdown structure, critical path method and earned-value method, tend to be ineffective for design (Austin et al., 1994). Those techniques are not able to cope with the high level of uncertainty and the iterative nature of design and the complex interdependences that exist amongst design disciplines (Austin et al., 2010; Koskela et al., 2002). In fact, iterative processes are necessary and beneficial as these may add value to a project, but should be controlled in order to avoid serious implications in time and cost (Knotten et al., 2015).

The ineffectiveness of design planning and control tends to be more critical in complex projects, i.e. projects that have a high level of structural complexity (e.g. large number of stakeholders and interdependent components) (Baccarini, 1996) and uncertainty related to goals or methods (Williams, 1999). Those projects demand closer integration and better collaboration between construction project participants, especially at the design process (Emmitt and Ruikar, 2012).

Engineer-to-order (ETO) prefabricated building systems can be regarded as complex projects as the customer order penetrates into the design phase of a product, that needs to be perceived, manufactured and assembled to be delivered to the client (Gosling and Naim, 2009). Bertrand and Muntslag (1993) pointed out that a high level of uncertainty exists in ETO environments as it is necessary to define delivery dates when the customer order is placed, even though the product is not completely defined yet.

The integration of planning and control processes from different project stages, such as conceptual design, detail design, fabrication and site assembly, plays a key role in the management of ETO prefabricated building systems. Such integration is important because the project lead-time is usually short, requiring some degree of overlapping between project stages. Ideally, both the design and the production of prefabricated components should be pulled from the site assembly process (Bulhões and Picchi, 2008) in order to keep a low level of work-in-progress, as well as to consider demand variability that typically exists in site assembly (Viana et al., 2013).

Moreover, in large construction projects complexity is also caused by design changes that are demanded by clients and designers after production has already started (Matt, 2014). This is partly due to the fact that large projects often involve many stakeholders, so the ability to coordinate changes across multiple companies is essential to avoid delays (Mello et al., 2015).

A number of planning and control approaches for the design process have been proposed in the literature. Some studies have devised prescriptive models for the whole product development process (PDP) of construction projects, including the design process (e.g. Kagioglou et al., 2000; Formoso et al., 2005). However, those models represent product development at a high level, providing simply an overview of this process, and their use as a reference for planning and control is limited by the fact that they contain very little detail (Tzortzopulos et al., 2001). Austin et al. (2010) suggest the use of the Design Structured Matrix, originally developed by Eppinger et al. (1994), as a core design planning technique. Although this technique is useful for sequencing design activities and identifying design clusters, it has some limitations, such as the little emphasis on control, and the fact that fairly detailed plans need to be generated in the early stages of the process, demanding much effort for revising plans (Tzortzopulos et al., 2001).

Several researchers have reported on successful implementations of the Last Planner® System of Production Control (LPS) in the design process (Hamzeh et al., 2009; Ballard et al., 2009; Kerosuo et al., 2012). Some of the core ideas of LPS seem suitable for the context of
ETO prefabricated building systems: collaborative and decentralized planning seem to be more adequate in highly complex projects (Williams, 1999); it is possible to have confirmation points at the look-ahead planning level, based on information collected in downstream processes in order to deal with uncertainty in demand (Viana et al., 2013); planning and control can be undertaken in a hierarchically organized set of meetings (Hamzeh et al., 2009), making it possible to integrate planning and control among different processes and managerial levels.

However, there seems to be several gaps in the implementation of LPS in the design process, such as: the need to make design planning and control more systematic (Koskela et al., 2002; Hamzeh et al., 2009); the lack of success in implementing look-ahead planning for design (Ballard, 2002; Codinhoto and Formoso, 2005); the need to increase process transparency and, consequently, the involvement of planning team members (Tzortzopoulos et al., 2001); and the need to devise metrics for assessing the impacts of LPS on the design process (Hamzeh et al., 2009). Moreover, none of the previous studies have investigated the implementation of LPS for ETO prefabricated building systems in a multiple-project environment.

The aim of this research is to propose a model for planning and controlling the design process in companies that design, manufacture and assemble ETO prefabricated building systems. This research is relevant due to the need to make the design process in those companies more reliable, by improving the effectiveness of the planning and control process. The model was devised as an adaptation of the LPS for the design process in ETO multiple-project environments, exploring the need to cope with the high degree of variability, to have a short lead-time, as well as to keep a low level of work-in-progress.

Design planning and control in ETO production systems

A common mistake in devising planning and control systems for the design process is to neglect the nature of the design activity, which makes it very different from production.

First, there is much more uncertainty and variability in design. Although it is often possible to take some steps toward improving the initial definition of the problem, by questioning the client and collecting data, some of the customer needs cannot be easily made explicit (Crosby, 1995). Moreover, there are usually conflicting requirements, demanding an effort to manage trade-offs, and some decisions must be made without complete information (Kamara et al., 2002).

Second, there is much more iteration in design, as the attention of the designer oscillates between understanding a problem and search for a solution (Austin et al., 2010; Cross, 2008). Although there is a hierarchical structure of decisions, from overall concepts to details, most designers move freely between different levels of detail, especially in the early stages of design (Cross, 2008).

Third, design work tends to expand to the time available (Reinertsen, 2009). As a result, design tasks tend to be finished either on time or late: if a satisfactory solution is found early, then the available time is used to refine the solution (Ballard, 2000).

Therefore, the development of planning and control systems for design must consider that this is an ill structured, solution-focused, highly iterative and opportunistic process, and that the steps for producing a design solution cannot be pre-established at a very fine level of detail (Cross, 2008).

In ETO production systems, as products are custom-made and one-of-a-kind, there are three main types of uncertainties (Bertrand and Muntzlag, 1993): as the product needs to be engineered at the start of a project, some decisions, such as capacity, lead-time, and price needs to be taken under uncertainty; it is difficult to make a detailed demand forecast in terms of mix and volume; and it is also difficult to make an estimation of the type and amount of resources required.
One way of dealing with uncertainty in planning and control systems is to establish different hierarchical levels. The literature often suggest three planning levels: long-term planning, which is concerned with setting objectives (Laufer and Tucker, 1987); medium-term planning, which is mostly concerned with the means for achieving those objectives, such as determining what to work on, and who will work on it, within existing constraints (Ballard, 2000); and short-term planning, which addresses control by taking whatever actions are required to ensure that the system continues to function toward its goal (Hopp and Spearman, 2008).

Different planning horizons imply distinct planning frequencies, modeling assumptions and levels of detail (Laufer and Tucker, 1987). A major challenge in any planning and control system is to keep consistency between different decision-making levels. In fact, its effectiveness depends on how well it coordinates the different planning horizons (Hopp and Spearman, 2008). Another important aspect is to define which processes will be pushed (release of work based on forecasts) and which ones will be pulled (based on system status) (Hopp and Spearman, 2008).

One of the key practices for managing the design process in ETO production systems is the reduction of design batch sizes, especially at the detail design phase. This allows designers to work simultaneously and iteratively, reducing the total design lead-time (Reinertsen, 2009). This approach contrasts with the traditional sequential design process that is often adopted in construction projects, in which designers are used to work in large batches, usually represented by a pack of design documents (Ballard, 2000). According to Reinertsen (2009), large design batches often result in a large amount of work-in-progress, especially in multiple-project environments.

The LPS is a planning and control model that attempts to deal with uncertainty and complexity by involving crew leaders and lower level management in decision-making (Ballard and Howell, 1997). It can be considered as a combination of pull and push planning. At the end of the short-term planning cycle, an overall assessment of planning effectiveness is carried out, by using an indicator named percent plan complete (PPC), proposed by Ballard and Howell (1997). This is the rate between the number of assignments concluded and the total number of scheduled work packages. The root causes for the non-completion of work packages are identified, so that corrective measures can be implemented.

Research method
Design science research, also known as prescriptive research, was the methodological approach adopted in this study. It is a way of producing scientific knowledge that involves the development of an artifact to solve a real problem (Holmström et al., 2009). In contrast with traditional descriptive research, in which theories need to be validated, this artefact must be assessed against criteria of value or utility (March and Smith, 1995). In this research, the proposed artefact is a model that can be used as a reference for devising design planning and control systems for companies that deliver ETO prefabricated building systems.

This research process was carried out in close collaboration and engagement of the managerial staff of a company, being conducted through a strategy similar to action research. As suggested by Järvinen (2007), this type of action research project fits very well the design science research approach.

This company is a leading steel fabricator in Latin America. It had more than 2,000 workers, three manufacturing plants, and around 200 simultaneous contracts. This study focused on light steel structural systems for warehouse and industrial buildings.

Figure 1 presents an outline of the research design. Phase 1 (October 2011 to April 2012) aimed to understand the existing company process (e.g. metrics, difficulties in performing the work, and compliance with design deadlines) as well as to identify opportunities for improving the design planning and control process. In Phase 2 (May 2012 to January 2013), an initial version of the model was devised and implemented with two detail design teams (T1 and T2).
Due to the initial results achieved by those two teams, the company decided to start a training program devised by the research team, and had the participation of technical staff from the Engineering Design Department (EDD), Planning Department, and Cost Estimating Department (overall around 50 people). The scope included design management, planning and control and client requirements management.

In Phase 3 (December 2012 to March 2013), the model was revised, and its implementation was extended to four other design teams, two involved in conceptual design (T3 and T4), and two involved in detail design (T5 and T6). Phase 4 (February to October 2013) focused on the connections between design planning and control and other planning systems in use by the company, aiming to enhance the final version of the model. At this stage, visual management boards were used to support decision-making. The results of the implementation were discussed in a set of five workshops, carried out along the research project.

At the end of Phase 4, a protocol was devised to assess the degree of implementation of 14 planning and control practices (see results in Figure 7) – that protocol was jointly devised and applied by the research team and design managers from the company. At the end of this stage, as suggested by March and Smith (1995) and Holmström et al. (2009), the benefits and limitations of the model were assessed based on two main constructs, utility and applicability. Those constructs were further divided into evaluation criteria: applicability: effort involved in planning meetings, and understanding of planning and control practices; and utility: shielding design work from variability, encouraging collaborative planning, creating opportunities for learning, increasing process transparency and providing flexibility according to project status.

Table I summarizes the sources of evidence used in each research phase.
Existing planning and control system

The company’s PDP comprised the following processes: sales, cost estimating, engineering design (divided into conceptual and detail design), fabrication, and assembly.

The EDD had nine design teams, which had on average 12 designers each, led by a design manager. This department carried out around 75 projects simultaneously. Four teams were in charge of conceptual design, while five teams carried out detail design. This configuration was adopted in November 2012 as an attempt to improve the EDD performance, by creating a decoupling point between conceptual design and detail design, with the aim of pulling the latter by manufacturing plants. An important change that had been gradually implemented by the company was the reduction of batch sizes. At the detail design, each project was divided into stages (building modules) that could be assembled independently from other batches.

The design process was mostly based on a long-term project plan deadlines (from design to assembly on site) produced by the Planning Department. A weekly design planning meeting was carried out between representatives of the Planning Department and design managers, in an attempt to devise an integrated plan for the EDD. At that meeting, the design managers reported the status of work in their teams, but little was done to increase compliance with deadlines.

Implementation process

Implementation in T1 and T2 teams

In T1, participant observation in short-term planning meetings was carried out in June and July 2012. During that period, only short-term planning was implemented and some
difficulties occurred: planning meetings were often interrupted by other demands; the performance metrics were not well understood by the participants; the level of participation of design team members in the meeting was low; they had difficulties in defining work packages (there was a trend of simply copying from the long-term plan); and the dissemination of information was poor. Those problems were related to the fact that the design manager centralized decisions and information flows.

In T2, participant observations in short-term planning and control meetings were carried out non-stop from August 2012 to January 2013. Team members were strongly involved in the definition of work packages and usually expressed commitments to weekly goals. Furthermore, the causes for the non-completion of work packages were systematically recorded. The design manager’s leadership was identified as a major factor for the successful implementation in T2.

In November 2012, T1 and T2 started systematic planning and control at the medium-term (look-ahead) level (T1 horizon: one month, updated monthly; T2 horizon: four weeks, updated every two weeks). However, it was only partially implemented and much of the effort involved in constraints identification and removal was carried out at the short-term.

In both T1 and T2, the average PPC was considerably high (76 percent and 79 percent), if compared to previous studies on the implementation of LPS in design: 50, 55, and 69 percent in the studies carried out by Tzortzopoulos et al. (2001), Ballard (2002) and Trescastro and Formoso (2006), respectively.

The causes for non-completion of work packages are presented in Table II. In both teams, around 50 percent of causes were external to the company, i.e. related to delays in decision-making by clients. However, there were internal problems in design teams (25 percent in T1, and 19 percent in T2), and also problems related to other departments in the company (26 percent in T1 and 29 percent in T2). This indicated that it was possible to achieve improvements in PPC by improving those processes that were internal to the company. For instance, at the beginning of the implementation process, the main cause for the non-completion of work packages in both teams was the underestimated duration of design tasks. Between January and March 2013, that problem did not happen at all, indicating that the design teams had learned to balance load and capacity, and therefore to make the internal design flow more reliable.

The effectiveness of look-ahead planning was accessed by the constraint removal index (CRI), which was calculated by using the formula:

\[
\text{CRI}(\%) = \frac{\text{NCR}}{\text{NCI}}
\]

where NCR is the number of constraints removed on time; NCI is the number of constraints identified for each period.

<table>
<thead>
<tr>
<th>Design teams</th>
<th>Design phase</th>
<th>Number of weeks</th>
<th>Average PPC (%)</th>
<th>Causes for the non-completion of work packages</th>
<th>Categories of causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Detail design</td>
<td>26</td>
<td>76</td>
<td>Client delay in design decisions: 25%</td>
<td>EDD processes: 25%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Client delay in design approval: 18%</td>
<td>Other company's departments: 26%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Underestimated time: 12%</td>
<td>External to the company: 49%</td>
</tr>
<tr>
<td>T2</td>
<td>Detail design</td>
<td>39</td>
<td>79</td>
<td>Client request for design change: 23%</td>
<td>EDD processes: 19%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Client delay in design approval: 15%</td>
<td>Other company's departments: 29%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Conceptual design delay: 15%</td>
<td>External to the company: 52%</td>
</tr>
</tbody>
</table>

Table II. Short-term design control data for T1 and T2
CRI has been used by several construction companies in Brazil (Oliveira, 2010; Trescastro and Formoso, 2006), and it is similar to other metrics that have been applied for assessing the effectiveness of look-ahead planning, such as the percentage of tasks made ready (Hamzeh et al., 2015). Both NCI and CRI are relevant measures for assessing the effectiveness of look-ahead planning, since it is necessary to be effective in both constraint identification and removal. If both NCI and CRI are higher, PPC tends to be higher.

Figure 2 presents the evolution of NCI and CRI in T1 and T2. The fact that look-ahead planning started to be systematic and had contributions of representatives from different design team members contributed to increase NCI in both teams. However, no trend was identified in terms of increasing CRI. On average, T2 was more effective (CRI 79 percent) than T1 (CRI 55 percent) in constraint removal. It was not possible to compare these results with data from other projects, since CRI has only been used for production control (Oliveira, 2010; Trescastro and Formoso, 2006).

A metric was also proposed to control the adherence of the monthly output of design teams in relation to the batches planned in the long-term plan. This was named as adherence to batch index (ABI):

\[
ABI(\%) = \frac{NWC}{NPW}
\]

where NWC is the number of planned work packages that were concluded; NPW is the number of planned work packages in the long-term plan.

This metric can be adjusted for different time periods, such as a fortnight or a week. It can be used to control the amount of work-in-progress, which is not usually done in LPS. An ABI is highly dependent on the effectiveness of both look-ahead and short-term (commitment) planning. Therefore, the higher NCI and PPC, the higher ABI tends to be. In T2, the average ABI for the period between November 2012 and May 2013 was 66 percent (Figure 3). Although no reference values were found in the literature, it is very unlikely that this indicator gets closer to 100 percent in ETO production systems, due to the high level of uncertainty involved. Similarly, to the PPC metric at the short-term planning level, the main causes for not adhering to the batches that have been planned should be monitored in order to generate information useful for learning.

The main conclusions of this phase were: first, PPC was lower in the first week of the month, especially in T1, which did not adopt a rolling look-ahead plan; second, considering that a relatively large percentage of work packages did not adhere the initial monthly plans (34 percent in T2), there was a need to monitor the execution of work packages that had not been planned, and identify the main causes for their inclusion; third, it was necessary to improve the identification of the causes for the non-completion of work packages; and fourth, there was a need to improve the integrated design planning meetings, when changing demands from downstream processes (fabrication and site assembly) were presented by planning staff to design managers.
Implementation in T3, T4, T5 and T6

Implementation in T3, T4, T5 and T6 faced initial difficulties similar to those of Phase 2: relatively long duration of planning meetings (around one hour), mostly because input data (e.g. architectural design) had not been previously analyzed, making it difficult to estimate the duration of activities; difficulty in breaking down design activities into smaller work packages; difficulty in obtaining information for defining priorities at the look-ahead planning level; lack of understanding of the difference between resource constrains and design interdependencies; and difficulty in identifying the root causes for the non-completion of work packages.

However, during the implementation process, some of those difficulties were overcome due to the active participation and leadership of the majority of design managers in planning meetings. At the end of this phase, the weekly meetings had the duration of around 20 minutes.

Table III presents a summary of the data collected for T3, T4, T5 and T6, including the number of weeks, CRI, PPC, the main causes and their relative importance, and the classification according to the categories of causes. The average PPC for conceptual design teams (T3 and T4) was lower than the average PPC for detail design teams (T5 and T6). This was expected as there is much more uncertainty in early design, due to the need for client approvals. At the end of this phase, T6 was merged with T3, and T3 stopped the implementation of the model, due to lack of support from the design manager.

The analysis of causes for the non-completion of packages indicated several opportunities for improvement within the company, as a large percentage of problems were related to internal processes. For the detail design teams, late conceptual design decisions by the client indicate that the idea of having a decoupling point between conceptual and detail design had not been fully implemented.

The performance of the look-ahead planning was relatively poor among the four teams. CRI ranged from 33 to 75 percent, and T6, which achieved the highest figure, did not perform well in constraint identification – only eight constraints were identified in four look-ahead plans.

Regarding the execution of work packages that had not been planned, these should be considered as normal to some extent due to the nature of the design process, widely discussed in the literature (e.g. Reinertsen, 2009; Cross, 2008). However, as pointed out by Ballard et al. (2009), unplanned assignments should be identified and analyzed in short-term
planning in order to consider them in future planning cycles. The design teams decided to monitor the incidence of those tasks, and take sometimes this type of information to discuss in design meetings. Although no analysis of performance measures related to unplanned tasks has been made in this investigation, design team members consider that monitoring those tasks was useful for highlighting some planning failures, including urgent demands from downstream processes.

The main contributions of this phase for the development of the model include: a joint analysis of performance measures was undertaken for each team with the aim of encouraging improvement – a monthly feedback cycle was suggested for this set of metrics; the use of rolling look-ahead plans was extended to all design teams; the control of design deliveries was improved by monitoring their adherence to planned design batches in the long-term plan, in an attempt to limit the amount of work-in-progress; and the level of standardization of design planning was increased, e.g. creating lists of constraints and categories for the most common causes for the non-completion of work packages.

Integrated medium-term planning and visual management

At Phase 4, the use of visual management boards to encourage collaborative planning and support decision-making was proposed. Two types of boards were used: one that integrates medium-term planning across different design teams; and another one that supports individual team planning meetings and to encourage improvement initiatives. The integrated medium-planning board (Figure 4) was updated weekly at design planning meetings, which had the participation of staff from the planning department.

The planning horizon for conceptual design was four weeks, while in detail design a two-week horizon was adopted, since design batches tend to be smaller in the latter. As mentioned above, the company expected that downstream processes could pull detail

<table>
<thead>
<tr>
<th>Design teams</th>
<th>Design phase</th>
<th>Number of weeks</th>
<th>Average CRI (%)</th>
<th>Average PPC (%)</th>
<th>Causes for the non-completion of work packages</th>
<th>Categories of causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>T3</td>
<td>Conceptual design</td>
<td>5</td>
<td>36</td>
<td>64</td>
<td>Changes in priorities (19%)</td>
<td>EDD processes: 37%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lack of design definitions by clients (19%)</td>
<td>Other company's departments: 16%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Underestimated duration (16%)</td>
<td>External to the company: 47%</td>
</tr>
<tr>
<td>T4</td>
<td>Conceptual design</td>
<td>5</td>
<td>59</td>
<td>61</td>
<td>Changes in priorities (19%)</td>
<td>EDD processes: 40%</td>
</tr>
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<td></td>
<td>Lack of design definitions by clients (19%)</td>
<td>Other company's departments: 33%</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Underestimated duration (16%)</td>
<td>External to the company: 27%</td>
</tr>
<tr>
<td>T5</td>
<td>Detail design</td>
<td>5</td>
<td>33</td>
<td>68</td>
<td>Changes in priorities (24%)</td>
<td>EDD processes: 37%</td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Client request for design change (24%)</td>
<td>Other company's departments: 63%</td>
</tr>
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<td></td>
<td></td>
<td>Lack of design definitions by clients (18%)</td>
<td>External to the company: 0%</td>
</tr>
<tr>
<td>T6</td>
<td>Detail design</td>
<td>4</td>
<td>75</td>
<td>78</td>
<td>Changes in priorities (15%)</td>
<td>EDD processes: 35%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Software related problems (20%)</td>
<td>Other company's departments: 15%</td>
</tr>
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<td></td>
<td></td>
<td>Delays in conceptual design (15%)</td>
<td>External to the company: 50%</td>
</tr>
</tbody>
</table>

Table III. Data for T3, T4, T5 and T6
design work packages. Moreover, a board for managing constraints at design planning meeting was devised.

Figure 5 presents an example of visual device to support the work of individual design teams. That board contains the look-ahead plan (two or four-week horizon, based on the integrated medium-term plan), a list of constraints to be removed, printed copies of short-term plans, and some performance metrics, including PPC and CRI.

The visual boards were useful for EDD and the Planning Department, but also for other departments that were involved in removing constraints, such as sales and cost estimating. After the visual management boards were implemented, the duration of the integrated design meeting was reduced to half a day, making the participation of all design managers possible.

Overview of the design planning and control model
Figure 6 presents an overview of the proposed design planning and control model. It is divided into four hierarchical levels, and contains some key elements of the LPS.

Level 1 is concerned with long-term planning, considering all projects being undertaken by the company, and the capacity of each design team. That plan is produced by the Planning Department, based on deadlines defined in contracts and on the integrated
medium-term design plan, in which monthly goals are established for EDD. ABI is the metric used at this level to control adherence of the monthly output to long-term plans.

At Level 2, a weekly integrated medium-term design planning meeting is carried out, in which the external constraints for design development can be jointly analyzed, supported by visual devices. This meeting should be connected with an integrated meeting between fabrication and assembly, so some information that could change design priorities come from that meeting (e.g. plant idleness, lack of payment by client and assembly delays). At this point, a decoupling point exists between conceptual and detail design. The integrated look-ahead plans are updated weekly, looking four weeks ahead for conceptual design and two weeks ahead for detail design, considering both the targets established in the long-term plan and also the level of work-in-progress for each team. CRI is the main metric used at this level.

Figure 5.
Individual team planning meeting board (including schematic representation of the tool)
A weekly meeting is carried out separately by each design team, supported by visual devices, to produce a medium-term plan at Level 3 (same horizons adopted at Level 2) and a short-term plan at Level 4. In those meeting, an analysis of constraints is performed, and a backlog of sound assignments to be included in the short-term plan is prepared (operational level). CRI is the metric used at medium-term plan. Causes for the non-completion of work packages and PPC are the metrics used at short-term plan.

**Evaluation of the model and discussion**
As mentioned in the research method section, the model was evaluated according to two main constructs: applicability and utility. Figure 7 presents the assessment of the degree of implementation of planning practices in March 2013 (T1, T2, T3, T4, T5 and T6) and August 2013 (T1, T2, T4 and T5).

**Applicability**
In four out of nine design teams, look-ahead and short-term planning meetings were carried out systematically. As pointed out by Ballard (2002) and Kerosuo et al. (2012), systematic planning and constraints analysis allow a better understanding of the design interdependences by the designers. In fact, the degree of implementation of practices 1 and 7 (Figure 7) was high (75 percent). Another evidence of success is the fact that the duration of the meetings was largely reduced along the implementation process: short-term design meetings took around 30 minutes for T1 and T2, and the duration of the integrated look-ahead planning meeting was reduced from two days to half a day.

There were differences between design teams in terms of making planning and control systematic. This was largely due to the impact of design managers commitment and leadership.
In the most successful teams (T2 and T4), the weekly planning meeting was always held, even when the design manager was unable to participate.

Following the suggestions of Tzortzopoulos et al. (2001), Ballard (2002) and Kerosuo et al. (2012), the training program, involving the six design teams, played an important role in disseminating the core design management and project planning and control concepts and practices among those teams. This program also helped to conceive the model, as implementation results were widely disseminated and discussed with representatives of different departments of the company, as suggested by Ballard (2002).

Utility

*Shielding design work from variability.* The main innovation introduced in the design planning and control process was the adoption of two levels of look-ahead planning: first, at a higher hierarchical level, the external constraints analysis was undertaken at the

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**Figure 7.**

Degree of implementation of design planning and control practices in March 2013 and August 2013
integrated design planning meeting; second, internal constraints analysis was carried out each design team. The average PPC (71 percent) for six different teams indicated that basic stability of design work was improved along the implementation process.

In fact, there were evidences that the proposed model was helpful in implementing medium-term planning: the practice “look-ahead planning and control routine” achieved the degree of 75 percent. This was pointed out as a major difficulty in previous studies (Miles, 1998; Tzortzopoulos et al., 2001; Codinhoto and Formoso, 2005; and Ballard et al., 2009). However, the design teams still faced difficulties in performing “systematic removal of constraints” (50 percent in August 2013) and no substantial growth was observed in CRI, especially at the conceptual design stage. Indeed, there was a large number of constraints related to client decisions that were identified late, only at the detail design stage. The strategy of making the design process more transparent to the client, especially at early design stages, was suggested by some design teams as an improvement opportunity related to that problem.

**Encouraging collaborative planning.** The company was also successful in terms of increasing the degree of participation in planning and control. Design team members increased the level of participation in planning meetings over time, and the level of collaboration between different teams increased with the introduction of the integrated design planning level. The practice “participative decision making in short-term meetings” achieved 88 percent. As a consequence, planning became less centralized and designers became more committed in terms of producing weekly design deliverables.

**Creating opportunities for learning.** There were also evidences that the model provided opportunities for learning due to systematic feedback obtained from performance metrics and the opportunities for discussion provided by participative planning meetings. For instance, the reduction in the incidence of the planning failure named “underestimated time” for T1 and T2 indicated that those teams improved their capacity of matching load and capacity.

Some of the feedback provided came from traditional LPS metrics (e.g. PPC, reasons for the non-completion of work packages, total number of constraints per week, and CRI). However, there were other metrics that played a key role in terms of pointing out improvement opportunities: adherence to batch (ABI metric), and monitoring unplanned design activities carried out weekly. In both cases, it is necessary to monitor deviations and also the reasons for it. Despite the importance of monitoring adherence to batch as a mechanism to limit the amount of work-in-progress, it was difficult to implement that measure in all design teams. This is partly due to the traditional practice adopted by the company of measuring design output in terms of weight (in tons).

Another practice related to learning, considered in the evaluation was the “monthly metrics analysis by teams,” with the support of visual boards. Such joint analysis was performed by individual design teams once a month, in a meeting for reviewing the monthly performance. Participant observation in design meetings indicated that the analysis of metrics with the support of the design manager had a motivating role in design teams, although the degree of implementation of this practice was limited (38 percent).

The main improvement at the short-term planning level was performing “corrective actions based on the reasons for non-completion of plans,” from 17 to 50 percent. That practice was much emphasized in the training program and it is often mentioned in the literature as a weak point in the implementation of LPS (Hamzeh et al., 2009).

**Increasing process transparency.** The use of visual management boards was crucial for improving the effectiveness of the implementation process by increasing the availability of the information to support decision-making both at a tactical and operational level. The degree of implementation of the practice “production of a visual long-term plan” was
improved from 50 to 75 percent. Such boards addressed one of the problems identified in Phase 1 of this research: lack of transparency in the design process, creating difficulties for the Planning Department to match the production capacity of EDD. Collaborative planning was also encouraged as more people were aware of project status.

Despite the importance of making visible LPS’s metrics (Ballard, 2002), the existing literature does not report that as being systematic in design planning and control. Additionally, process transparency is particularly important in the context of ETO prefabricated building systems, due to the high level of complexity involved.

Flexibility according to projects status. Some degree of flexibility should be provided by allowing plans to be produced according to project status, due to the high uncertainty involved in ETO production systems. Therefore, some order confirmation points must be established in the planning and control process (Viana et al., 2013), in which activities must be pulled from downstream processes (Hopp and Spearman, 2008).

The fact that the model divides planning and control in four hierarchical levels provides opportunities for revising plans, based on an update of project status. In this respect, the integrated look-ahead design planning meeting played a key role in providing such flexibility, as it involves both design managers, and planning staff that are able to confirm orders from manufacturing and assembly production units. This strategy can only be made effective if design batches are kept small. For that reason, monitoring the adherence to batch size, measured by ABI, can contribute to achieve the necessary flexibility.

Conclusion

The main outcome of this research is a design planning and control model for companies that design, manufacture and assemble prefabricated ETO building systems. In this type of production system uncertainty tends to be high, and many interdependencies exist among different production units, since these share resources (e.g. plants, equipment, crews, etc.).

The model was devised as an adaptation of the LPS for ETO multiple-project environments, being formed by four levels of planning, a set of metrics and visual devices that support communication and collaboration. By using a design science research approach, this investigation has a prescriptive character: the proposed model can be used by companies that deliver prefabricated ETO building systems as a starting point for developing engineering design planning systems.

Several contributions have been proposed to improve the design planning and control process: use of two levels of look-ahead planning, based on the assumption that there are two types of constraints (external and internal) and that these should be dealt with at different hierarchical levels in the company; introduction of the integrated design planning meeting, which is a mechanism to allow plans to be produced according to project status; introduction of a decoupling point between conceptual and detail design, allowing the latter to be pulled by the demands of construction sites and manufacturing plants; extending the set of metrics of the LPS, so that adherence to batch size is controlled as well as the incidence of non-planned work packages, including the causes of failures; and understanding the potential role of visual management to support collaborative planning and joint analysis of metrics in an environment of much complexity.

The implementation of the model indicated that it helps to shield design work from variability, support collaboration among design team members, as well as provide opportunities for learning by providing systematic feedback to decision makers. However, some limitations were identified in the implementation process: similarly to some previous studies (Ballard, 2002; Codinhoto and Formoso, 2005), the success of constraint analysis was still limited; some of the metrics produced (e.g. ABI, causes of planning failures) have not been fully used for process improvement; and systematic feedback about project status was not properly implemented and tested.
Moreover, it must be emphasized that the development of the model was based on a single empirical study, carried out in a company that delivers steel structures. Further work is necessary to test and refine the model in other organizational contexts and also for other prefabricated building systems.

Finally, based on the development of this investigation, some other opportunities for future studies must be pointed out: investigate the role of leadership in medium and short-term planning meetings; explore the use of design batches as planning and control units, instead of design activities or deliverables (e.g. drawings); improve the integration between the different planning levels proposed in the model, such as between design and downstream processes (e.g. manufacturing and site assembly), and between individual and integrated medium-term planning level; further test the use of the metrics proposed in this research work (CRI and ABI), and establish a theoretical basis for analyzing those data; and investigate mechanisms to manage client related constraints at the conceptual design stage.

References


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Construction manager’s technical competencies in Malaysian construction projects

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Abstract
Purpose – Problems of Malaysian construction industry have often been associated, in part to incompetent construction manager (CM) when managing the construction projects. Although various education and training provisions have been introduced, critics argue that the provisions have not been effective. Central in the debate on the adequacy of the CM education and training offered is the answer to the question of “what constitutes the technical competency of the CM?” The purpose of this paper is to present the study that identifies the technical competencies required by the CM to address the question.

Design/methodology/approach – Multi-layered thematic analysis of literature was first carried out to identify the technical competency elements. Then, interviews were undertaken to confirm the elements of competencies. It was followed with questionnaire surveys to test the validity of the technical competencies against different contractors’ category and grade/size.

Findings – The findings suggest that the technical competencies of CM are generic, regardless of the size of construction organisation or the types of projects they undertake. A total of 16 CM technical competencies were identified which include the ability to manage: staff, materials, labour, plant, sub-contractors, safety, money, quality, time, environment, site administration, pre-construction activities, project closeout and handover, third parties, computer literacy, and construction contract.

Originality/value – The findings suggest that generic education and training is possible to develop technically competent CM. It also provides insights to the CM technical competencies which the industry is expecting.

Keywords Construction, Management, Construction planning

Paper type Research paper

1. Introduction
The Malaysian construction industry has always been of enormous significance to the national economy. Since independence in 1957, the industry has contributed to the development of infrastructure facilities needed by the growing population and has been the impetus for economic growth through the creation of value chains across many sectors of the economy, which include the housing, transportation, manufacturing, and financial sectors (Rum and Akasah, 2011). The impact can also be exemplified by industry’s current contribution to the national GDP at 8.4 per cent (Bank Negara Malaysia, 2015). However, the industry has also been plagued with many serious problems such as delays, excessive resource consumption, poor quality, low productivity, delays, wastages, cost overruns, disputes, low technology, overreliance on foreign workers, and sustainability issues (Abdul-Rahman et al., 2006; Sambasivan and Soon, 2007; Bakar and Hassan, 2009; Ibrahim et al., 2010). Most of the problems have been blamed on the inability of the contractors to deliver the projects according to the project objectives (Abdul-Rahman et al., 2006; Sambasivan and Soon, 2007; Bakar and Hassan, 2009; Jabatan Audit Negara Malaysia, 2010a, b; Unit Penyelarasan Pelaksanaan, 2013). Likewise, construction manager (CM) who supposedly play central roles in assisting the contractors have also been criticised for failing to achieve the objectives. The significance of the CM in construction projects was
drawn from the Akintoye (1998) (Hassan, 2005). They commonly stress that CMs are crucial as they are the pivot around which everything else in the construction projects revolves. The CM job is among the most arduous, demanding, and single responsible function in the building process. Although the responsibility and authority in a project are shared with other project personnel, CM is the one who normally has to take the blame if anything goes wrong.

The Construction Industry Development Board (CIDB) Malaysia estimates that there are more than 67,000 contractors and about 58,000 registered CMs in the industry (Construction Industry Development Board Malaysia, 2011). Although the numbers are impressive, their actual level of competency is unknown and very questionable as claimed by Yaman et al. (2015) and Mohammad et al. (2016). The need for the industry to persist in addressing the competency problems of the workforce, including the CM, was already highlighted back in 2006 with the launch of the Construction Industry Master Plan (Construction Industry Development Board, 2007). Despite the many initiatives mooted, results have been poor. The need to continue to address the problem was again raised in the Construction Industry Transformation Programme (CITP) 2016-2020 (Construction Industry Development Board Malaysia, 2015). All along, the education of CM has been provided by the institutions of higher learning, while training is mostly provided by CIDB, with some in collaboration with higher learning institutions and training organisations. CM training is also offered as bespoke in-house training company by contracting organisations.

While new initiatives are being considered to expand the education and training of CM following the CITP, the continuing poor performance of contractors of which the CMs play a major part suggest that there are critical problems in the way their education and training have been offered (Bakar and Hassan, 2009; Ibrahim et al., 2010; Hassan, Maisham, Khan, Alwi and Raml, 2010; Russell et al., 2007). Supporting this proposition is the report stressing that the industry has yet to establish the competency standards for CM (NOSS Division, Department of Skills Development, 2015). Therefore, this research was put forward to gain insights on the factors that have contributed to the ineffective CM education and training, and to assist explanation of the phenomenon. On the premise that the terms of reference for workforce competency development are crucial for their development (Russell et al., 2007), the aim of the research was to establish the technical competencies required by CM. In line with the aim, the objectives of the research were to identify the elements of technical competencies of CM, to confirm the elements of technical competencies of CM, and to analyse the importance of the elements towards different contractor’s category and grade/size.

Therefore, owing to the aim of research, this paper is structured into several sections, namely literature reviews (in three sections), research methodology (in three sub-sections), result and analysis (in three sub-sections), discussion (in two sub-sections), and finally a section for the conclusion.

2. Construction management

A project life cycle characteristically comprises design and construction stages, within which project management, construction management, and site management take place (Mohammad et al., 2016; Halpin, 2006; Gray and Larson, 2008). According to Koskela (1992) and Yaman et al. (2015), construction management is defined as the transformation of detailed design into a construction/fabrication plan before management of day-to-day processes either on-site or in a factory can be made. Construction management is primarily focussed on project’s construction stage where the contractors undertake the project production process at the construction site. In a typical traditional procurement system, which is widely practised in Malaysia (Jaafar and Nuruddin, 2012), the contractors’ involvement would usually start from the tendering stage at the end of the project’s design stage. The task of transforming the
designs into the actual physical follows when the project is awarded and ends when project
handed back to the client at the project closeout (Halpin, 2006; Gray and Larson, 2008).
Although most construction management activities take place at the project site, there are
activities such as liaison with project financiers, local authorities for approvals, and suppliers,
which have to be carried out off-site. Additionally, during the construction phase, project’s
resources (i.e. money, materials, plant/machinery, and manpower) are consumed to achieve
project objectives of time, cost, quality, and health and safety, and eventually, determine
whether the contractor makes profit or loss (National Center for Construction Education and
Research, 2008; Oberlender, 2000).

Construction management is a very tough undertaking, and the responsibility is shouldered
by CM (Love and Haynes, 2001; Toor and Ogunlana, 2008; Isa, 2007). Usually sandwiched
between top managers and supervisory personnel, CMs from contractors are sharing a similar
level of management as a construction coordinator, superintendent, and site manager
(Isa, 2007). Their responsibility to transform the design into built infrastructure facilities would
typically include the application of appropriate management functions (e.g. planning,
organising, staffing, coordinating, and controlling) towards commonly identified construction
components (e.g. manpower, materials, machines, and money) within the entire processes
of construction phase (Mohammad et al., 2016). The demands of the job require them to
be competent to execute all activities within very challenging and dynamic circumstances. This
includes handling activities which involve numerous contracting parties, which consumes a lot
of resources and operating on tight deadlines, working in unpredictable and harsh weather
conditions, risky working undertakings, and when money is being spent at a very fast rate
(Isa, 2007). This necessitates the CM to be wholly competent. Table I tabulates the common
construction characteristics and management approaches led by CM as highlighted by several
researchers (Halpin, 2006; Gray and Larson, 2008; Koskela, 1992; Isa, 2007; Burke, 2003;
Ritz, 1994). In summary, construction has a definite period of development where time, cost,
quality, and scope are critical. And by having several resources to be utilised, appropriate
knowledge, skills, tools, and techniques are direly needed to be applied within an uncertain
environment. From the perspective of contractor’s CM, all phases of construction from
tendering stage to handover are paramount and have to be managed properly. Thus, suitable
management approaches have to be acquired and applied thoroughly especially by CM.

The extents to which CM are expected to be competent have been vexing due to the
many variables that can impact the way the construction management is carried out at the
project site. This includes the size and value of the project, location, procurement system,
type of work, resources availability, and duration of the project (Hassan, 2005). Adding on to
these variables in Malaysian construction industry is the classification of contractors

<table>
<thead>
<tr>
<th>Element</th>
<th>Characteristic</th>
<th>Management approach by CM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>Have definite start and end</td>
<td>Need to be properly managed</td>
</tr>
<tr>
<td>Product/services</td>
<td>Unique development for new or existing building</td>
<td>In line with client’s requirements</td>
</tr>
<tr>
<td>Critical</td>
<td>Time, cost, quality, scope, and resources</td>
<td>Need to be balanced and in equilibrium</td>
</tr>
<tr>
<td>components</td>
<td></td>
<td>Need to be properly utilised and managed</td>
</tr>
<tr>
<td>Main resources</td>
<td>Manpower, materials, machines, and money</td>
<td>Inclusion of risk management, change management, etc.</td>
</tr>
<tr>
<td>Medium</td>
<td>Appropriate knowledge, skills, tools, and techniques</td>
<td>Need to be properly acquired and applied</td>
</tr>
<tr>
<td>Environment</td>
<td>Complex, dynamic, uncertain, demanding</td>
<td>Need to be properly managed</td>
</tr>
<tr>
<td>Phases</td>
<td>From notice of advertising (tendering to bidding)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to inspection and acceptance of project</td>
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Table I. Characteristics of construction management

Construction manager’s technical competencies
according to the size/value of projects and types of construction projects they are allowed to undertake (Construction Industry Development Board Malaysia, 2012; Kementerian Kewangan Malaysia, 2012). There are seven (7) classes of contractors, and this ranges from G1 to G7 contractors (Contractors and Levy Division, Construction Industry Development Board Malaysia, 2016). The range of project’s value which the contractors are allowed to undertake are as follows: G1 < RM200,000; G2 < RM500,000; G3 < RM1,000,000; G4 < RM3,000,000; G5 < 5,000,000; G6 < RM10,000,000; and no limit for G7 contractors. Within each class, contractors are further classified into areas of specialisation which ranges from civil engineering, building, and mechanical and electrical works. These variables have not been helpful in assisting the industry in identifying the competencies expected of the CM, and further complicates the design of their education and training provisions (Hassan, Maisham, Khan, Alwi and Ramlı, 2010; Hassan, Samad, Hassan, Che Mat and Isnin, 2010).

3. Competency

White (1959) defined the term “competence” as a concept for performance motivation. Later in the 1970s, the concept had been further elaborated by Lundberg (1972) in “Planning the Executive Development Program” and David McClelland (1973) through a seminal paper entitled “Testing for Competence Rather than for Intelligence”. It has since been popularised by Richard Boyatzis and many others, such as Gilbert (1978) who used the concept in relationship towards performance improvement. Later, its use varies widely and rather spawned which leads to considerable misunderstanding. Nevertheless, competence or competency has been extensively discussed particularly in the literature of management strategy since the 1990s (Deist and Winterton, 2005). Its concept is frequently used in the area of education, as well as training and continuing professional development, largely in establishing a new or improvise an existing educational method as described by Hassan, Maisham, Khan, Alwi and Ramlı (2010), Hassan, Samad, Hassan, Che Mat and Isnin (2010) and Stoof et al. (2002).

Cambridge Advance Learner’s Dictionary defines the term “competency” as “the ability to do something well” or “an important skill that is needed to do a job” (Cambridge University Press, 2008). A quite similar definition by Boyatzis (2008) also echoed on capability or ability with regard to competency. Furthermore, according to Hager and Gonca (1996), competency concept is an integrated approach by blending tasks involved and attributes, where preceding identification of knowledge, skills, attributes, and attitudes can be envisaged comprehensively. Hackett (2001), on the other hand, had been suggesting competency concept as having a single pillar named attributes. Attributes may come in a cohesive form of skills, knowledge, and attitudes in order to visualise the overall attributes of a worker. Next, a constructivist approach was mooted by Stoof et al. (2002) due to the argument of “one size – does not fit all”. They have asserted that three variables, namely the people, the goals, and the overall context need to be cohesive, through the inclusion of inside-out approach (that based on several dimensions), and the outside-in approach (based on several terminological hygienes) (Stoof et al., 2002). Meanwhile, Potgieter and Van Der Merwe (2002) asserted that competence comprises three key elements which include performance in diverse settings, achievement of outcomes, and specific skills and standards. They recommend that in job settings, competence can be regarded as the skill and ability of a person to perform and cope with job demands in the workplace effectively. Apart from that, multiple-dimensional competency was suggested by Deist and Winterton (2005), where the inclusion of knowledge (or cognitive), skills (or functional), attitudes (or social competence), and meta-competence (e.g. person’s personality, and learning to learn) were deemed important. Nevertheless, a recent work by Dogbegah et al. (2009) on task performance competency is focussing on input competency, output competency, and also personal competency in order to encapsulate entire job-specific competency. Finally, to
simplify conceiving competency, Hassan, Maisham, Khan, Alwi and Ramli (2010) divide competency into technical and behavioural competencies. Technical competency consists of hard skills and knowledge, while behavioural competency comprises soft skills and abilities.

The review of the related literature found that ideas and thinking surrounding the notion of competence is not uniform and has different meanings in different contexts that can only be defined and measured through its intended usage and function. Notwithstanding, common in the literature that knowledge, skills, and abilities (including attitudes) are the primary elements of competency (Hassan, Maisham, Khan, Alwi and Ramli, 2010; Hager and Goncz, 1996; Mansfield, 1996; Egbu, 1999), whilst knowledge and skills are the “visible” elements of competency (Hassan, Maisham, Khan, Alwi and Ramli, 2010; Deist and Winterton, 2005; Stoof et al., 2002). Being categorised as a technical or hard competency, knowledge and skills are noticeable and teachable competencies since they can be flourished easily through proper training and education. In term of a learning curve, technical competency requires much shorter time to acquire as opposed to non-technical competency (Rudarakanchana et al., 2015). Unfortunately, although technical competency (i.e. knowledge and skills) is more critical to be accomplished as compared to the non-technical competency (i.e. soft skills, abilities, and attitudes) regarding matching individuals with their job scopes, it is often ignored by the common competency approaches (Mansfield, 1996). This excessive emphasis on previous competency models on non-technical competency has relatively declined the significance aspects of technical competency. Likewise, it necessitates substantial endeavour to determine the overall competencies for a certain workforce extensively. Therefore, a focus on technical competency and a rather modest yet comprehensible competency concept by Hassan, Maisham, Khan, Alwi and Ramli (2010) are reckoned by the authors to be appropriate for subsequent discussion. Separation of competency into technical and non-technical are indeed comprehended and much simpler to be deliberated (see Figure 1). Technical competency consists of hard skills and knowledge, whereby non-technical competency entails soft skills and abilities.

To delve deeper into the gist of technical competency, it was defined as the ability to apply techniques and procedures (Isa, 2007). Within the context of construction project management, technical competency is the knowledge and skills that are pure construction related such as estimating, scheduling, project management, cost management, construction materials, and equipment utilisation (Isa, 2007; Ahn et al., 2010; Wandahl and Ussing, 2010). Identification of technical competency through analysis of production process including key tasks or work outputs will eventually outlay the required knowledge and skills (Hassan, 2005; Mansfield, 1996; Mullin and Williams, 2010). In the interim, outside the context of technical competency, non-technical competency emerges as a collection of quality largely related to human (Isa, 2007; Lee et al., 2011). Non-technical competency is usually referred to as the “softer” part of competency, where soft skills and worker’s abilities dominate. Since they are very much depending on how an individual reacted to others, Akintoye (1998)
expressed the importance of their development that needs to be individually and contextually (Mullin and Williams, 2010). Contextual in the sense of local factors, economic, environmental or political circumstances may project different needs or application towards that of non-technical competency. There are several generic non-technical competencies such as leadership, communication, motivation, writing, team working, and listening (Egbu, 1999; Wandahl and Ussing, 2010; Mullin and Williams, 2010; Gunderson et al., 2002).

In highlighting the importance of technical competency to be apprehended by managers, Egbu (1999) has come up with the definition of both elements of technical competency, namely knowledge and skills. He defines knowledge as “the ideas, wisdom, and facts managers acquire through experience, theory, and practice; the acquisition of which gives them an ability to understand”, whereas skills as “the activities or patterns of behaviour which managers undertake in order to accomplish a given desired outcome”. A quite similar interpretation by Nonaka on knowledge, where he encapsulated knowledge into two general types; tacit and explicit. Tacit knowledge is regarded as subjective and experience-based knowledge, while explicit knowledge is considered as objective and rational knowledge (Nonaka, 1997). Separately, Lex et al. (1997) are in the same boat with Egbu for skills, where they emphasised that a person without proper skills will not be able to produce similar job output against a skilled person. In conclusion, when relating knowledge to a certain activity or task, trainees should learn about the “know-how” without the need to physically implement it yet. Furthermore, in many instances, a complete “know-how” can be achieved through the integration of knowledge. On the other hand, skills involve the use of human anatomy (e.g. hand and leg) and things, and can be enhanced by repeated practices, actions, and conducts. Due to the complimentary nature of both knowledge and skills in project management, knowledge becomes the basic principle for the formulation of skills. In most occasions, a variety of knowledge and skills may be required to perform a complex task. Thus, it is clear that acquiring knowledge and skills is a matter of the utmost importance about the technical competency of CM.

4. Past researches on CMs competency
The importance of managers’ competency towards project success is well documented by others. Particularly within the construction realm, Ashley et al. (1987) found that manager’s competency is significant in determining project success. Later, according to Chua et al. (1999), competency of manager is critical although projects may have different objectives. Furthermore, most identified critical success factors are human-related, where the competent manager is among the top (Nguyen et al., 2004). This view was also supported by Chan and Kumaraswamy (1997) and Toor and Ongunlana (2008), where competency is fundamental to project success. However, a work by Cheng et al. (2000) stressed that possessing adequate competency is not just critical to the manager, but to all participants of the project. Thus, equilibrium of adequate competency level among participants is preferred to achieve predetermined objectives.

With regard to construction management, unfortunately, there is quite some accompanying literature that pointed out the inadequacy of formal learning for construction management, which in turn resulting in the detrimental nature of the industry itself (Ahn et al., 2010; Benhart and Shaurette, 2011). The argument was also supported by several researchers which stressed that the lack of competency and unqualified construction workforces are situational needs that triggered the call for the formalisation of construction-related learning, which skills standardisation, knowledge expansion, and meeting the related challenges and problems had initially become the main concern (Russell et al., 2007; Elzaliti and Lees, 2007; Wang et al., 2008; Justelian, 2009; Graham et al., 2011; Chinowsky and Diekmann, 2004). Thus, a review in the common area of problems on the particular programme shows that the predicament stems from the
curriculum development process where the essential part lies in the contents generation, which fundamentally related to the competency identification. It was observed that the lack of apposite term of references on the competency for CM becomes the major setback. Most of the literature highlighted the needs to reconsider prior to identifying competency which was embedded in the learning process and stressed the importance of infusing feedbacks from academic and industry participants. In a consistent relation, McDaniel (2005) has developed a model to demonstrate the magnitude of competency identification as a crucial deliberation in designing a curriculum for CM.

Through the authors’ in-depth observation, collectively, a qualitative-to-quantitative approach is being preferred by the majority. Qualitative compilation from previous researches and legitimate documents and some through interviews provide a context-rich competency for CM aligned with the predetermined scopes. Following that, questionnaire surveys are the preferred choice for quantitative undertakings. In addition, clustering of CM’s competency into its meaningful groups was also observed, either via construction project stages (Riggs, 1998; Arditi et al., 2009), or through suggestion by past researchers (Isa, 2007; McDaniel, 2005), or based on the nature of the competency itself (Farooqui and Saqib, 2010), or according to computational mathematical formula towards quantitative data (Dogbegah et al., 2009; Ahn et al., 2010). Nonetheless, there was evidence that the clustering efforts is beyond the unique construction management’s phase, less focussed on technical/non-technical competency, unsuitable clusters which prone to difficulty during curricular design, and side lining the key party in the construction phase, namely the contractor (Mohammad et al., 2016). Thus, initial conceptualisation of particular competency identification was upheld by the authors as paramount due to issues stated earlier.

Therefore, it is obvious that the success of any construction project is very much dependent on the CM who should comprehensively and adequately possess technical (i.e. hard skills and knowledge) and non-technical (soft skills and abilities) competencies. Both of these competencies would assist the CM to perform their roles and tasks more professionally in the ever challenging construction world (Benhart and Shaurette, 2011). As such, appropriate undertakings in the establishment of the said term of reference are needed. Therefore, based on earlier discussions, the authors limit the research only to encapsulate the construction management phase, where a focus on the key person representing the contractor named the CM is being made and required competency identification will solitary covered their technical aspect.

5. Research methodology
A pragmatic study was employed through a combined research method (qualitative-quantitative), which include literature analysis, structured interview, and questionnaire survey, respectively, to the objectives as outlined in Section 1. Most of the works were guided by Creswell (2008) and several others which were cited accordingly in this paper.

5.1 Literature analysis
Initially, identification of technical competency for CM was carried through rigorous literature review incorporating a multi-layered thematic (MLT) process. MLT is synonymous to qualitative analysis undertaking when analysing bulk information gathered from the interview, document, and so on. Basically, during qualitative analysis, emerging themes are captured, and MLT is used to reduce initially identified themes into more sophisticated ones (Creswell, 2008). However, as illustrated in Figure 2, the authors have used MLT for predetermined themes identified in the literature and assisted by a loop for data gathering process (Kariya et al., 2016). Themes were organised according to its scopes and doubled as screening nets. The move was deemed sufficient to yield exhaustive and holistic results, so as to ensure the reliability of literature analysis. Furthermore, given
the facts that subjective definitions given by past researchers for certain keywords are
direly needed for explanation in the form of example, MLT is seen as a valuable aid.

Layers as in Figure 2 are performed as guidance in sieving past researchers’ documents in
identifying CM technical competency items. For documents, no restriction has been made, but
keywords’ combination was employed during the searching process (i.e. construction
management + education and training + competency). For Layer 1, themes generated from
Section 2 were utilised especially regarding the boundary of the construction phase. Thus, for
example, any competency that is beyond the boundary will be ignored. Subsequently, Layer 2
will be focussed only on themes generated from technical competency’s themes, including its
definition/concept, and given examples by previous researchers. Later, due to the gist of
technical competency which comprises knowledge and skills, the authors attempt to
differentiate initial collected technical competency into both elements in Layer 3. The move
was believed to strengthen preceding findings in Layer 2 and clarify their differences which in
a way useful for programme development. Then, Layer 4 is dedicated to cluster prior technical
competency into meaningful group helped by suggestions from past researchers including
Isa (2007), since it was the closest validated work on CM competency in Malaysia. Afterwards,
quality measures were imposed to data within each loop iteration (i.e. for each literature) and
at the end of the whole processes. Actions such as reassessment according to layers and
improvisation of clusters’ paradigm were conducted to this layer.

5.2 Interview
The second phase of the methodology employed interview as an instrument. As feedbacks
from local academic-industry experts are concerned, further exploration of the related central
phenomenon and thus validating prior technical competencies of CM identified from literature
analysis is paramount (Creswell, 2007, 2008). The respondents were deliberately selected to
suit the delineated criteria which include their current position in the organisation, their
cumulative experience of at least ten years, their familiarity with CM, and their availability to
the researcher. Two types of questions were constructed, namely close-ended which is to seek
affirmatory on all observed technical competencies in the form of a checklist with a
dichotomous indicator, and open-ended which is to explore possible additional technical
competency. Both of the types are deemed to complement each other within acceptable
one-on-one interview’s time frame since the length of the checklist is concerned by the authors.
Since the authors are inclined to use manual type of qualitative undertaking due to the nature
of questions that is requiring relatively brief answers, respondents’ feedbacks were recorded
by using pen and paper, and later transcribed and typed them into a computer file.
Afterwards, the analysis was done manually with minimal thematic analysis effort as most respondents expressed similar opinions and the summary of results was tabulated. The particular interview approach is believed to be appropriate as it could minimise time and effort from both parties (i.e. interviewer and interviewee). Prior to the actual interview, initial comments on pre-submission of interview script to the respondents were obtained, and slight modifications were made to the final interview scripts.

5.3 Questionnaire survey
The third phase of research entailed mass distribution of questionnaire survey to construction practitioners around the state of Johor. The aims for mass distribution of questionnaire surveys were to analyse indigenous contractors' perception towards the importance of technical competency of CM, and also as an endeavour to validate and generalise the findings to the masses (at least over the state of Johor). Accordingly, importance level was chosen as the dependent variable, and technical competency as an independent variable, whereas contractors’ category and grade as control variables. Moreover, structured questions on technical competency were developed in neutral intonation throughout five-point Likert scale without an option of the neutral answer. All questions were prepared in dual languages (i.e. English as the main language, and Malay as a secondary language) in order to cater for the different convenience of respondents. Then, stratified purposive sampling is selected, along with multiple distributional efforts including online-based and self-administrated route.

Additionally, the authors did not incline to distribute detail breakdown of technical competency for validation and generalisation in this phase since time completion and response rate were the major hindrances. Furthermore, a complete breakdown of technical competency had already been shared and inspected during previous interview sessions. However, full exertion is being given during preparation of questionnaire construct in order to present entire paradigm of CM technical competency accordingly to previously identified clusters. Guidance for the respective respondents regarding the lower level of competency hierarchy is prepared in the questions by using keywords within bracket’s representation “()”.

To ensure its reliability, the questionnaires were initially undergone a small pilot test towards 10 representatives from several contractors. After thorough considerations had been taken care of, and the pilot test presented reliable results, the final version of questionnaires were reprinted and distributed.

Both methods of questionnaires distribution covered the entire state of Johor in order to represent the opinions of the targeted respondents fairly. The combination of self-administered and online survey deemed to be a better option to maximise response rate. Nevertheless, for self-administered distribution, the authors also pursuing assistances from several parties including the officers of CIDB Johor and individuals, thus snowballing is likely presented. Meanwhile, for online survey, “Survey Monkey” as an online survey provider was selected. It became the main database frame to gather all responses since the online software grants the simplicity of results generation. Layout for the electronic version was designed according to suggestion by Toepoel et al. (2009). At the same time, the online survey was carried out through e-mail. E-mail addresses of targeted respondents were obtained from “Daftar Projek CIDB 2007-2012” which was published by the CIDB Malaysia, and only active contractors are considered regardless of their categories and grades (Lembaga Pembangunan Industri Pembinaan Malaysia, 2012). Online survey responses were automatically included in the database, while self-administered responses were keyed in manually. Later, generation of results for both Microsoft Excel and SPSS formats were made, and SPSS v.20 was utilised to ease the process of analysis. In order to treat the missing data and errors, the returned questionnaires were sieved where only fully completed results were accepted and processed further.
For analysis, careful considerations had been made to preserve the originality of data through suitable descriptive analysis. Since collected data were ordinal in nature, therefore the non-parametric type of analysis is preferred. As confirmations, data screening process had been done through reliability test and outlier test, accordingly. Outliers are extreme values as compared to the rest of the data and are capable of showing if there is any single item that has extremely recorded data which might disturb the rest of the analysis. Outliers can be pre-analysed by looking at the mean, 5 per cent trimmed mean (by removing 5 per cent of extreme data), and interquartile range (IQR) where IQR value of more than 3 is considered extreme value (Dawson, 2011; Walfish, 2006). Then, the importance of technical competencies for CM was analysed up to the macro level, and contractor’s grades were further categorised into small, medium, and large size as suggested by Isa (2007), to simplify the findings. Meso-level items (with 34 nos.) were reduced to macro-level items (with 16 nos.) by using a function of “compute-median” in SPSS. Then, the authors selected mean value as a central tendency which will be shown along with its individual standard deviations (SDs) and ranks.

6. Results and analysis
Given that the research has several pertinent phases, this section is divided accordingly into three sub-sections, namely literature analysis, interview, and questionnaire survey.

6.1 Literature analysis
The authors have selected and analysed a number of closely related literatures (Love and Haynes, 2001; Isa, 2007; Egbu, 1999; Ahn et al., 2010; Wandahl and Ussing, 2010; Mullin and Williams, 2010; Lee et al., 2011; Gunderson et al., 2002; Benhart and Shaurette, 2011; Riggs, 1998; Arditi et al., 2009; Farooqui and Saqib, 2010; Fester and Haupt, 2008; Gunderson, 2008; Hauck, 1998; Waluyo, 2007; Souder and Gier, 2006; Koch and Benhart, 2010; Young, 1993; Construction Management Association America, n.d.). All literature were individually sieved through prior constructed MLT process and concluded with 271 of technical competency items (micro level). Subsequently, all items were grouped into 34 items (meso level) and further clustered under 16 elements (macro level). Clusters were formed according to suggestion by past researchers which centred on general construction project’s resources, objectives, general tasks, and essential competency. Hence, Table II summarises the identified CM’s technical competencies resulted from the process (up to meso level) which able to offer simplistic and perceptive views.

6.2 Interview
Concerning the second phase of research method, a total of nine experts had involved in the interview sessions. The interviewees or experts are three academicians and six construction practitioners. All academicians were senior lecturers teaching construction management subject, whereas all practitioners were senior professionals in their respective legitimate positions within construction companies (i.e. three CM, a project manager, a contract manager, and an engineer). All interview respondents have aptly followed criteria set by the authors and able to identify CM competency. Averagely lasted for an hour, each interview sessions were conducted within the convenience of the interviewees. For close-ended questions, the interviews demonstrated that all respondents were collectively agreed with a prior collection of CM technical competency. Of all the 271 items along with their prescribed elements and clusters, answers of “yes” were recorded throughout. Meanwhile, for open-ended questions, a large majority of respondents expressed that the collection is adequate without the need for additional items. A brief answer to “no, it was ok” was mostly recorded. However, slightly different
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Macro level Elements</th>
<th>Meso level</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Staff</td>
<td>Knowledge and skills of staff management (i.e. development, welfare, laws, etc.)</td>
<td>Isa (2007), Egbu (1999), Wandahl and Ussing (2010), Lee et al. (2011), Riggs (1998), Farooqui and Saqib (2010), Young (1993), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td>Materials</td>
<td></td>
<td>Knowledge of construction materials (i.e. concrete, steel, wood, soil, etc.)</td>
<td>Ahn et al. (2010), Wandahl and Ussing (2010), Gunderson et al. (2002), Benhart and Shaurette (2011), Farooqui and Saqib (2010), Gunderson (2008), Hauck (1998), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge and skills of materials management (i.e. procurement, logistics, supplier, etc.)</td>
<td>Isa (2007), Egbu (1999), Gunderson et al. (2002), Benhart and Shaurette (2011), Arditi et al. (2009), Farooqui and Saqib (2010), Koch and Benhart (2010), Young (1993), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td>Labour</td>
<td></td>
<td>Knowledge and skills of labour management (i.e. productivity, welfare, laws, etc.)</td>
<td>Isa (2007), Egbu (1999), Wandahl and Ussing (2010), Lee et al. (2011), Benhart and Shaurette (2011), Riggs (1998), Farooqui and Saqib (2010), Koch and Benhart (2010), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td>Plant/equipment</td>
<td></td>
<td>Knowledge of construction plant/equipment and their utilisation</td>
<td>Ahn et al. (2010), Farooqui and Saqib (2010), Hauck (1998), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge and skills of plant management (i.e. requisition, maintenance, supplier, etc.)</td>
<td>Isa (2007), Egbu (1999), Arditi et al. (2009), Farooqui and Saqib (2010), Young (1993), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td></td>
<td>Subcontractor</td>
<td>Knowledge and skills of sub-contractor management (i.e. claims and payments, variations, insurance, etc.)</td>
<td>Isa (2007), Egbu (1999), Riggs (1998), Arditi et al. (2009), Gunderson (2008), Hauck (1998), Koch and Benhart (2010), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td>(including NSC)</td>
<td></td>
<td>Knowledge and skills of sub-contractor tendering and bidding (i.e. procedures, pretender, bid analysis, quantity take-off, etc.)</td>
<td>Isa (2007), Egbu (1999), Gunderson et al. (2002), Riggs (1998), Arditi (2009), Farooqui and Saqib (2010), Fester and Haupt (2008), Construction Management Association America (n.d.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge and skills of health and safety management (i.e. practices, compliance, regulation, training, etc.)</td>
<td>Isa (2007), Egbu (1999), Ahn et al. (2010), Mullin and Williams (2010), Lee et al. (2011), Gunderson et al. (2002), Arditi et al. (2009), Farooqui</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Macro level</th>
<th>Meso level</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment</td>
<td>Knowledge and skills of environment management (i.e. assessment, environmental management system (EMS), etc.)</td>
<td>Love and Haynes (2001), Isa (2007), Mullin and Williams (2010), Lee et al. (2011), Gunderson et al. (2002), Farooqui and Saqib (2010), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td>General Administration</td>
<td>Knowledge and skills of construction administration (i.e. documentation and record, submissions, plans/drawings, meeting, etc.)</td>
<td>Isa (2007), Lee et al. (2011), Gunderson et al. (2002), Benhart and Shaurette (2011), Riggs (1998), Arditi et al. (2009), Farooqui and Saqib (2010)</td>
<td>(continued)</td>
</tr>
<tr>
<td>Cluster</td>
<td>Macro level Elements</td>
<td>Meso level</td>
<td>Literature</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------</td>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Pre-construction</td>
<td>Knowledge and skills of construction site surveying, site layout, temporary structures/work, etc.</td>
<td>(2010), Hauck (1998), Souder and Gier (2006), Koch and Benhart (2010), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge of civil and structural design</td>
<td>Gunderson et al. (2002), Benhart and Shaurette (2011), Fester and Haupt (2008), Hauck (1998), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge of mechanical and electrical systems</td>
<td>Gunderson et al. (2002), Fester and Haupt (2008), Hauck (1998), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge of value engineering (i.e. to eliminate unnecessary cost which does not contribute to the value of construction)</td>
<td>Lee et al. (2011), Farooqui and Saqib (2010), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Knowledge of constructability (i.e. analysis of construction coordination issues associated with various trades)</td>
<td>Lee et al. (2011), Farooqui and Saqib (2010), Koch and Benhart (2010), Construction Management Association America (n.d.)</td>
<td></td>
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<tr>
<td></td>
<td>Knowledge of lean construction (i.e. application of production management to construction)</td>
<td>Lee et al. (2011)</td>
<td></td>
</tr>
</tbody>
</table>

Table II. Construction manager’s technical competencies
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Macro level Elements</th>
<th>Meso level</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closeout and handover</td>
<td>Knowledge and skills of construction closeout and handover procedures (i.e. management, commissioning, acceptance, transfer, etc.)</td>
<td>Arditi et al. (2009), Farooqui and Saqib (2010), Koch and Benhart (2010), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td>Responsibilities to 3rd</td>
<td>Knowledge and skills of construction law and legislation (i.e. authorities processing, etc.)</td>
<td>Isa (2007), Egbu (1999), Wandahl and Ussing (2010), Mullin and Williams (2010), Gunderson et al. (2002), Arditi et al. (2009), Farooqui and Saqib (2010), Waluyo (2007), Koch and Benhart (2010), Young (1993), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td>parties, main</td>
<td>Knowledge and skills of construction businesses (i.e. sales, commercial, trades, economic analysis, etc.)</td>
<td>Wandahl and Ussing (2010), Mullin and Williams (2010), Gunderson et al. (2002), Farooqui and Saqib (2010), Fester and Haupt (2008), Waluyo (2007), Koch and Benhart (2010), Young (1993), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td>contractor, client, clerk</td>
<td>Knowledge and skills of administering and assisting/facilitating client, senior manager and junior manager (i.e. coordination, liaison of works, orders, etc.)</td>
<td>Isa (2007), Arditi et al. (2009), Farooqui and Saqib (2010), Koch and Benhart (2010), Construction Management Association America (n.d.)</td>
<td></td>
</tr>
<tr>
<td>competency</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
responses were observed for Academician 1 and Academician 2. Both academicians uttered the need for the inclusion of nominated sub-contractor (NSC) within their respective element. Answers of “do you consider the NSC?” are repeated twice, on the basis that management of NSCs is quite different from that of normal sub-contractors. On the other hand, Academician 2 have also suggested for the addition of management of construction wastages (e.g. from materials, labours, etc.) within the list, as concerned with sustainability is on the rise. Therefore, all suggestions were analysed and critically taken into considerations. Minimal changes were made without jeopardising prior structure of CM technical competency elements.

6.3 Questionnaire survey
The final version of questionnaire scripts was initially distributed to ten (10) construction practitioners as a pilot survey in order to seek for the internal reliability of the questions before they were ready for mass distribution. Reliability analysis by using SPSS had resulted in Cronbach $\alpha$ of 0.977 for all questions, which indicate that they would be able to measure the research’s intended objectives (Gliem and Gliem, 2003; Tavakol and Dennick, 2011). A total of 300 questionnaires had been distributed through a combination of online and self-administered options.

From Table III, regardless of the contractor representatives’ demographics, a response rate of 33.67 per cent had been achieved through 101 collected and completed questionnaires. Moreover, it has been observed that the contractors’ organisation might have more than a single category/specialisation, as the total number of responses (135 nos.) was more than the collected questionnaires (101 nos.). Meanwhile, seven grades of the

<table>
<thead>
<tr>
<th>Details</th>
<th>Test/data</th>
<th>Results</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot survey</td>
<td>Reliability ($\alpha$)</td>
<td>0.977</td>
<td></td>
</tr>
<tr>
<td>Actual survey</td>
<td>Reliability ($\alpha$)</td>
<td>0.979</td>
<td></td>
</tr>
<tr>
<td>Highest IQR</td>
<td></td>
<td>0.999</td>
<td></td>
</tr>
<tr>
<td>Accepted responses/distributed</td>
<td></td>
<td>0.977</td>
<td></td>
</tr>
<tr>
<td>Percentage of response (total)</td>
<td></td>
<td>0.977</td>
<td></td>
</tr>
<tr>
<td>Category of contractors</td>
<td>Civil engineering</td>
<td>47</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td>Building construction</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical and electrical</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Grade of contractors</td>
<td>G1 (tendering ≤ RM200,000.00)</td>
<td>9</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>G2 (tendering ≤ RM500,000.00)</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G3 (tendering ≤ RM1 million)</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G4 (tendering ≤ RM3 million)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G5 (tendering ≤ RM5 million)</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G6 (tendering ≤ RM10 million)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>G7 (tendering = no Limit)</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Position of respondents</td>
<td>Director/executive director/executive chairman/corporate manager</td>
<td>29</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Project manager/project coordinator</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Contract manager/contract executive</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CM/construction coordinator/construction superintendent</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Site manager/site agent</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Site supervisor/clerk of work</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Architect/engineer/quantity surveyor</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Experience of respondents</td>
<td>4 years and below</td>
<td>20</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>5-9 years</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 years and above</td>
<td>49</td>
<td></td>
</tr>
</tbody>
</table>

Table III. Summary of respondents’ demographics
contractor were further categorised into small (with 32 nos.), medium (with 25 nos.), and large size (with 44 nos.). Apart from that, the majority of respondents were from top management level within their organisation (i.e. director), whereas the least were from middle management level (i.e. contract manager, CM, and site manager). Most of them were having more than ten years of working experience.

Subsequently, screening of data through reliability test and outlier test were conducted. The calculated Cronbach’s $\alpha$ of all responses for each of the 34 items is 0.979, which obviously depicted that internal reliability is maintained. Besides, through outlier test, data have not shown any indication for the outlier, where the highest value for IQR is 2, and very minimal differences were spotted between values of normal mean and 5 per cent trimmed mean. Therefore, the subsequent descriptive analysis was carried forward which included all items (34 nos.) within the calculations. Nevertheless, in order to simplify the analysis processes without diminishing meaningful results, meso-level items (with 34 nos.) were reduced to macro-level items (with 16 nos.) within four main clusters, namely resources, responsible for/objectives, general construction management tasks, and overall essential competency. Later, as shown in Tables IV and V, mean values were tabulated along with SDs and clusters’ ranks, respectively, to the category of construction organisations and their sizes. In general, recorded means based on contractor’s categories (see Table IV) were mostly leaning between 4.00 (important) and 5.00 (very important). Only a value of sub 4.00 (i.e. 3.700) is recorded specifically for computer and information technology (IT) in the mechanical and electrical group. On the other hand, a similar pattern was visualised towards means based on contractor’s sizes (see Table V). Despite majority, two values were below 4.00 (i.e. 3.92 and 3.94) specifically for plant and equipment, and environment in medium size contractors.

7. Discussions
In this section, discussions were separated into two sections accordingly to the selected methodologies, namely qualitative and quantitative.

7.1 Qualitative methods
As the literature reviews for the research is developed, it was deemed essential to differentiate between knowledge and skills, and further grouped them according to the suitable level, namely macro level, meso level, and micro level, respectively. Thus, as identified and summarised in Table II, technical competency specifically for the CM are believed to be exhaustive and comprehensive. Helped by proper clustering approach towards its elements, significant meanings for each cluster were visualised noticeably. Additionally, confirmation with local academic-industry experts through interviews was judged to support prior undertakings.

First, by focussing on the “Resources” cluster, it was agreed by many that there are several important resources that need to be managed properly by the CM, namely staff, materials, labour, plant and equipment, and sub-contractors. Some of the elements are requiring proper embedment of knowledge (such as materials and plants/equipment) before the inclusion of knowledge and skills, especially towards their management paradigm. For staff, materials, labour, and plant management, common technical competency are required and expected to be equipped to the CM. Meanwhile, for sub-contractor, apart from having technical competency on their associated general management, CM needs to have adequate competency regarding tendering and bidding within this element. As a key representative of contractor/main contractor, more often than not, engagement through a proper contract with sub-contractors and NSC is inevitable. Large construction project might be parcelled out to a small section and sub-contracted to others. Additionally, works that required special trades (e.g. blacksmith, carpentry, etc.) are usually handled by competent groups
<table>
<thead>
<tr>
<th>Category/specialisation</th>
<th>Resources</th>
<th>Responsible for/objectives</th>
<th>General construction management tasks</th>
<th>Overall essential competency</th>
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<tbody>
<tr>
<td></td>
<td>Staff</td>
<td>Materials</td>
<td>Plant and equipment</td>
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<td>Computer and IT</td>
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### Civil engineering construction

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<th>Plant and equipment</th>
<th>Subcontractor</th>
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<th>Pre-construction</th>
<th>Closeout and handover</th>
<th>Responsibility</th>
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### Building construction

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**Table IV.** Mean of importance and ranks of technical competency for construction manager’s construction competencies.
Table V.

Mean of importance and ranks of technical competency for CM based on contractor's sizes

<table>
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<th>Size and grades</th>
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<th>Plant and equipment</th>
<th>Subcontractor</th>
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<th>Administration</th>
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through sub-contracts. Therefore, important competency related to their technical procedures and undertakings are seen as valuable to the CM.

Second, with regard to construction “Objectives”, the common analogy of time, money, and quality has now become too mainstream, due to the fact that elements of safety and environment have gained greater concerns. Nevertheless, among them, “quality” required the embedment of adequate knowledge in order for the CM to execute their management job effectively. This includes knowledge of construction specifications, codes, and standards. Similarly, with safety and environment, sufficient knowledge regarding health and safety equipment and associated manuals and guidelines (i.e. specifically for safety), and underlying concepts of environment (including sustainability approaches) are deemed paramount for the CM. Given that a large proportion of contractor’s works is executed on-site, technical competency regarding those elements are considered mandatory.

Third, the emphasis on “General construction management tasks” is on administration, pre-construction, closeout and handover, and responsibility to third parties, main contractors, clients, clerk of work, and designer. All those elements significantly contribute towards the delivery of any construction project. For instance, during the pre-construction stage where the overall plans are being prepared, roles of CM and reliance towards their technical competency become apparent. By not just having adequate technical competency related to construction site management, broad knowledge on civil and structural, construction systems, mechanical and electrical, and quantity surveying are seen helpful to encapsulate the particular task. Additionally, CM’s insight on value engineering, constructability, and also lean construction are somewhat emergently useful for ensuring smoothness of day-to-day construction activities. On the other hand, as can be seen in the last element (i.e. responsibilities), surprisingly that technical competency of related construction businesses are gaining acceptance and consideration to be equipped by the CM. A shift towards CM’s entrepreneur ability is expected by a number of past researchers due to the dynamic nature of the industry and the responsibility held by CM to maintain their organisation’s competitiveness.

Last but not least, within the “Overall essential competency” cluster, two essential elements are highlighted, namely computer and IT, and construction contract administration. Since computer and IT offer the convenience of day-to-day management efforts, multitasking nature of CM is effectively facilitated. From general computer applications (e.g. word processing) to rather specific applications for construction (e.g. scheduling and computer-aided design), CM are reckoned to have the adequate knowledge and skills. On the other hand, given that the selected contractors are bonded to the agreed contract between stakeholders, the administration of a particular contract throughout the construction phase is crucial. Since the contract stipulates several conditions and requirements to be adhered by the contractors, CM plays an important role to convey that particular information throughout the prescribed contract period effectively. Thus, technical competency regarding its administration is deemed paramount to be instilled to the CM.

7.2 Quantitative methods

With regard to validation and generalisation effort, 101 respondents (33.67 per cent of response rate) from various contractors’ company have completely answered the questionnaire survey (see Table III for a summary of data). However, since contractor may register beyond a single category as long as within the requirements stipulated by the Malaysia’s CIDB, a mismatched between the total number of contractors’ category (at 135 nos.) and the total number of respondents has been observed. According to the record, the majority of the respondents came from building construction contractors (52 per cent), followed by civil engineering contractors (35 per cent), and mechanical and electrical contractors (13 per cent). Meanwhile, respondents from large contractors
(G6 and G7) topped the list and dominated for nearly one-third of the total response. The least was from medium contractors with only 25 per cent of the response. Apart from that, respondents with the highest positions (i.e. director, executive director, executive chairman, and corporate manager) in the contracting companies dictated a huge percentage of 28 per cent, and it was followed by the remaining positions where contract managers/executive contributed the least responses of 5 per cent. On the other hand, nearly half of the respondents (48 per cent) have had at least ten years of construction experience. In general, all respondents have the appropriate acumen in order to validate prior findings. The combination of their organisation’s nature, positions, and experience were believed to strongly outlaid acceptable results by covering both integrity and significant.

Moreover, by referring to Table IV, all items of CM’s technical competency has scored between 4.00 (important) and 5.00 (very important) of means based on contractors’ category/specialisation. Except for “Computer and IT” from mechanical and electrical contractors’ point of view, a score of 3.75 is recorded – which is in the region of 3.00 (slightly important) and 4.00 (important). Nonetheless, based on the result, the authors have concluded that all respondents were collectively in agreement towards the importance of all technical competency items which need to be equipped to the CM, despite differences of construction category/specialisation (although with varying levels from important to very important). Further, similar ranks shared by several items (i.e. staff, plant and equipment, environment, computer and IT, and construction contract) throughout diverse contractor’s category has somewhat supported the view and to a certain extent generalising the outcome to the masses.

On another perspective, contractors’ sizes and grades were deemed to give a critical overview on the perception of technical competency’s importance level. Due to the fact that sizes of contractors determined their value of construction project, it is a common conviction that people recognised the higher size of contractors requires extra technical competency since their project is frequently more difficult and complicated. Surprisingly, it can be seen from Table V that all items of CM’s technical competency have scored between 4.00 (important) and 5.00 (very important) of means based on various contractors’ size and grade. Except for two items (i.e. plant and equipment, and environment), scores below than 4.00 by medium contractors (G4 and G5) were recorded. However, since the scores were very much closer to 4.00 (importance level), the similar conclusion as the previous paragraph are likely. Thus, apart from having a majority consensus of perception (i.e. vary from important to very important), similar ranks shared by a number of items (i.e. plant and equipment, environment, computer and IT, and construction contract) were an indication of agreement towards respondents. Additionally, through a spontaneous visual inspection, Tables IV and V have presented identical ranks especially towards plant and equipment, environment, computer and IT, and construction contract. This circumstance is partly showed that regardless of contractor’s category and size; similar items were needed to encapsulate entire paradigm of technical competency for CM.

8. Conclusion
A rigorous qualitative process through MLT analysis is deemed to be adequate in identifying technical competency of CM. Later, the application of interview sessions for confirmation of prior collected data is pragmatically seen as pertinent. Apart from validation per se, interviews which infusing local academic-industry experts were reckoned to accentuate different opinion on research’s central phenomenon. Then, as mass validation and generalisation are concerned, distribution of questionnaire surveys within the study area are paramount. To sum up, findings from all objectives were considered to present consistent results. Technical competency for CM encompasses the ability to manage: staff, materials, labour, plant, sub-contractors, safety, money, quality, time, environment, site
administration, pre-construction activities, project closeout and handover, third parties, computer literacy, and construction contract. Nevertheless, given that the research is only covered the entire state of Johor, immediate usage of findings throughout Malaysia is yet to be determined. However, up to this point, the research has provided useful insight and paved the way for subsequent undertakings. Apparently, the authors were optimist that final findings might serve as term of reference for CM’s technical competency and provide faster applications for a lot of purposes, including designing proper training for CM, assessing and auditing the training of CM, recruitment, termination or dismissal of CM, and registration of local professional CM.

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Conflicts and management styles in the Sri Lankan commercial building sector

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Nirodha Fernando
Department of Architecture and Built Environment, Northumbria University, Newcastle Upon Tyne, UK

Abstract
Purpose – The purpose of this paper is to understand the prevailing conflict management styles in Sri Lankan commercial building industry from the main stakeholders' perspective. The dual concern theory is applied to this study as a theory foundation.
Design/methodology/approach – The Sri Lankan commercial building industry is currently experiencing a construction boom after 30 years of civil war. Creating a dispute free environment through well conflict management is one of the main ways to keep the continuous demand and development of construction. However, the Sri Lankan construction sector is arranged in such a way that they directly approach the dispute resolution rather than avoiding the dispute initially through proper conflict management. Four cases are selected for this study with the intention of conducting meetings with three main stakeholders of each case who represented client, consultants and contractors, respectively.
Findings – The research findings reveal that compromising is the most common conflict management style used by the industry. Forcing style obtained the second place in the ranking whereas obliging and avoiding received third and fourth places.
Originality/value – This study is conducted to provide a full picture of conflicts faced by the Sri Lankan commercial building industry and their proper management so that the future projects will use this information to diminish the destructive effects of conflict situations and provide a real value for money.
Keywords Management, Case study, Construction
Paper type Research paper

1. Introduction
The construction industry inherits several unique characteristics such as complexity, high human diversity and lengthy process of construction due to which the conflicts will occur (Jaffar et al., 2011). However, having conflicts will not always barricade the project success (Ohbuchi and Suzuki, 2003). Conflicts can generate constructive outcomes as well as destructive outcomes (Tjosvold, 2006). Constructive conflicts often make path to creative thinking and innovation (Gorse, 2003). On the other hand, destructive conflicts will reduce the trust and respect over each other; resulting numerous adverse effects on the performance and productivity (Femi, 2014). As per the Oxford Dictionary (2017), the management is defined as “the process of dealing with or controlling things or people.” Thus, conflict management can be defined as the process of dealing with or controlling conflicts in such a way that they will not cause any negative effect on the project success. It is obvious that through a proper management, the constructive conflicts can be utilized to enhance the productivity of the project while eliminating the destructive conflicts (Tjosvold, 2006).

According to Femi (2014), conflicts in construction can be defined as a disagreement between two parties over a common action. When these disagreements go beyond the control of project management and possibility of amicable settlement, they become disputes which require a legal application for their resolution (Adnan et al., 2011; Yusof et al., 2011).
Therefore, it can be concluded that unmanaged conflicts are destructive and create harmful effects to the project success by escalating themselves into disputes which require expensive and time consuming resolution process (Adnan et al., 2011). Hence conflict management should be given a prior consideration in the construction sector (Huan and Yazdanifard, 2012). The previous studies indicate that when compared to other industries, the amount of unmanaged conflicts escalating to disputes are tremendously high in the construction sector (Yiu and Cheung, 2006; Yusof et al., 2011). The findings of Chen et al. (2014) revealed that the firm focus on the constructive aspects of the conflicts and the mutual trust establishment are the keys to reduce the conflicts. Latiffi et al. (2013) introduced Building Information Modeling as one of the main techniques of eliminating the sources of conflicts. Zhang et al. (2015) revealed that there is a positive relationship between the emotional intelligence of the people and conflict management; thus, it can be utilized to minimize the conflict situations. Meyer et al. (2012) mentioned that conflicts can be well managed and utilized constructively by adhering to a predefined strategy. Lu et al. (2017) introduced a novel concept of dispute negotiations and the role of the justice over the so called negotiations.

Sri Lankan commercial building industry is currently experiencing a construction boom after 30 years of civil war (Seneviratne et al., 2015). The industry obtained a massive demand and development in the past few years due to the increment of new investments, tourism, infrastructure development and industrial development (The Report, Sri Lanka, 2016). With the so called development, the rate of occurring conflict situations in the construction field is considerably increased (Heenkenda and Chandanie, 2012). Conflicts and disputes in construction projects will barricade the timely completion, lose productivity and prevent gaining value for money (Yiu and Cheung, 2006). Thus, creating a dispute free environment through proper conflict management is one of the main ways to keep the continuous success and development of construction (Fenn et al., 1997; Popovic and Hocenski, 2009). However, the Sri Lankan construction sector is arranged in such a way that they directly approach the dispute resolution rather than avoiding the dispute initially through proper conflict management (Thalgodapitiya, 2010). Currently, the Institute for Construction Training and Development of Sri Lanka encourages the construction parties to adhere to alternative dispute resolution methods (Abeynayake and Weddikkara, 2012). Since dispute resolution is very expensive, time consuming and harmful to the professional relationship (Abeynayake and Weddikkara, 2007), conflict management draws more attentions now to save money and time in the later project stage (Heenkenda and Chandanie, 2012).

The aim of this research is to understand the prevailing conflict management styles in Sri Lankan commercial building industry from the main stakeholders’ perspective. Four construction projects are selected which are handled by the largest and the most reputed construction companies, consultancy firms and client organizations in Sri Lankan commercial building industry. These companies obtain a diverse professional involvement and acquire a great demand in the construction sector. Further, they provide high quality output and maintain good professional relationships inside their companies as well as outside. Furthermore, these companies considered to be the highest profit gaining entities in the industry. Therefore, by conducting an in-depth analysis on how they proceed with conflict situations, the study intends to understand the current effective conflict management practices in the country. The findings of the study can be used by the medium and small-scale construction entities which struggle in different conflict situations as they are not capable of affording expensive and time consuming dispute resolution process. The research outcomes will assist the medium and small scale construction stakeholders by filling the knowledge gap currently existing in the industry and providing a systematic and comprehensive knowledge on the effective conflict management. Ultimately, the study will contribute to adopt a dispute free environment in the Sri Lankan commercial building sector.
building industry. Further, the research findings can be used to plan proper conflict management strategies prior to construction. This paper initially provides a literature review on the existing knowledge of conflict management practices and theory. Four case projects are investigated and compared to understand the ways of solving conflicts followed by discussions on the future improvement.

2. Conflict types and their sources
A number of researchers introduced different categorizations of conflicts. Among them, the most discussed categorization is task conflicts, relationship conflicts and process conflicts (Chou and Yeh, 2007; DeChurch et al., 2007; Desivilya et al., 2010; Huan and Yazdanifard, 2012; Jehn and Chatman, 2000; Senaratne and Udawatta, 2013; Simons and Peterson, 2000). Task conflicts occur due to the disagreements raised between people working in the same group regarding the content of the decisions they make (Simons and Peterson, 2000). The execution of work-related conflicts such as resource allocation, agreeing on rates, variation procedures and policies and judgment on quality can be identified as task conflicts (Dreu et al., 2001). The task conflicts occur mainly due to people having different ideas, viewpoints and opinions (Huan and Yazdanifard, 2012). Relationship conflicts occur due to the disagreements of people who work together (Chou and Yeh, 2007). The main sources of relationship conflicts are tension, hostility and annoyance among the individuals inside the group (DeChurch et al., 2007). Process conflicts occur due to the disagreements regarding the working strategies and delegation of duties and authority which are more related to the contractual documentation (Jehn and Chatman, 2000). The main sources of process conflicts are poor communication, avoiding rules and regulations, issues regarding working methods, issues regarding workload distribution and issues regarding scheduling (Senaratne and Udawatta, 2013).

Acharya et al. (2006) introduced another categorization consisting of five main conflict types considering the main stakeholders in a project. The conflict types are owner evoked conflicts, consultant evoked conflicts, contractor evoked conflicts, third parties evoked conflicts, and other project matter evoked conflicts. The name of the conflict type itself provides the explanation of the content. The main sources of aforementioned conflicts are confusing requirements of owner, excessive change orders, supremacy of owner/consultant, errors and omissions in design, non-payment to subcontractors, conflicts in documents, lack of communication, changes in site condition, public interruption and union strikes.

Friedman et al. (2000) introduced another categorization consisted of five main conflict types. They are interpersonal conflicts, role conflicts, intergroup conflicts, multi-party conflicts and international conflicts. Interpersonal conflicts occur due to the incompatible needs, approaches and goals of two individuals with regard to their personal relationship or/and professional relationship. The main sources for this conflict type are poor communication, personality issues and human nature. Role conflicts occur due to the differences in role definitions, line of authority and unclear boundaries of responsibilities. The main sources are poor communication, lack of information, documentation errors and delegation of power. Intergroup conflicts occur between the construction stakeholders; especially between work groups. The main sources are design errors, documentation errors, delays, non-payments, differences in attitudes and variations. Multi party conflicts occur between two or more parties to the project such as consultants with authorities, client with environmental organization and contractor with financial institute. The main sources are environmental hazards, land acquisition, improper garbage disposal and pollution. International conflicts occur when a construction project becomes a threat, annoyance or competition to another country. The main sources are competition for resources, hunger of power and threat to the economy.
According to the literature, most of the categorizations regarding the conflict types are put forward by considering the characteristics of conflicts (Acharya et al., 2006; Chou and Yeh, 2007; DeChurch et al., 2007; Desivilya et al., 2010; Friedman et al., 2000; Huan and Yazdanifard, 2012; Jehn and Chatman, 2000; Senaratne and Udawatta, 2013; Simons and Peterson, 2000). These categorizations provided a general view of conflicts rather than specifically identifying the conflicts related to a particular scenario. However, this study is interested in providing more specific view of conflicts based on the most common conflict situations that can be practically experienced in the Sri Lankan commercial building industry. Based on the literature, the study has recognized 15 individual conflict situations that can be commonly seen in the particular industry. All the 15 conflict situations are included in the categorizations provided in literature, sometimes in different names, sometimes as a sub category and in other times as a source of conflicts (references provided in Table III).

The 15 conflict situations are categorized into four main conflict types. They are payment issues, relationship conflicts, documentation-related conflicts and execution of work-related conflicts. This categorization is done by considering the nature and background of the conflict situations. It will clearly distinguish in which circumstances the conflict situations are occurred for the better understanding of the readers. It should be noted that most of these conflict situations are interconnected with each other and some of them may become a source of another conflict situation. If further elaborated, even a whole category can become a reason for another conflict situation. Nevertheless, by categorizing the aforementioned 15 conflict situations, the study attempts to emphasize the specific areas in which there is high tendency to have conflict situations. Even though the categorization is new to the prevailing literature, it seems to be in line with the categorization discussed by Jehn and Chatman (2000), Senaratne and Udawatta (2013) and Simons and Peterson (2000) which includes task conflicts, relationship conflicts and process conflicts. Further, the 15 situations are discussed in different literature under different categorizations yet the ultimate concept lies behind is almost the same. These situations are further elaborated in Table III with their respective references. However, it can be seen that the prevailing literature rarely discuss the conflict situations in the relationship conflicts as situational wise (Ex: consultant – contractor, between laborers, contractor – subcontractor and between specialized contractors) yet highly discuss about the relationship conflicts in general.

3. Conflict management theories
A number of conflict management theories are put forward considering the Managerial Grid of Blake and Mouton (DeChurch et al., 2007). The two dimensions used by Blake and Mouton are slightly changed in the other theories yet the ultimate concept given with regard to conflict management is almost the same (Lee, 2008). Some of these other theories are Mary Parker Follett Model (1940), Hall's Win-Lose approach (1969), Thomas Kilmann Conflict Mode Instrument (1977) and Devito Model (1995) (Atteya, 2012; Giritli et al., 2009; Lee, 2008; Ozkalp et al., 2009; Vu and Carmichael, 2009; Zhang et al., 2015). Mary Parker Follett Model (1940) suggested that the conflicts occur due to the differences in thoughts and ideas of individuals, thus these differences can be used to manage the conflicts (Giritli et al., 2009). Accordingly, Follett introduced five conflict management styles, namely; evasion, suppression, domination, compromise and integration (Al-Sedairy, 1994). Hall believed that conflicts can be well managed by considering two dimensions; concern for personal goals and concern for relationships (Vu and Carmichael, 2009). Accordingly, he introduced approaches based on winning and losing (Atteya, 2012). Thomas Kilmann Conflict Mode Instrument (1977) suggested that conflicts can be well managed by considering assertiveness and cooperativeness and introduced five conflict management styles, namely; competing, collaborating, avoiding, compromising and accommodating (Trippe and Baumol, 2015). Devito Model (1995) argued that the conflicts can be effectively managed...
through five stages; identifying the conflict, examining the possible solutions, testing the solution, evaluating the solution and accepting or rejecting the solution (Giritli et al., 2009).

It is recognized that Follett Model did not consider about obliging as a conflict management style (Al-Sedairy, 1994) whereas Thomas Kilmann Model is more interested in competing style rather than dominating style (Trippe and Baumoel, 2015). However, it is obvious that there should be flexible means of conflict management such as obliging (Verma, 1998). Moreover, competing will create more conflicts rather than managing them. The Hall’s Win-Lose Approach and Devito Model provide a common approach to conflict management rather than behavioral approach. Since the management of conflicts highly depending on the behavior of the parties, it is better to use a behavioral approach rather than a common approach (Giritli et al., 2009; Vu and Carmichael, 2009). On the other hand, dual concern theory follows a behavioral approach and consider the actions of both conflicting parties (Zhang et al., 2015). Further, this theory is highly accepted among the conflict management researches due to its inherited qualities such as ease of use, clear interpretation and effective predicting capability when compared to other theories (Vu and Carmichael, 2009). Since the dual concern theory consists of all possible rigid and flexible ways of conflict management and provides the full picture of conflict management, this study will apply it in the case studies to understand the Sri Lankan practices.

4. Dual concern theory
Dual concern theory is introduced by Pruitt and Rubin (1986) (Chou and Yeh, 2007; Dreu et al., 2001; Gorse, 2003) based on the Managerial Grid introduced by Blake and Mouton (DeChurch et al., 2007). According to the dual concern theory, the way two parties willingly behave or forced to behave in a conflict situation can be used to manage the conflicts (Lee, 2008). The theory suggested that based on the high or low concern given to achieve self-desires and the desires of the other party, the conflicts can be properly managed (Desivilya et al., 2010). There are five conflict management styles, namely; integrating (problem solving), obliging, dominating (forcing), avoiding and compromising (Chou and Yeh, 2007). The dual concern model is clearly demonstrated by Rahim (2002) as shown in Figure 1.

4.1 Integrating style (problem solving style)
According to Chou and Yeh (2007), the two dimensions considered in this style are high concern for self and high concern for the other party. The conflict is considered as a problem in this style which required an answer, thus both parties took considerable attempts to find the solution or better alternatives while improving their creativity and skills (Chou and Yeh, 2007; Verma, 1998).

![Figure 1. Dual concern model](source: Rahim (2002, p. 217))
4.2 Obliging style

The two dimensions considered in this style are low concern for self and high concern for other party (Chou and Yeh, 2007). According to Verma (1998), this conflict management style directed the parties to highlight the agreements rather than disagreements thus provided a short term solution.

4.3 Dominating style (forcing style)

According to the description given by Chou and Yeh (2007), the two dimensions considered in this style are high concern for self and low concern for the other party. This style is normally used by the party who had more power and authority over the other party; demanding the other party to accept their interests (Giritli et al., 2009).

4.4 Avoiding style

According to Chou and Yeh (2007), the two dimensions used for conflict management are low concern for self and the other party. Cheung and Chuah (1999) and Akiner (2014) identified this style as denying or ignoring the disagreement between the parties that is actually occurred or yet to come. Gunarathna and Fernando (2014) explained that this conflict management style can be used for conflicts which are not related to the construction project yet occurred inside the construction environment.

4.5 Compromising style

In this style, the two dimensions considered for conflict management are moderate concern for self and others at the same time by providing a mutually acceptable decision (Tsai and Chi, 2009). Both parties to the conflict would gain some degree of satisfaction by using this style and the degree of satisfaction they gained would be enough to manage the conflict and avoid its escalation (Cheung and Chuah, 1999).

Different countries manage conflicts by using different techniques. In North America, the traditional conflict management styles are compromising, forcing, persuading and problem solving (Appelbaum et al., 1998). The construction industry of Hong Kong traditionally used compromising and withdrawal for conflict management yet currently prefers confrontation as the main conflict management style (Cheung and Chuah, 1999). Malaysian construction industry preferred integrating, compromising and to some degree of obliging as the conflict management styles as they are correlated to each other (Lee, 2008). The Project Managers of Nigerian construction industry often used highly improved communication procedure, interpersonal trust and collective responsibility to reduce conflict situations (Ogunbayo, 2013). Japan business industries used a three-way strategy for conflict resolution; collaborative strategies which suggested the concern for group performance, confrontational strategies which suggested the concern for group order and avoidance strategy which suggested the concern for self-interests (Ohbuchi and Suzuki, 2003).

The managers in Turkey generally use integrating and compromising style for conflict management (Ozkalp et al., 2009). Further to authors, obliging and forcing is used depending on the level of hierarchy, which was highly accepted in Turkey. Both Australian and Vietnamese construction stakeholders often used collaborating conflict management style in the international construction projects they worked together to reduce cultural conflicts (Vu and Carmichael, 2009). However, the authors revealed that the Australians, in their local construction industry preferred confrontation and dominating styles whereas the Vietnamese, inside their country preferred obliging and avoiding styles. Saudi Arabian construction industry used compromising, problem solving and smoothing conflict management styles (Al-Sedairy, 1994) due to the multi-cultural involvement in the industry.
The Sri Lankan construction stakeholders usually use negotiation as the basic conflict management style (Abeynayake and Weddikkara, 2012). This style is introduced as the compromising style in the dual concern theory. However, the term “compromising” is not used in the industry. According to Thalgodapitiya (2010), the conflict management is considered as a part of construction risk management in the Sri Lankan commercial building sector. Further to authors, they are highly depending on the dispute resolution than the conflict management.

5. Research methods and process

Naoum (2007) and Ellis and Levy (2009) emphasized that the most appropriate method for conducting an in-depth analysis of a person, a group of persons, an organization or a particular project is case studies. Accordingly, it is recognized that conducting case studies for data collection would be more appropriate for this study due to the requirement of carrying out an in-depth analysis. According to Yin (2009), the best method of data collection for researches which require a proper understanding of a prevailing situation is conducting a multiple case study. Hence, four cases are selected from the Sri Lankan commercial building industry among which, two are private projects and the other two are the public projects. They are the largest and highly recognized construction companies, consultancy firms and client organizations involved in Sri Lankan commercial building sector. Their recognition in the field is summarized in Table I. An in-depth analysis is conducted in order to understand how these companies are solving the conflicts while maintaining their reputation, demand and integrity. The collected knowledge from these companies will be beneficial for the medium scale and small scale construction stakeholders to understand how they should proceed in conflict situations in a highly professional manner. A systematic and comprehensive knowledge will be invaluable to such stakeholders since they cannot afford the expensive and time consuming dispute resolution procedure.

These specific four cases are selected since they cover all the aspects to be considered; in diverse range, such as magnitude, complexity, professional involvement, government involvement, project scope and other secondary factors, in order to understand the conflict management practices in Sri Lanka. Further, the characteristics of these four cases enable to provide a full picture of the current commercial building sector of the country and they obtain almost all conflict situations that can be encountered in such construction. Furthermore, they are fully capable of showing the state-of-art of conflict management practices. All four projects are successfully completed and fully handed over to the clients during the time of the study. Table II shows the project profile. Case study 1 is an eight storied multipurpose building with luxurious facilities. The building consisted of apartments, shopping complex, offices and a cafeteria. Case study 2 is a 14 storied hospital building with super luxurious facilities. Case study 3 is a 14 storied office complex with semi luxurious facilities for a ministry of the Sri Lankan Government. Case study 4 is an administrative building for a government university of Sri Lanka. All four cases exceeded their initial contract price and the estimated duration due to various conflict situations. The stakeholders involved in these projects are from large-medium scale companies.

The case studies are initially observed by examining the relevant documentation supplied by the authorities. Subsequently, three individuals from each case who represented the three main stakeholders of the project (client, consultant and contractor) are identified for interviews. Semi structured interviews are conducted in site offices and approximately last for 1 hour. The main reason for selecting the above stakeholders is that they all position at the management level to solve the project issues and have sufficient knowledge on the project from the design stage to the handover.

The questions are asked regarding the role of the particular stakeholder, their general view of conflicts in construction sector, specific conflict types occurred in the project, sources of those conflicts, the effects of those conflicts, how they managed the conflicts with
regard to dual concern theory and the final outcome they achieved. The collected data through the meetings are then subjected to a content analysis. The main purpose of the content analysis is to quantify the qualitative data under the pre-determined categories in a systematic manner. The analysis is conducted as a cross-case analysis to compare and contrast the similarities and differences of the four cases. Cross-case analysis enabled to generalize the findings to meet the research aim and objectives. The findings are then summarized by using cognitive mapping, visualizing the connections, observations and concepts with regard to the research topic. Accordingly, the conclusion is made and the recommendations are put forward.

6. Conflict types and sources
The study identified 15 common conflict situations in the Sri Lankan commercial building industry. They are categorized into four main conflict types. The categorization is further elaborated in Table III with the common sources for having particular conflict situations.

<table>
<thead>
<tr>
<th>Case</th>
<th>Stakeholder entity</th>
<th>Company profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Client company</td>
<td>A highly experienced and well recognized conglomerate in Sri Lanka. Owns number of high rise buildings. Multidisciplinary involvement can be seen.</td>
</tr>
<tr>
<td></td>
<td>Consultancy firm</td>
<td>A firm of chartered quantity surveyors, providing diversified quantity surveying services, project management services and dispute resolution services within Sri Lanka and overseas.</td>
</tr>
<tr>
<td></td>
<td>Construction company</td>
<td>An award-winning construction company which undertake large-scale contracts of huge value and complexity. Acquire international standards and recognition. The company uses modern technologies and techniques to provide a high-quality output and on time delivery.</td>
</tr>
<tr>
<td>2</td>
<td>Client company</td>
<td>A well-recognized hospital chain in Sri Lanka. Owns several super luxury hospitals and private medical centers. Considered as one of the best medical services providers in Sri Lanka. Consecutive award winning company for high quality service.</td>
</tr>
<tr>
<td></td>
<td>Consultancy firm</td>
<td>One of the leading quantity surveying consultancy firms in Sri Lanka. Undertake both local and international projects. Several highly reputed quantity surveyors who did a great service to the quantity surveying academia are owning the firm.</td>
</tr>
<tr>
<td></td>
<td>Construction company</td>
<td>Recognized as one of the best service providers with high quality products. Internationally recognized. Undertake almost all the types of construction by using modern technology and qualified labor.</td>
</tr>
<tr>
<td>3</td>
<td>Client company</td>
<td>One of the ministries in Sri Lanka. Multidisciplinary involvement can be seen. Owns several high-rise office complexes due to the number of departments and numerous workers. Acquire a high reputation in providing a friendly service.</td>
</tr>
<tr>
<td></td>
<td>Consultancy firm</td>
<td>The main semi-government construction and consultancy firm in Sri Lanka. Multidisciplinary involvement can be seen. All construction-related professionals are available. Undertake both consultancy and construction activities. An award-winning firm for many high-quality services.</td>
</tr>
<tr>
<td></td>
<td>Construction company</td>
<td>One of the leading construction companies in Sri Lanka with long term experience. Obtains a good reputation for providing high quality output and maintenance. Undertake most of the government projects in Sri Lanka. Multidisciplinary involvement can be seen. A leading training provider in Sri Lanka.</td>
</tr>
<tr>
<td>4</td>
<td>Client company</td>
<td>One of the government universities of Sri Lanka. Obtains a good reputation for high quality education and training. Provides considerable facilities to students and maintain good professional relationships.</td>
</tr>
<tr>
<td></td>
<td>Consultancy firm</td>
<td>The main government consultancy and construction company in Sri Lanka. Multidisciplinary involvement can be seen. All construction-related professionals are available. Well recognized for providing a high-quality service and best training.</td>
</tr>
<tr>
<td></td>
<td>Construction company</td>
<td>A medium scale construction company which obtains a rapid development. Well reputed for providing a high-quality service and hard working. Maintains good professional relationships with government and private entities.</td>
</tr>
</tbody>
</table>
6.1 Payment issues

The most common conflict situations that can be seen are delayed payments and non-payment. Payment issues are usually caused by the clients and the contractors. According to the meetings conducted with the main stakeholders, it is found that the most common conflict situation out of the two aforementioned payment issues is delayed payments from client to the contractor. CR02 stated that “Our payments are delayed most of the time and the client did not even pay us in few months. This created our cash flow negative and put us into a critical situation. Actually, he also had some problems with his cash flow.” The contractor’s representatives of other three cases agreed with the fact that delayed payments are a massive headache they had to face during the time of construction.

Non-payment is the other common conflict situation with regard to payment issues. This can be equally seen between the contractors and subcontractors and contractors and laborers. CN01 stated that “The contractor did not pay the subcontractors properly. Therefore, subcontractors stopped continuing the works. Furthermore, the subcontractors did not like to work with the main contractor due to the payment issues and they wanted the

<table>
<thead>
<tr>
<th>Description</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
<th>Case 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Multi purpose building</td>
<td>Hospital building</td>
<td>Office complex building</td>
<td>Administrative building</td>
</tr>
<tr>
<td>Employer</td>
<td>Private</td>
<td>Private</td>
<td>Government</td>
<td>Government</td>
</tr>
<tr>
<td>Condition</td>
<td>Completed</td>
<td>Completed</td>
<td>Completed</td>
<td>Completed</td>
</tr>
<tr>
<td>Category</td>
<td>Luxury</td>
<td>Super luxury</td>
<td>Semi luxury</td>
<td>Normal</td>
</tr>
<tr>
<td>Condition</td>
<td>Estimated: 18 months</td>
<td>Estimated: 20 months</td>
<td>Estimated: 24 months</td>
<td>Estimated: 15 months</td>
</tr>
<tr>
<td>Actual</td>
<td>Actual: 30 months</td>
<td>Actual: 26 months</td>
<td>Actual: 40 months</td>
<td>Actual: 18 months</td>
</tr>
<tr>
<td>Contract price</td>
<td>Accepted: US$1.6 million</td>
<td>Accepted: US$8.55 million</td>
<td>Accepted: US$15.61 million</td>
<td>Accepted: US$0.55 million</td>
</tr>
<tr>
<td>Number of stories</td>
<td>8</td>
<td>14</td>
<td>14</td>
<td>5</td>
</tr>
<tr>
<td>Parties interviewed</td>
<td>CL01</td>
<td>CL02</td>
<td>CL03</td>
<td>CL04</td>
</tr>
<tr>
<td>Labels for interviewees</td>
<td>CN01</td>
<td>CN02</td>
<td>CN03</td>
<td>CN04</td>
</tr>
<tr>
<td>Interviewees’ designation of the project</td>
<td>CL01 – Representative of the client’s company who appointed as the team leader of the project</td>
<td>CL02 – Head of the consultant team</td>
<td>CL03 – Head of the contractor’s team</td>
<td>CL04 – Head of the contractor’s team</td>
</tr>
<tr>
<td>Interviewees’ areas of expertise</td>
<td>CL01: Civil engineering</td>
<td>CL02: Architecture management</td>
<td>CL03: Construction management</td>
<td>CL04: Civil engineering</td>
</tr>
<tr>
<td></td>
<td>CN01: Quantity surveying</td>
<td>CN02: Project management</td>
<td>CN03: Civil engineering</td>
<td>CN04: Quantity surveying</td>
</tr>
<tr>
<td></td>
<td>CR01: Project management</td>
<td>CR02: Quantity surveying</td>
<td>CR03: Project management</td>
<td>CR04: Mechanical engineering</td>
</tr>
<tr>
<td>Interviewees’ experience</td>
<td>CL01: 15 years</td>
<td>CL02: 23 years</td>
<td>CL03: 20 years</td>
<td>CL04: 26 years</td>
</tr>
<tr>
<td></td>
<td>CN01: 16 years</td>
<td>CN02: 38 years</td>
<td>CN03: 15 years</td>
<td>CN04: 8 years</td>
</tr>
<tr>
<td></td>
<td>CR01: 14 years</td>
<td>CR02: 13 years</td>
<td>CN03: 21 years</td>
<td>CR04: 53 years</td>
</tr>
<tr>
<td>Interviewees’ company scale</td>
<td>CL01: Large scale</td>
<td>CL02: Large scale</td>
<td>CL03: Large scale</td>
<td>CL04: Medium scale</td>
</tr>
<tr>
<td></td>
<td>CN01: Medium scale</td>
<td>CN02: Large scale</td>
<td>CN03: Large scale</td>
<td>CN04: Large scale</td>
</tr>
<tr>
<td></td>
<td>CR01: Large scale</td>
<td>CR02: Large scale</td>
<td>CR03: Large scale</td>
<td>CR04: Medium scale</td>
</tr>
</tbody>
</table>

Table II. Case profile
<table>
<thead>
<tr>
<th>Conflict type</th>
<th>Conflict situation</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payment issues</td>
<td>Delayed payment (Acharya et al., 2006)</td>
<td>Financial issues of the client Delays in government procedure Financial issues of the contractor Late submission of interim payment applications</td>
</tr>
<tr>
<td></td>
<td>Non-payment (Acharya et al., 2006; Fisher, 2000; Verma, 1998)</td>
<td>Selection of an underpriced bid Financial issues of the contractor Claims submit after completion of the project</td>
</tr>
<tr>
<td>Relationship conflicts (Dreu and Vianen, 2001; Jehn and Chatman, 2000; Senaratne and Udawatta, 2013; Simons and Peterson, 2000)</td>
<td>Consultant – contractor (Chen et al., 2014)</td>
<td>Payment issues Unprofessional behavior Poor communication Design changes Contradictory record keeping Disagreements between parties Difficulties in coordination Differences in attitudes Late submissions of documents Less experience</td>
</tr>
<tr>
<td></td>
<td>Between laborers (Acharya et al., 2006)</td>
<td>Personal matters Unethical behavior Bad temper Authority issues</td>
</tr>
<tr>
<td></td>
<td>Contractor – subcontractors</td>
<td>Payment issues Difficulties in coordination Unprofessional behavior Poor communication Competition Bad history</td>
</tr>
<tr>
<td></td>
<td>Between specialized contractors</td>
<td>Unprofessional behavior Bad history Competition Material and equipment handling</td>
</tr>
<tr>
<td></td>
<td>Design errors (Acharya et al., 2006; Ng and Skitmore, 2000)</td>
<td>Poor documentation Supremacy of professionals Poor communication Impracticable design</td>
</tr>
<tr>
<td></td>
<td>Documentation errors (Acharya et al., 2006; Jaffar et al., 2011)</td>
<td>High workload of the parties Supremacy of professionals Poor communication Negligence Delays caused by parties Convenience of one party High workload of the parties Internal and external problems of the parties Disagreements</td>
</tr>
<tr>
<td></td>
<td>Late submission of documents (Acharya et al., 2006; Verma, 1998)</td>
<td>Impracticable design</td>
</tr>
<tr>
<td></td>
<td>Contradictions between documents (Acharya et al., 2006; Jaffar et al., 2011)</td>
<td>Disagreements by parties High workload of the parties Poor communication Negligence Poor documentation</td>
</tr>
<tr>
<td></td>
<td>Designs are not finalized (Acharya et al., 2006; Ng and Skitmore, 2000)</td>
<td>Impracticable design Personal delays</td>
</tr>
</tbody>
</table>

Table III. Conflicts and their sources

(continued)
client to pay them directly. In order to keep the labour in the project, the contractor only paid half of the wages and this created a situation where the contractor was unable to do the payments to the labourers properly due to the accumulative liable amounts. This statement revealed that non-payment extremely disturbed the timely completion of the project occurring unnecessary wastage of time and relationships issues. In addition, all stakeholders agreed that non-payment will be a generator of other issues such as labor shortage, poor quality in construction and labor idling. Friedman et al. (2000) identified non-payment as an intergroup conflict where two groups in one unit obtain incompatibilities. However, according to Verma (1998), non-payment can either often be an administrative conflict or rarely an interpersonal conflict depending on the situation.

6.2 Relationship conflicts
The interviewees indicated that the commercial building industry often faced four relationship conflict situations. They are consultant – contractor conflicts, conflicts between laborers, contractor – subcontractor conflicts and conflicts between specialized contractors. Findings suggested that human diversity is a common fact yet difficult to control by making everyone focus on one target. It is a known fact that people with different attitudes, agendas, social status, educational background and characteristics will often generate conflicts. Accordingly, the Sri Lankan commercial building industry has to face the same problem due to the involvement of many parties. This is in line with the findings of Chou and Yeh (2007), DeChurch et al. (2007), Desivilya et al. (2010), Huan and Yazdanifard (2012), Jehn and Chatman (2000), Senaratne and Udawatta (2013) and Simons and Peterson (2000) as they identified relationship conflicts as disagreements between people who work to achieve one target. However, the previous literature of the aforementioned authors indicated that relationship conflicts are often personal and rarely related to the task yet this study found that the relationship conflicts often occur due to task-related matters. Nonetheless, relationship conflicts affect the project performance even though they are personal or task related (Wild, 2002).

The most frequent conflict situation is conflicts between the consultant and contractor. CLO4 mentioned that “The consultant and the contractor are not very close. The problem is
not with the management of the consultant and contractor. They work friendly. However, the problem is with the subordinate level. The subordinate crew of the consultant’s side and the contractor’s side have lot of mismatching ideas which often lead them to disagreements.” This statement revealed that most of the consultant – contractor conflicts are occurred in the intermediate or the operational level of the organizational hierarchy. This is in line with the findings of Chen et al. (2014) as they indentified that conflicts can be often occurred between these two parties due to the task-related issues, process-related issues and the status of the prevailing relationship between the client and the contractor.

The second most common relationship conflict is between laborers. This is more critical due to the tendency of having severe arguments, quarrels and even destruction of the property. According to CR03, number of conflicts is taken place between the laborers and in few occasions, the contractor had to intervene to solve them. Further to CR03, the works had to be temporarily stopped in such occasions since other laborers are automatically become the spectators of such quarrels and severe arguments and sometimes taken part in the tempered situation. CN01 confirmed this fact by revealing that his project had similar experiences, yet not as much as in Case 3. Similarly, DeChurch et al. (2007) explained that the critical relationship conflicts will inversely affect the work performance. Further, Huan and Yazdanifard (2012) mentioned that conflicts between employees certainly affect the commitment of employees and cause absenteeism.

Conflicts between the contractor and subcontractors are often occurred due to payment issues and resource handling. This is in line with the findings of Acharya et al. (2006) and Verma (1998) as the authors pointed out late or poor administrative procedure and resource allocation issues would critically affect the parties who continue the onsite functions. As revealed by CN01, the subcontractors of the project stopped working due to the conflicts with the contractor and refused to deal with him. Instead, they requested the client to correspond directly with them. This is not the general procedure of the project yet the client had to agree with their demand in order to continue the project. CR01 revealed that contractor – subcontractor relationship is the weakest when compared to other professional relationships in the project. CL03 mentioned that it is hard to find good professional relationships between contractors and subcontractors in the Sri Lankan commercial building industry due to the high competitive nature yet most of them are highly professional and focus on the project rather than fulfilling their own agendas when it came to working together.

The final conflict situation under the relationship conflicts is between specialized contractors. This cannot be often seen due to the less usage of the particular procurement arrangement. However, if the project procurement arrangement consists of more than one specialized contractor, this conflict situation is common. According to CL03, it is very hard to coordinate the specialized contractors with regard to resource handling. The specialized contractor who did the architectural and structural construction had to facilitate the other contractors yet he had to face difficulties in providing facilities simultaneously to several parties. As a result, there are conflicts between them, especially during the finishing stage. Majority of the stakeholders who attended the meetings agreed with the fact that the conflicts between specialized contractors are not just situational yet more personal due to the historical incidents. They also pointed out that the ethical behavior of these contractors are not up to a professional level when compared to other stakeholders, thus lead to conflicts more often. According to Rahim (2002), this kind of interpersonal conflicts will barricade the successful completion of project since the parties will give more attention to reduce the threat coming from the other party and try to increase their power over the project.

6.3 Documentation-related conflicts

According to the meetings conducted, there are five common conflict situations under documentation-related conflicts. They are design errors, documentation errors, late submission

The most frequent conflict situation is design errors. CN01 stated that “There are many design errors which created lot of difficulties such as increasing budget, getting approvals, etc. On the other hand, many changes had to be done to the initial design due to the issues in the initial design.” This statement revealed that lot of time and energy are wasted to correct the design errors and it is a frustrating procedure. The end result of such procedure is to leave the actual construction on site on hold creating room for more and more conflicts. According to CN02, the more the design is complex, the more the design errors. During the discussions with the stakeholders, it is revealed that all four cases had design errors. Most of the conflicts arising with design errors are dealt with variations which created unnecessary wastage of time, money and energy. Similar findings are put forward by Ng and Skitmore (2000) by revealing that the design errors and incompatibility in designs will definitely create more conflicts in the future when real construction occurred and negatively affect time and quality standards.

The second most common conflict situation in relation to documentation is documentation errors. However, Jaffar et al. (2011) identified that the errors, omissions and defects in documents as a major source of conflict. CL02 mentioned that “Actually, there is no proper condition in the contract regarding the price escalation of imported material and what currency should be used to calculate the price escalations of duty free materials [...] It is a serious issue occurred due to documentation errors.” CR02 added more information by mentioning that “Furthermore, we needed lot more steel than it is mentioned in the Bills of Quantities (BOQ). So we had to buy local steel as well. In this case, we faced the problem of how to take the duty free facility because it is given for USD prices only.” This is happened due to the under measured steel quantity in the BOQ. Both stakeholders confirmed that the main reason for the increment of initial contract amount is the under measured items in the BOQ which is a huge documentation error. The other stakeholders who attended the meetings further contributed to the topic by revealing that most documentation errors are not just reasonable human errors yet the acts of negligence.

The third documentation-related conflict is late submission of documents. CN04 stated that “The contractor did not submit the documents on time and as we required. We argued several times about this. However, the client had no problem with the way of the contractor’s submissions of monthly statement so that he said it to be submitted once two months. I still do not agree with this method because it creates a huge workload for the client in one month and there will be no much work in the second month. Actually, it’s an imbalance.” Further to CN02, late submission of documents often created arguments and frustrations harming the professional relationship of both parties. CR01 mentioned that due to the late submission of documents, construction on site often got delayed and the workload of the receiving party always got high due to the limited time they had to finish the particular items. Both Acharya et al. (2006) and Verma (1998) identified this conflict situation in a broad manner by introducing it as a delay and as a goal oriented conflict, respectively.

Contradictions between documents are another conflict situation which can be commonly seen in the Sri Lankan commercial building industry. According to Jaffar et al. (2011), the contradictions of documents often led the professionals into conflicts. CL03 mentioned that “In this project, there is a conflict regarding the BOQ item for screed concrete. In the BOQ, only the screed concrete is priced yet in the drawing, there are some other layers additional to the screed concrete. In addition, the screed thickness given in the drawing is different to the thickness mentioned in the BOQ. The contractor argued about this and there are some discussions related to the matter. This conflict occurred due to the
contradiction between BOQ and drawings.” It is a known fact that normally there is a condition regarding the priority of documents in the conditions of contract. Yet the problem is with the price since the other layers which are on the drawings are not priced in the BOQ. CN03 agreed that it is a responsibility of the consultant team due to the high workload within a limited time.

Another general conflict situation that can be commonly seen in the Sri Lankan commercial building industry is non-finalized designs. CR03 mentioned that “By the time we started the construction, some items of the project such as mechanical, electrical and Plumbing (MEP) works, ceiling layouts, etc are not finalized. Furthermore, those parts are not finalized even though we completed a major part of the structural work. Therefore, when they are finalized, we had to change several completed items. This led to a big conflict. In addition, this wasted a lot of time and money.” This is a critical issue which led the parties to several arguments and disagreements. It is also a huge waste of money, time and energy by destroying the concept of value for money. These findings are similar to Ng and Skitmore (2000) as they argued the conflicts related to design often occurred due to the incorrect selection of the design team and incompatibilities of their work.

6.4 Execution of works-related conflicts
According to the stakeholders who attended the meetings, there are four common conflict situations with regard to execution of work-related conflicts. They are variations, issues regarding agreeing on rates, issues regarding resources and quality issues. However, the researches of Huin and Yazdanifard (2012), Jehn and Chatman (2000), Senaratne and Udawatta (2013) and Simons and Peterson (2000) identified this conflict type as task conflicts.

The most common execution of work-related conflict is variations. Acharya et al. (2006) categorized variations as a consultant evoked conflict which occurred due to confusing requirement of the owner and unclear project scope established by the owner. However, the above stated two sources of variations are categorized into owner evoked conflicts. Variations are common to all four cases and all the stakeholders who attended the meetings confirmed that variations are common to all projects they are previously engaged with. CR03 mentioned that “Both client and architect did several major changes to the initial design so that there are lot of variations; nearly 150 variations at the end of the project. This took so much additional time and money and created lot of conflicts regarding the design, cost and quality.” Further to CR03, the workload carried by them is enormous when compared to a similar project thus the effective contribution of the employees are considerably low. According to CN02, it is hard for them to meet the deadlines due to the high amount of variations and a number of discussions had to be made to manage the conflict situations arising from the variations.

The second most common conflict situation with regard to the execution of works-related issues is issues regarding agreeing on rates. This is not commonly addressed by the previous literature yet considered as a task conflict which makes the path to relationship conflicts (Simons and Peterson, 2000). CN04 stated that “Basically, we had huge and long term conflict of agreeing on rates. As the consultant, we always tried to save and utilize the client’s money. So if the rates are not reasonable, we had to disagree with them. So we had several occasions in which we had to thoroughly argue about the matters arising from rates. However, this conflict created some delays to the project and destroyed the good relationship we had with the Contractor.” It is further revealed that due to the issues regarding agreeing on rates, all subsequent works are delayed and the lengthy discussions regarding the matter often ended up with heated arguments, leaving the problem as it is.

Another execution of works-related conflict is issues regarding the resources. The findings of Acharya et al. (2006), Cheung and Chuah (1999) and Senaratne and Udawatta (2013) identified this conflict situation as a source of conflicts. However, this study
identified the issues in resource handling as a conflict situation; not as a source of conflict since it obtains its own sources. According to CR01, it is hard for them to find skilled labor and keep them in the project in the long run. Whenever there is any other conflict such as delayed payments, non-payment, late submission of documents or any relationship conflict which hold the work for a while, the laborers went looking for other jobs. Therefore, labor handling is a big problem in this project. CL03 mentioned that they have faced difficulties in providing facilities to the specialized contractors simultaneously. CR03 agreed with CL03 by revealing how hard it is to provide scaffolding, formwork and the like concurrently to several contractors.

Quality issues are one of the most critical execution of works-related issues since it directly affected the client’s expectations. CR01 mentioned that “Quality of labour is low. For example it is very difficult to find good masons and carpenters, and also their wages are too high.” Due to the low quality in workmanship, the end product would not gain the value for money. Moreover, the finish would not be according to the standards. Ultimately, the building would not be finished according to the client’s requirements. Similarly, CN03 mentioned that they often had to check the quality of the materials supplied by the suppliers to the project due to frequent identification of low quality materials. Moreover, several constructed items of the building required rework due to the usage of low quality materials. Similarly, Ng and Skitmore (2000) stated that the current construction industry require high quality product while allocating less time and money for design and construction and this will often lead the project to conflicts related to quality standards.

7. Conflict management
The findings revealed that every project has its own conflict management procedure with different magnitudes. The stakeholders who took part in meetings revealed that conflict management is crucial for the successful completion of the project and to avoid expensive and time consuming dispute resolution procedure. Further to them, conflict management is not eliminating the conflict yet dealing with it in such a way that it will not generate harmful effects. This is in line with the findings of Popovic and Hocenski (2009) since they introduced the principle of conflict management as handling the conflict in such a way that it will not generate harmful effects. Similarly, Jaffar et al. (2011) stated that it is more effective and practical to manage the conflicts rather than trying to resolve it by wasting time, money and energy since conflicts are inevitable due to the complexity, lengthy time of construction and multi-disciplinary involvement.

According to the stakeholders who attended the meetings, conflict management is a large spectrum of the stages of avoiding the possibilities of having conflicts, preparation for potential conflicts by considering the past experiences, early identification of conflicts, utilize the constructive part of the conflicts, conflict management by using management styles, dispute avoidance and maintaining records for future use. Similarly Verma (1998) introduced three stage conflict management strategy: getting ready for the conflict by expecting of conflict and planning to face the conflict; experiencing the conflict by recognizing its real nature; and managing the conflict as per the plan with necessary changes. However, Verma (1998) did not give a consideration for the aftermath of the conflict management. Out of the five conflict management styles in dual concern theory, four styles are using in the Sri Lankan commercial building industry. They are compromising, authority, obliging and avoiding. Problem solving style can be rarely seen yet the probability of using it is considerably low due to the fact that providing high consideration for both self and others simultaneously is not practicable in the competitive commercial building industry. This is partially in line to the findings of Vu and Carmichael (2009) as they argued most of the Eastern countries, due to their cultural values and desire of group harmony, tend to use avoiding and obliging styles.
7.1 Compromising
Compromising is the most common conflict management style used in the Sri Lankan commercial building industry. CN01 mentioned that “The most common method we used is negotiation. We always talk with both client and the contractor about the conflict situations and how we should manage them. Similarly, we talked with subcontractors as well. Lot of conflicts are managed through proper negotiation. It never provided the opportunity to have everything we need but it always gave an acceptable solution for both parties.” This statement revealed that even though the parties could not achieve their full intentions, they are able to manage the conflict situation by gaining the maximum satisfaction according to the situation. Further to him, negotiation is the most effective conflict management style since it enabled them to avoid unnecessary cost and time increments and protect the good professional relationships. According to CR01, good professional relationships are the path to more future projects, thus certain sacrifices had to be made for the sake of future success. During the discussions with the stakeholders, it is revealed that all four cases used negotiation as their main conflict management style. This is in line with the findings of Appelbaum et al. (1998) in relation to North America, Lee (2008) in relation to Malaysia, Ozkalp et al. (2009) in relation to Turkey and Al-Sedairy (1994) in relation to Saudi Arabia as they all prefer negotiation as their key conflict management style.

7.2 Forcing
The second most common conflict management style with regard to the Dual Concern Theory is forcing which is commonly known as authority in the building industry. CN01 mentioned that “Of course we had to use our authority to come to the conclusion that we pay directly to the subcontractors. Furthermore, we had to use our authority to manage the conflicts occur due to delayed submissions of monthly statements and some design changes.” According to him, using authority should be done carefully in the right occasion. Nevertheless, it is a famous technique to manage the conflict since all stakeholders respect the organizational hierarchy as well as line of authority. CR03 further explained the effectiveness of this technique by stating “As an Engineer, I know the rules of engineering and if a client or a consultant says something that opposes the rules of Engineering which could also effect on strength or finishes of the building, I cannot negotiate or accept what they say. For instance, if perimeter of walls is 9 inch, then it should be nothing less than that. If we cannot go for the plasterboard walls or the dry walls due to the weather and the surroundings, we must not use them. Basically, in some areas we are very confident of what we should and should not do. In these situations, I have to make them accept my decision because I know the technology well.” This statement revealed that in some occasions, using authority is crucial in order to avoid structural failures. Further to CR03, having a certain authority for every construction professional is itself a conflict management technique which should be used in the correct situation. According to the opinion of Appelbaum et al. (1998), forcing style is a better style to be used in conflict management either individually or with other conflict styles. Similarly, Vu and Carmichael (2009) suggested that most of the Western countries tend to use dominating style as they are more individualistic in professional matters. However, this is an opposing idea with regard to this study since Sri Lankan building industry use forcing style more often than obliging or avoiding which are generally preferred by the Eastern countries.

7.3 Obliging
The third conflict management style used in the Sri Lankan commercial building industry is obliging. This is opposite of using authority. CN04 stated that “The contractor did not submit the documents on time and as we required. We argued several times about this. However, the client has no problem with the way of the contractor’s submissions of monthly
statement so that he said it to be submitted once two months. I still do not agree with this method because it creates a huge workload for the client in one month and there will be no much work in the second month. Actually, it's an imbalance. However, as the consultant, we had to agree with the client.” This statement revealed that obliging style created a win for one party while other party obtained a total loss. However, the losing party had to accept it due to the authority carried by the third party (Client in this scenario). Nevertheless, the winning party did not achieve their win due to their own authority yet due to the authority of the third party had over both conflicting parties. Therefore, obliging can be seen in two different ways; if one party has more power than the other party, the latter party had to use obliging style, and if a third party has more power than the conflicting parties, both parties have to use obliging style. CN01 mentioned that “The contractor at most of the times agreed with our decisions. When we decided to pay the subcontractors directly, the contractor agreed with that. He is always supportive to the consultant’s decisions when he thought that the consultant’s decision is more reasonable.” This statement revealed that obliging is not always a loss. It can be a way of accepting the right thing to do even though it is not beneficial to one party. Further to CN01, obliging is a professional way to manage the conflict if one party is more reasonable and factually strong than the other party. The stakeholders agreed to the fact that obliging is not merely a win-lose approach yet it provided advantageous results such as reducing the professional responsibility of the losing party. This is opposite to the findings of Zhang et al. (2015) as the authors argued that even though Eastern countries preferred obliging in the past, the current preference has changed, ranking obliging as one before the last due to the competition, rapid development and globalization. Malaysian construction sector prefer obliging as a combined conflict management technique with either compromising or integrating (Lee, 2008).

7.4 Avoiding
The final conflict management style used by the Sri Lankan commercial building industry is avoiding. CR02 explained this by using his experience; mentioning that “The client did not pay us around USD 0.75 Million. His argument is that he will not pay for the claims issued after the completion of project. Nevertheless, we ignored that because we wanted to have a good professional relationship with the employer.” In this incident, the contractor’s party did not consider about the financial loss they gained. Instead, they consider about maintaining the good professional relationship with the intention of having all future projects of the client. When consider about the client, even though he did not have to pay the additional costs, he became liable to the contractor, creating an ethical liability to favor the contractor in all future tendering procedure. In addition, the client lost his power over the contractor. CN01 stated that “However, we avoided the labourer’s conflicts because they are not relevant to us.” Avoiding style can be used for the conflicts which are not directly relevant to the construction. However, in this situation, the labor conflicts wasted a considerable time. Nevertheless, the relevant parties refused to involving in them due to the fact that if they involve, the conflicts might become severe with labor strikes and harming the property. Using avoiding style enabled the project to keep both conflicting parties on site since no managerial level professionals took any side. The findings of the study partially agreed with Friedman et al. (2000) since they argued avoiding is suitable for conflicts which cannot be managed due to lack of knowledge regarding the conflict. However, this study identified that avoiding style can be used for the aforementioned conflicts as well as for the conflicts which occur in project yet not relevant to the project. Moreover, the study agreed with the findings of the Ohbuchi and Suzuki (2003) in relation to Japan and Zhang et al. (2015) in relation to China as they rarely use avoidance currently, changing their preference toward compromising and integrating.

During the meetings, the stakeholders pointed out the conflict management styles used for the conflict situations they have faced. They are shown in Figure 2.
8. Discussion

The study focused on whether the magnitude of the project and its complexity has any impact on having conflicts. Accordingly, the magnitude of the project has a direct relationship with the tendency of having conflicts. The main reasons for such relationship can be identified as lengthy process of construction, involvement of more parties, high workload, enormous documentation, high human diversity and limited resources. This is in line with the findings of Jaffar et al. (2011) and Alzahrani and Emsley (2012) as they emphasized the conflicts are increasing in an alarming rate due to the construction of high rise buildings with lot of facilities, new technology and advanced services.

However, a connection between the complexity of the project and the tendency of having conflicts cannot be derived according to the available information due to the disturbance
occurred by Case 3. It obtained the highest number of conflicts even though it is less complex than Case 1 and Case 2. The study then observed the reason for the disturbance and found that the procurement arrangement of Case 3 is different to other three cases. In Case 3, the involvement of professional parties is way higher than the other three cases. The project had nine specialized contractors who directly involved with the client and four subcontractors who dealt with the specialized contractor for architectural and structural works. Therefore, it can be pointed out that the one main reason for having more conflicts is high multi-disciplinary involvement. This is in line with the findings of Yousefi et al. (2010) as they indicated that multi party involvement in construction often complicate the project and generate conflicts due to the lack of coordination among the parties, poor communication and high work load. Further to this study, having a vast documentation process which involved more parties led the project toward more conflicts. Theoretically, Case 3 had to face the problems eight times multiplied when compared to the other three cases; especially the relationship conflicts. Therefore, the number of conflicts of Case 3 is a special condition. If consider about the other three cases, a pattern can be identified with regard to complexity and having conflicts; they obtained a direct relationship. This is in line with the findings of Jaffar et al. (2011) and Yousefi et al. (2010) as both studies specifically mentioned about the direct relationship between the conflicts and complexity of projects.

Even though the magnitude and complexity had a direct relationship with the tendency of having conflicts, the severity of conflicts did not have a relationship with the project. During the meetings, the stakeholders are questioned about the severity of the conflict situations they experienced. Accordingly, Case 1 is having severe conflicts than the other three cases even though it is not big as Case 2 and Case 3. The main reason for having severe conflicts is the personal respond of the parties and how the situation is initially handled. This is in line with the findings of Tjosvold (2006) and Giritli et al. (2009) as they argued conflicts did not rise themselves or escalate themselves yet they are created and developed by the wrong behavior of people.

According to Tjosvold (2006), it is obvious that humans are behind the creation of conflicts as well as the management of them. This theory is common to the Sri Lankan commercial building industry as well due to the involvement of many people with different backgrounds, attitudes, characteristics, education and skills. However, every stakeholder in a project carries a professional responsibility to complete the project by doing his part without giving priority to their personal goals and personal matters. Nevertheless, a question should be raised whether the professionalism of stakeholders create any impact on the tendency of having conflicts.

During the meetings with stakeholders, it is identified that most of the relationship conflicts during construction are occurred between the operational level stakeholders who continuously dealt with each other. According to the data analysis, Case 2, Case 3 and Case 4 had number of relationship conflicts between consultant’s staff and contractor’s staff. The major reasons for this situation are identified as less experience and lack of interpersonal skills. As pointed out by the stakeholders in meetings, if there is no enough experience, it is hard to survive in the construction world since it is all about handling people in such a way that they would willingly agree for everything even though it is not their main intension. Further, less experienced stakeholders often handle the situations according to books, yet in this kind of an industry; “work by the book” concept could create more harm than good. Furthermore, having good interpersonal skills would assist the stakeholders to deal with other people. Hence, it can be said that the level of experience of stakeholders obtain an inverse relationship with conflicts. Even though past literature did not directly talk about the particular matter, Huan and Yazdanifard (2012) argued that the relationship between supervisors and subordinates often decided the amount of conflicts occurred between them.
The study further focused on whether the organization culture has any impact on the tendency of having conflicts. It is found that the contracting companies maintain a result oriented organization culture whereas the consultancy companies maintain a process oriented organization culture in most of the Sri Lankan commercial building sector. These findings are in line with the findings of Rameezdeen and Gunarathna (2003) as they identify the consultancy companies as goal oriented and well organized on the process while identifying the contracting companies as competitive and well encouraged for output maximization. According to the analysis, it is visible that contracting companies tend to have a diverse range of conflicts than the consultancy companies (example Case 1 and Case 2). Therefore, it can be said that the tendency of having conflicts is high in a result oriented organization culture. This is mainly due to the eager to gain profit. However, it can be also seen that the contracting companies are more interested in proper conflict management and willing to compromise and make sacrifices whereas the consultancy companies hesitate to go above the rule.

9. Conclusion and recommendations
Conflicts are natural and inevitable in the Sri Lankan commercial building industry. According to the findings of this study, there are 15 conflict situations that can be commonly seen in the Sri Lankan commercial building sector which can be categorized into four main conflict types, namely; payment issues, relationship conflicts, documentation-related conflicts and execution of works-related conflicts. The study focused on the sources of these conflict situations and found out that some of the most common sources of the aforementioned 15 conflict situations are financial issues of the parties, selection of underpriced bids, unprofessional behavior, poor communication, poor coordination, bad history, poor documentation, supremacy of professionals, high work load, disagreement of parties, design errors, less experience, unavailability of resources and negligence.

According to the findings, the most commonly used conflict management style in Sri Lankan commercial building sector is compromising style which enabled both parties to gain some degree of satisfaction. It is surprising to see that forcing style received the second place irrespective of the value given to the collectivism qualities in Sri Lanka. It is highly argued and well accepted that most of the conflict situations can easily managed by using forcing styles. Obliaging style received the third place in the ranking of common conflict management styles. According to the stakeholders in the Sri Lankan building industry, obliaging style is a way of protecting good professional relationships which can be a good investment for future. However, obliaging style is not famous as compromising and forcing. The least common conflict management style is avoiding. The findings revealed that avoiding style is used whenever the conflict is not relevant to the project or when the parties are not equipped with information to manage the conflict. It is shocking to see that Sri Lankan commercial building sector rarely use problem solving style for conflict management even though it is the most effective conflict management style with long term solutions and creative thinking. However, it should be noted that these findings only indicate the commonness of using the styles yet not the perfect conflict management style to a particular conflict. Further, the study does not introduce the best conflict management style which satisfy both parties. It only provides information about the common conflict management styles used for a particular conflict situation. Selecting the perfect conflict management style as per the situation is completely in the hand of the parties by using their knowledge, experience and historical data. However, when they decide which conflict management style should be used, the parties can rely on these findings (what is the most commonly used management style to a particular conflict) as these have demonstrated positive outcomes.
It is identified that tendency of having conflicts in the construction projects has a direct relationship with the magnitude of project and the complexity of the projects. However, there is no relationship between the severity of conflicts and the magnitude and the complexity of projects. The severity of conflict will be decided by the human behavior. Further to findings, the experience of the stakeholders has an inverse relationship with the tendency of having conflicts.

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Further reading


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An analysis of the delivery challenges influencing public-private partnership in housing projects

The case of Tanzania

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Abstract

Purpose – The purpose of this paper is twofold: first, to identify and rank the challenges influencing the delivery of the housing public-private partnership (HPPP) in Tanzania; and second, to suggest solutions in the form of a conceptual public-private partnership (PPP) framework model that will address the identified challenges and boost the chances of success.

Design/methodology/approach – Using a convergent parallel (concurrent) mixed method approach, data were collected from 28 stakeholders involved with HPPP projects in Tanzania using a hand-delivered and e-mail survey and 13 semi-structured interviews with public and private sector respondents. The quantitative data included subjecting the 19 challenges as identified from the literature to parametric tests such as one-sample t-tests and descriptive statistics tests such as measures of central tendencies and frequency analysis through Statistical Package for Social Sciences (SPSS 22.0). Qualitative data employed content analysis. The research was further underpinned by a number of theoretical perspectives such as Gidden’s structuration theory, contingency theory, relational and equity theory.

Findings – The top five ranked challenges influencing the delivery of HPPP were “inadequate PPP skills and knowledge”; “poor contracting and tendering documents”; “inadequate project management”; “inadequate legal framework”; and “misinformation on financial capacity of private partners”. The least six ranked and most significant challenges based on the one-sample (single) t-tests were as follows: “Poor risk allocation”; “inexperienced private partner”; “unequal qualification and contributions of expertise”; “poor enabling environment to attract competent partners”; “inadequate mechanisms for recovery of private investors’ capital”; and “high costs in procuring PPP projects”. The qualitative study further confirmed the challenges and cited the reason for the failure of joint venture projects as the lack of motivation for undertaking similar PPP projects. Despite the increased awareness of PPP projects and associated marginal benefits, the main impediment to the uptake and delivery of PPP housing projects remained the lack of skills and expertise.

Research limitations/implications – The proposed framework model is not yet tested, but since this paper is part of the ongoing research, the next stage involves the testing and validation of the model. Future studies could test the applicability of the proposed framework in other HPPP projects in Tanzania, and in other similar developing countries. Second, the validated framework can contribute towards addressing similar challenges as well as providing guidance. The proposed framework model is not yet tested, but since this paper is part of the ongoing research, the next stage involves the testing and validation of the model. Furthermore, recommendation for future research is to test the alignment of the identified challenges to the proposed remedial solutions across the five phases within the proposed PPP framework with a number of case studies.

Practical implications – The identified challenges were used to form the basis of the framework presented in this paper. Furthermore, these provide useful information, thus leading to increased awareness to enable...
successful delivery of HPPP in Tanzania. Similarly, both the government and policy makers could use the findings as the basis for re-examining the existing PPP policy and regulations, and reflecting on the existing situation with a view to improving the delivery of future HPPP projects.

**Originality/value** – The empirical study is among the first that identifies and ranks the challenges of PPP for housing projects delivery within the Tanzanian context. The identification of the challenges enabled their ranking, resulting in the mapping out of the most critical challenges. Furthermore, using the Gidden’s structuration theory, the study illustrates how institution mechanisms (structures) address these delivery challenges, thus influencing the implementation of HPPP in Tanzania, and how individual stakeholders (human agents or agency) are able to make choices (advocated solutions) in dealing with the challenges. More so, these constraints (challenges) as identified and viewed through the contingency and equity theoretical lenses form the foundation for developing the PPP conceptual framework. The proposed framework would thus serve as a mechanism for providing practical solutions as well as reducing the level of severity of the identified challenges.

**Keywords** Project management, Questionnaire survey, International practice

**Paper type** Research paper

1. **Introduction**

Many African countries, such as Tanzania, continue to lack suitable policies for housing development, and this has largely contributed to the growth of informal and poor housing conditions. Since independence in 1961, Tanzania like many African countries, for example, has experienced a large increase in population from 12.3 million in 1967 to almost 45 million today. Coupled to this is a raise in the urban population from 5.7 per cent in 1967 to 29.1 per cent in 2012. The overall trend in population growth averaged nearly 3 per cent annually, while urbanisation grew by 5 per cent annually (Smith, 2015). The result is that the available social facilities and services have been significantly strained. This is an African-wide problem with most of the cities in Africa finding themselves needing to accommodate an extra 40,000 to 50,000 people every day because of this rapid population growth (UN-HABITAT, 2011).

Such rapid growth in population and urbanisation has contributed towards inadequate housing for a number of decades. Across Africa, there is a severe housing deficiency, for example, in Tanzania, this is currently projected at three million houses while the rate is growing at a rate of 200,000 houses per annum (National Housing Corporation (NHC), 2010). The situation has worsening in urban regions of Tanzania, where the data show that urban population had grown from 14.8 per cent in 1980 to 37.5 per cent in 2005 and further rise to 46.8 per cent is expected by 2015 (NHC, 2010). Coupled to which is the supply of housing in countries, such as Tanzania, has failed to keep up with investment in both the public and private sector services falling rapidly behind (World Bank, 1992). Because of this widening gap, the Tanzanian Government has had to seek alternative ways to address this issue, such as the public-private partnership (PPP) strategy, to relieve the existing situation (Kidata, 2013; NHC, 2010). The adoption of these PPPs has more recently been considered the next best alternative to deliver public services such as housing (Sengupta, 2006; Moskalyk, 2011). However, despite the adoption of PPP in-house delivery, the prevailing problems remain unresolved. For instance, more high-cost houses have been built but attracting the required private partners has remained problematic in developing countries (Sharma, 2012). Furthermore, according to Ngowi (2006), PPP application in countries, such as Tanzania, is a new phenomenon, and still in its infancy.

In spite of numerous studies on PPP, the majority of them have identified the challenges hindering the growth and success of PPP across various sectors. In both developing and developed countries, empirical studies on the challenges affecting the delivery of housing PPP projects, as well as the development of conceptual frameworks, are very limited. Furthermore, according to Tang *et al.* (2010), the majority of these empirical studies on PPP in construction have largely centred on three themes: risks; relationships; and financing. However, some of the Tanzanian-specific studies, for example, have investigated
institutional arrangements and constraints within the solid waste management (Nkya, 2004) and PPP challenges in Tanzanian municipalities (Ngowi, 2006), providing some insights into African-centric issues. Mboya’s (2013) study, although covered implementation roles and legal issues as well as PPP framework road map, was more on a country level and based on non-empirical data. The only exception in identifying the challenges to the delivery of housing PPP projects is the Kavishe and An (2016) study. However, this study did not offer detailed solutions or a conceptual framework. The above suggests that in spite of these rather limited Tanzanian PPP studies, they are mostly policy related and not based on empirical data (i.e. Mboya, 2013; URT, 2009), and include non-construction and housing studies with emphasis on local authorities (Ngowi, 2006) and solid waste management (Nkya, 2004). This highlights the need for construction and housing-specific empirical studies on a number of areas affecting PPPs. More recently, Akintoye and Kumaraswamy (2016) renewed the calls for more research on PPP. The need for the Tanzanian context-specific PPP studies is nested in the different prevailing regulatory and framework conditions. As observed by Tang et al. (2010), and more recently, the World Bank (2016) report, the implementation issues (including challenges) and emergent benefits should take stock of the internal and external conditions in the host country by PPP partners. It is also acknowledged that the implementations of PPPs in Tanzania are still in the infancy stage and a new phenomenon. Furthermore, in contrast to other African countries, such as Nigeria and South Africa, Tanzania continues to lag behind neighbouring countries in terms of improving its business environment (World Bank, 2016, p. 30).

Similarly, some selected recent studies in developing countries have been both housing and non-housing specific. For example, Hashim et al. (2016) investigated the delivery of facilities management in Malaysia. In Nigeria, Babatunde et al. (2012) focused on the critical success factors (CSFs) in PPP in infrastructure delivery. In Ghana, Kwofie et al. (2016) studied a critical success model for housing public-private partnership (HPPP) delivery. Within the developed countries context, recent studies, such as Akintoye and Kumaraswamy (2016), have highlighted equally a number of significant challenges for PPP and directions for future research. It is therefore evident that, despite the proliferation of PPP-related studies, there are limited empirical studies undertaken within the many African countries and their housing projects. The identified challenges call for the need to address them, and this provided a basis and drive for developing an HPPP framework model. Therefore, there is a need to explore the specific challenges affecting the delivery of PPP in housing projects within the African context. In order to respond to the research agenda and knowledge gaps identified by Akintoye and Kumaraswamy (2016), the main objective of this study is to identify the challenges affecting the delivery of the HPPP using Tanzania as its focus, to provide a conceptualising HPPP framework model that will guide HPPP affordable housing projects in Tanzania. This will ultimately provide a framework for other developing countries, particularly those in Africa, that have similar socio-economic and political characteristics.

1.1 Conceptualisation and theoretical basis: Gidden’s structuration theory

In formulating the above objectives, the underlying theoretical basis is premised on the following two issues of “Agency” and “Structure”, as postulated by Giddens (1984) structuration theory. According to Giddens (1984 cited in Chileshe et al., 2013, p. 164), structure refers to the rules for acting, thinking, and feeling that are general throughout a society or an organisation, and the available materials and non-material resources that are needed for an action to take place. HPPP projects in Tanzania are structured as joint ventures (JVs). Drawing upon the definition as provided, within the context of this study, the “structure” refers to the rules that permeate through the Tanzanian private and public organisations with the responsibility for the delivery of HPPP, and the consideration of
the resources that these organisations might have or not have (hence the need for PPP) would be required for “action” or implementation of PPP to take place. Therefore, within the context of our present study, these “structures” refer to the “PPP policy, guidelines, legal framework and procurement regulations” which act as a set of rules, with power to manage and informing over the actions of the members of a society or organisation (i.e. PPP coordinating units, Tanzanian public and private organisations/ stakeholders). In contrast, Baker (2005 cited in Chileshe et al., 2013, p. 164) defines the “Human agency” as the capacity for human beings to make choices and take action to implement these choices (i.e. whether to undertake PPP training or not). Therefore, considering the poor PPP performance and its underlying challenges in Tanzania (World Bank, 2016), it is important to pay attention to both the human agency and PPP structures, as they are inseparable and their interactions are significant (Giddens, 1984). Studies, such as Agyenim-Boateng et al. (2017), have applied Giddens structuration theory in examining the accounting and governance of PPPs.

2. Literature review
2.1 Various forms of PPP procurement arrangements
According to Li et al. (2005), eight types of PPPs have been acknowledged by the UK Government including JVs, policy partnerships, partnership investment, private finance initiative, sales of business, wider market, asset sales and partnership companies. However, in Tanzania, JVs have been the dominant type/form of PPP in their housing projects. Likewise, both developing and developed countries, such as Nigeria, Yemen, Philippines, India, Ghana, the Netherlands, UK and Ireland, have also adopted the JVs in delivering housing projects (Ibem, 2011a; Al Shareem et al., 2014; Sengupta, 2006).

Seminal studies, such as Stevenson et al. (1994), have defined JVs as an association of two or more persons who contractually agreed to contribute to a specific venture, which is usually limited to a specific task or period of time. Undertaking this type of procurement arrangement by the Tanzanian stakeholders further highlights the need of identifying the challenges associated with the implementation of PPP based on the equity theory in order to model the appropriate solutions to these challenges. For example, Adams (1965 cited in Zhang and Jia, 2010) and Scheer et al. (2003) defined equity theory as for where a partner will assess its own inputs and a return against the other partner’s input and return in an existing relationship. For a detailed discourse on the various PPP meanings, forms and models within the western literature, please see Mouraviev and Kakabadse (2012).

2.2 PPP housing in Tanzania
HPPP is still in its early stages in Tanzania primarily because of a lack of direct experience and inadequate new investment in housing projects. To date, two public organisations, namely the National Housing Corporation (NHC) and the National Social Security Fund (NSSF), have used the PPP method for housing provision. Since the 1990s, NHC used the PPP approach in building development, but most of these partnership projects were not very successful. This was primarily due to the lack of an adequate PPP legal framework to guide the implementation of such projects, which delayed its progression (URT, 2009).

Despite recent developments undertaken by the Tanzanian Government in enhancing the regulatory frameworks via PPP regulations in 2011 and the Public Procurement Act 2011, there still remain a number of challenges such as the relative infancy of rather complex PPP and lack of experience across the stakeholder chain (Mboya, 2013). The NHC is the oldest and largest real estate developer in the country, owning many buildings in various conditions. The redevelopment or rehabilitation of such buildings required substantial funds, which NHC itself could not afford. Therefore, the Corporation
had to consider PPP strategy. The NSSF is a public organisation, which provides social security/pension funds to Tanzanians. However, it recently started to undertake HPPP projects in 2013.

2.2.1 Financing of PPP housing projects in Tanzania. In a recent review-related study undertaken by Chileshe (2016), inadequate funding and revenue problems were among the challenges identified as inhibiting the managing of infrastructure in Africa. While PPPs were among the advocated solutions to these problems, in Tanzania, like in many other developing countries, real estate development financing is usually problematic, since there are no mortgage banks to facilitate effective financing. A few banks, such as Azania Bank and Commercial Bank of Africa, started offering housing loans but mainly to small-scale developers. Such funds are not adequate to enable the NHC to execute its large projects. Moreover, the interest rates charged by these banks are high, ranging between 20 and 25 per cent, and loan repayment terms are generally short and the near absence of mortgage financing also limited the property developers or investors who depend on equity financing. NHC was, therefore, forced to depend mainly on equity to finance its projects. Equity funds are normally derived from the existing projects, particularly houses for sale and rental revenue. However, the latter source of funds is inadequate since tenants frequently do not pay rent in time. Equally, house buyers were having trouble with agreed schedules of payments.

According to Kavishe (2010) and Kavishe and An (2016), NHC Joint Venture Policy had loopholes and flaws that led to the failure of some of these projects. Similarly, in their very early projects, the selection of their partner was in the manner of “first come first served”. There was no room for competition, which would have assisted the Corporation to secure more potential investors. Figure 1 describes the 1995-2010 NHC procurement framework models, which illustrate the procurement selection process of partners and projects.

The NHC PPP process was non-competitive, and it depended on the ability of the private partner to submit a quick proposal. Other factors such as skills and capacity, experience, viability of the project and integrity to mention a few were not considered. In addition, the absence of any financial assessment of private partners highlighted the lack of integrity due to the limited scrutiny of the process. As a result, a number of investors were facing financial difficulties a few months after the start of the project, which led to delays, poor performance and unsuccessful delivery of projects.

On the government side, there have been serious efforts to improve and promote private sector participation in PPP projects. This culminated in first a PPP Policy, then a PPP Act in 2010 and finally, in 2011, PPP regulations being approved. In order to coordinate and oversee the mainland Tanzanian PPP projects and PPP Financing Unit within the Ministry of Finance, a PPP Coordination Unit was established with the duty of assessing and examining all PPP proposals in their financial aspects. This body was formed as a result of the 2010 PPP Act within the Tanzania Investment Centre. Despite the establishment of these units, no HPPP projects actually were submitted to them for assessment and approval. Having suitable PPP strategies, policies and regulatory framework is one thing, but making them effective and efficient is entirely another.

2.3 PPP housing in other countries
Both the public and private sectors are adopting partnerships for the delivery of housing and urban development worldwide (Moskalyk, 2011). Developed countries, such as the UK, Canada, the USA, Australia, and some developing countries, such as India, Nigeria, South Africa and Malaysia, have employed PPP projects in delivering affordable houses (Moskalyk, 2011; Abdullahi and Aziz 2011; Liu et al. 2014; Chan et al., 2004) although not always successfully. For example, Trangkanont and Charoenngam, 2014a explained, “A number of developing countries such as Thailand, Vietnam, the Philippines, Malaysia
and Indonesia have experienced failures in their PPP Low-Cost Housing (PLCH) projects due to different factors. Trangkanont and Charoenngam identified ten factors of PLCH in Thailand which led to failure: inadequate tender documents, inefficient management change, poor contractors, political intervention, ineffective PPP policy and strategy, weakened institutional culture, policy pressure, and difficulties to low-income group, economic problems and housing finance constraints. Similarly, a number of other studies identified different challenges in PPP projects, as listed in Table I.

Furthermore, the study undertaken by Moskalyk (2011) noted that rich countries have only been successful in delivering affordable housing due to the high level of government subsidies that lower housing cost. Moskalyk’s study further added that these subsidies were a “luxury” that could not be afforded in the developing world. The researcher criticised this...
## Table 1
Summary of selected literature on challenges affecting the delivery of PPP housing projects

| No. | Challenges                                                                 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | No. F (%) |
|-----|----------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|        |
| 1   | Differing goals between partners                                           |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 2   | Corruption                                                                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 3   | Misinformation on financial capacity of private partners                   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 4   | Poor PPP contract and tender documents                                     |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 5   | Delays                                                                     |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 6   | Inadequate PPP legal framework and guidelines                              |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 7   | Inadequate PPP skills and knowledge                                        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 8   | Lack of competition                                                        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 9   | Inadequate feasibility study                                                |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 10  | Inadequate project management by the public sector                          |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 11  | Long term disputes and conflicts between parties                           |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 12  | Inadequate government commitment and support                               |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 13  | Insufficient capacity in procurement and negotiations                       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 14  | Poor risk identification, allocation and management                         |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 15  | In experienced private partner                                             |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 16  | Unequal qualifications and contributions of expertise                      |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 17  | Poor enabling environment to attract competent partners                      |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 18  | Insufficient mechanisms for recovery of private investors' capital         |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 19  | High cost in procuring PPP projects                                        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 20  | High end user charges                                                       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 21  | Lack of transparency                                                        |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 22  | High cost of building materials and construction equipment                  |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 23  | Poor infrastructure services                                                |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 24  | Public acceptability                                                       |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 25  | Lack of uniform policy in PPP housing provision                             |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 26  | Lack of coordinating agency in PPP housing                                  |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 27  | Poor access to developable land                                            |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |
| 28  | High building standards                                                     |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |        |

argument on the basis that subsidies can be a luxury to any government where there have been no previous plans and strategies for their inclusion during budget preparation. Subsidies, provided they are treated as priorities and carefully planned by whichever government of the day, can be affordable. Hence, it is necessary to have strategic plans and the correct policies in place in order to successfully deliver affordable housing.

2.3.1 **PPP housing in selected developing countries**. 2.3.1.1 Malaysian experience. Malaysia has benefited greatly from the use of PPP arrangements in delivering affordable houses. The secret behind its success is the provision of favourable housing policies. One of the major concerns of Malaysian housing policy was making sure the low-income group had guaranteed access to housing. The study by Abdullahi and Aziz (2011) stated that the third Malaysian plan 1976-1980 indicated better performance within the private sector than in the public sector and thus provided a larger portion of low-cost housing. The “cross-subsidy policy” was a key feature of the housing policy, where the rich subsidised the poor. This meant that any housing development project had to follow the regulation of developing at least 30 per cent of the houses as low-cost housing and the rest can be for the high- and the medium-income group. Also, it made an effort to remove the financial barriers for low-income families through government loans and regulations that required the financial institutions to increase their loan facilities as much as 100 per cent to those with low incomes (Abdullahi and Aziz, 2011). The Malaysian Government made sure that the allocation of the low-cost houses was open and applied through an open registration system. This eliminated much corruption, cheating and inequality as a fair system was adopted. From the Malaysian experience, it is clear that detailed groundwork, strong policies and clear objectives need to exist before the adoption of the strategy.

2.3.1.2 Indian experience. Another study conducted by Sengupta (2006) highlighted a number of constraints to PPP housing projects in Kolkata that include: “poor access to finance by low income families”, “out dated legislation”, “high levels of municipal taxes”, “stamp duties” and “sanction fees”. But despite these challenges, Kolkata has been successful in adopting PPP in housing in terms of cost and quality because its government focused on appropriate regulations rather than rapid changes.

2.3.1.3 Nigerian experience. According to a study by Ibec (2011a, b), PPP is still a new approach to housing provision in Nigeria and the main reason for adopting PPP is to address the increasing housing challenges. The HPPP in Southern Nigeria took a JV approach like in Tanzania. Ibec (2011a, b) obtained data through interview surveys from government housing agencies in six cities and identified that PPP had not made any substantial impact on housing the low-income group. Instead, more houses were built for the high- and middle-income earners. The lack of uniform National Policy was acknowledged as the main challenge. Likewise, a similar study by Ukoje and Kanu (2014) identified that a PPP mass housing scheme in Abuja, Nigeria was undertaken in the absence of adequate planning and implementation and the partners appeared to lack the capability. It was difficult for this project to achieve the aim of delivering affordable housing. Therefore, Ukoje and Kanu (2014) study concluded that to improve HPPP in Nigeria, “capacity building for the partners”, “positive quality enabling environment”, “stricter control” and “government’s support for the sake of the low-income earners” were necessary.

2.3.2 **CSFs for delivery of PPP housing projects**. A review of the literature has identified a number of studies, which reported on CSFs in the developing countries (Babatunde et al., 2012; Ismail, 2013; Kwofie et al., 2016; Dairu and Muhammad, 2015). These studies identified the following success factors: good governance; appropriate risk allocation and risk sharing; availability of financial markets; defensive policy against political risks; political stability; strong private consortium; favourable legal framework; government support participation in providing vital guarantees; and genuine commitment of collaborating parties.
Recent studies, such as Osei-Kyei and Chan (2015), have produced an equally comprehensive list of CSFs for PPPs.

### 2.3.3 Summary of literature review

In addition to the summarised studies in Table I, a review of a number of related literature was undertaken. This was mostly in the areas around the key principles and success factors. Examination of interviews shows that the majority of reviewed studies were from both developing and developed countries and focussed on inadequacies around PPP skills and knowledge (40 per cent, \( n = 8 \)); inadequate PPP legal frameworks and guidelines (33 per cent, \( n = 7 \)) and high cost in procuring PPP projects (35 per cent, \( n = 7 \)). These observations are consistent with the recent studies by Akintoye and Kumaraswamy (2016) which highlighted significant challenges facing PPP. Interestingly, the least flagged challenges based on the frequencies have equally been identified as areas requiring further research and development agendas by Akintoye and Kumaraswamy (2016), for example, risk management (20 per cent) and inadequate feasibility study (10 per cent) within the themes of “Risk allocation and management” and “PPP project evaluation”. Other challenges have been associated with the delivery of affordable PPP housing and these items are numbered as 20 through 28 within Table I. The main challenges, although limited in the number of studies, were associated with high building standards, land affordability, lack of transparency, poor access to land and public acceptability amongst others.

It is worth noting that some of the developing countries studies, which have included examples from the African perspective, have used stringent selection criteria for their inclusion. For example, the study by Sharma (2012) only had Nigeria and South Africa as the African countries based on having at least one PPP project in two successive years. The review of the literature thus identified the need for undertaking empirical studies on challenges affecting the PPP particularly within the Tanzanian context, as well as formulation of conceptual frameworks. There is also scope for the application of the measures or solutions for dealing with these challenges as identified from other developing and developed countries within the context of the Tanzanian construction industry.

### 3. Research methods

As the main objective was to obtain different but complementary data to answer a single research question, a convergent parallel (concurrent) mixed method approach was adopted. From the level of interaction perspective, the data were collected and analysed independently. As opined by Molina-Azorin et al. (2007), both the quantitative and qualitative approaches had equal priority status. Simply put, different methods are used to assess the same phenomenon towards convergence and increased validity (Cameron, 2009). This method is similar to that of Nguyen and Chileshe (2015) and Kurniawan et al. (2014) and included the following six steps: literature review (see Table I); pilot survey; questionnaire survey; interviews; statistical analysis; and content analysis. Drawing upon the study by Nguyen and Chileshe (2015), the justification for adopting the mixed methods approach is well established in literature, and furthermore, this provides the opportunity for increasing the reliability of the research (Easterbrook et al., 2008). It has also been known to offset the weakness of each tool considering the sample nature, time and accuracy of data (Kothari, 2004). More so, as highlighted by Jogulu and Pansiri (2011, p. 690), in concurrent mixed methods, qualitative and quantitative data collection techniques are undertaken at the same time for the analysis of the data. In our study, as recommended by Holt and Goulding (2014), both approaches, qualitative (semi-structured interviews) and quantitative (questionnaire survey), were applied concurrently with equal status. Finally, this concurrent approach enabled the usage of the results of one method to corroborate the findings of the other about a single phenomenon (Halcomb and Hickman, 2015).
The specific objectives of the study are to:

1. Identify and rank the challenges influencing the delivery of the HPPP in Tanzania; and
2. Suggest advocated solutions in the form of a conceptual PPP framework model that will address the identified challenges and hence boost its success.

3.1 Measurement Instrument
The questionnaire as administered in the Tanzanian construction industry was comprised of the following three distinct sections:

- Section 1 encompassed general demographics of the study sample and included a number of control variables (i.e., working experience, designation, professional background, and experience within PPP housing projects).
- Section 2 captured opinions on a range of issues affecting affordable housing projects.
- Section 3 comprised five sub-sections in order to capture the respondent’s perception on the following issues: (i) assessment of skills and training needs for PPP project delivery; (ii) factors hindering the acquisition of the PPP skills and training; (iii) evaluation of costs and affordability; (iv) aspects of PPP policy and regulatory framework; and (v) challenges in implementing PPP projects. For Sub-sections (i)-(v), the respondents were asked to rate their levels of agreement using a five-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree and 5 = strongly agree.

Sub-section (v) of Section 3 included 19 challenges drawn from the summarised studies (Table I). The majority of the items were mostly from the following countries and studies: in Malaysia, Abdullahi and Aziz (2011); China, Liu et al. (2014); Hong Kong; Chan et al. (2004); and Thailand, Trangkanont and Charoenngam (2014a). The rationale for following prior research in the identification of the measures (i.e., challenges) was to ensure construct validity. Such an approach has been used in PPPs studies such as De Schepper et al. (2015). Therefore, the detailed results presented in this paper relate to Sections 1 and 3 of the questionnaire, particularly sub-section (v) on the challenges. It is beyond the scope of this paper to report on Section 2 and part of the remaining sub-sections.

3.2 Survey Administration
In order to obtain the relevant information needed, the approach engaged purposively sampling amongst the targeted population, namely the stakeholders involved in PPP housing projects in Dar es Salaam, Tanzania were used. The rationale for choosing Dar es Salaam as the study area includes: accessibility to conduct a survey to obtain required data and the fact that about 60 per cent of HPPP projects, PPP experts, construction professionals and head offices are located in Dar es Salaam (Kavishe, 2010). Therefore, the target population includes public sector authorities (i.e., ministry, department, and housing agencies), private partners and the project consultants involved in HPPP projects in Dar es Salaam. Unfortunately, there is no official list or standard database specifying the number of stakeholders’ organisations involved in HPPP projects within the study area. In view of this, the target population involved in this study cannot be easily determined. Based on this, the researcher identified the target population through public agencies involved in HPPP projects and PPP experts. It is on this note that only two public organisations, including their list of projects (NHC 187 projects and NSSF 1 project), 60 per cent being based in the study area, with their private partners and consultants were identified. Although the population size is small (n = 28), the selected sample is typical of the whole and allowed intensive study (Kothari, 2004). According to Kavishe (2010),
these 187 PPP projects as administered by the NHC and carried out in partnership with private real estate developers or investors were at different implementation stages (i.e. initial and completion stages). For example, the majority 100 (53.47 per cent) were still under preparation, 48 (25.66 per cent) under construction, 29 (15.50 per cent) completed and a minority, 10 (5.37 per cent) had stalled. It could thus be argued that, despite the small sample size, with 60 per cent (n = 112) of the projects located in the study area, namely Dar es Salaam and 40 per cent in other regions, the study typified the whole population with particular emphasis on the projects under preparation, construction and completed. The characteristics of the respondents according to the designation, professional background, length of experience and the number of PPP projects undertaken are summarised in Table II.

Based on the reported demographic background of the respondents (see Table II), it can thus be demonstrated that all key actors in PPP housing projects as well as varying management levels were involved in the survey thus enhance the reliability and validity of the findings.

3.3 Statistical methods – analysis of results
Quantitative data were analysed using the Statistical Package for Social Sciences (SPSS) computer programme version 22.0. The SPSS procedure involved in the analysis of the quantitative data comprised of the following two methods or techniques: parametric tests

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Number (frequency)</th>
<th>Overall (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Designation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultant</td>
<td>9</td>
<td>32.15</td>
</tr>
<tr>
<td>Private developer</td>
<td>2</td>
<td>7.14</td>
</tr>
<tr>
<td>Public partner</td>
<td>11</td>
<td>39.29</td>
</tr>
<tr>
<td>Contractor</td>
<td>1</td>
<td>3.57</td>
</tr>
<tr>
<td>Financer</td>
<td>1</td>
<td>3.57</td>
</tr>
<tr>
<td>Researcher Academic</td>
<td>2</td>
<td>7.14</td>
</tr>
<tr>
<td>PPP advisor</td>
<td>2</td>
<td>7.14</td>
</tr>
<tr>
<td><strong>Professional background</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity surveyor</td>
<td>5</td>
<td>17.86</td>
</tr>
<tr>
<td>Engineer</td>
<td>4</td>
<td>14.29</td>
</tr>
<tr>
<td>Land valuation agent</td>
<td>3</td>
<td>10.71</td>
</tr>
<tr>
<td>Architect</td>
<td>3</td>
<td>10.71</td>
</tr>
<tr>
<td>Lawyer</td>
<td>1</td>
<td>3.57</td>
</tr>
<tr>
<td>Other professional roles</td>
<td>12</td>
<td>42.86</td>
</tr>
<tr>
<td><strong>Length of service in current position (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 5</td>
<td>8</td>
<td>28.57</td>
</tr>
<tr>
<td>5-10</td>
<td>7</td>
<td>25.00</td>
</tr>
<tr>
<td>11-15</td>
<td>8</td>
<td>28.57</td>
</tr>
<tr>
<td>More than 15</td>
<td>5</td>
<td>17.86</td>
</tr>
<tr>
<td><strong>Experience with PPP housing projects (number of projects)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; than 1</td>
<td>4</td>
<td>14.29</td>
</tr>
<tr>
<td>1-2</td>
<td>7</td>
<td>25.00</td>
</tr>
<tr>
<td>3-5</td>
<td>4</td>
<td>14.29</td>
</tr>
<tr>
<td>6-10</td>
<td>6</td>
<td>21.42</td>
</tr>
<tr>
<td>Over 10</td>
<td>7</td>
<td>25.00</td>
</tr>
</tbody>
</table>

Notes: The land valuation agent is also known as the “land valour”. *These designations (researcher and PPP advisor) were specified by the respondents as they were not part of the options given within the survey questionnaire; the breakdown of the “other” professional roles were as follows: managers (two), staff (three), consultant (two), sales supervisor, assistant director, principal consultant, advisor, and director.
such as one-sample t-tests; and descriptive statistics tests such as measures of central tendencies and frequency analysis (Forza, 2002). The ranking analysis based on the “frequencies” analysis was further undertaken using the generated values from the central tendencies such as the standard deviation and mean scores. In addition to the SPSS generated values, the third technique of “relative agreement index (RAI)” was computed. The following sub-sections present a brief discussion of each approach.

3.3.1 Ranking analysis and RAI. The ranking of challenges influencing the delivery of PPP in Tanzanian housing projects was based on the mean score. Drawing on the approach by Ibrahim et al. (2006) in Nigerian PPP infrastructure projects, this involved attributing the lower value as assigned to the challenge as an indication of its lower importance. The standard deviation as generated by the descriptive statistics provided the variability that exists in the information for ease of comprehending the information (Forza, 2002, p. 182). Other PPP-related studies that have previously employed this approach of the mean score ranking technique and RAI include Hwang et al. (2013) in Singapore and Ismail and Haris (2014) in Malaysia. Similarly, in order to summarise the advancement of the identified challenges, the RAI as derived has to overcome the weaknesses associated with the computed mean score (Holt, 2014; Doloi et al., 2012).

3.3.2 Single-sample t-test of the mean. A one (single) sample t-test of the mean was undertaken to measure the significance of the challenges influencing the delivery of the HPPP. Drawing upon the findings of Ling and Nguyen (2013), the cut-off point for five-point scale was set at “3.5” (μ = 3.5) and the hypothesis was introduced to measure the extent of influence of HPPP delivery challenges. The study by Ling and Nguyen (2013) had a seven-point scale to measure the strategies for waste management practices, and provided justification for its selection of “5” as the cut-off point for comparison. This study applies the same logic. By inference, the value of “3” would be the middle point for the challenges influencing the delivery of HPPP. This would further be equivalent to 50 per cent of implementation. However, given the importance and lack of HPPP implementation within the Tanzania context, a value higher than 50 per cent of the delivery and implementation effort is appropriate. To that end, the μ value is set at 3.5, and using the procedures as outlined in Cronk (2012), the analysis for the single-sample t-test was conducted. The rationale and explanation of the null hypothesis thus are that the HPPP challenge affects the delivery of the projects to a significant amount, whereas the alternative hypothesis is that HPPP challenge is not significant and less important.

3.4 Interviews
The interview processes were conducted between July and August 2016. These took place in Dar es Salaam, Tanzania. The duration of the semi-structured interviews was between approximately 45 and 100 minutes and was undertaken and conducted following the protocol suggested by Sharifirad (2011). Sharifirad’s procedure required the translation and review of the transcripts as some of the (performed) interviews were conducted in one of the local languages, namely Kiswahili. Semi-structured interviews were the preferred mode due to their ability to produce detailed information, since they are flexible enough to explore questions into areas that could provide new dimensions of issues not pre-conceived (Axinn and Pearce, 2006). In total, 13 semi-structured interviews were carried out with the management staff of the public and private sectors, while the questionnaire participants were restricted to company staff involved in similar projects. The structure of the interview questions followed four distinct sections:

1. background information (organisation and number of PPP projects);
2. training and needs assessment;
(3) challenges in implementing PPP housing projects; and
(4) challenges in the successful implementation of PPP in affordable housing schemes.

The questions were prepared following the guidance as suggested by Qu and Dumay (2011) and underpinned by Giddens structuration theory in understanding the structural issues affecting the implementation of PPP. In order to enhance the validity and reliability of the collected interview data, the transcripts were e-mailed to the interviewees to obtain their agreement on the correctness and their feedback. This approach is also known as "participation checks and validation" and has previously been utilised in the study by Ardichvili et al. (2003) and Chileshe et al. (2016).

3.4.1 Selection criteria for interviewees. Due to the fact that PPPs were relatively a new phenomenon in Tanzania, as suggested by Maxwell (2005 cited in Liu and Wilkinson, 2011), a criterion-based approach was used in the selection of the interviewees. The selection for the interviewees included the following criteria: the respondent’s willingness and prior involvement in HPPP projects and the respondents needed to be a public partner, or private partner or a financier, consultant or a contractor to the housing PPP projects. In light of only two public sector departments undertaking the HPPP, the sample size is very small. In order to compensate for the sample size of public sector interviewees, the invitations also extended to the PPP unit, PPP coordinating unit and National Construction Council. This was deemed suitable as these organisations also played an advisory role in all PPP projects.

3.4.2 Profile of the interviewees. Table III presents the profile of the interviewees. In all, 13 interviews were undertaken. The number of interviewees (response rate) for the qualitative survey can be considered as very good in view of the total population and limited research undertaken within the Tanzanian context to date.

As can be seen from Table III, the majority of the interviewees (38 per cent) fell within the “11-15 years” and “more than 15 years” categories, whereas two (15 per cent) were in the “six to ten years” category. Table III further illustrates that, based on the sector, the majority (69 per cent) were from the public sector. The limited number of the public sector interviewees is due to the fact that, in Tanzania, there are currently only two public organisations undertaking PPP in housing projects. These organisations are the NHC and NSSF. However, due to confidentiality associated with their projects, in some cases detailed information could not be provided. Despite the potential of bias due to the majority of respondents being from one sector, the findings from the questionnaire survey overcame this shortcoming by including the private sector respondents (see Table II). This was complemented by the literature review to reinforce and validate the private sector’s views.

3.5 Characteristics of the sample
Out of the 38 questionnaires administered to the targeted population, 28 questionnaires were considered valid. The response rate, which is equivalent to 78 per cent, was well above the similar studies in PPP survey-related research. Examination of Table II shows that the majority (11(39.3 per cent) of the respondents were from the public sector. This was followed by nine (32.2 per cent) consultants. With regards to professional background, a fair proportion five (17.9 per cent) was quantity surveyors. There was a fair distribution of varying professions amongst the remainder of the survey respondents. For example, there was an equal number of the minority, one (3.6 per cent) being a lawyer, sales supervisor and assistant director. The inclusion of the Lawyer was particularly significant, given the different forms of HPPP and the legal implications of the JV in Tanzania. The need for opinions from a knowledgeable respondent (such as a lawyer) for checking the credentials of the other party during the selection process within the JV process was therefore necessary. With regards to experience, the majority of the respondents eight (28.6 per cent) fell within the “less than 5” and “11-15” years categories.
4. Survey and interview results

4.1 Reliability analysis

The reliability and internal consistency of the survey instrument, comprising the 19 challenges affecting the delivery of PPP projects (see Table I), were tested by using Cronbach’s \( \alpha \) coefficient to examine and assess the adequacy of the measurement instrument. Previous and recent PPP-related studies, such as Hashim et al. (2016), have used similar approaches for the reliability analysis. Furthermore, according to Cronbach (1951), this (Cronbach’s \( \alpha \) coefficient) is one of the most popular reliability statistics aimed at determining the internal consistency or average correlation of items in a survey instrument to gauge reliability. Based on the results (not illustrated in this paper), the Cronbach’s \( \alpha \) was found to be 0.585 (\( F \)-statistic = 9.899, Sig. = 0.000) for the challenges sub-instrument, thus indicating that the five-point scale measurement was reliable at the 5 per cent significance level as the value was greater than 0.5 (Tabish and Jha, 2011).

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Name of organization</th>
<th>Current position</th>
<th>Experience (years)</th>
<th>Sector</th>
<th>Professional background</th>
<th>Experience with HPPP projects (number of projects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>NHC(^a)</td>
<td>Legal officer</td>
<td>6-10</td>
<td>Public partner</td>
<td>Lawyer</td>
<td>Over 10</td>
</tr>
<tr>
<td>B</td>
<td>NHC(^a)</td>
<td>Director of property</td>
<td>&gt; 15</td>
<td>Public partner</td>
<td>Engineer</td>
<td>Over 10</td>
</tr>
<tr>
<td>C</td>
<td>NSSF</td>
<td>Project manager</td>
<td>11-15</td>
<td>Public partner</td>
<td>Engineer</td>
<td>1-2</td>
</tr>
<tr>
<td>D</td>
<td>TBA</td>
<td>Managing director</td>
<td>&gt; 15</td>
<td>Public partner</td>
<td>Engineer</td>
<td>1-2</td>
</tr>
<tr>
<td>E</td>
<td>PPP Unit(^c)</td>
<td>PPP Advisor Consultant</td>
<td>11-15</td>
<td>PPP Unit</td>
<td>Economist</td>
<td>None</td>
</tr>
<tr>
<td>F</td>
<td>NCC</td>
<td>Consultant</td>
<td>&gt; 15</td>
<td>Public Sector</td>
<td>Quantity surveyor</td>
<td>Over 10</td>
</tr>
<tr>
<td>G</td>
<td>PPP Coordinating Unit(^cd)</td>
<td>Assistant director</td>
<td>11-15</td>
<td>Investment centre</td>
<td>Economist</td>
<td>None</td>
</tr>
<tr>
<td>H</td>
<td>Salim Company</td>
<td>Director</td>
<td>&gt; 15</td>
<td>Public partner</td>
<td>Architect</td>
<td>3-5</td>
</tr>
<tr>
<td>I</td>
<td>Contractor</td>
<td>Director</td>
<td>11-15</td>
<td>Contractor</td>
<td>Engineer</td>
<td>1-2</td>
</tr>
<tr>
<td>J</td>
<td>NSSF</td>
<td>PPP Clerk of works</td>
<td>6-10</td>
<td>Public partner</td>
<td>Engineer</td>
<td>1-2</td>
</tr>
<tr>
<td>K</td>
<td>NSSF</td>
<td>Manager</td>
<td>11-15</td>
<td>Public partner</td>
<td>Quantity surveyor</td>
<td>1-2</td>
</tr>
<tr>
<td>L</td>
<td>Maksoor Company</td>
<td>Director</td>
<td>&gt; 15</td>
<td>Public partner</td>
<td>Business</td>
<td>3-5</td>
</tr>
<tr>
<td>M</td>
<td>NHC</td>
<td>Regional manager</td>
<td>None (&lt; 1 year)</td>
<td>Public partner</td>
<td>Land valuation agent (valour)</td>
<td>Over 10</td>
</tr>
</tbody>
</table>

Notes: NHC, National Housing Corporation; NSSF, National Social Security Fund; NCC, National Construction Council; TBA, Tanzania Building Agency. \(^a\)In Tanzania, so far, NHC is leading housing agency which has carried out a large number of joint venture projects for both commercial and residential properties since 1990s. \(^b\)In Tanzania, there are currently only three public organisations undertaking PPP in housing projects. These organisations are the National Housing Corporation (NHC), National Social Security Fund (NSSF), and Tanzanian Building Agency (TBA). \(^c\)These organisations (PPP Unit, NCC and PPP coordinating unit) are included as they are responsible for the assessment, approval as well as the coordination of all PPP projects in Tanzania. They have also been involved in the formulation of PPP Policy as well as the regulations. \(^d\)The PPP Coordination Unit was established by the 2010 PPP Act within the Tanzania Investment Centre (TIC) to coordinate and oversee the mainland Tanzanian PPP projects and PPP Financing Unit within the Ministry of Finance with the duty of assessing and examining all PPP proposals in their financial aspects.
The Cronbach’s $\alpha$ coefficient for the challenges sub-instrument was less than the required threshold of 0.7, thus indicating low reliability of scales (Nunnally, 1978), although Nunnally has pointed out that lower thresholds are sometimes used in the literature. Furthermore, investigation of the item-total statistics revealed that only the deletion of the two ranked items, namely “inadequate PPP skills and knowledge leading to poor planning and application” and “poor PPP contract and tender documents”, would improve the reliability to 0.586 and 0.592, respectively. However, due to negligible impact on the Cronbach’s $\alpha$ values and the importance attached to “project management and legal issues in PPP delivery”, these two items were not deleted, but included in the overall survey instrument.

4.2 Engagement of PPP training skills and self-reflection

In order to ascertain their PPP training capabilities, the interview question requested the respondents to indicate whether they had undertaken any PPP training to improve their skills in the type of housing projects. Figure 2 shows the profile of the respondents according to the PPP training undertaken.

The majority nine (69.2 per cent) of the interview respondents have not undertaken any formal PPP training. The respondents were further asked if they were to assess themselves, whether they considered that they had enough (sufficient) skills and knowledge on PPP. A similar result with the majority nine (69.2 per cent) responded negatively. Interestingly, out of the minority four (30.8 per cent), who responded affirmatively, Interviewee F, working for the National Construction Corporation, acknowledged as still needing further skills development in PPP due to changes in technology and techniques in the world. Similarly, Table IV shows the cross-tabulation results in response to the following survey questions: “If you are to assess yourself, do you think you have enough skills and knowledge on PPP?” and “Have you undertaken any PPP training to improve your skills into this type of projects (HPPP)?”

As can be seen from Table IV, the majority, 12 out 26, responded negatively. However, despite 42.9 per cent (12) of the respondents indicating that they had enough skills and knowledge on PPP, only a minority (5 of the 12) indicated that they had undertaken any PPP training to improve their skills, while the resultant majority ($n = 7$) who responded negatively might suggest that the results are contradictory. The results from $\chi^2$ tests using
continuity correction values \( (p = 0.260 > 0.05) \) demonstrated that the proportion of respondents who assessed themselves as having enough skills and knowledge on PPP and had also undertaken training were not statistically significantly different from the proportion without skills and knowledge on PPP. More so, in spite of the majority indicating that they did not have enough skills and knowledge on PPP as obtained through formal training, the examination of Table II shows that the majority 17 (61 per cent) had experience with more than two PPP housing projects. Second, some of the respondents indicated that they had learnt about PPPs through self-directed learning (i.e. through reading books) and by undertaking the projects. Similarly, it could be inferred that these interviewees are the same people (actors) who had initiated, procured and managed the PPP housing projects in Tanzania irrespective of the number of successful and unsuccessful outcomes. These findings are further supported by Gidden (1984) identification of the three dimensions of structure, namely signification, domination and legitimation. Drawing upon Gidden’s definition of “signification”, it could be inferred that despite these interviewees lack of skills and knowledge, they nevertheless had the ability to produce meanings of the structure as well as informing and defining interaction and direct the manner in which the problems (challenges) are interpreted. As such, based on informal training, the experience (see Table II) of the interviewees and Gidden’s (1984) definition of “signification”, the interviewees were qualified to provide reliable and authentic feedback on the subject, and thus enhancing the validity of the findings.

However, the implication of this finding is indicative of the problems developing countries face with regard to the training of its professionals. Tanzania, like many other developing countries, faces the issue of training its workforce in a number of skills. For example, the study by Osabutey et al. (2012) established that the majority of construction professionals normally acquire their skills through informal means like on site or within their work place. Furthermore, according to Chileshe and Kikwasi (2014), the study established that only the Tanzanian professionals working for foreign contractors (i.e. through JVs) have the ability to get training. These findings are also consistent with the literature on PPP training skills (Osabutey et al, 2012; Debrah and Ofori, 2005, 2006). For example, according to Osabutey et al. (2012), in many developing countries, there are no reputable institutions for training lower-level personnel, on-the-job training is largely inadequate and the personnel at that level remains largely unskilled. Vocational training schools do exist in most of the countries, but many workers and contractors see formal training as a cost rather than investment.

4.3 Ranking of the challenges influencing the delivery of HPPP

This section presents a combined discussion of the quantitative (survey) and qualitative (interviews) results. Based on the aggregated 19 challenges influencing the delivery of HPPP projects, the questions are designed to require the respondents to rate their opinions using a five-point Likert as described in Section 3. Table V shows the results of these mean
agreement responses, descriptive statistics such as the standard deviation, one-sample t-values, degrees of freedom (df), and sig. (two-tailed).

As illustrated in Table V, the mean agreement scores of the 19 challenges ranged from 4.82 (inadequate PPP skills and knowledge leading to poor planning and application) to 3.36 (higher costs in procuring PPP projects). In contrast, the standard deviation of all the 19 challenges ranges from 0.390 to 1.193, the highest standard deviation being "higher costs in procuring PPP projects". Table III also shows that a third (31.5 per cent) of the challenges to the HPPP are statistically significantly different (Test 1: mean \( W \equiv 3.5 \), t value positive, \( p < 0.05 \)) with mean differences ranging from 1.321 to 0.393 as delivered in Tanzania. Further examination of the different values for the minimum and maximum scores (not listed in Table V) suggests that the data and sample were not biased. For the ease of discussion, only the top five ranked challenges (mean score \( > 4.50 \)) as based on the degree of central tendency as well two of least ranked and not significant challenges are discussed here. While there was no statistical difference (Table V, \( p < 0.05 \)) between the opinions in the perception for the majority (68.4 per cent) of the challenges, it is evident that the top five challenges were as follows:

1. inadequate PPP skills and knowledge leading to poor planning and application (mean = 4.82, SD = 0.390);
The following sub-sections present a brief discussion of these highly ranked challenges.

4.3.1 Inadequate PPP skills and knowledge leading to poor planning and application. According to Abdul-Aziz and Kassim (2011, p. 155), the public agencies’ negotiation skills and adequacy of negotiation staff have an effect on the delivery of housing projects and are equally inter-related. Based on the mean score, “inadequate PPP skills and knowledge leading to poor planning and application” was the highest ranked challenge (mean = 4.82, see Table V) and significant (t (27) = 17.928, p = 0.000 < 0.05) with a mean difference of 1.321. The lower value of the standard deviation (SD = 0.390) further reinforces the consensus among the respondents in the higher ranking of this challenge. Support of the high ranking of this challenge can be found in previous PPP studies (Akintoye and Kumaraswamy, 2016; Moskalyk, 2011; Wibowo and Alfen, 2015; Zhang, 2005a, b).

Similarly, a number of Tanzanian studies have equally highlighted the issue of skills and knowledge among construction professionals (Debrah and Ofori, 2005, 2006; Chileshe and Kikwasi, 2014) and the lack of experience has been linked to the inappropriate perception of risk (Mboya, 2013). Elsewhere, within specific PPP studies, “shortage of workers” has been identified as among the project-specific commercial associated with the PPP projects (Gunawansa, 2012). For example, the study by Moskalyk (2011) suggested that this clearly indicates the cause for its slow progress and failures. Similarly, the Zhang (2005a, b) study had previously considered this as a big challenge. The study by United Nations for Economic and Social Commission for Asia and the Pacific (2012 cited in Wibowo and Alfen, 2015) highlighted the benefits of having well-trained and experienced public sector officials, with benefits ranging from having the knowledge of where difficult issues would most likely to arise, and the ability to select the appropriate tools for addressing the identified problems.

The interviews as conducted further confirmed the findings from the survey and literature reviews. For example, Interviewees B, C, D and I identified “Inexperienced private partners”, “inadequate PPP skills and capacity” and “Incapacity of contractors employed by private partners”, respectively, among some of the challenges in implementing PPP housing projects in Tanzania. Interviewee D attributed this challenge to “a new approach hence lack of experience”. By inference, the following implications emerge from the above results: the lack of skills and capacity will eventually result in poor planning for the PPP project, poor risk identification, allocation and management as well as poor PPP project management. While this study did not measure any specific items associated with “procedural justice” constructs (see Zhang and Jia, 2010), the over reliance of the public partners on the private partners for acquiring the desirable PPP skills is recipe of having inequity among the partners as posited by the equity theory (Scheer et al., 2003).

4.3.2 Poor PPP contract and tender documents and inadequate legal framework. “Poor PPP contract and tender documents (mean = 4.64, SD = 0.621)” and significant (t (27) = 9.9731, p = 0.000 < 0.05) with a mean difference of 1.143, and “inadequate legal framework (mean = 4.54, SD = 0.693)” and significant (t (27) = 7.909, p = 0.000 < 0.05) with a mean difference of 1.036 were ranked second and fourth, respectively. The synergies between “procurement” and “interpretation of contractual issues” as nested within the second challenge with the overall legal issues were inherently included within the fourth challenge. These findings are also consistent with other studies (Sengupta, 2006;
Trangkanont and Charoenngam, 2014a; Ismail and Haris, 2014; Abdul-Aziz and Kassim, 2011). For example, the study by Abdul-Aziz and Kassim (2011), albeit within the Malaysian context and which was aimed at examining the objectives of housing PPP, the success and failure factors observed that the failure factor which had the most influence was the absence of robust and clear agreement. Similarly, within the context of Thailand, the study by Trangkanont and Charoenngam (2014a) pointed to “ineffective PPP policy and strategy”. Similarly, Tanzanian-specific studies, such as by Mboya (2013), attributed the poor performance of PPP to unfavourable contractual terms for the contracting authorities.

The findings from the interviews further supported the above observations from the survey and literature reviews. For example, the majority (53.8 per cent) of the interviewees (A, C, D, G, H, J and L) identified some of the legal issues. Interviewee I identified the following as major causes of failure of JV Corporations projects (also referred to as PPP): lack of an exit clause; contradictory provisions; agreements biased in favour of (some) partners; and non-adherence to the rules and regulations. With regard to the “poor PPP contract and tender documents”, the issue of the “bidding processes” was identified. Some of the selected comments by Interviewee I (i.e. Legal officer for the NHC) are as follows:

These agreements have no exit clause. Generally, these agreements comprised of determination clauses, of which it provides for the circumstances upon which the Agreements can be determined.

With regard to the contradictory provisions, and hence “inadequate legal framework”:

The provisions in the Agreements are badly crafted to the extent that they do contradict each other and thus distort the whole meaning of their presence in the agreement.

With regard to the “non-adherence of the rules and regulations […]”:

[...] It has been discovered that there are some projects which are run without adhering to the rules and regulations set by regulatory authorities. In most, the construction site is quite different from the agreed and authorised design. This once proved, might engage the corporation in ordering the private partner contractor to stop, demolish, or being fined […].

The challenge of “poor PPP contract and tender documents” was further evident as observed by Interviewee I:

[...] It has been observed that some partners were given more projects to add on to the already awarded projects. Meaning that there was double allocation of projects, without following the necessary procedures. There has been a trend among partners to add more plots on the acquired project on pretext of expanding the magnitude of the projects […].

From the above observation, the inference to be drawn is that the procedures of awarding more projects to partners were improper. Second, the board is being misled regarding the expansion of the magnitude of the projects. The above behaviour of the private partners is reflective of their power and domination over the public partners, as highlighted in Gidden’s (1984) duality of structure. Accordingly, irrespective of the appropriate “contractual and tendering” rules associated with this type of procurement (PPPs), the private partners demonstrated the power that they had in effecting or having transformative capacity over the other actors, namely “public partners”.

The other interviewees expressed similar although not as detailed comments. For example, Interviewee C (project manager) identified “Poor contractual relationship”, whereas Interview D (managing director) highlighted the issue of “involving long negotiations” as the challenge. Similarly, Interviewees G and H singled out the “inadequate PPP policy and legal institutional framework” and “complexity of PPP projects”, respectively. The only other comment related to the challenge of “Inadequate legal framework” noted by Interviewee L was “poor contract”. The views expressed by Interviewee H regarding “complexity” are consistent with the
research and development agenda, as proposed by Akintoye and Kumaraswamy (2016). Akintoye and Kumaraswamy (2016, p. 26) drew the impacts arising from the complexity of the contractual structure of PPP on transparency, evaluation of proposals and performance amongst other issues.

The following implications emerge from the above results:

1. That poor legal framework will lead to poor contracts and the rise of disputes.
2. In identifying what the impediments are and how these challenges are managed, this study therefore makes an important contribution by enhancing awareness.
3. Because of the inability to identify existing challenges, the failure will prevail in such projects. Additionally, wastage of resources and housing shortage will persist. The consequence of these actions leads to abandonment, stalling and delaying of a number of projects undertaken. These implications and findings from the interviews further suggest some departure from fairness which should be the foundation of any type of economic transactions (Zhang and Jia, 2010), and a clearer demonstration of the equity theory where some of the Interviewees identified some of the inequity in the relationship with regards to unfavourable agreements (see Interviewee I).

4.3.3 Inadequate project management and monitoring by public sector. “Inadequate project management and monitoring by public sector (mean = 4.57, SD = 0.573)” and significant \( t (27) = 9.899, p = 0.000 < 0.05 \) with a mean difference of 1.071, was the third-ranked challenge. As with most developing countries, the application of project management best practice has always been an issue. For example, the seminal study by Rwelamila et al. (1999) determined that the following two propositions are leading to project failure amongst the African countries: the lack of Ubuntu between project stakeholders is primarily due to an inappropriate project organisational structure; and a default traditional construction procurement system provides a poor relationship management system. Similarly, within the Tanzanian context, the studies by Kikwasi (1999, 2012) linked the poor delivery of projects using the pre-estimated time and cost to the adoption of conventional procurement method. Some more recent studies such as by Chileshe and Kikwasi (2014), albeit within the same context (Tanzania), have attributed this poor performance to the lack of effective risk management implementation. The findings from the interviews also supported the above observations from the literature review and survey findings. For example, some of the interviewees acknowledged that inadequate project management was a major issue. A number of reasons put forward by the interviewees ranged from “the work of managing and project monitoring was left to the private partners in NHC HPPP thus giving them a loophole to make alterations” to “construction in site has been quite different from the agreed and authorised design hence leading into disputes”. Furthermore, Interviewee H considered “complexity of PPP projects”, while Interviewees J and M identified “delays” as major challenges.

4.3.4 Misinformation of financial capacity of private partners. According to Mboya (2013, p. 22), the Tanzanian capital market is not mature enough to be conducive to the promotion of complex PPPs. The same study blamed the lack of adequate long-term financing instruments. Leventhal (1980, cited in Zhang and Jia, 2010) identified the need for using accurate information as one of the six principles desirable for achieving procedural justice. Despite the importance of transparency throughout the procurement process (Osei-Kyei and Chan, 2015), this challenge of “misinformation on financial capacity of private partners” still remains an issue within the Tanzanian housing sector as evidenced by being ranked fifth (mean = 4.50, SD = 0.509) and significant \( t (27) = 10.392, p = 0.000 < 0.05 \) with a mean difference of 1.000. As previously highlighted by the study in Malaysia (Abdul-Aziz and Kassim, 2011), misinformation can lead to the loss of trust, and subsequently results in the
selection of inappropriate partners. The findings from the interviews were also consistent with the observations from the literature review and survey findings. For example, some of the interviewees stated that poor determination of the shareholding ratio and recovery period, and lack of proper procedure on determining the financial status of the partners who are engaged in the JV agreement projects have been major challenges and have resulted into project termination.

4.3.5 Other challenges—lack of competition, delay and corruption, inadequate feasibility study, and differing goals between partners. Despite not being in the “top five” of highly ranked challenges, the issues of “lack of competition”, “delay” and “corruption” which ranked sixth, seventh and eighth, respectively, are worth mentioning. Studies have shown that competitive bidding is imperative in order to eliminate corruption and allow for transparency and best partner selection. Narasimhan (1997 cited in Tabish and Jha, 2011) has suggested punitive measures such as mechanisms for effective investigation in dealing with corruption. Similarly, while “inadequate feasibility study” and “differing goals between partners” had a mean score of 4.21, 4.18, respectively, and they were ranked as ninth and tenth position, studies such as Moskalyk (2011) identified and cited “differing goals between partners” among the five common challenges governments were facing in HPPP projects.

4.4 One-sample t-test results
A single-sample t-test was conducted to determine if a statistically significant difference existed between challenges affecting the delivery of HPPP from the sample as used in this study and the general population of Tanzanian stakeholders involved in housing projects. Prior to undertaking this t-test, although not reported, the normality of the data was undertaken through the examination of the descriptive statistics such as the skewness and kurtosis. No assumptions were found to be violated. Examination of Table V shows that with the exception of top 13 ranked challenges, the mean values of the remaining six challenges were not significantly different from the t-test value of 3.500 as follows: “Poor risk allocation and management”, \( t(27) = 1.580, p = 0.126 > 0.05 \) with a mean difference of 0.286; “Inexperienced private partner”, \( t(27) = 1.154, p = 0.259 > 0.05 \) with a mean difference of 0.179; “Unequal qualifications and contributions of expertise”, \( t(27) = 0.366, p = 0.718 > 0.05 \) with a mean difference of 0.071; “Poor enabling environment to attract competent partners”, \( t(27) = 0.000, p = 1.000 > 0.05 \) with a mean difference of 0.000; “Inadequate mechanisms for recovery of private investors’ capital”, \( t(27) = -0.500, p = 0.621 > 0.05 \) with a mean difference of 0.107; and “High costs in procuring PPP projects”, \( t(27) = -0.634, p = 0.532 > 0.05 \) with a mean difference of 0.143. The conclusion to be drawn is that there is a statistically significant difference of opinion in the rankings at the \( p < 0.05 \) level in 13 out of the 19 challenges.

4.5 Interview survey findings
In order to enhance the validation of the results, the findings from the survey research were triangulated with those from the interviews. Response to the interview question was posed to the PPP experts in relation to political willingness and stakeholders’ readiness towards PPP. All interviewees agreed that there is a high political willingness towards the strategy. The reason put forward was not only due to successful case histories from other developing countries like Malaysia and India, but because of an inadequate enabling environment in Tanzania; PPP approach has not been successful as in other countries. Some of the PPP experts in PPP units claimed to have visited these countries for PPP training and were seconded to PPP projects for hands-on experience. However, it was reported by two interviewees that the PPP unit has little or no impact on the proposed PPP projects despite its existence. A number of new PPP projects have been initiated and some started without
being submitted to PPP units for assessment and approval due to the fear of government bureaucracy, for example, “Dege Eco Village”. This reveals that PPP unit has been ineffective and underutilised; it is also possible that the PPP regulations are not enforced, thus allowing a PPP project to take off without being evaluated and approved by the PPP unit. There is a need for the Government of Tanzania to re-examine its PPP unit, policy and its guidelines.

4.5.1 Status and performance. In response to the question about the status and performance of the PPP housing projects, it was reported that during the survey period, NHC had 183 JV projects, out of which 104 were completed, while 35 were currently under construction. Of those under construction, the majority were facing delays for a couple of years. The findings also established that 29 projects had been discontinued or were terminated, while 21 projects have stalled due to various reasons. This status clearly indicates the existence of challenges to its performance. Respondents were further asked to rate the performance and 70, 21 and 9 of the respondents reported that there is poor performance, average performance and very poor performance, respectively. The majority of interviewees commented that since a large number of NHC JV projects were unsuccessful, there was little motivation for more similar projects. For the NSSF HPPP project, its progress was reported to be good but it has faced delays, which resulted in changes in design, shipping of the imported materials and adverse weather conditions. Further reports suggested that the private partner was facing financial difficulties.

4.5.2 Awareness and benefits. In response to awareness of PPP and its benefits, 60 per cent of respondents’ awareness is still little; benefits are marginal and very slow because of the lack of enough skills and expertise. Subsequent to that one of the interviewee, who was a quantity surveyor and a project manager, commented as follows:

Even the said affordable houses are still not affordable to the low income, the reason given for the lack of affordability is that, the government is not willing to provide subsidies to such projects and no good policies have been put in place.

Hence, for decades, the preferred method for providing affordable houses to the low-income group in Tanzania has been through personal effort in saving and building which can take 10-15 years or more to complete the construction, and sometimes some of these houses remain incomplete, yet people currently live in them despite their poor conditions.

5. Model development approach
The model development approach followed an efficient methodology and tools to aid the process comprising the following three stages: literature review; questionnaire survey; and interview survey:

- A literature review was undertaken on PPP housing projects across a variety of other countries in order to identify best practices and success factors. Table I presents the summary of the studies.
- Questionnaire and interview surveys were carried out in order to study the local context in terms of the practice, challenges and perceptions.

As part of the study, in order to investigate what has been happening over the last two decades or so globally, as far as PPP in housing and infrastructure project is concerned and incorporate the lessons learnt into the proposed framework model, further review of the literature was considered as necessary. Drawing upon the approach undertaken in the study by Chileshe et al. (2013) which proposed diagnostic models for strategic risk assessment, according to Archer (2003 cited in Chileshe et al., 2013), the agents (Tanzanian public and private stakeholders) have the ability of incorporating the lessons learnt due to their prior
understanding of historical issues. The main purpose was to address and enhance the HPPP challenges in Dar es Salaam Tanzania. In view of the fact that PPP has not commonly been associated with housing projects, but rather civil infrastructure projects, there have been limited studies conducted on HPPP. It can be inferred from the reviewed literature (Table I) that different countries adopted different success factors in PPP housing projects, as well as in other PPP projects. Table VI shows and summarises the factors identified as significant for the successful delivery of PPP housing projects and for PPP projects in the construction industry.

As can be seen from the given list of success factors, it is quite evident that some success criteria are similar and cut across all the sectors in the construction industry. However, other success factors such as selecting private developers with a sense of social obligation to enhance compatibility, just enough government subsidies to support affordable housing projects and favourable housing loan terms from the financial institution appeared to be more specific to HPPP projects. Likewise, based on best practices and lessons learned, Moskalyk (2011) listed eight key principles for PPPs in housing and urban development, which are as follows:

1. interest of the public is supreme;
2. such projects should mirror the needs of the community and blend into stakeholders’ priorities;
3. transparency and accountability methods should be maintained throughout the project lifecycle;
4. clearly defined scope and objectives with careful planning;
5. the preferred model must offer value for money in terms of cost, time and risk allocation;

<table>
<thead>
<tr>
<th>No.</th>
<th>Success factors for PPP housing projects</th>
<th>Success factors for PPP projects in construction industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Government involvement</td>
<td>Strong and good private consortium</td>
</tr>
<tr>
<td>2</td>
<td>Government support through subsidies and guarantees</td>
<td>Appropriate risk allocation and risk sharing</td>
</tr>
<tr>
<td>3</td>
<td>Accurate project Identification</td>
<td>Available financial market</td>
</tr>
<tr>
<td>4</td>
<td>Competitive and transparent procurement</td>
<td>Government support and guarantee</td>
</tr>
<tr>
<td>5</td>
<td>Adequate legal framework</td>
<td>Favourable economic condition</td>
</tr>
<tr>
<td>6</td>
<td>Stable macro-economic condition</td>
<td>Available financial market</td>
</tr>
<tr>
<td>7</td>
<td>Favourable economic policy</td>
<td>Transparency in procurement process</td>
</tr>
<tr>
<td>8</td>
<td>Presence of strong financial market</td>
<td>Fairness and competitive tendering</td>
</tr>
<tr>
<td>9</td>
<td>Favourable housing loan terms from the financial institution</td>
<td>Favourable legal framework</td>
</tr>
<tr>
<td>10</td>
<td>Selecting private developers with a sense of social obligation to enhance compatibility</td>
<td>Project technical feasibility</td>
</tr>
<tr>
<td>11</td>
<td>Public sector to carry out feasibility study rather than the private sector to avoid exaggeration</td>
<td>Realistic cost benefit analysis</td>
</tr>
<tr>
<td>12</td>
<td>Just enough government subsidies to support affordable housing projects</td>
<td>Good governance</td>
</tr>
<tr>
<td>13</td>
<td>Conducive socio-economic structure to boost income generation</td>
<td>Shared authority between parties</td>
</tr>
<tr>
<td>14</td>
<td>Trust between parties</td>
<td>Trust between parties</td>
</tr>
<tr>
<td>15</td>
<td>Favourable housing policies</td>
<td>Well-formulated and detailed contract</td>
</tr>
<tr>
<td>16</td>
<td>Adequate PPP Capacity</td>
<td>Constant communication and monitoring</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>Careful ground work</td>
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<tr>
<td>18</td>
<td></td>
<td>Political support</td>
</tr>
</tbody>
</table>

Table VI.
Summary of comparative analysis between success factors for PPP projects in housing projects and construction industry.
competitive tendering is crucial;
project viability must be measured against the set criteria to determine its PPP suitability; and
accountable management of the project must exist throughout its lifespan.

In the context of this study, the above eight principles and the success factors were identified as the appropriate mitigation strategies or responses in solving the challenges faced in PPP housing projects in Dar es Salaam, Tanzania. Furthermore, these principles and success factors were regarded as the basis for the development of the PPP conceptual framework (see Figure 3). Therefore, the proposed framework model was designed to facilitate the attainment of these features in the Tanzania HPPP projects in consideration of the identified challenges. It is visualised that the more opportunity for these features to be incorporated in the model, the better the chances of successful implementation of HPPP because the absence of these “principles and success factors” could equally be considered a constraint.

6. The proposed framework model

In developing the PPP housing framework model, the adopted approach was based on the project life cycle approach. This involved designing systematically and customising to address the vital stages that need careful attention throughout the life cycle of the project with respect to weaknesses identified. The key features of the model will address major constraints thwarting the delivery of adequate housing in Tanzania. In contrast to other developed PPP framework models by Trangkanont and Charoenngam (2014b) and Tutesigensi and Mohammad (2008), the proposed model consists of five major phases, featuring five key aspects: skills, planning, procurement, monitoring and controlling. Through a critical analysis of the problems, inadequacy of these features was determined as the main cause of the challenges. Hence, unlike other models, the proposed model aims at providing systematic

<table>
<thead>
<tr>
<th>Phase 1</th>
<th>Phase 2</th>
<th>Phase 3</th>
<th>Phase 4</th>
<th>Phase 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation</td>
<td>Planning</td>
<td>Procurement</td>
<td>Building</td>
<td>Operating</td>
</tr>
<tr>
<td>Set up to launch PPP project steering committee</td>
<td>Prepare detailed feasibility study</td>
<td>Submit prequalification criteria to align with project goals</td>
<td>Set up project operation</td>
<td>Prepare a pilot project</td>
</tr>
<tr>
<td>Prepare training programmes</td>
<td>Select preferred bidder</td>
<td>Proposal</td>
<td>Project operation</td>
<td>Pilot project goals</td>
</tr>
<tr>
<td>Strategies for PPP enabling environment</td>
<td>Award and agreement</td>
<td>Performance</td>
<td>Project operation</td>
<td>Set up in-house PPP project steering committee</td>
</tr>
<tr>
<td>Housing PPP legal framework (mortgage financing, government subsidies)</td>
<td>Monthly report</td>
<td>Management</td>
<td>Project operation</td>
<td>Prepare in-house PPP training programmes</td>
</tr>
<tr>
<td>Prepare a pilot project</td>
<td>Performance</td>
<td>Management</td>
<td>Project operation</td>
<td>Arrange for PPP enabling environment</td>
</tr>
<tr>
<td>Pilot project goals</td>
<td>Management</td>
<td>Control and measurement</td>
<td>Project operation</td>
<td>Housing PPP legal framework</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Performance</td>
<td>Project operation</td>
<td>mortgage financing</td>
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<td></td>
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<td></td>
<td></td>
<td>government subsidies</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>PPP expert/advisors</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Prepare a pilot project</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pilot project goals</td>
</tr>
</tbody>
</table>

**Figure 3.** Proposed PPP framework model for Housing projects
guidance while addressing the challenges to enhance the delivery of PPP housing projects. Previous PPP models address risk management in PPP low-cost housing (Trangkanont and Charoenngam, 2014b) and initiation of PPP in the construction industry (Tutesigensi and Mohammad, 2008). The proposed framework is shown in Figure 3.

The basis and justification for the selection of the Trangkanont and Charoenngam (2014b) and Tutesigensi and Mohammad (2008) as a point of comparative reference with the proposed Tanzanian model is the fact that they are all from developing countries, with similar socio-economic conditions.

In order to address the second objective of the study, namely to “suggest advocated solutions in form of a conceptual PPP framework that will address the identified challenges and hence boost its success”, the following section illustrates how the framework as presented in Figure 3 is mapped to the identified challenges 1-19 (see Table I and Table V with the advocated remedial solutions). These challenges and solutions were further mapped to the appropriate phase of the framework. Table VII presents the summary of this mapping exercise.

Examination of Table VII shows that the majority 6.5 (34.21 per cent) of these challenges were more prevalent in the “Procurement phase” followed by the “Preparation phase” with 6 (31.58 per cent) and in third place was the “Planning phase” with 4 (21.04 per cent). Interestingly, within the last “Operating phase”, no challenges were assigned. The implication of this “mapping exercise” highlights the need for the Tanzanian stakeholders to address the issues associated with procurement for effective implementation of PPPs. As recently acknowledged by the World Bank (2016, p. 30) report, “the rules and procedures governing PPP selection and decision making in Tanzania are clearly delineated, but the implementation is less than perfect”.

Further application of the “mapping exercise” and explanation of the model are provided in the following sub-sections.

6.1 Phases of the model explained

6.1.1 Phase 1: preparation. In Phase 1, the main focus of the model is on the preparation of the necessary groundwork in order to enhance skills and improve a PPP-enabling environment. This phase is equivalent to the “pre-contract” stage and crucial in the attainment of procedural justice, as identified by Zhang and Jia (2010, p. 518). Because Tanzania is still immature in PPP projects in the areas of skills and experience, this challenge ranked as the highest in Table IV (mean = 4.82) and significant ($t(27) = 17.928$, $p = 0.000 < 0.05$) with a highest overall mean difference of 1.321, and highlighted as one of the major challenges from the reviewed studies in Table I ($n = 8, 40$ per cent). To overcome this challenge caused by economic problems and financial constraints, it is important to provide training to public officials. However, it is expensive to send a group of people abroad for training, hence an “in-house” steering committee is proposed in the model as the best alternative to assist with addressing the “skills training” and “enabling environment”. The need for better PPP training was a major concern raised by Morledge and Owen (1998) and Mitchell (2007). Therefore, during this stage, emphasis is on the need to equip public officials with adequate skills so that they gain skills and knowledge to deal with the complexity of PPPs. In order to prove that the trained personnel have acquired the PPP skills, a pilot project should be undertaken. The ultimate goal of this pilot study will be to assess the capacity and understanding of the trained personnel. The control method for this phase is the PPP training programme. This control method will ensure that personnel with the necessary skills set will administer such projects.

6.1.2 Phase 2: planning. In Phase 2, the client/public sector needs to carry out a detailed feasibility study in order to determine the real needs of the public not considering the
<table>
<thead>
<tr>
<th>No.</th>
<th>Challenges</th>
<th>Advocated remedial solutions</th>
<th>Supporting literature</th>
<th>Model strategy</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Differing goals between partners</td>
<td>Careful ground work; selecting private developers with a sense of social obligation to enhance compatibility; and compatibility between partners</td>
<td>Moskalyk (2011), Abdull-Aziz and Kassim (2011), World Bank (2016)</td>
<td>Set prequalification criteria to align with project goals</td>
<td>P3</td>
</tr>
<tr>
<td>2</td>
<td>Corruption</td>
<td>Transparency in procurement process; and action against errant developers</td>
<td>Abdull-Aziz and Kassim (2011)</td>
<td>Less negotiations after bidder selection</td>
<td>P3</td>
</tr>
<tr>
<td>4</td>
<td>Poor PPP contract and tender documents</td>
<td>Well-formulated and detailed contract and adequate legal framework; and good preparation</td>
<td>Kwofie et al. (2016), Babatunde et al. (2012), World Bank (2016)</td>
<td>Detailed preparation and planning; “in-house” steering committee is proposed in the model to enhance PPP training programme</td>
<td>P3</td>
</tr>
<tr>
<td>5</td>
<td>Delays</td>
<td>Constant communication and monitoring; and strong and good private consortium</td>
<td>Akintoye et al. (2003), Li et al. (2005), Abdull-Aziz and Kassim (2011), Ismail (2013), World Bank (2016)</td>
<td>Tier-two project management system to enhance communication</td>
<td>P4</td>
</tr>
<tr>
<td>6</td>
<td>Inadequate PPP legal framework and guidelines</td>
<td>Adequate legal framework</td>
<td>Ismail (2013), World Bank (2016)</td>
<td>Arrange for PPP-enabling environment</td>
<td>P1</td>
</tr>
<tr>
<td>7</td>
<td>Inadequate PPP skills and knowledge</td>
<td>Adequate PPP capacity; and PPP training and awareness</td>
<td>Jefferies et al. (2002), Cheung et al. (2012), World Bank (2016)</td>
<td>“in-house” steering committee is proposed in the model to enhance PPP training programme</td>
<td>P1</td>
</tr>
<tr>
<td>9</td>
<td>Inadequate feasibility study</td>
<td>Careful ground work; and public sector to carry out feasibility study rather than the private sector to avoid exaggeration</td>
<td>Jefferies et al. (2002), Cheung et al. (2012), Ismail (2013), World Bank (2016), URT (2009)</td>
<td>Need levels must be identified clearly by public sector</td>
<td>P2</td>
</tr>
<tr>
<td>10</td>
<td>Inadequate project management by the public sector</td>
<td>Good governance; constant communication and monitoring; trust between parties; and consistent monitoring</td>
<td>Jamali (2004), World Bank (2016)</td>
<td>Tier 2 project management controlling</td>
<td>P4</td>
</tr>
<tr>
<td>11</td>
<td>Long-term disputes and conflicts between parties</td>
<td>Transparency in procurement process; trust between parties; constant communication and</td>
<td>Ismail (2013), Jamali (2004)</td>
<td>Agree on key issues upfront and management/disputes procedures</td>
<td>P3 and P4</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>No.</th>
<th>Challenges</th>
<th>Advocated remedial solutions</th>
<th>Supporting literature</th>
<th>Model strategy</th>
<th>Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>Inadequate government commitment and support</td>
<td>Just enough government subsidies to support affordable housing projects; and commitment of the public and private sectors</td>
<td>Ismail (2013)&lt;sup&gt;a&lt;/sup&gt;, Kwofie et al. (2016)&lt;sup&gt;b&lt;/sup&gt;, World Bank (2016)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Arrange for PPP-enabling environment during the preparation</td>
<td>P1 and P2</td>
</tr>
<tr>
<td>13</td>
<td>Insufficient capacity in procurement and negotiations</td>
<td>PPP capacity and awareness; and PPP training</td>
<td>Jefferies et al. (2002), Cheung et al. (2012), World Bank (2016)&lt;sup&gt;c&lt;/sup&gt;, URT (2009)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Prepare in-house PPP training programmes and enabling environment</td>
<td>P1</td>
</tr>
<tr>
<td>14</td>
<td>Poor risk identification, allocation and management</td>
<td>Appropriate risk allocation and risk sharing</td>
<td>Jamali (2004)&lt;sup&gt;a&lt;/sup&gt;, Jefferies et al. (2002), World Bank (2016)&lt;sup&gt;c&lt;/sup&gt;, URT (2009)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Set prequalification criteria to align with project goals; PPP training programmes</td>
<td>P3</td>
</tr>
<tr>
<td>15</td>
<td>In experienced private partner</td>
<td>Fairness and competitive tendering; strong and good private consortium; PPP capacity and awareness; and public empowerment</td>
<td>Chan et al. (2010), Jefferies et al. (2002), Cheung et al. (2012)</td>
<td>Submit proposal to advisory team in PPP unit</td>
<td>P1</td>
</tr>
<tr>
<td>16</td>
<td>Unequal qualifications and contributions of expertise</td>
<td>Adequate PPP capacity; PPP capacity and awareness; and shared responsibility between public and private sectors</td>
<td>Ismail (2013)&lt;sup&gt;a&lt;/sup&gt;, Jefferies et al. (2002), World Bank (2016)&lt;sup&gt;c&lt;/sup&gt;, URT (2009)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Arrange for PPP-enabling environment</td>
<td>P1</td>
</tr>
<tr>
<td>17</td>
<td>Poor enabling environment to attract competent partners</td>
<td>Good governance; sound economic policy; and availability of finance market</td>
<td>Ismail (2013)&lt;sup&gt;a&lt;/sup&gt;, Jefferies et al. (2002), Cheung et al. (2012)</td>
<td>PPP Unit enforcing its advisory role and arrange for PPP-enabling environment</td>
<td>P2</td>
</tr>
<tr>
<td>18</td>
<td>Inadequate mechanisms for recovery of private investors’ capital</td>
<td>Conductive socio-economic structure to boost income generation; accurate project identification and technical feasibility; thorough and realistic assessment of the cost and benefits; government should provide free land to private investors to lower the cost of the houses; and empowering the low-income group financially</td>
<td>Ismail (2013)&lt;sup&gt;a&lt;/sup&gt;, Kwofie et al. (2016)&lt;sup&gt;b&lt;/sup&gt;, World Bank (2016)&lt;sup&gt;c&lt;/sup&gt;, URT (2009)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Prepare in-house PPP training programme to train local people</td>
<td>P1 and P2</td>
</tr>
<tr>
<td>19</td>
<td>High cost in procuring PPP projects</td>
<td>Adequate PPP capacity building; PPP capacity and awareness; available financial market; thorough and realistic assessment of the cost and benefit; and economic viability</td>
<td>Jefferies et al. (2002), Cheung et al. (2012), Ismail (2013)&lt;sup&gt;a&lt;/sup&gt;, World Bank (2016)&lt;sup&gt;c&lt;/sup&gt;, URT (2009)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>Prepare in-house PPP training programme to train local people</td>
<td>P1 and P2</td>
</tr>
</tbody>
</table>

Notes: <sup>a</sup>Denotes studies from African countries such as Ghana and Nigeria; <sup>b</sup>denotes studies from developing countries such as Malaysia, Ghana, Nigeria and Lebanon; <sup>c</sup>denotes Tanzanian-specific studies; <sup>d</sup>The phase relates to the states as shown in Figure 2 and P1: preparation; P2: planning; P3: procurement; P4: building; P5: operating

Table VII.
political needs as the public needs because the two may utterly differ. However, as observed by Trangkanont and Charoenngam, (2014a), leaving such tasks in the remit of the private sector may result in dishonesty and artificial demands. According to Trangkanont and Charoenngam, there were cases where the private sector had convinced the public sector that a project was viable and demand for it was high as was the case in Thailand. Realistic demands will enhance the assessment of PPP projects enabling genuine and correct decisions to be made. The following challenges were significant (see Table V), namely “inadequate PPP skills and knowledge leading to poor planning and application”, “poor PPP contract and tender documents”, “inadequate project management and monitoring by public sector” and “feasibility study”, and ranked first, second, third and ninth, respectively (see Table IV), and will be addressed in this planning phase. This is because they are project management and procurement oriented, as evidenced by the Project Management Body of Knowledge areas (see Project Management Institute, 2008). For example, planning is a critical element in project management, because it provides the basis for investment decisions and aids in developing a project that mirrors the real needs of the community. Furthermore, within PPP projects, consideration of the approval process is vital. This process is undertaken to allow a proposed PPP project to go through screening and checks in order to further ascertain its viability, affordability, value for money and appropriate risk transfer. Thus, the proposal is submitted to the national PPP unit, which is an independent body made up of different professionals to assess the legal, financial, technical, cultural and social aspects. In this phase, the consideration of the feasibility study report, value for money and affordability assessment and PPP unit approval constitute the control methods. If these are not completed, then the project cannot proceed to procurement stage.

6.1.3 Phase 3: procurement. In this phase, the contracting authority revisits the procurement package and a set of prequalification criteria to make sure that they align with the project goals. Following on from this would be advertising of the project and submission of bids by prequalified bidders. A preferred bidder is then selected. Since “corruption” ranked as the eighth challenge affecting the delivery of PPP projects (mean score = 4.29) and significant \( t (27) = 6.931, p = 0.000 < 0.05 \) with a mean difference of 0.786, in this stage negotiations are discouraged because they sometimes lead to corruption or unnecessary alterations. Hence, adequate planning and preparation minimise the need for negotiations. However, parties still have to agree early on a number of issues on management procedures as challenges ranked second, third and fourth are project management, procurement and legal issues related. This may include the structure of communication, decision making, problem solving, performance evaluation and conflicts management. Competitive tendering and transparency are the control method for this phase, hence unsuccessful bidders should be informed why the winner was chosen in preference. As asserted by Zhang and Jia (2010, p. 518), effective cooperation among the parties could be achieved through exercising procedural control.

6.1.4 Phase 4: building. The special purpose vehicle would be utilised in the execution of the project. This stage requires adequate monitoring and controlling. Since the government remains accountable for the delivery of its services, it is important to have a clear mechanism to monitor its performance. In this case, project authorities may create a two-tier system, contracting authority as tier 1 and ministry/PPP unit as tier 2 in order to address the third-ranked challenge which is “inadequate project management and monitoring by public sector” and significant \( t (27) = 9.899, p = 0.000 < 0.05 \) with a mean difference of 1.071. In order to facilitate the compilation of a monthly report, the site manager should produce daily reports. The architect would then facilitate and certify the submission to the tier 1 authority. Likewise tier 1 submits its monthly report to tier 2, which can be the ministry in charge of the project or the PPP unit. The two-tier monitoring mechanisms provide a double check, thus ensuring effectiveness and accountability. Finally, in order to meet the key
6.1.5 Phase 5: operating. The last phase is the operating one and involves the allocation of the completed housing units through sales/renting. The private partner will operate as per the agreed contract. The operation in this phase will depend on the nature of the project. For example, low-income housing projects as noted in the Malaysian (Ismail and Haris, 2014; Abdul-Aziz and Kassim, 2011) and Thai studies (Trangkanont and Charoenngam, 2014a, b), both required an honest, fair and transparent allocation system to ensure that the houses reached the intended group. Thus, in order to have a listing of public sector and qualified house buyers, mechanisms would have to be established. In addition, for transparency and trust building, there would be a need for depositing the monthly collection into a joint account. Following this, the production of monthly sales performance and financial status reports would then be undertaken in a similar way. The control mechanism for this stage is the openings of a joint account with the inclusion of a specific clause in the contract that will compel the private partner to submit monthly financial reports.

7. Contributions, recommendations and implications

7.1 Contributions

A number of contributions emerge from this study. First, to the best of our knowledge, our empirical study is among the first in construction and housing-specific empirical studies on a number of areas affecting PPPs, and that identifies and ranks the challenges of PPP for housing projects delivery within the Tanzanian context. The identification of the challenges enabled their ranking, resulting in the mapping out of the most critical challenges (see Table VII) with the “Procurement” and “Preparation” phases being identified as the most critical. Second, using the Gidden’s structuration theory, the study illustrates how institutional mechanisms (structures) address these delivery challenges, thus influencing the implementation of HPPP in Tanzania, and how individual stakeholders (human agents or agency) are able to make choices (advocated solutions) in dealing with the challenges (see Table VII). Third, while the linkages between procedural justice and corporation effects were not empirically tested, the application of the equity theory to the qualitative (interviews) and quantitative (questionnaire) findings demonstrated the existence of “inequity” among the Tanzanian partners with the private partners having the upper hand in dealing with the majority of the issues affecting the delivery challenges influencing PPP in Tanzanian housing projects. Finally, using the project life cycle approach, the study proposes a framework (see Figure 3) aimed at addressing major constraints thwarting the delivery of adequate housing in Tanzania. Drawing upon Chileshe et al. (2013, p. 165), the proposed framework opens the possibility of examining both the CSFs (Table VI) of the agents (Tanzanian practitioners) in relation to the delivery of the PPP in housing projects and their failures (challenges) in dealing with the external environment and associated regulatory factors. Furthermore, through the alignment and mapping the identified challenges to the proposed remedial solutions across the five phases within the proposed PPP framework (see Table VII), the study has contributed to the PPP research agenda albeit within the developing countries context by responding to and addressing the study by Akintoye and Kumaraswamy (2016) which renewed the calls for more research on PPP.

7.2 Recommendations and implications

Some suggested recommendations and implications for government, policy makers, practitioners and research are as follows:

(1) Government and policy makers would be required to consider carefully improving and/or revising the existing PPP policy and regulations as well as put forward a
housing policy that will initiate the supply of more affordable housing. Correspondingly, in-house training should be emphasised, facilitated and coordinated by the government through the PPP Coordinating Unit to both the public sector and private sectors in order to acquire the necessary PPP skills and knowledge. As illustrated in Table VII, the majority of the challenges are nested within the “Procurement phase” of the proposed framework, followed by the “Preparation phase”. Therefore, training programmes should be tailored to address these challenges early on in the process.

(2) For practitioners, the identified challenges have formed the basis of the framework presented in this paper. Furthermore, these provide useful information, thus leading to increased awareness and to successful delivery of PPP in Tanzania. However, these managerial (practitioner) implications should be considered in light of the contingency theoretical perspective which requires all the partners in an alliance such as the prevailing JVs to be compatible (Vivek and Richey, 2013). Clearly, this is not the case within this study where the interviewee findings (see Interviewee I responses) highlighted the private sector as having agreements more favourable to them than the Tanzanian public sector partners. Similarly, on the one hand, the findings in Table V point to the private sector withholding financial information from their public partners, and more so, there is clear lack of “equity” compounded by the numerous challenges or unexpected contingencies (Zhang and Jia, 2010) facing the public partners. In particular, these public partners are disadvantaged by the lack of knowledge across a number of project management areas such as “Inadequate PPP skills and knowledge” and “Inadequate project management and monitoring”. On the other hand, Table VII might have suggested some advocated remedial solutions to these “challenges” and simplified the process by mapping them to the appropriate stages within the framework. As illustrated in Figure 3, there is a clear need for managerial attention in PPP’s implementation during the initial preparatory phase, and re-evaluation of the basic tenets of the “equity theory”.

(3) For academia, drawing upon the recommendation of Chileshe and Kikwasi (2014), there also appears a need for increased training of the desirable skills for overseeing PPP projects. These would include negotiation, risk allocation and the selection of partners (see Table IV). In the opinion of Moskalyk (2011), local- or national-level PPP units should be leading in the provision of effective instruments to build the expertise of governments. The application of effective risk management frameworks has also been suggested as the mechanism for improved decision making on risk response strategy selection and resource allocation in the PPP project life cycle (Trangkanont and Charoemgum, 2014b). Tanzanian stakeholders could learn lessons from that. Therefore, the Tanzanian PPP units and coordinating units as listed in Table III should be championing this cause. As illustrated in the proposed PPP framework (see Figure 3), this training should be undertaken during Phase 1, namely the “preparation”.

8. Limitations and further research

While a number of contributions to PPP theory such as Gidden’s structuration theory, contingency theory, relational and equity theory, and practice emerge from this study, the following limitations related to the geographical setting, sample size and model validation are noted.

The interview and survey sample consisted of stakeholders drawn from only one city in Tanzania, namely Dar es Salaam, and consequently the results may not be generalised to other surrounding countries sharing similar economic conditions such as the East Africa
Community (namely, Republics of Burundi, Kenya, Rwanda, South Sudan, and Uganda). The framework can contribute towards addressing similar challenges as well as providing guidance; however, this needs validation. As asserted by Tang et al. (2010, p. 690), these conceptual models can be developed based on case studies, and further tested by the use of a representative sample. Furthermore, as this study is part of ongoing research, at this stage, the paper does not offer a conclusive answer to the question of validity of the model.

Drawing upon the studies of Yalegama et al. (2016) and Abdul-Aziz and Kassim (2011), our study further acknowledges that the identified challenges particularly from the qualitative research (interviews) may be considered as Tanzanian specific. Therefore, whereas the advocated solutions in the form of the PPP framework (see Figure 3) might work in Tanzania and a country with similar socio-economic, legal, procurement and cultural aspects, our study further acknowledges that the outcome may be different in another country. Any future research on challenges to PPP delivery as well as advocated solutions needs to take into consideration the prevailing conditions within the country of study, and thus tailoring the research to them. As articulated by Abdul-Aziz and Kassim (2011, p. 151), these success and failure (labelled as “challenges”) factors for housing PPP programmes may be country specific. Another requirement would be the monitoring of both the internal and external conditions in the host country by partners (Tang et al., 2010). The proposed framework model will be tested and validated to examine the applicability of the proposed framework in other housing PPP projects in Tanzania, and in other similar developing countries.

9. Conclusions
In order to facilitate creative and innovative approaches in stimulating the private sector, it is widely accepted that engagement of PPP is a viable option. Furthermore, governments in both developed and developing economics normally require bidders to compete on the basis of developing unique and creative approaches to the delivery of many physical infrastructure facilities. Despite the importance and role of PPPs, research on the challenges affecting the delivery of PPP in housing projects remains underexplored.

The purpose of this research was to investigate the perception of the challenges affecting the delivery of PPP projects among the construction professionals in Tanzania, and propose a PPP framework to address the identified challenges, and hence boost opportunities for the successful delivery of these projects. A number of theoretical perspectives, such as Gidden’s structuration theory, contingency theory, relational and equity theory, were applied in interpreting the findings as well as underpinning the methodological approaches. In all, 19 PPP challenges as identified from reviewed literature (see Table I) were revised and adopted. These challenges formed the basis for the questionnaire survey development and semi-structured interviews. As a result, the identification of the challenges towards the growth and successful delivery of PPP projects in Tanzania was undertaken.

The results demonstrated that Tanzanian construction professionals ranked the following challenges as having significant ($p < 0.05$) opportunity to derail the delivery of the PPP (mean score > 4.50):

1. inadequate PPP skills and knowledge leading to poor planning and application (mean = 4.820);
2. poor PPP contract and tender documents (mean = 4.640);
3. inadequate project management and monitoring by public sector (mean = 4.57);
4. inadequate legal framework (mean = 4.540); and
5. misinformation on financial capacity of private partners (mean = 4.500).
The least ranked and not significant ($p > 0.05$) five challenges were as follows:

1. inexperienced private partner (mean = 3.680);
2. unequal qualifications and contributions of expertise (mean = 3.570);
3. poor enabling environment to attract competent partners (mean = 3.500);
4. inadequate mechanisms for recovery of private investors’ capital (mean = 3.390); and
5. high costs in procuring PPP projects (mean = 3.360).

The study applied the Adams (1965) equity theory as cited in Zhang and Jia (2010) and Scheer et al. (2003) to both the qualitative and quantitative findings. This theory enabled the explanations of inequity among the private and public Tanzanian stakeholders (partners) particularly with regards to addressing and managing issues associated with the “Poor PPP contract and tender documents” and “inadequate legal framework”. For example, some of the findings from the interviews indicated that the majority of the NHC HPPP contracts had major legal issues such as lack of an exit clause, contradictory provisions in an agreement, bias in favour of their private partners, double standards and uncertain practice in the transfer of right of occupancy and non-adherence to the rules and regulations among partners. The study also revealed that despite of the survey respondents having assessed themselves as having enough skills and knowledge on PPP, they still had not undertaken any PPP training to improve their PPP management skills (of PPPs). In summation, the study reinforced the belief that Tanzania, like other developing countries, experiences insufficient government funds and poor housing conditions. Therefore, public organisations, in this case NHC and NSSF, have adopted the PPP strategy to deliver housing projects. However, these HPPP projects have not been as successful as expected. Finally, the findings from the interviews revealed the existence and interplay between the three dimensions of structure as represented by signification, domination and legitimation and those (dimensions) of agency as represented by communication, power and sanctions. For example, Interviewee’s I responses related to the challenge of “non-adherence of the rules and regulations” were clear evidence of the existence of the duality between “domination” and “power”. From this, a conceptual framework for HPPP has been developed and examined using the theoretical underpinnings of Gidden’s theory of structure as well as exploring the synergies and interactions between the various dimensions of the structure and agency.

References


Further reading


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A comparison of the suitability of FIDIC and NEC conditions of contract in Palestine
A perspective from the industry

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Abstract
Purpose – The standard forms of construction contract are receiving greater attention in the management of projects scholarship as they probably influence the project success and project disputes. The extant literature suggests that the standard forms of construction contract are one of the top sources of disputes. The purpose of this paper is to examine the effectiveness of the standard forms of construction contract, FIDIC and NEC, in reducing disputes in the Palestinian construction industry.
Design/methodology/approach – The researchers have used qualitative methods to collect data and more specifically have undertaken 12 semi-structured interviews.
Findings – The study reveals that the standard forms of construction contract can be a tool to minimise disputes, but certainly not to eradicate them, and NEC appears to be more capable than FIDIC to do so.
Originality/value – This study contributes to knowledge by bringing an industrial perspective into the role of standard forms of contract in disputes creation and avoidance. The interviewees, recurrent users of FIDIC contract, criticised certain features and expressions and proposed some solutions.
Keywords Construction, Interview, Project management, International construction
Paper type Research paper

1. Introduction
Construction disputes are an important area for academics trying to understand why construction contracts go wrong. Constructions disputes are problematic, unpleasant, and dysfunctional, destroy client-supplier business relationship, costly, and may lead to cost/time overrun (Fenn, 2012). The literature includes a growing body of scientific research investigating the role of contracts in dispute materialisation. For instance, Clegg (1992) proposed that, from a sociologist view, contracts cause conflict. Cheung and Pang (2012) argued that contracts are the root cause of all types of construction disputes. Specifically, Fenn et al. (1997) argued that one of the top factors creating disputes in the construction industry is standard form of construction contract. They empirically compared a wide range of standard forms of construction contract and concluded that certain contracts may cause more disputes than others. However, it is unknown how standard forms of contracts may contribute differently to the formation and evolution of disputes. Therefore, this research theoretically and empirically examine this notion by comparing the effectiveness of FIDIC and NEC standard forms of construction contract in minimising disputes.

The choice of FIDIC and NEC contracts in this research is based on three-folds. First, the fundamental aim behind drafting and bringing NEC into life is to resolve the problem of disputes arising and the adversarial behaviour in construction. Indeed, the Palestinian construction industry suffers from the adversarial relationships between construction parties and the increasing level of disputes (Enshassi, Choudhry and EL-Ghandour, 2009). Second, infrastructure and construction projects are implemented by the government or by foreign or international employers. The government uses FIDIC (1999) conditions of
contract[1] and many foreign or international employers or organisations financing
collection of projects use FIDIC such as the World Bank, the Asian Development Bank, the
Islamic Bank for Development, the European Commission, and different United Nations
bodies (Aljarosha, 2008; Swiney, 2007; Zhanglin and Yuli, 2010). Yet, some of these
organisations are testing the potential usage of NEC instead of FIDIC in their projects. For
instance, the Asian Development Bank and the UK’s Overseas Development Agency are
testing replacing FIDIC by NEC for their sponsored projects (Ndekugri and Mcdonnell,
1999). Third, FIDIC is the most widely used international form of construction contract in
the world (Seifert, 2005). At the same time, the usage of NEC in the UK and 30 other
countries in the world is an indicator of its increasing popularity worldwide (Thompson
et al., 2000). This means that the research findings may be transferable to many
jurisdictions.

The remainder of the paper is structured as follows. First, five aspects of FIDIC
conditions of contract are compared and contrasted with those of NEC. This is followed by
brief explanations of the conceptual framework and the interviews which were carried out
with 12 professionals working in the Palestinian construction industry. The views and
opinions of the interviewees with regards to the effectiveness of FIDIC and NEC in reducing
disputes in the Palestinian construction industry are then discussed prior to the
presentation of the conclusion.

2. FIDIC compared and contrasted with NEC
This comparison is neither clause-to-clause nor is it claimed to be exhaustive and
encyclopaedic. A comprehensive and holistic comparison between FIDIC suite of contracts
and NEC suite of contracts is very ambitious and broad aim because there are many
contracts in each family. Therefore, the scope of this study is limited to FIDIC 99 Red Book
vs ECC3 (NEC3 Engineering and Construction Contract). Further, the study concentrates on
the five most important aspects that normally give rise to construction disputes in Palestine,
as the available literature suggests. These include disputes arising from misunderstanding
and misinterpretation of contract conditions written in English, and onerous terms
(i.e. unfair risk allocation) (Enshassi, Mohamed and El-Ghandour, 2009; Murtaja, 2007;
Enshassi, 1999), variation orders (Abedmousa, 2008), the lack of trust between contractors
and engineers (Saqfelhait, 2012) that creates an adversarial environment in which one of the
most important factors determining bid-no-bid and mark up decisions are “project engineer”
(Enshassi et al., 2010) in addition to the endemic volatile and unstable political environment
(e.g. borders’ closures, blockade, and hostilities) that leads to cost and time overruns
(El-Sawalhi and El-Riyati, 2015; Enshassi, Mohamed and El-Ghandour, 2009).

2.1 Clarity and simplicity
Chong and Zin (2009) argued that one of the main causes of disputes is misunderstanding
and misinterpretation of contract clauses and the preventive solution lies in the use of plain
English. Clarity is important to ensure that all parties of a contract understand what they
are getting themselves into, their rights and obligations, and the risk apportionment and
thus what risks they bear.

FIDIC has been criticised for using obscure, complicated, inscrutable, and legal language
that has phrases traced back to contracts of the nineteenth century in England (Broome
and Hayes, 1997). In addition, FIDIC’s poor layout, long sentences, and substantial
cross-referencing make it difficult to understand (Cutts and Maher, 1986; Wydick, 1978).
Nevertheless, it is important while reviewing these critiques to consider their time context,
as they were written prior to or just after the release of FIDIC (1987). It worth mentioning
that one of the objectives behind drafting the FIDIC (1999) Rainbow edition was to simplify
the language. However, it is uncertain whether FIDIC has been completely successful in this
aim. Probably, FIDIC has been improved much from its earlier editions and has moved
towards fewer clauses and clearer language and contract structure, but the real judgment is
left to its users. Indeed, this area is a worthwhile investigation for further research.

NEC is different from FIDIC as one of its three declared objectives is to minimise the
incidences of disputes arising from unclear language. NEC uses non-legalistic ordinary
unequivocal language, straightforward, simple and plain English, short sentences (with no
more than 40 words), a bulleted structure and avoidance of confusing cross-references.
Also, there are guidance notes and flow charts to assist in the understanding of how to
create and operate the contract (Eggleston, 2006; Gould, 2007; Li, 2006). The abandoning of
"legal language" is a revolutionary step by the NEC drafters which is much debated.
The drafters claim that they sacrificed legal concepts in the interests of better management
of projects. This makes the language more understandable to builders at site level
(Lavin and Potts, 1998; Li, 2006). Moreover, it saves time and money paid to lawyers to
translate the contract to legal phrases, and then translate it back to users so they know what
it means (Abrahamson, 1979). On the other hand, the main criticism of this approach is that
it discards the accumulated contractual wisdom of generations, reinvents the wheel, and
reduces the legal certainty which could increase the chance of contractual disputes
(Eggleston, 2006; Valentine, 1996).

To sum up, the research acknowledges that NEC is not perfect, but it is a considerable
improvement in clarity compared to FIDIC. Indeed, what is required to avoid disputes is clear
English, and certainly not a long history of case law and judicial precedents on a particular
clause or phraseology. To avoid disputes in the first place, people at the site level should be able
to understand the conditions, and not need to memorise a dozen cases about particular clauses.

2.2 Risk allocation and management
It is inherent for any project, particularly in the construction industry, to involve risks.
It is not possible to eliminate all risks, but what can be done is to allocate the risks to the
various parties who then manage them (Kozek and Hebbard, 1998). The standard forms of
conditions of contract provide a framework to regulate the process of risk allocation by
defining the rights and obligations of both parties.

Both FIDIC and NEC attempt to allocate risks fairly and reasonably between the
employer and the contractor (Ndekugri and Mcdonnell, 1999). The basic principle to achieve
this is by allocating the risk to the party best able to control and manage the risk event and
bear the risk consequences (Bunni, 2005; Eggleston, 2006; Potts, 2008; Williams, 2001).

FIDIC is based on the principle of balanced risk sharing and has been widely accepted by
employers and contractors as a reasonable compromise (Bunni, 2005; Osinski, 2002).
The employer bears only the risk of unforeseen negative conditions that are not offset by
unforeseen positive conditions. This means that there is less chance for contractors to get
time extensions and cost compensation for unforeseen events since they have to be
unforeseen, and if they are, they need to be offset by other favourable conditions. At first
glance, FIDIC’s new philosophy of “conditions-balancing” seems fair, equitable, and
desirable and similar to pain/gain partnering arrangements. However, it potentially
increases disputes because it provides the parties with more things to argue about, which
could be costly and impossible to settle (Swiney, 2007).

Unlike FIDIC, NEC recognises that the standard form should not only be a mechanism
for risk allocation, but also for a proactive and dynamic risk management. NEC
acknowledges that an important part of risk management is effective communication
between the parties. This includes risk registers, risk prevention, early warning, and risk
reduction meetings (Wassenaer, 2009).

The controversy and comparison between NEC and FIDIC regarding this area hinges on
two views on the purpose of a standard form of construction contract. Should the standard
form be a manual for project management procedures and practices or an agenda for legal actions? FIDIC tends to be skewed towards the latter narrow view of a contract, as it is principally designed to focus more on the risks, liabilities, obligations, and responsibilities of the parties (Heaphy, 2011). Therefore, the parties will use the contract when things go wrong or disputes surface in an attempt to find a clause that will support their contractual position or justify a claim or to allocate blame (Brown, 2000; Eggleston, 2006). NEC is radically different from FIDIC in that it focuses on informed, proactive and foresight-based management and decision making, rather than a reactive and hindsight-based negative approach. Collaboratively applied foresight mitigates problems, shrinks risks and adversarial behaviour, and removes most of the grounds for disputes (Lavin and Potts, 1998). However, focusing on the management side at the expense of the legalistic and contractual side could produce an “obligatorily incomplete” contract (Eggleston, 2006; Hughes and Maeda, 2002).

Apparently, NEC has been more successful than FIDIC in expanding standard forms’ role towards risks. NEC manages risks proactively and dynamically, and, unlike FIDIC, is not only concerned about risk allocation.

2.3 Force majeure and prevention events

Force majeure events are of great importance, particularly under the unstable conditions in Palestine. The legal definition and interpretation of the events may vary from country to country, and from one jurisdiction to another, which will accordingly lead to different legal consequences. Therefore, most standard forms, including FIDIC and NEC, cover these matters by express terms (Eggleston, 2006; Jaeger and Hök, 2010). FIDIC clause 19.1 defines force majeure events to be:

- beyond a party’s control;
- could not reasonably be provided against before entering into the contract;
- having arisen, could not reasonably be avoided or overcome; and
- are not substantially attributable to the other party.

Indeed, clause 19.1 provides a non-exhaustive list, including events such as war, terrorism, riots, and natural disasters. The above definition of a force majeure event is entirely open-ended, such that a human-caused event would be covered if it met the above criteria. This gives more risk to the employer as he bears the cost and time impacts (Swiney, 2007). Jaeger and Hök (2010) criticised the ambiguity of the extent of the contractor’s entitlement to an extension of time, and loss and expense, as to whether it covers direct and indirect consequences of the event. It is worth mentioning that a force majeure event does not need to pass the “unforeseeability” test. This means even if an event is foreseeable, it will be considered force majeure as long as it is beyond the control of the parties (Jaeger and Hök, 2010).

NEC 3 has introduced a new clause (clause 19.1) called “prevention” under which the employer bears the time and cost risks of events similar to, but potentially wider than, force majeure. Clause 19.1 defines a prevention event as an event which:

- stops the contractor completing the works;
- stops the contractor completing the works by the date shown on the accepted programme;
- neither party could prevent; and
- an experienced contractor would have judged at the contract date to have had such a small chance of occurring that it would have been unreasonable to have allowed for it.
Eggleston (2006) criticised this clause as it opens the door for a very wide interpretation because its definition goes well beyond what is adopted in law as force majeure. For instance, a contractor may argue that insolvency of suppliers or the supply of defective materials, works, and designs by others had a small chance of occurring and could not have been prevented by either party. He also critiqued the words “small chance” and “unreasonable” which are difficult tests to examine in dispute resolution proceedings, and would indicate the event to be one of “prevention” even though it was foreseeable, the same as FIDIC. Furthermore, the “prevention” clause seems to apply to delay events which are endemic and it does not make sense that the clause operates for each and every delaying event (Eggleston, 2006).

To sum up, both FIDIC and NEC share the same philosophy of transferring the risk of force majeure events to the employer to avoid padding the tender prices by contractors. It appears that both FIDIC and NEC fail to provide a decisive and conclusive definition of what constitutes a force majeure or prevention situation. The problem with the force majeure definition is that people do not know what might happen, so that they always struggle to define it. This could cause disputes as a notice of force majeure would be rejected by the defendant denying the existence of this event, and in turn suing the claimant or plaintiff for a breach of contract. Bunni (2005) stated that not covering these exceptional events in the conditions of contract, and leaving them to the applicable law in the relevant jurisdiction would reduce the likelihood of conflicts. However, not covering them at all will make the resort to litigation inevitable, which is not desirable.

2.4 Variations

According to Seppala (1991), the inevitable variations are the second major area giving rise to claims under FIDIC. FIDIC is unable to cope with significant variations because it is essentially a re-measurement contract that assumes the project scope is well defined prior to letting the tender documents. FIDIC (1999) sub-clause 12.3 limits variations of items to 10 per cent by quantity and other criteria which necessitate new rates to be agreed. The process of determination of the new rates, whereby a contractor submits a proposal and then the engineer determines suitable prices, is a rigorous and tough process that inevitably will lead to disagreement and dispute.

FIDIC details that a change is to be valued at the same or by considering rates and prices set out in the contract, or the engineer agrees new suitable rates and prices through the procedure of “due consultation” with the employer and the contractor. If no agreement is reached, the last resort is determining the appropriate prices by the engineer. This procedure assumes that the value will be calculated after the variation or change has been carried out (FIDIC, 1999; Forward, 2002).

On the other hand, FIDIC introduces a new innovation allowing contractors to initiate variations under a “Value Engineering” clause. The contractor may submit a proposal, which needs the approval of the engineer to proceed, to increase efficiency, reduce cost and time etc. to the benefit of the employer (FIDIC, 1999). Obviously, this feature encourages collaboration and partnering, and it should have been introduced within NEC.

Normally, standard forms make it clear via express terms that the contractor is obliged to perform variations. NEC does not recognise the phrase “variations” or “changes”, but addresses them indirectly through Clause 14.3 (instructions) which serves as the variation clause (Eggleston, 2006). Although there is no explicit limit to changes, Clause 12.3 tends to limit them by stating that no change to the contract has effect unless it is provided for in the conditions of contract or unless it has been agreed, confirmed in writing, and signed by the parties (Eggleston, 2006).

NEC provides for pre-pricing a variation/change before it is carried out. This means that the instruction – variation order or change order – by the client will at first be an instruction
to submit a price (quotation) for the work, which, if accepted, will be followed by an instruction to carry out the work (Eggleston, 2006). This is beneficial for both parties. The client can decide whether to go ahead or not based on the price. The contractor ensures the price of the work is accepted and thus avoids disputes. Yet, the drawback of the NEC system could be a delay in reaching an agreement on the price, and in turn a delay to the project activities.

In summary, FIDIC tries to avoid disputes by minimising variations to a certain limit after which a new process should be agreed. However, the process of price determination is still problematic. On the other hand, NEC is very flexible as it does not limit variations, but it requires pre-pricing and quotations that fix the prices before commencing the variation. Overall, it is obvious that both use different approaches to tackle the same problem, but NEC tends to be more successful, as what really does matter, at the end of the day, is price agreement and not the 10 per cent limit on quantity or some other constraint.

2.5 The role of the engineer vis-à-vis the project manager

The aim of this section is to critically examine and compare the role of the engineer under FIDIC with the project manager under NEC.

Under the FIDIC’s old Red Book, the engineer has two main duties. First, he is the employer’s agent for design, supervision of the works’ construction and execution, and contract administration. Second, he is a neutral and independent third party responsible to decide and determine the contractor’s claims for additional payment or extensions of time, and to resolve disputes fairly between the contractor and the employer (Seppala, 1991).

The employer is responsible for the engineer’s default in the first group of duties and in turn may be in breach of contract, but he is not responsible for the engineer’s performance in respect of the second group of duties, except in the case of total failure to perform these duties. The duality of the role of the engineer as the employer’s agent and a neutral third party is much criticised because of the conflict of interests in his duties. For example, the engineer may be the cause of problems like design errors and delays in making decisions. Moreover, he is appointed and paid by the employer and may seek future work with him, or at least avoid being sacked (Ndekugri et al., 2007; Seppala, 1991).

NEC resolves these problems, or tries to resolve it, by splitting the engineer’s role into four entities: the project manager, supervisor, designer, and adjudicator. All these roles are agents of the employer except the adjudicator. The project manager is required to make the plans, administer the contract, certify and value payments, etc. with a main mission to get the project delivered on time and within budget. The supervisor is concerned with the quality of works and defects. Those two roles can be combined and occupied by one person (Eggleston, 2006). It is important to keep in mind that the new roles of the engineer under NEC, compared to other forms, would encourage engineers not to recommend such a standard form that considerably reduces their own authority and workload (Lavin and Potts, 1998).

The project manager is the representative of the employer and works on his behalf. There is no express requirement in NEC provisions obligating the project manager to be impartial. However, some routine tasks and activities such as issuing certificates, and valuing compensation events seem to require impartiality and fairness. As a certifier and valuer, the project manager shall not work to secure the employer’s interests. This was emphasised in the unusual case of Costain Ltd and Others v. Bechtel Ltd (2005) cited in (Eggleston, 2006), in which the judge made the decision that the project manager’s duty is to act fairly and impartially when acting as a certifier (Eggleston, 2006). This case shows that the role separation is not as simple as appears on the face of it.

Under the new Red Book, there is an attempt to abandon the “independent engineer” concept. This appears from three changes: removing the requirement to “act impartially”,
expressly stating that the engineer is to act as the employer’s agent, and introducing the Dispute Adjudication Board (DAB) to which the parties may refer any dispute. It is important to view the development and changes of the contract holistically. The non-neutral engineer and DAB are closely related and have been introduced as one package (Swiney, 2007). Certainly, this has significantly reduced the dispute resolution role and power of the engineer (Ndekugri et al., 2007).

The total abandonment of the “independent Engineer” concept is questioned since it replaces the duty to “act impartially” by the duty to make “fair determinations” of the claims between the employer and the contractor, which appears to reinstate the old concept. However, a new mechanism to allow the employer to regain control over the engineer is introduced in clause 3.1. This is achieved by stating that the engineer is to act as the employer’s agent in the particular conditions. Furthermore, unlike the old Red Book, the new book empowers the employer with express authority to replace the engineer for any reason whatsoever, subject to two procedural requirements (Ndekugri et al., 2007).

Lina (1997) argued that although the dual role of the engineer should be abandoned, the new FIDIC and NEC approaches are less efficient than the traditional system. For instance, the NEC approach of separating the duties of the engineer to multiple people or firms ignores the consistency gained by one party working over the whole project life cycle from project inception to completion. Also, the engineer’s knowledge of the project’s day-to-day activities enables him to make decisions better than the DAB or adjudicator. In addition, the interference of the DAB or adjudicator may create a confrontational rather than a cooperative environment and in turn increase claims, especially as the engineer no longer has an obligation to act impartially. Finally, the additional fees payable to the DAB or adjudicator make the works more expensive (Lina, 1997).

Summarising, the new Red Book has moved towards the NEC approach to dispose of the independent engineer concept. However, FIDIC has not gone all the way because the duality of engineer’s role has not been eliminated completely. Arguably, this is favourable as the new Red Book is structured flexibly enough to serve the requirements of different parties (Ndekugri et al., 2007).

3. Conceptual framework
This research is of a qualitative nature because it aims to induce the relationship between the choice of a standard contract and contractual disputes. The research method depends on reviewing the literature and conducting interviews.

The variables or units of analysis in the theoretical framework of this research are the FIDIC and NEC standard contracts and construction disputes. The main assumption here of the interaction between the variables is that the choice of the contract has a direct effect on the disputes between construction parties. In other words, the contract is the independent variable whereas the dispute is the dependent variable. The proposition here is that NEC may minimise disputes. The validity of this proposition will be investigated by surveying the opinions of practitioners through interviews.

4. Interviews
The interview questions were built with the proposition that knowledge about FIDIC is expected, but no prior knowledge about NEC is assumed. The interviews were conducted via Skype, which gives almost the same atmosphere of a face-to-face personal interview because of the inclusion of video communication. The average interview duration was 85 minutes. Selected “expert” sampling has been followed in this research. This involves selecting people who have expertise in the research topic, which is in this case is construction contracts, especially FIDIC.
The data are obtained from 12 semi-structured interviews with eminent professionals in the Palestinian construction industry. The interviewees fall under the following job titles or positions: project manager, technical manager, executive manager, procurement/contract manager, programme manager, academic, and arbitrator. The interviewees have been selected with the intention in mind to be as diverse as possible. Therefore, it is very likely to obtain diverse and various opinions and experiences that may disagree on many issues. This should be viewed as a healthy debate giving rise to more rounded conclusions, and covering the topic in a holistic view from many angles. The interviewees represent employers, contractors, engineering and consulting firms, and development agencies. In addition, the researchers have interviewed people of different genders, different ages and experiences. The range of experience ranges from 8 to 30 years.

5. Results and discussions

5.1 Clarity and simplicity
The respondents were asked to describe the clarity, readability, understanding, interpretation, and certainty of meaning of FIDIC clauses.

There was a clear disagreement regarding the degree of clarity, but all respondents argued that FIDIC is not clear enough. The interviewees maintain that FIDIC's extensive cross-referencing and many very long sentences separated by commas reduce the readability and the understanding. Further they think the lack of clarity, or the difficulty in understanding, which either lead to various interpretations of the contract comes from the fact that almost all of its users are engineers not schooled in law, while the contract was drafted by lawyers using very legalistic language. Further, the fact that the contract users are non-native English speakers brings more difficulties as to the need to understand the ordinary meaning of the words/phrases and the legal meaning that usually is built on a legal tradition of long case law particular to the country of origin. They think that the use of Arabic version is very useful especially for first-time users; however, it is not a panacea. This is mainly because of the potential problem of deviation or distortion of the meaning when translating legal terms and phrases to other languages, particularly if this is combined with different legal systems. It seems that the simple and plain English of NEC helps to reduce disagreements and disputes resulting from the FIDIC's legal and obscure wordings. Also, the translation of NEC to Arabic would be much easier and clearer than FIDIC because of its ordinary language.

Also, they state that FIDIC uses phrases which are uncertain in meaning and could have more than one interpretation such as "in the contractor opinion", "unforeseeable", "exceptional", "experienced contractor", and "physical conditions".

In the allocation of ground conditions risk, FIDIC uses a "foreseeability" test ("unforeseeable for an experienced contractor"), whereas NEC uses a "probability" test ("have a small chance of occurring"). Although some authors criticise both expressions as being uncertain and slightly different approaches (Eggleston, 2006; Ndekugri and Mcdonnell, 1999), FIDIC's foreseeability test appears to be more problematic because it is undertaken only after the occurrence of the event, i.e. the test calls for an assessment ex ante. Psychologically, it is next to impossible to ignore this ex-post knowledge and therefore this retrospective investigation to determine what was foreseeable and what was not suffers from the notorious "hindsight bias" (perceiving past events to have been more predictable than they actually were). Almost all the interviewees expressed their discomfort with this test. Some interviewees stated that the "foreseeability" test is defective and judgements on the foreseeability of events are unpredictable, a pure gamble or a speculative exercise. Another interviewee criticised the essence of how FIDIC treats the concept of foreseeability as a binary either-or construct, whereas in fact it is a continuum from ultimate uncertainty to inevitable certainty. So, where does the dividing line between foreseeable and unforeseeable lie?
In the allocation of weather conditions risk, FIDIC uses a subjective test ("exceptionally adverse climatic conditions"), whereas NEC uses an objective statistical test (weather conditions which occur "average less frequently than once in ten years"). The judgment on whether the conditions are "exceptional" is inherently subjective and hence leads to disputes on its interpretation.

One participant says that “experienced contractor” is a “hollowed out and meaningless phrase”. The elasticity of the phrase comes from fallacies such as the failure to assign objective threshold of time-based experience or number-based experience of similar projects or similar tasks, and the failure to distinguish between the experience of the organisation itself, and the experience of its staff. Sometimes, new organisations hire staff with lengthy experience in order to claim “expertise” but then form teams which suffer from low performance. On the other end of the scale, old construction companies with an extensive past experience may be in a situation whereby most of its staff that implemented the past similar projects left the company, and is left with juniors of minimal experience. Is there a room to differentiate between the organisational learning and individual learning? Further, does the expertise of the project team or the expertise of the organisation’s head office staff matter? It is unknown. Therefore, the concept of “experienced contractor” is entirely uncertain in meaning, and its interpretation will likely be a lottery that depends on the discretion of the tribunal deciding the dispute. The participant suggests linking the concept to the prequalification requirements in terms of detailed criteria covering financial and technical strength, experience in similar projects, similar key activities, head office personnel and project team, etc.

Four respondents propose to use more specific terms and to attach objective values to the risk events such as rainfall duration and intensity, wind speed, earthquake degree, etc. Others propose to provide a commentary about such vague phrases, and to supplement the contract with guidance on its interpretation.

5.2 Risk allocation and management

The respondents were asked if they think risk allocation clarity or fairness or both would be major causes of disputes, and then if they think FIDIC adopts fair and clear risk sharing principles.

The interviewees disagree about the clarity (i.e. part of the clarity of the overall document) and fairness of FIDIC risk sharing, and this disagreement is shared by engineers and contractors.

Ten interviewees agree that disputes will arise if risk allocation is unclear. This is because arguments will occur over who bears which risks. The parties will blame each other, and will keep searching for ways to support their contractual position. This is simply because either party will be unhappy to pay money. However, two people say that even if risk allocation is clear, contractors continue to make claims. The clarity of the risk allocation, as part of the clarity of the whole contract, is discussed in Section 5.1 Clarity and Simplicity.

On the other hand, the interviewees disagree about fairness and disputes. While eight respondents say that if risk allocation is unfair and unrealistic, this will inevitably lead to disputes, others argue that this affects bid price and not claims or disputes. Yet, some participants maintain that fairness does not usually result in higher prices, as contractors usually use zero overhead, because they are working in a very highly competitive market with a desperate need to work. One interviewee refers to this situation as a prevailing “claim-hunting culture” which means that a contractor offers a price based only on the direct “dry” cost, and then depends on claims to make profit. Obviously, such unjustified claims create disputes. Therefore, it can be argued that the unfair risk allocation creates disputes in an indirect way (backdoor form of dispute creation).
Seven interviewees say that FIDIC is well-balanced, fair or relatively fair in that FIDIC views parties as partners. They gave some examples such as force majeure and termination clauses, clause 17 (risk and responsibility), and clause 18 (insurance) that provide fair contracting principles. Also, they believe that the claim procedure allows contractors to be compensated fairly.

Five interviewees feel that FIDIC is or tends to be unfair because it shifts most of the risks to contractors, except for a few things such as employer’s risks and force majeure. Many of the risks shifted towards contractors are illogical because they are weaker than clients to bear certain risks. Hesitantly, they gave some examples such as the weather conditions risk clause that gives an entitlement to only time compensation. They referred also to clauses that provide for compensation only if the risky events are unforeseeable, but the de facto result is that the employer and the engineer consider the risky events to be foreseeable and hence contractors ultimately bear the risks of ground conditions, shortage in the availability of materials, and so on.

5.3 Force majeure and prevention events
Eight interviewees say that force majeure is one of the most dispute generating clauses because of its lack of clarity. For instance, one interviewee states that it is unclear whether an “insurrection” constitutes force majeure. Also, after the tightening of the blockade on Gaza by Israel, there were many arguments about whether this constitutes force majeure or not, as the outcome would cost certain organisations a large amount of money.

Moreover, some local employers delete the provisions of force majeure. They argue that most of the events that are included under this clause, such as war, hostilities, unrest, etc. have become normal things and circumstances in Gaza. Nevertheless, the authors believe that deleting this clause just because a force majeure event has become normal or foreseeable is illogical. This is because the main part of the definition of such an event is being out of the control of either party even if it is foreseeable. Thus, allocating this risk to the contractor is a default practice with devastating consequences on bid price or final project cost, and definitely disputes, and may result in project failure.

Quite often, the contractor is the “victim” as he must bear the financial consequences of these events, because employers have a strict and limited budget for each project. Employers try to cooperate or share some aspects of these risks by granting an extension of time so that contractors are not liable to pay liquidated damages.

5.4 Variations
The interviewees were asked if they think variations are a major source of disputes and why.

There was disagreement between the respondents about this issue. Some argue that variations often lead to disputes, while others claim that variations very rarely cause disputes. Another group stands in between and says disputes sometimes happen, particularly when a variation order requires new prices or rates to be agreed. This disagreement between the interviewees may be because of the different definition and perception of what constitutes a dispute. Possibly, some consider that a rejection or disagreement about the first quotation is a dispute, while others consider a dispute arises when disagreements occur after signing and agreeing the variation price.

The common practice in Palestine is to agree the price of the varied work before commencing the works. However, contractors sometimes start working before agreeing the price to avoid delaying the project. Some people think that FIDIC is flexible in this way and does not oblige pre-pricing or post-evaluation. Instead, FIDIC obliges the contractor to commence the work even if the price of this work has not been agreed. It has been shown by the majority of interviewees that disputes are usually avoided when they follow the pre-pricing route. One contractor states that sometimes disputes arise even if a schedule of
cost components and analysis of the price breakdown structure are provided. The arguments arise over the value of direct cost, and overhead percentage, and so on. This conflict of interest is normal because contractors consider a variation to be an opportunity to make profit, while employers want to adhere to the rates defined in the bill of quantities. All in all, this clearly indicates that the NEC approach is much better than FIDIC’s approach to avoid disputes in the area of variations.

It has been shown that disputes do not only arise from disagreements about evaluation of the impact of the variation, but also from the definition of variation. In some cases, the engineer instructs the contractor to do certain work, which falls outside the contract and thus constitutes a variation in fact, but refuses to acknowledge that his order constitutes a variation. While at other times, the contractor attempts to “make up” variations by delaying the progress or sequence of works, or otherwise, which necessitates new work. Also, contractors may argue that a normal instruction which does not constitute a variation, to be variation.

5.5 The role of the engineer vis-à-vis the project manager

The interviewees were asked whether they think the duality of the role of the engineer (being the client agent and, at the same time, the independent third party to determine matters fairly between the employer and the contractor) is efficient or problematic and why. At the same time, they were asked if they prefer the engineer to be the adjudicator of the disputes between the employer and the contractor and why.

Again, the respondents have different views about this matter. While three engineers defend this role, two engineers, and all other respondents (employers and contractors) criticise this role.

The proponents claim that the engineer knows “the nuts and bolts” of the project and contract documents. They argue that if the role is divided into design, supervision, contract administration, and adjudication this will lead to inconsistency, misinterpretation of contract documents, and may result in significant “rework” because each entity needs to understand the work done by others. Furthermore, in case of dispute, they think the engineer is in a better position to make the correct decision because he will interpret the contract documents correctly and because of his day-to-day knowledge of the project progress and works.

Four interviewees say that this role is not problematic in nature, but its efficiency depends on the professionalism and expertise of the engineer. The engineer who is required to do all these tasks must be very experienced to recognise, distinguish and split which tasks require him to be agent, and which require him to be independent. Whether the engineer shall be the adjudicator is a mere matter of experience and not basically about trust and honesty. This is because experienced engineers consider it dishonourable and disreputable to make wrong or biased decisions. One interviewee states that he prefers the engineer to be a member of the DAB, but not the sole member.

The rest of respondents, five interviewees, argue, giving different reasons, that the role is problematic, theoretical, and not practical and combines conflicting roles. Engineers may make things personal and do not understand their roles properly, what is required from them and what their lines of authority and power, rights, and obligations are. The interviewed contractors told “horror stories” of the abusive and oppressive behaviour of some engineers. In their experience, this reaches its maximal limit when the engineer (performing the supervision, contract administration, and dispute resolution functions) is also the designer of the works. This combination of roles is not uncommon in Palestine and it is next to impossible for the engineer to hold himself guilty and hence awards the contractor compensation for the defective design, or inconsistent contract documents, or faulty specifications from the pocket of his employer. It is just nonsense! An example for this, as stated by an interviewed contractor, is that when the engineer is aware of his contract administration pitfalls, delayed decisions on approval requests, delayed responses
on RFIs, etc. he may award the contractor compensation but on alternative neutral grounds such as delays because of weather conditions or events outside of the control of the project parties. The interviewed contractors say that employers and engineers sometimes appear to change or swap their roles, which clearly indicates that they behave as one party. An interviewed employer admits that in some cases the engineer becomes part of the problem, and then ironically the employer intervenes to settle the controversies between the engineer and the contractor. In addition, it is not unusual to find in construction contracts that the engineer and the employer are the same organisation. Therefore, it is against the natural justice to make a party the judge in its own cause or in a case in which it has an interest.

The impartial role of the engineer in performing the functions of certification, valuation, and dispute resolution has often been misunderstood or viewed with great scepticism by practitioners in Palestine. The prevailing attitude is that engineers are the agents or the representatives of employers, and in case of dispute, the engineer will not attempt to, or will feel embarrassed to blame the person who pays him. Therefore, engineers tend to be consciously or subconsciously biased and partial, and hence cannot be reliable and trusted adjudicators. The prevailing adversarial culture between contractors and engineers in Palestine, as the available literature suggests, is an imperative obstacle to the adjudicatory role of engineers.

6. Conclusion
This study sets out to assess the role of the standard form of contract, FIDIC or NEC in particular, in dispute minimisation. The main results and findings suggest that both contracts have commendable and desirable features for all parties. However, there are certain areas of concern and sometimes limitations in both contracts.

NEC has probably many advantages over FIDIC particularly in clarity, risk management, and variations. The authors argue that these advantages or benefits are for all parties to a construction contract because disputes minimisation is a matter of mutual interest.

The position of the engineer/project manager has benefits and limitations in both contracts; however, it seems that the project manager role under NEC is more sensible in Palestine. This is primarily because of the adversarial relationship and lack of trust between contractors and engineers and the conflict of interests which makes it more reasonable to separate the impartial and neutral role of dispute adjudication from the supervisory and contract administration role in which the engineer works as the client’s agent.

The *force majeure* or prevention provisions are inconclusive in both standard forms, a challenge that arises from the inherently uncertain nature of these events.

On the other hand, FIDIC has the advantages of familiarity and precedence, widespread popularity, and endorsement by many governments, development banks and institutions, and major employers in Palestine and worldwide.

In a nut shell, the standard form of contract can be a tool to “minimise” disputes, but certainly not to eradicate them, and NEC appears to be more capable than FIDIC to do so. The standard form of contract provides the regulatory regime for the parties’ relationships, roles, and responsibilities. The more fair and clear the regulations, the less room available for disputes. Clarity necessitates a move from subjectivity to objectivity, from abstraction to comprehensiveness, and from generalisation to particularisation. This definitely helps in shrinking the margin of contract’s incompleteness and uncertainties. Although the “theory of contracts” is incapable to cope with the challenges of “uncertainty”, risks are also problematic. Risks are those events that may or may not occur. They can be assigned probability values and hence undergo a probability test (NEC term) or a foreseeability test (FIDIC term). Although NEC’s objective approach is a remarkable improvement compared to FIDIC’s subjective approach, it is probably still vulnerable to different interpretations.

The aforementioned discussions illustrate the boundaries and the extent of the contract capability to tackle disputes. It is the opinion of the authors that the significant sources of
disputes are the users of the contracts and not the contracts themselves. Nevertheless, there is no clear demarcation line between the shortcomings of the standard form of contract, and the pitfalls of people. To give one example, the issue of clarity may be attributed to the contract’s drafting or to the user’s lack of knowledge and experience to understand the contract. Such arguments are expected to go on and on.

Note

References


Further reading


Harmon, K. (2011), “To be or not to be – that is the question: is a DRB right for your project?”, Journal of Legal Affairs and Dispute Resolution in Engineering and Construction, Vol. 3 No. 1, pp. 10-16.


Appendix. Semi-structured interview template

This is a template to be used for each interview. It is only a template; not all of these questions will necessarily be asked, nor will they be phrased the same way or be asked in the same order or asked in every interview. Further questions may emerge during the conduct of the interviews.

Part 1: background of interviewees

(1) What is your position within the current organisation or project?

(2) How many years have you been working with construction contracts?

(3) What are the standard forms of contract you have used? Who does suggest its usage? Which one do you prefer and why?
Part 2: interviewee’s experience and opinion of FIDIC conditions of contract

(1) Do you have any experience of using FIDIC, for how many years, and on what types of projects?

(2) Were there any disputes, what caused them, and what were the used dispute resolution techniques, was you satisfied with these techniques and why?

(3) How would you describe the clarity, readability, understanding, interpretation, and certainty of meaning of FIDIC clauses? Can you give examples to support your answer?

(4) As Palestinians are non-native English speakers, do you think the use of English version (which is the original version used in litigation) is a challenge and reduces clarity and understanding that ultimately creates disputes? Do you think the usage of Arabic version is a solution? What options would you suggest to overcome this?

(5) Do you think the duality of the role of the engineer (being the client agent and at the same time independent third party to determine matters fairly between the client and contractor) is efficient or problematic and why? Do you prefer the engineer to be the adjudicator of the disputes between the client and contractor and why?

(6) In your opinion, would risk allocation clarity or fairness or both, be major causes to disputes? How?

(7) Do you think FIDIC adopts fair and clear risk sharing principles and why? Could you give examples?

(8) What do you think about the clarity and fairness of physical ground conditions and weather conditions risks allocation? Do you think words such as “foreseeable”, “experienced contractor”, and “exceptionally adverse climatic conditions” are certain in meaning and why? Could you propose ways to enhance the clarity and fairness?

(9) What do you think about the efficiency and effectiveness of dispute resolution mechanism adopted by FIDIC? Do you think the inclusion of Dispute Adjudication Board in this mechanism adds value to disputes avoidance, minimisation, amicable, quick, efficient and fair resolution? How and why? Could you give examples of the pros and cons of FIDIC’s approach?

(10) Do you think variations are a major source of disputes? Why? How FIDIC clauses cover this, is it clear what constitutes a variation, is it valued fairly, etc.? Do you suggest any improvement in the drafting of variation clauses?

(11) What do you think are the main causes of disputes between the employer and the contractor in the Palestinian construction industry, and can the contract be the tool to minimise their occurrence and/or impact? How?

(12) Do you think the clauses of FIDIC are appropriate (clear, comprehensive, fair, etc.) for the abnormal conditions in Palestine (e.g. borders closure, aggressions, fluctuations in construction material availability and prices, etc.) and why? If no, how can it be enhanced?

(13) What are the main problems and challenges facing you in managing contracts?

(14) Have you heard about the new engineering contract standard form of contract? If yes, how and what is your feedback with any experience in dealing with it?

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Understanding why Chinese contractors are not willing to purchase construction insurance

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Abstract

Purpose – Construction insurance has been advocated as a useful financial means to transfer risks and mitigate potential project losses. However, there is a general reluctance to purchase construction insurance in China. The purpose of this paper is to develop an extended theory of planned behavior (TPB) model to understand and predict contractors’ construction insurance purchasing intention.

Design/methodology/approach – Quantitative data were collected through a questionnaire survey. The respondents comprise 130 project directors/managers and contract managers/administrators who were involved in or familiar with the construction insurance purchasing or managing. Data were analyzed using structural equation modeling.

Findings – This study developed an extended TPB model to explain the contractors’ intention formation. The results indicated that the insurance purchasing intention was mainly influenced by attitudes and subjective norm, rather than perceived behavioral control. The analyses also revealed that the added variables (risk perception and past experience) had a significant impact on the attitudes and perceived behavioral control.

Originality/value – This study identified the factors leading to Chinese contractors’ low willingness to purchase construction insurance by extending the TPB model to the context of construction insurance purchasing. The extended TPB model may serve as a theoretical framework and basis for the Chinese contractors, insurers, and regulators to understand the root causes of contractors’ low willingness to purchase construction insurance and make joint efforts to address the risks and insurance in the construction industry.

Keywords Organization, Risk management, Construction, Questionnaire survey

Paper type Research paper

1. Introduction

Construction projects always confront substantial uncertainties and risks, such as national, legal, social, economic, manpower, and natural disasters, during project implementation (Ren and Yao, 2009). Construction industry turns to financial market for viable solutions to transfer risks. Purchase of construction insurance is considered as an effective way to transfer the risks and protect the project from major losses. Construction insurance may be the only feasible way of repaying project stakeholders and ensuring the project is back on track. The initiatives of risk transfer and insurance purchasing can help to reduce loss to an acceptable level and contribute to project success (Choy et al., 2006; Christian, 2003; Hussels et al., 2005; Petrolia et al., 2013).

However, construction insurance was not as effective as expected for some reasons in some developing countries, especially in China. Contractors, who are the primary stakeholder and main responsible insurance purchaser, usually purchase insurance just to meet the lowest requirements of relevant law and contracts, or even do not purchase any insurance to cover the risks in the context of Chinese construction industry (Liu et al., 2007). In addition, the construction projects may not be effectively protected by construction insurance without...
extensive knowledge about construction insurance and proper subsequent management, even if the contractors purchased enough insurance to cover project risks. Once major accidents occur, contractors may not get enough compensation from the insurer, which may lead to major economic loss or even project failure. As can be seen from Table I, the purchase of main insurance including construction all risks insurance and installation project all risks insurance only accounted for slightly over 30 percent in China, whilst in the developed countries, the insured rate was more than 90 percent (Li and Li, 2006). Low purchase rate of construction insurance has serious implications for China and many other developing countries. There is tremendous room for contractors to improve in transferring risks by construction insurance.

There is an increasing tendency of research on construction insurance. Most previous studies took the perspective of insurance marketing (Chen and Lu, 2014) or government mechanism (Guo et al., 2016; McAneney et al., 2016) to find out strategies to stimulate insurance development, which provides opportunities to understand contractors’ intention or behaviors of insurance purchasing (Lee and Back, 2005). However, little research has been conducted to develop theoretical models to explain why contractors are not willing to purchase construction insurance. This research was motivated by the need for a theoretical framework incorporating various aspects of insurance and construction contractors.

While it is hard to know contractors’ intention directly, it is generally believed that the intention formation process can be a clue to understand their intention to purchase construction insurance (Lam and Hsu, 2006; Han et al., 2010). Specifically, an investigation of the underlying volitional and non-volitional factors affecting intention may provide insights into their purchasing intention formation process (Ajzen and Fishbein, 1980). This study employed the extended theory of planned behavior (TPB) (Ajzen and Fishbein, 2004) to gain a better understanding of contractors’ intention on construction insurance purchasing. The objectives of this study are: to identify the factors influencing contractors’ intention of purchasing construction insurance based on the extended TPB; to investigate the interrelationships among these factors using confirmatory factor analysis (CFA); and to explain how these factors affect contractors’ willingness to purchase insurance.

This paper begins with extending the TPB based on the exact conditions of construction insurance by adding two domain-specific variables, i.e., risk perception and past experience. The paper then develops an initial insurance purchasing intention model based on the extended TPB. Structural equation modeling (SEM) was used to analyze the data collected from a questionnaire survey. Finally, major findings are discussed and further research directions are provided.

### 2. Literature review and conceptual framework

#### 2.1 TPB

The TPB, an extension model of the theory of reasoned action (Ajzen, 1985, 1991; Ajzen and Sheikh, 2013), is one of the most widely cited models for predicting behavioral intentions by
social psychologists (Collins and Carey, 2007; Fielding et al., 2008; Cheon et al., 2012; Leeuw et al., 2015). According to the TPB model, an individual’s performance of a specific behavior is determined by his/her behavioral intention to perform the behavior. This behavioral intention is in turn determined by three factors related to the behavior: the person’s attitude toward the behavior, subjective norm, and perceived behavioral control. In this study, TPB is used as the theoretical basis to understand contractors’ construction insurance intention formation.

2.1.1 Attitude. Attitude was defined as the degree of an individual’s positive or negative evaluation of behavior performance (Eagly and Chaiken, 1993). Based on the research of Taylor and Todd (1995), attitude has positive impacts on the intention toward behavior. In the context of construction insurance, contractors’ attitude is measured by two types of items: contractors’ attitudes toward purchasing insurance and contractors’ attitudes toward insurance products (Botzen and Van den Bergh, 2012).

2.1.2 Subjective norm. Subjective norm is a social factor, which means the social pressure from the environment felt by the person exerted to engage in the behavior (Ajzen and Driver, 1992). Many researchers have examined the relationship between subjective norm and intention and confirmed that subjective norm positively affects intention (Taylor and Todd, 1995; Tonglet et al., 2004; Hsieh, 2015). According to the context of insurance, the social pressure to purchase construction insurance is considered from the following five aspects: local laws and regulations; contract requirements; market guides; insurance market; and other similar projects (Sola, 2013; Lo, 2013; Brody et al., 2017).

2.1.3 Perceived behavioral control. The third determinant of intention is a non-volitional factor termed perceived behavioral control, which reflects a person’s perception of the ease or difficulty in performing a specific behavior (Ajzen and Fishbein, 1980). The greater ability a person can perform a specific behavior, the more likely such a behavior will be engaged in. The contractors’ ability regarding construction insurance mainly includes purchasing ability and claim ability (Wallach and Jasper, 2010). Based on the literature, the following hypotheses were proposed:

\[ H1. \text{ Attitude has a positive influence on purchasing intention.} \]
\[ H2. \text{ Perceived behavioral control has a positive influence on purchasing intention.} \]
\[ H3. \text{ Subjective norm has a positive influence on purchasing intention.} \]

2.2 Derivation of extended TPB model

Based on the research and development on TPB in the past few decades, researchers have attempted to modify the TPB model by altering paths and/or adding critical constructs to explain or predict people’s behavioral intentions in particular settings (Perugini and Bagozzi, 2001; Chen and Tung, 2014; Bagot et al., 2015; Kashif and Run, 2015). Ajzen (1991, 2015) stated that the modification of TPB should occur cautiously and need to meet the following two criteria: similar to existing predictors of the theory and the factors are conceptually independent of existing constructs of the theory. Although TPB has been successfully applied in various contexts, e.g., green hotel, online shopping, safe food (Han et al., 2010; Hsu et al., 2006; Phillip and Anita, 2010), it seems that no research has been conducted to apply the theory to construction insurance purchasing. The current study attempted to extend the TPB model by introducing constructs which are important in the construction insurance context (e.g., past experience and risk preference) and altering the path in the model to explain contractors’ purchasing intention of construction insurance.

2.2.1 Risk perception. Risk perception is the individuals’ subjective feeling and understanding toward the risks. Construction businesses are risky ventures. However, people often underestimate the risks (Chivers and Flores, 2002; Kunreuther and Pauly, 2006).
If contractors underestimate the risk probability or potential magnitude of loss in a project, insurance may be unattractive to them (Petrolia et al., 2013).

Researchers have found that risk perception tends to play an important role in predicting people’s purchasing decisions by significantly influencing their attitude toward the behavior (Petrolia et al., 2013; Zhao et al., 2016; Lobb et al., 2007). Stronger risk perception of contractors is always related to more positive attitude toward insurance purchasing. According to the context of insurance, this study mainly chooses two dimensions to measure risk perception, risk probability and risk influence (Botzen and Van den Bergh, 2012; Voon et al., 2015).

2.2.2 Past experience. Although past experience is not originally included in TPB, some researchers have identified the need to add this construct to enhanced the predictive power of the TPB (Perugini and Bagozzi, 2001, Ryu and Jang, 2006; Lee and Back, 2009; Wang et al., 2012). Lee and Back (2009) verified that past experience is an important determinant of attitude and perceived behavioral control. Han and Kim (2010) also found that past experience plays a significant role in decision-making processes. Studies in various fields (Lee and Back, 2009; Lo, 2013; Petrolia et al., 2013) have attempted to include this variable to enhance the predictive power of the TPB.

The contractors’ overall experience of insurance can be regarded as equivalent to a subjective evaluation of all past experience (Huang and Hsu, 2009). In this study, past experience includes the overall past construction insurance purchasing experience and the overall past claims experience. Based on the above literature support, it is therefore appropriate to incorporate past experience into a model designed to explain the formation of insurance purchasing intention in order to ensure a sounder theoretical underpinning. Thus, the following hypotheses were proposed:

- **H4.** Risk perception has a positive influence on attitude.
- **H5.** Past experience has a positive influence on attitude.
- **H6.** Past experience has a positive influence on perceived behavioral control.

In summary, the extended TPB model is presented in Figure 1. The model includes the original variables (attitude, subjective norm and perceived behavioral control) and new constructs (past experience and risk perception). The bold lines indicate the newly added paths to the original TPB model.

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**Figure 1.** Proposed extended TPB model for contractors’ purchase intention on construction insurance.
3. Methodology

3.1 Questionnaire design

Questionnaire survey was used to collect data for this study. The literature (Ajzen and Fishbein, 1980; Ajzen, 2015) shows that no standard questionnaire was available for TPB research. The design of the survey questionnaire involved two steps in this study. The first step was to develop the measurement scales for attitude, perceived behavioral control, subjective norm, risk perception, past experience and purchasing intention. This was done by conducting a comprehensive literature review and face-to-face interviews with personnel who were in charge of or very familiar with insurance purchasing. The second step involved a pilot survey to validate and improve the draft questionnaire in terms of wording, contents, format, and layout. Based on the feedback, revisions were made to improve the readability and accuracy of the questionnaire.

In the final questionnaire, the research aims and contact details were presented in the cover letter, followed by the questions about the profile of the respondents, including the types of job, work experience, education, and two screening questions (i.e., “How about your familiarity with construction insurance?” and “Have you ever taken part in construction insurance purchasing and insurance management?”). We used the original questionnaire items developed by Ajzen (1991) for TPB model and also quoted some items from Han et al. (2010). Based on the context of construction insurance, the measurement methods for each variable are shown in Table II. The questionnaire includes six constructs and 20 scale items: five items for attitude, five items for subjective norm, two items for perceived behavioral control, three items for past experience, two items for risk perception, and three items for purchasing intention. The respondents were asked to rate each item based on a completed project in which they have been involved using a five-point Likert scale (1 = the lowest level; 3 = medium level; and 5 = the highest level).

3.2 Sampling and procedure

The target respondents include project directors/managers and contract managers/administrators who were involved in or familiar with the construction insurance purchasing or management. Due to the vast number of construction contractors in China, it was impractical to conduct nationwide sampling in the whole population of construction contractors. In this regard, the sampling was limited to three typical cities in China including...
Beijing (the capital city of China), Shanghai (the largest city in China), and Tianjin (one of the four direct-controlled municipalities of China). The three cities were considered representative in the Chinese construction industry because 20 percent of the top 500 Chinese construction companies in 2016 were located in Beijing, Shanghai, and Tianjin (Chinese Construction Enterprises Management Association, 2016). Snowball sampling (also referred to as chain sampling, chain-referral sampling, or respondent-driven sampling) method was adopted by this study considering the notoriously low response rate and lack of reliable data with the random sampling approach (Zhai et al., 2014). Salganik and Heckathorn (2004) argued that unbiased estimations can be made from hidden populations using respondent-driven sampling and these estimates are asymptotically unbiased no matter how the initial informants are selected. The initial participants consist of 30 project managers and contract managers from different construction contractors in Beijing, Shanghai, and Tianjin; and they were selected through the professional networks of the researchers. The initial participants were then requested to recommend other potential participants who were: at similar levels; working for construction contractors in Beijing, Shanghai, and Tianjin; and involved in or familiar with the construction insurance purchasing or management. Finally, a total of 186 questionnaires were sent out and 167 completed questionnaires were returned. The returned questionnaires were checked by the two screening questions, and 130 questionnaires were retained, representing a pass rate of 69.9 percent. According to the requirements of TPB and statistical analysis, the sample size is considered sufficient.

The profile of the respondents is reported in Table III. The profile shows that around half of the respondents had over five years’ experiences in construction industry and around 90 percent of them were well educated (i.e. bachelor degree and above). Such extensive working experience and education level of respondents would ensure that they had proper knowledge and experience regarding construction industry and construction insurance.

3.3 Method of data analysis

SEM has been recognized as one of the most suitable techniques for analyzing the interrelationships among variables (Chen et al., 2011; Feng et al., 2017; Xiong et al., 2014). In SEM, observable variables can be directly measured, while latent variables are theoretical constructs inferred from observable variables. Additionally, SEM consists of measurement and structural models. SEM enables a maximally efficient fit between data and a structural model because both CFA and path analysis can be performed simultaneously in a single structural equation model (Lim et al., 2011). Furthermore, there are two types of SEM: covariance-based SEM (CB-SEM) and partial least squares structural equation modeling (PLS-SEM). PLS-SEM has some advantages over CB-SEM. For instance, PLS-SEM does not require a large sample size and normal distribution of data, and can estimate latent

<table>
<thead>
<tr>
<th>Category</th>
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<tr>
<td><strong>Work experience (years)</strong></td>
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<tr>
<td>Below 5</td>
<td>67</td>
<td>51.5</td>
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<td>5-10</td>
<td>49</td>
<td>37.7</td>
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<td>11-15</td>
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<td>7.7</td>
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<tr>
<td>16-20</td>
<td>4</td>
<td>3.1</td>
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<tr>
<td><strong>Education</strong></td>
<td></td>
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<tr>
<td>Beneath the bachelor degree</td>
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<td>9.2</td>
</tr>
<tr>
<td>Bachelor degree</td>
<td>93</td>
<td>71.5</td>
</tr>
<tr>
<td>Master degree or above</td>
<td>25</td>
<td>19.2</td>
</tr>
</tbody>
</table>

Table III. Profile of the respondents
constructs as linear combinations of observable variables through weight relations (Chin, 1998; Fornell and Bookstein, 1982; Hair et al., 2012). Thus, PLS-SEM has been widely adopted in construction studies in recent years (Doloi, 2014; Feng et al., 2017; Ning and Ling, 2013; Zhao et al., 2017).

CFA can test the relationship between the observable variables and their latent variable. In this study, the five TPB and extended TPB construct groupings were seen as the latent variables in the structural and measurement models. CFA was performed to test whether the data fitted the measurement model. Four types of reliability and validity of the measurement models should be assessed: internal consistency reliability; indicator reliability; convergent validity; and discriminating validity (Shan et al., 2015).

Composite reliability (CR) is used to assess the internal consistency reliability and its value should be at least 0.70 (Hair et al., 1998). Cronbach’s $\alpha$ coefficient should be above 0.70 (Patterson and Neailey, 2002), however, in social science research, it is also accepted that Cronbach’s $\alpha$ coefficient is above 0.60 (Moss, 1998). Loadings of observable variables on the corresponding latent variables are used to assess the indicator reliability. The indicators with loadings below 0.70 should only be removed if deleting this indicator leads to an increase in CR above the suggested threshold value (Hair et al., 2011). Nevertheless, the indicators with loadings below 0.70 could be retained because of their contributions to content validity (Hair et al., 2011). In most studies using PLS-SEM, the actual threshold value of loadings was 0.40 (Comrey, 1973; Matsunaga, 2010; Ning, 2014). The average variance extracted (AVE) is used to evaluate the convergent validity, and the threshold value is 0.50 (Fornell and Larcker, 1981). For adequate discriminant validity, the square root of the AVE of each latent construct should exceed the inter-construct correlation and a measurement item’s loading on its respective grouping should exceed the cross-loadings (Chin, 1998; Fornell and Larcker, 1981).

Then, the bootstrapping technique (Davison and Hinkley, 1997; Efron, 1987) was applied to estimate the significance of path coefficients and evaluate the structural model. In this study, the number of bootstrap samples was 5,000, as recommended by Hair et al. (2011), and the number of cases was equal to the number of responses (i.e. 130). The critical $t$-value for a two-tailed test was 1.65 (significance level $= 0.10$).

4. Results

4.1 Data quality testing

Tables IV and V show the evaluation results of the measurement model. As shown in Table IV, the observable variables obtained loadings ranging from 0.554 to 0.922, indicating the acceptable indicator reliability. All the CR and Cronbach’s $\alpha$ values were above their respective thresholds, suggesting a satisfactory level of internal consistency reliability. Furthermore, the AVE of each construct was higher than 0.50, showing an acceptable level of construct convergent validity. As can be seen in Table V, the square root of the AVE value of each group is higher than its correlation with any other construct. These results indicate the high discriminate validity of the groups. Thus, the measurement model was reliable and valid for the structural path modeling.

4.2 Hypotheses testing

The bootstrapping technique (Efron, 1987; Davison and Hinkley, 1997) was applied to estimate the significance of path coefficients and test the hypotheses. In this study, the number of bootstrap samples was 5,000, as recommended by Hair et al. (2011), and the number of cases was equal to the number of responses ($n = 130$). The results show that five out of the six path coefficients are positive and significant at the 0.10 level ($\alpha = 0.1$) (see Table VI and Figure 2). The results of hypotheses testing are discussed in the following section.
5. Discussion

5.1 Impacts of attitude, subjective norm, and perceived behavioral control on insurance purchasing intention

The results of hypotheses testing (see Table VI) indicate that attitude ($\beta = 0.192$, $t = 2.276$, $\alpha = 0.1$) and subjective norm ($\beta = 0.417$, $t = 5.173$, $\alpha = 0.1$) are positively and significantly
associated with insurance purchasing intention, supporting H1 and H3. These findings are consistent with previous studies (Ly et al., 2015; Borges and Lansink, 2016), implying that an increase in attitude and subjective norm may result in an increase in the likelihood of contractors’ insurance purchasing intention.

As predicted earlier in the context of construction insurance, subjective norm has a positive impact on contractors’ insurance purchasing intention. Unlike the purchasing of life insurance, where there are no laws or contracts forcing people to buy life insurance (Jacobs-Lawson et al., 2010), the insurance purchasing in the construction industry is largely required by laws and contracts. The owners usually specify the insurance requirements clearly in the contracts. In addition to laws and contracts, construction insurance purchasing is also subject to company rules and insurance marketing guide. To sum up, contractors’ decision on insurance purchasing is largely associated with the perceived social pressure from the environment.

Attitude also significantly influences contractors’ insurance purchasing intention, which is consistent with the previous studies (e.g. Fichten et al., 2016; Arshad et al., 2015). Contractors who believe in the value of construction insurance and the availability of high-quality insurance service and accept the idea of “prevention is better than cure” tend to be more willing to transfer the risks through the construction insurance.

The results show that perceived behavioral control was not a significant predictor of insurance purchasing intention ($\beta = 0.130$, $t = 1.439$, $\alpha = 0.1$). However, this finding is inconsistent with the findings of previous studies (Han et al., 2010; Hartmann and Apaolaza-Ibáñez, 2012). Perceived behavioral control reflects people’s perception of the ease or difficulty in performing a specific behavior (Han et al., 2010). Han et al. (2010) examined people’s intention to visit green hotels, where the perceived behavioral control was measured by whether people have time or money to do it. However, in the context of construction insurance, it requires professional skills to purchase insurance and transfer risks. It is a common practice for contractors to get assistance from insurance brokers and legal advisers (Sammon, 2002; Beloucif et al., 2004); and usually the insurers can recommend the combination of insurance products according to risk characteristics of projects. There is no required insurance purchasing ability for contractors, so perceived behavioral control did
not significantly influence intention. Thus, $H2$ was not supported in this context. Hence, insurance purchasing intention is mainly explained by attitude and subjective norm from the results of this study.

5.2 Impacts of risk perception and past experience on attitude and perceived behavioral control

The results (see Table VI) indicate that risk perception significantly influences contractors’ attitude toward insurance purchasing ($\beta = 0.147$, $t = 1.777$, $\alpha = 0.1$). These results are in line with previous studies in different settings (e.g. Lobb et al., 2007). Construction businesses are risky ventures. However, researchers have found that people’s behavioral decisions are associated with perceived rather than actual risks as people do not always have a clear understanding of the project risks, or the likelihood of various outcomes of the risks (Covell et al., 1991; Feng et al., 2014, 2015). If contractors underestimate the risk probability or potential of loss, they tend to develop a negative attitude toward construction insurance, which may appear unattractive under such situations.

In addition, $H5$ and $H6$ were tested. The results indicate that past experience is positively and significantly associated with attitude ($\beta = 0.557$, $t = 8.145$, $\alpha = 0.1$) and perceived behavioral control ($\beta = 0.504$, $t = 6.938$, $\alpha = 0.1$), thus supporting $H5$ and $H6$: This finding is consistent with the results of previous studies (e.g. Lee and Back, 2009; Lo, 2013; Petrolia et al., 2013). With pleasant past insurance experience, the contractors tend to improve their capacity of insurance purchasing and management and develop a positive attitude toward insurance purchasing in the future.

5.3 Implications of the findings

Some managerial implications can be inferred from the findings. The findings imply that the general reluctance of construction contractors to purchase construction insurance in China was caused by various factors. As discussed earlier, attitude is a key factor influencing the formation of contractors’ intention to purchase the construction insurance. It is therefore necessary that Chinese contractors change their mindset and accept the concept of proactive risk management and insurance. In addition, a supportive environment should be created for construction insurance purchasing. Compulsory requirements, laws and strict regulation are required for the purchase of construction insurance. Meanwhile, the insurers should endeavor to improve their service quality and technical competence. More attractive construction insurance products may be developed if the cooperation between the insurance industry and construction industry is strengthened and mutual understanding of the construction risks between contractors and insurers is developed. To sum up, various parties (including the contractors, insurers, and government) of construction projects need to work together and implement multi-dimensional strategies to improve the risk management of construction projects and achieve the healthy development of the construction insurance market in China.

5.4 Limitations of the research

Despite the achievements of this research, there are still some limitations. The first limitation concerns the generalizability of the findings. The findings were reached based on the data collected in China focusing on three major cities including Beijing, Shanghai, and Tianjin. Thus, the findings of this research should be interpreted in the context of the construction industry in China. Generalizations to other populations may be difficult. However, in the future, the methodology and modeling process of this research may be applied to investigate the insurance purchasing issues in other settings. The second limitation of this study lies in the choice of research approaches. The correlation/regression
research design was used by this research. This research design is effective in testing the associations between variables, but not effective in explaining the causal mechanism among variables. In a future study, qualitative data (e.g. observation, focus group discussion, and in-depth interview) may be collected and analyzed to further explain and validate the relationships among variables. Lastly, this empirical research takes the perspective of contractors and gives us an understanding of contractors’ insurance purchasing intention formation. Future research should further develop the proposed psychological constructs and take the insurers as a sample to examine their viewpoints of construction insurance. In addition, future studies could explain the insurance purchasing intention from other point of view. For example, contractors’ intention on insurance could be comprehended from the perspective of national culture.

6. Conclusions
This study explored why contractors are not willing to purchase construction insurance in China. The study developed an extended TPB model to explain the contractors’ purchasing intention formation. Specifically, the added constructs (i.e. risk perception and past experience) provide sufficient impetus for insurance purchasing decision-making process, improving our understanding of contractors’ intention formation. The key findings of this research include: subjective norm, which refers to social pressure from the environment (e.g. local laws and regulations, contract requirements, company policies, market guides and other similar projects’ actions) has a positive impact on the contractors’ willingness to purchase the construction insurance; contractors’ attitude toward insurance (e.g. value of insurance and quality of insurance service) has a positive impact on their willingness to purchase the construction insurance; and contractors’ attitude toward insurance is positively influenced by their risk perception and past insurance experience.

Theoretically, the research identified the factors leading to Chinese contractors’ low willingness to purchase construction insurance by extending the TPB model to the context of construction insurance purchasing. The extended TPB model may serve as a theoretical framework for the Chinese contractors, insurers, and regulators to understand the root causes of contractors’ low willingness to purchase construction insurance and make joint efforts to address the risks and insurance in the construction industry. Although empirical evidence of this study is from China, the methodology and framework derived from this study may be used for similar studies in other countries.

References


Further reading


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Abstract

Purpose – The purpose of this paper is to investigate the influence of priming on people’s risk perceptions and safety decisions in a virtual construction simulator.

Design/methodology/approach – Civil engineering students were recruited to interact with a virtual reality (VR) safety simulator. They were divided into four groups covering with and without sound and with and without priming factors. Data were collected on the risks that they perceived and the safety levels of their actions.

Findings – It was found that obvious stimuli in a virtual environment with sound help people to recognise more hazards near the location of the stimuli. Sound is helpful in training simulations to create high levels of presence. However, priming factors are not suitable to be added to VR simulators for training purposes. Priming of safe choice results in people taking fewer risks in the VR simulator, but this does not carry over into other situations. Compared to priming effects, being “injured” in a training simulator with sound improves trainees’ ability to make safe decisions.

Originality/value – VR simulation is helpful in construction training because of its unique ability to give trainees exposure to dangerous situations without physical risk. However, the overloading the working memory of users is detrimental to the outcomes. Therefore, the optimum level of complexity in VR simulators should be further studied.

Keywords Decision making, Construction management, Safety, Virtual reality, Training methods, Priming

Paper type Research paper

Introduction

Construction employers around the world have the obligation to provide adequate safety training to employees, involving instruction, live demonstrations and hands-on practice, etc. (Huang and Hinze, 2006; Menzel and Gutierrez, 2010; Stromme, 2011). The reason safety training is of great importance is that the construction industry has high fatality and injury rates, for example, in Australia the construction industry has the third highest fatality and injury rate (Safe Work Australia, 2015). This has led researchers to look for improved methods of training in order to reduce the number of accidents in construction work. Virtual reality (VR) simulation is one of the most advanced tools under development that can be used in construction safety training. VR simulators are already being used in many situations, for example, the US Air Force uses them for recruiting youth (Nafarrete, 2015). VR enables training to take place in an environment that does not exist in, or is not suitable to be created in, the real world due to safety or cost concerns. Many researchers focus on the study of achieving a high level of presence in a VR simulator (Sanchez-Vives and Slater, 2005; Price and Anderson, 2007; Lin et al., 2011). A high level of presence in a VR simulator means that the user experiences the virtual environment (VE) as if they were in the real world. Some researchers have also studied the practicability of applying VR simulators to safety training (Waly and Thabet, 2003; Van Wyk and De Villiers, 2009). Though a number of construction vehicle simulation games exist online, VR simulation has rarely been used in construction safety studies.

In this study, the influence of priming on people’s risk perception and safety decisions in a virtual construction simulator is investigated. Priming is the implicit memory effect that
previous stimuli have on the response to a subsequent stimulus (Gulan and Valerjev, 2010). It can occur in many circumstances. There are two types of priming that may affect people’s risk perception and safety decisions: conceptual priming and repetition priming. Conceptual priming occurs when an item with a similar form or meaning is primed (Nunez and Blake, 2003). In an experiment by Marsh et al. (1999), participants were divided into two groups. One group was given three pictures of hostile space creatures to watch for 30 seconds each, and another group was asked to sit for 90 seconds with no pictures. Both groups were asked to draw their own space creatures. The features of the creatures drawn by the first group are closer to the features of the given space creatures (fangs, spikes and weapons) than those drawn by the second group. Similarly, the actions of other people in a situation will affect how someone will respond in that situation. This particularly happens when the person is seeking social acceptance, or feels that another person has more expertise (Pendry and Carrick, 2001). Repetition priming occurs when a stimulus or a task is similar to what people have experienced previously (Schacter and Addis, 2007). When a similar situation is experienced or a similar stimulus repeatedly appears, people can respond faster and make more accurate responses (Allenmark et al., 2015). For example, in a two-phase experiment by Ellis et al. (1990) on face processing, the participants were first primed by 12 famous people (four politicians, four actors and four sportsmen) and their faces when rating their familiarities with these faces, and then were asked to identify the role (politician/actor/sportsman) of 24 given faces including the 12 faces in phase 1. The participants responded more accurate and faster on the 12 repeated faces than the other 12 new faces.

Previous research has suggested that sound and priming factors may interact to influence users’ level of presence in a VE (Lu and Davis, 2016). Thus in this study, both sound and priming are considered as independent variables. There are two types of sounds in this study: background sound and priming sound.

Literature review
The construction industry is one of the industries with the highest fatality and injury rates in many countries, such as the USA (Abudayyeh et al., 2006), the UK (Cameron and Duff, 2007) and China (Choudhry et al., 2009; Cheng et al., 2012). Abdelhamid and Everett (2000) consider accidents to arise from either unsafe conditions or unsafe acts and hence identified three root causes of construction accidents: failing to identify hazards before starting the work; working despite hazards being present; and acting unsafely. These reasons can be summarised into risk perception and safety decision. The ability to identify safety risks and make safe decisions can be upgraded by safety training. Research has suggested that construction workers’ safety performance is highly related to how they are trained (Sawacha et al., 1999). Carrying out safety training is helpful in changing the safety culture among workers, and subsequently changes workers’ safety attitudes (Harvey et al., 2001). Therefore, adequate health and safety training can effectively reduce the injury rate in a construction project.

VR simulation is attracting research as an emerging training tool. A VE is a collection of 3D geometric entities rendered in real-time by computer, which provides the users an opportunity to interact with the environment. Simulation is the imitation of a real-world process or system over time (Banks et al., 2000). Thus, a VR simulation can be defined as the imitation of a real-world process or system in a VE. It has been considered as a more realistic and interesting tool than traditional training methods, and thus highly demanded by trainees. Past studies have evaluated the effectiveness of applying VR in construction education. Sacks et al. (2013) examined the training value of VR in conventional safety training, and found that training with VR is more effective, and the duration of participants’ concentration is longer than traditional safety training. The advantage of applying VR simulation in construction training is that when the
trainees make improper decisions, they can experience the consequences without being exposed to any real danger (Filigenzi et al., 2000). On the other hand, the problem of VE simulation is that trainees may not take the consequences as seriously in the virtual world as in the real world, because they do not physically get injured. Therefore, a main focus of VR simulation technology has been on enhancing trainees’ sense of presence in the VE.

Witmer and Singer (1998) pointed out that involvement and immersion are the two main interdependent characteristics of presence. Furthermore, four contributing factors (control factors, sensory factors, distraction factors and realism factors) influence presence (Witmer and Singer, 1998). Psychologists and neuroscientists have also linked presence to brain and body responses, such as cognition (Sanchez-Vives and Slater, 2005). Attention is an important aspect related to how people perceive information in the VE and in the real world. Darken et al. (1999) suggested that attention may be a reasonable quantitative measure of presence. Different levels of attention lead to different levels of involvement and immersion. Attention is a cognitive process of selection and selective processing (Wood et al., 2006). Meanwhile, when people are exposed to a VE, their attention has been found to be highly correlated with how they have been primed (Dinh et al., 1999). Research has found that people can observe more objects in a VE when they have been primed by related information, and their memory about the objects in the VE lasts longer after priming (Dinh et al., 1999). This finding supports the conclusion by Wood et al. (2006) that attention is a top-down, cognitively driven process. Research also shows that strong stimuli can capture people’s visual attention, and people can observe more objects in a high fidelity VE (Nunez and Blake, 2003). Nunez (2004) proposed a constructionist cognitive model that describes the construction and reconstruction of cognitive processes considering the information flow between working memory and long-term memory. Thus, the addition of different stimuli (related or unrelated to people’s expectation of the VE) result in paying attention to different things.

Previous research also suggests that priming is a mediator variable for presence (Nunez and Blake, 2003). This means that priming will increase the effects of other variables on presence, compared to their effect without the priming present. Thus, if the designers make good use of stimuli in a VE, priming can reinforce the effects of these stimuli on people’s sense of presence.

In a study conducted by Nunez and Blake (2003) of the effect that conceptual priming has on presence, subjects were split into two groups that were initially given passages to read that were either related or unrelated to a subsequent VE that they experienced. Each group was then further divided into two groups, one of which would experience a high fidelity VE, while the other experienced a low fidelity VE. The difference in presence reported by the people experiencing the different levels of fidelity was affected by the initial level of priming. Orgs et al. (2006) designed an experiment considering both environmental sound and words as priming factors, where they found that the subjects reacted faster when an environmental sound was followed by a related word appearing on a screen than vice versa. Thus sound may function as a priming factor similar to the conceptual priming of Nunez and Blake (2003). Lu and Davis (2016) found that participants have higher safety performance when background sounds and animations of other construction workers are either both present or both not present in the VE. These animated workers act as a conceptual priming factor, which helps the participants to behave safely. Thus, it is important to understand the interaction between sound and priming. This study aims to examine the potential interaction between sound and priming, and their influence on people’s safety decisions in a virtual construction simulator. Figure 1 presents a hypothesised model for these interactions. It is based on (Figure 1) Lu and Davis (2016) with the addition of the two types of priming.
Hypotheses

Based on the literature review, the hypotheses proposed in this study are:

**H1.** Obvious stimuli in a VE with sound lead to people recognising more hazards.

**H2.** Priming of safe choices results in people taking fewer risks in a VR simulator.

**H3.** The priming effect is persistent to a different environment.

Methods

One of the safety problems on construction sites is workers deciding to cut corners in order to finish their tasks more quickly. Thus, the scenarios in this study have been designed to examine this behaviour.

**Test environment**

Considering experimental bias may occur in a single environment, two virtual 3D environments with different features were created to investigate people’s safety decisions in this study. The basic activity of the experimental subject in both environments is to move bricks using a wheelbarrow from one location to another, where they have to choose between a hazardous shortcut and a safe route. The first environment includes a safety hazard on the ground, and the second environment includes a safety hazard in the air. Each of the environments has four types of settings: with sound and with priming factors, with sound and without priming factors, without sound and with priming factors, without sound and without priming factors. The environments with sound are considered as having higher fidelity. As verbal sound has been studied as a conceptual priming factor (Orgs et al., 2006), the warning sound in this study was considered to be a priming factor, whereas background sounds were categorised as sound factors. The verbal sound and visual priming factors are all based on the concept of “safety”. If this conceptual priming successfully influenced the participants’ safety behaviours, they should choose the safe route when walking in the construction sites. In this study, when a subject repeats a task in a second virtual construction simulator, the previous experience in the first virtual construction simulator is the repetition priming factor.

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**Figure 1.**

Model of how priming influences user safety decisions in a construction VR simulator

*Source: Lu and Davis (2016)*
The first virtual environment (VE1). VE1 is a simulation of a construction site with an excavation dividing the site. The excavation is filled with water and a pump is pumping out the water. An electronic depth gauge has been placed in the water with its cable supported by a plank across the excavation and connected to a laptop. There was a virtual researcher analysing the data on the laptop. In the east end of the construction lab, two bridges with handrails have been placed to allow people to cross the excavation safely, as shown in Figure 2.

A number of priming factors were added to this environment. A red warning safety net was installed around the excavation. Warning boards were hung from the safety net. The safety net at both sides of the plank was cut and dropped on the ground. A danger sign was placed on the broken fence so that it would be clearly visible. This was designed to make it clear that the plank was not meant to be used as a normal thoroughfare. In addition, virtual workers were added to the VE pushing wheelbarrows along the longer safe route. This is a hint that the avatar controlled by the participant should also walk on the safe route. When an avatar steps on the plank, the nearest virtual researcher turns around and flashes his palm to show he wants the avatar to stop walking. At the same time the virtual researcher shouts “Stop! Watch out!” to the avatar. These priming factors added in VE1 are marked as in Figure 3.

In the environment without priming factors, the excavation was left unattended. No barriers or safety net around the excavation, and no workers working in the construction lab except for the researcher. When an avatar steps on the plank, the researcher does not warn to stop.

The sound factors added to VE1 included: the creaking sound of the thin plank when the avatar walks on it; the avatar’s footsteps; the sound that the sand makes as wheel of the wheelbarrow rolls over it; other construction workers talking in the background; the researcher warning the avatar when the avatar was attempting to walk on the thin plank; other construction workers digging with a spade; the engine and sound of water running when the water pump was working; a truck’s engine in the background; a steel saw working in the background; a hammer knocking on steel in the background.

The second virtual environment (VE2). VE2 was a simulation of a construction site, which is enclosed by temporary walls. The construction site mainly consists of a building area, a storage area and some construction accesses. As shown in Figure 4, two virtual
workers were standing at one entrance of the storage area, helping tie a universal beam to the hook of a crane and directing the crane to lift the universal beam to the building area. Thus it is unsafe to walk under the universal beam. These two workers were always looking towards the steel being lifted.

In the environment with priming factors, safe work and first aid notices were “painted” on the enclosures of the construction site. There were fences around the storage area and near each side of the truck. However, the fences that intended to block the path near the truck crane looked like they had been moved by someone so an unsafe shortcut had been created. Additional virtual workers pushed their wheelbarrows containing sand around the storage area, which provides a safe path, but much longer than the shortcut. When the
avatar controlled by the participant walks through the unsafe shortcut, the workers standing by would shout “Stop! Watch out!” at the avatar. The priming factors added in VE2 are marked as in Figure 5.

In the environment without priming factors, there are no safe work or first aid notices on the enclosures, or fences, no virtual workers walking on the safe route, and no warnings from the other two workers. The two virtual workers assisting the crane are still present, but they do not react to the avatar.

The sound factors added to VE2 included: the creaking sound of crane rope when it was lifting a steel bar; the avatar’s footstep; the wheel of the wheelbarrow rolling on the ground; other construction workers talking in the background; the truck’s engine; the worker near the truck warning the avatar when the avatar was attempting to walk on the unsafe route; the creaking sound of a plank in the background; an excavator working in the background; other construction workers digging with a spade in the background; the engine and sound of a water pump working in the background; a steel saw working in the background; a hammer knocking on steel in the background.

Interface and layout. The VR simulator interfaced with keyboard and mouse. The keys were same as the standard keys used in first-person computer games (W forwards, A and D left and right, S backwards). The TAB key was used to toggle between holding the wheelbarrow and not holding it, so that bricks could be loaded and unloaded. The participants could use the mouse to control the avatar’s viewpoint and its direction of forward movement. There was a cursor (“+”) at the centre of the avatar’s viewpoint. A brick could be picked up, moved and released by clicking, dragging and releasing the mouse when the cursor was hovering over the brick. The “1” key functioned as restart, so that when the participants made mistakes and “broke” the wheelbarrow they could have a new wheelbarrow to continue their simulation. Figure 6 shows a player view of VE1.

Sampling procedure
Postgraduates and final-year undergraduates studying civil engineering in a university in Australia were invited to participate in the study through the school’s e-mail list. The students invited all have at least three years’ full-time study and general knowledge of
the construction industry. The recruiting e-mail contained the information of the aim, payment, content, location and health concerns (such as motion sickness), as well as the criteria of selecting participants and the investigator’s information. There was also a pre-experiment questionnaire in the e-mail. Each participant received an AU$20 guaranteed payment, and potentially an extra $10 in bonus payments. Questions included in the pre-experiment questionnaire are: gender, age, construction work experience, first-person computer game frequency (hours per week), and first-person computer game experience (months/years). These questions were used for randomizing the subjects into different groups. The reason for asking the participants both of their first-person computer game frequency and experience was because there might be some participants who had given up playing first-person computer games, and hence have a game frequency of 0, but actually have many years’ game experience.

Over a five-week period 72 students expressed interest in participation. In total, 51 of these students became experimental subjects.

Based on the sample results, significant differences were found between the two situations: both sound and priming were present or neither of them was present, and only sound or only priming was present. Therefore, to calculate the required sample size between these two situations, using the sample size calculation equation for binomial distribution given by Van Belle (2011):

$$n = \frac{16\pi(1-\pi)}{(\pi_0-\pi_1)^2}$$  \hspace{1cm} (1)

In Equation (1), $\pi = (\pi_0 + \pi_1)/2$, where $\pi_0$ and $\pi_1$ are the probability of success in each proportion. This equation is based on a level of significance of 0.05 and a power of 0.8.

According to this equation, the required sample size is 47. Thus, a sample size of 51 is sufficient.

Test procedure

The experiment for each participant consisted of four parts: an introductory video, a two-minute trial, two virtual tests and a survey.
First, the participants were required to read and sign a consent form and watch a three-minute introductory video prior to their tests. The participants were told that the aim of this study was to test the wheelbarrow simulation and to investigate the essential factors for a VR simulator, i.e. they were not told that the experiment was actually about safety. This deception was used to reduce the Hawthorne effect (Wickström and Bendix, 2000). The video introduced the basic information and requirements of the experiment, as well as the user interface. The VE in the introductory video is a simplified environment. It consisted of a plane which represented the ground, a wheelbarrow, several virtual bricks and a target area.

After watching the introductory video, each participant was given two minutes to complete the whole process of moving the bricks by manipulating a virtual trial. The process involved: walk towards the back of the wheelbarrow, "hold" the wheelbarrow, push the wheelbarrow to the brick pile, release the wheelbarrow, load the wheelbarrow with several bricks, "hold" the wheelbarrow again, push the wheelbarrow to the target area and unload the wheelbarrow. The VE in this trial was also the same simplified environment as used in the introductory video.

The third part included two tests on the computer in different virtual construction environments. The participants were assigned to different groups, thus, the order of VE and elements of the virtual tests were different (Table I).

As shown in Table I, Groups A1, A2, C1 and C2 had sound in their VR simulator, and the other four groups did not have sound in their VR simulator. Groups A1, A2, B1 and B2 had priming factors in their VR simulator, and the other four groups did not have priming factors in their VR simulator. Participants in Groups A1, B1, C1 and D1 experienced VE1 before VE2, and the other four groups experienced VE2 before VE1. No matter which group the participants were in, all of them have their second test without priming factors. The aim of this was to investigate whether the prior experience of priming will influence the participants’ safety behaviours in the subsequent environment without any priming factors.

The task for the participants was to move 60 bricks from the brick pile to the destination point without dropping any bricks in each environment. Both tests have a time limit of 20 minutes. If they made any mistake that broke the bricks, the time limit would be reduced as a penalty. The length of time deducted depended on the severity of the “injury” or “loss”.

Table II illustrates the circumstances and the length of time being deducted.

A monetary reward was given to the participants based on how long they took to complete the tests. If the participants finished one virtual task in less than 12 minutes, they would receive an extra AU$5 reward. Thus, if they finished both basks in 12 minutes, they would receive a total of AU$30 (including the guaranteed payment of AU$20).

<table>
<thead>
<tr>
<th>With priming</th>
<th>Without priming</th>
</tr>
</thead>
<tbody>
<tr>
<td>VE1 → VE2</td>
<td>VE2 → VE1</td>
</tr>
<tr>
<td>A1 (n = 7)</td>
<td>A2 (n = 7)</td>
</tr>
<tr>
<td>B1 (n = 6)</td>
<td>B2 (n = 6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Virtual test grouping</th>
<th>VE1</th>
<th>VE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>With Sound (70 dB)</td>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td>Without Sound</td>
<td>B1</td>
<td>B2</td>
</tr>
</tbody>
</table>

**Table I.** Virtual test grouping

<table>
<thead>
<tr>
<th>Circumstances</th>
<th>Length of time deducted</th>
</tr>
</thead>
<tbody>
<tr>
<td>VE1</td>
<td>VE2</td>
</tr>
<tr>
<td>The avatar or the wheelbarrow fell into the excavation</td>
<td>The avatar was hit by the steel lifted by the crane</td>
</tr>
<tr>
<td>The participant overturned or overloaded the wheelbarrow</td>
<td></td>
</tr>
</tbody>
</table>

**Table II.** Time deduction
After the experiment the participants were debriefed about the real aim of the study. After they were fully informed about the experiment, they then filled a questionnaire in accordance with their virtual tests.

Subject grouping
A total of 51 students were randomly assigned to eight groups according to their answers to the pre-experiment questionnaire, as shown in Table I. The factors in the pre-experiment questionnaire are considered to be confounding factors that are best controlled by assigning the participants randomly. Participants’ age and gender are the two main concerns when grouping. Table III shows the basic information of each group.

Analysis method
The variable of interest in this study is priming factors. As sound has been found to have an interaction effect with some priming factors, the results distinguished those with sound and those without sound.

Results were analysed using the between-subjects method (Birnbaum, 1999). This is because it is expected that the participants’ behaviour in the second test would be significantly altered by their experience from the first test, in particular the knowledge that the simulation might contain hazards. Thus, the data drawn from any second test could not be compared with people’s behaviour the first time they use the simulator, except when explicitly testing for learning effects. As each group contained two subgroups that had the same settings but different VEs, both the overall results (VE1+VE2) and the results of each individual VE were analysed. Table IV represents how the groups were compared in the result analysis and the methods used.

The method of testing hypotheses on the equality of two binomial proportions (two-tailed) was applied to analyse the relationship between priming factors and people’s cognition, especially whether they noticed the safe route far away from their starting point or not (Montgomery et al., 2009; Walpole, 1974).

<table>
<thead>
<tr>
<th>Information</th>
<th>With sound</th>
<th>Without sound</th>
<th>Without sound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>14</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Average age (years)</td>
<td>24.4</td>
<td>25.4</td>
<td>23.7</td>
</tr>
<tr>
<td>Percentage of females (%)</td>
<td>14.3</td>
<td>16.7</td>
<td>23.1</td>
</tr>
<tr>
<td>Work experience (months)</td>
<td>14.0</td>
<td>6.88</td>
<td>4.27</td>
</tr>
<tr>
<td>Game frequency (hours/week)</td>
<td>4.00</td>
<td>2.63</td>
<td>4.31</td>
</tr>
<tr>
<td>Game experience (years)</td>
<td>3.47</td>
<td>3.09</td>
<td>2.28</td>
</tr>
</tbody>
</table>

Table III. Subject information in different groups

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>A1(VE1)+A2(VE2)</td>
<td>C1(VE1)+C2(VE2)</td>
</tr>
<tr>
<td></td>
<td>B1(VE1)+B2(VE2)</td>
<td>D1(VE1)+D2(VE2)</td>
</tr>
<tr>
<td>H2</td>
<td>A1(VE1)+A2(VE2)</td>
<td>C1(VE1)+C2(VE2)</td>
</tr>
<tr>
<td></td>
<td>B1(VE1)+B2(VE2)</td>
<td>D1(VE1)+D2(VE2)</td>
</tr>
<tr>
<td>H3</td>
<td>A1(VE2)+A2(VE1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B1(VE2)+B2(VE1)</td>
<td>D2(VE2)+D1(VE1)</td>
</tr>
<tr>
<td></td>
<td>C1(VE2)+C2(VE1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>D1(VE2)+D2(VE1)</td>
<td></td>
</tr>
</tbody>
</table>

Table IV. Analysis groups and methods
According to Walpole (1974), to test the difference between two proportions should test the null hypothesis $H_0$: $p_1 = p_2 = p$, where $p_1$ and $p_2$ are the two population proportions of the attribute under investigation:

$$p_1 = \frac{x_1}{n_1}, \text{ and } p_2 = \frac{x_2}{n_2}$$  \hspace{1cm} (2)

where $x_1$ and $x_2$ are the number of successes in each of the two samples. Therefore, the value of the standard normal variable $Z$ when $H_0$ is true is:

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{pq\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$  \hspace{1cm} (3)

where $\hat{p}_1$ and $\hat{p}_2$ are the proportion of success, $n_1$ and $n_2$ are the selected independent samples’ sizes. To estimate the value of $p$ in Equation (2), pool the data from both samples:

$$\hat{p} = \frac{x_1 + x_2}{n_1 + n_2}$$  \hspace{1cm} (4)

Thus:

$$z = \frac{\hat{p}_1 - \hat{p}_2}{\sqrt{\hat{\sigma} q\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$  \hspace{1cm} (5)

where $\hat{\sigma} = 1 - \hat{p}$.

Reject $H_0$ if $z$ falls in the critical region, which is $Z > 1.96$ and $Z < -1.96$ when $\alpha = 0.05$, otherwise accept $H_0$.

As some of the results in this study are not significant, it is essential to calculate the power of the results. According to Chow et al. (2007), the power considering the hypotheses:

$$H_0: p_A = p_B$$

$$H_1: p_A \neq p_B$$

when testing the binomial proportions $A$ (with probability $p_A$ and sample size $n_A$) and $B$ (with probability $p_B$ and sample size $n_B$) is:

$$1 - \beta = \Phi\left(z - z_{1-\alpha}\right) + \Phi\left(-z - z_{1-\alpha}\right), \quad z = \frac{p_A - p_B}{\sqrt{(p_A(1-p_A))/n_A + (p_B(1-p_B))/n_B}}$$  \hspace{1cm} (6)

where $\Phi$ is the standard Normal distribution function, $\alpha$ is Type I error, and $\beta$ is Type II error.

**Results**

**Cognition and risk perception**

As expected in $H1$, a higher percentage of participants in the environment without priming factors reported that they did not notice the safe route in the environment with sound. Table V shows the percentage of participants who saw the safe route in each group.

In Table V, the second columns of $p$-value and power are the calculation for the two situations mentioned in the sampling procedure section, that is, either sound or priming vs both or neither. The individual tests are not conclusive for either rejecting the null hypothesis ($p$-value > 0.05) or the alternative hypothesis (power < 0.8). This indicates that
larger sample sizes are required to give the experiments more power so that one of these hypotheses can be rejected conclusively. However, it is noted that priming seems to increase the likelihood that participants will see the safe route when sound is present, but decrease it when the sound is absent. Testing this hypothesis yields a $p$-value of 0.036 despite having a power of only 0.583. Thus, we can accept that there is an interaction between sound and priming on the effect of influencing people’s cognition in the VEs.

As shown in Table V, although differences occurred in different environments, it could be concluded that people are more likely to notice details regarding the environment when sound and priming factors are both present. When either sound or priming factors were missing from the environment, a higher proportion of participants did not notice the safe route. However, these effects are not additive. In fact, in VE1 the subjects without either priming or sound all noticed the safe route.

In terms of risk perception, the particular risks that the participants were expected to identify under the influence of the priming factors are: the thin plank in VE1 may break if overloaded; the steel lifted by the crane in VE2 may drop and hit people walking under it.

From Table VI, more people identified the risks in the environments with both sound and priming factors on the whole. However, when analysing the two environments separately, differences were revealed. In line with the results in a previous study, in the first environment, more people identified the related risk when sound and priming factors were either both present or both not. On the other hand, in the second environment, the results turned out to be the opposite. More people identified the related risk when either only sound or only priming factors was added to the environment. It appears that this difference is strongly related to the location of the risk. People are not used to looking up. It is, therefore,
recommended that separate studies are performed to investigate the effect that the location of the risk has on the ability of people to notice it. Since the $p$-value for the first environment where the risk is not in an unusual location is significant it seems reasonable to accept that under normal circumstances sound moderates priming.

**Safety decision**

The ultimate goal of employing a virtual construction simulator in safety training is to train people to make safe decisions. Thus, it is essential to test the effect on people's safety decisions in order to decide whether priming factors should be added to a virtual construction simulator. In this study, the particular safety decisions investigated was which route the participants chose to use for their tasks in the construction environment. Table VII presents the percentage of the participants who used the unsafe route. The reasons they use the unsafe route may include: not recognising the related hazards, or deciding to act unsafely to get the job done faster.

It can be seen from Table VII that 47 out of 51 people used the unsafe route at some stage. The fact that so many people used the unsafe route shows that the experiment met the goal of making the unsafe route an easy default for people to follow. Only 4 out of the 51 participants did not use the unsafe route at any stage in their first VE. For two of these people it was VE1 and for the other two it was VE2. Both of the participants that never used the unsafe route in VE1 had sound and priming factors. For the corresponding participants in VE2 one of them had both sound and priming factors, and the other had neither. Thus having both sound and priming factors present appears to give the highest probability of ideal behaviour.

Some participants always used one route all the other, while others used both at different times. The percentage of participants who used the safe route at any stage is shown in Table VIII. The reason they used the safe route may because: they noticed the related hazards and decided to act safely, or the virtual workers primed their behaviour and so they followed the safe route without considering any other route.

It can be seen from Table VIII that more people decided to use the safe route when sound and presence were either both present or both absent. Overall, more people chose the safe route in VE2 than in VE1. However, both of the two environments show the same trend in terms of their decision on whether to use the safe route. The primary result of this is that priming is only useful when there is sound present. Without sound the priming seems to have a negative impact. It is conjectured that the addition of sound “normalises” the VE to create a higher level of presence in such a way that the participants are free to notice the priming. Therefore, they trust the priming cues. In the case where there is no sound, the priming does not seem to be noticed by the participants. Perhaps when there is no sound,

<table>
<thead>
<tr>
<th>Overall</th>
<th>With priming</th>
<th>Without priming</th>
<th>$p$-value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>With sound</td>
<td>78.6% (n = 14)</td>
<td>100% (n = 13)</td>
<td>0.076</td>
<td>0.498</td>
</tr>
<tr>
<td>Without sound</td>
<td>100% (n = 12)</td>
<td>91.7% (n = 12)</td>
<td>0.308</td>
<td>0.181</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VE1</th>
<th>With priming</th>
<th>Without priming</th>
<th>$p$-value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>With sound</td>
<td>71.4% (n = 7)</td>
<td>100% (n = 7)</td>
<td>0.126</td>
<td>0.389</td>
</tr>
<tr>
<td>Without sound</td>
<td>100% (n = 6)</td>
<td>100% (n = 6)</td>
<td>–</td>
<td>0.050</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VE2</th>
<th>With priming</th>
<th>Without priming</th>
<th>$p$-value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>With sound</td>
<td>85.7% (n = 7)</td>
<td>100% (n = 6)</td>
<td>0.336</td>
<td>0.192</td>
</tr>
<tr>
<td>Without sound</td>
<td>100% (n = 6)</td>
<td>83.3% (n = 6)</td>
<td>0.296</td>
<td>0.196</td>
</tr>
</tbody>
</table>

Table VII. Percentage of participants who used the unsafe route at any stage.
the participants can easily focus on their task when there are fewer stimuli “distracting” them even though their sense of presence is low. On the whole, absence of sound results in less safe behaviour than absence of priming.

To further study whether sound influences the priming effects in the VE, it is important to analyse the proportion of participants who revealed the behaviour of being primed. The students who used the unsafe route initially may change their mind in two circumstances: the first one is that their behaviour was influenced by the priming factors; the second one is that their initial behaviour caused injury so they have to change their decision. Table IX is the analysis of the proportion of participants who were primed in the VE.

As shown in Table IX, the proportion of participants who used the safe route without or before being injured in the group with both sound and priming factors is significantly larger than the other three groups. In the group with priming factors but without sound, the proportion of participants who used the safe route without or before being injured does not vary much from the groups without priming factors. Thus, it can be concluded that the priming effect on the participants’ safety decisions is greater when sound is present.

**Training effectiveness**

In reality, not all unsafe behaviours cause injuries every time. That is the reason why people would take a chance on the unsafe behaviours. In this study, the “lucky” situations included: in VE1, when the load on the plank was under its limit (i.e. the wheelbarrow was empty or contained less than 14 bricks); in VE2, when the steel lifted by the crane was not hanging above the unsafe road. In VE2, when the avatar walks on the unsafe route, the crane starts moving and stops when the beam is lifted above the unsafe route. Thus, the next time when they walk under the beam, they would be hit. However, if they see the beam and decide to take the safe route, after they unload the wheelbarrow at the target area, the crane would keep moving and finish moving the beam. Moreover, identifying the risk did not necessarily lead to the safest decision. For example, in VE2, some students noticed that the route near the crane was unsafe and so chose to speed up when walking under the lifted beam.

<table>
<thead>
<tr>
<th>Group</th>
<th>With priming</th>
<th>Without priming</th>
<th>( p )-value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall With sound</td>
<td>71.4% (n = 14)</td>
<td>46.2% (n = 13)</td>
<td>0.182</td>
<td>0.070</td>
</tr>
<tr>
<td>Without sound</td>
<td>33.3% (n = 12)</td>
<td>58.3% (n = 12)</td>
<td>0.218</td>
<td>0.247</td>
</tr>
<tr>
<td>VE1 With sound</td>
<td>42.9% (n = 7)</td>
<td>28.6% (n = 7)</td>
<td>0.576</td>
<td>0.396</td>
</tr>
<tr>
<td>Without sound</td>
<td>16.7% (n = 6)</td>
<td>33.3% (n = 6)</td>
<td>0.504</td>
<td>0.104</td>
</tr>
<tr>
<td>VE2 With sound</td>
<td>100% (n = 7)</td>
<td>66.7% (n = 6)</td>
<td>0.098</td>
<td>0.046</td>
</tr>
<tr>
<td>Without sound</td>
<td>50.0% (n = 6)</td>
<td>83.3% (n = 6)</td>
<td>0.220</td>
<td>0.259</td>
</tr>
</tbody>
</table>

| Table VIII. Percentage of participants who used the safe route |
|---------------|-----------------|---------------|-------|
| Overall With sound | 71.4% (n = 14) | 46.2% (n = 13) | 0.182 | 0.070 | 0.280 | 0.712 |
| Without sound | 33.3% (n = 12) | 58.3% (n = 12) | 0.218 | 0.247 |
| VE1 With sound | 42.9% (n = 7) | 28.6% (n = 7) | 0.576 | 0.396 | 0.088 | 0.139 |
| Without sound | 16.7% (n = 6) | 33.3% (n = 6) | 0.504 | 0.104 |
| VE2 With sound | 100% (n = 7) | 66.7% (n = 6) | 0.098 | 0.046 | 0.411 | 0.565 |
| Without sound | 50.0% (n = 6) | 83.3% (n = 6) | 0.220 | 0.259 |

| Table IX. Proportion of participants who used the safe route without or before being injured |
|-----------------|---------------|-------|
| Group | With priming | Without priming |
| percentage | With sound | Without sound | With sound | Without sound |
| overall | 50% (n = 14) | 16.7% (n = 12) | 15.4% (n = 13) | 8.3% (n = 12) |
| \( p \)-value compared to with both priming and sound | 0.074 | 0.056 | 0.026 |
| Power | 0.494 | 0.546 | 0.765 |
To investigate the priming effect on training effectiveness of the virtual construction simulator, the percentage of uninjured participants in each group was analysed (Table X). As described above, each participant took two tests, one in each environment. Different priming and sound settings were used for different groups in the first test. However, all second tests had the same settings: without sound and without priming factors. In the group that had their first test without sound and without priming factors, the percentage of the uninjured participants was 25% ($n = 12$).

Table X shows that there is no strong relationship between priming in the first test, being injured in the first test, or being injured in the second test. This would indicate that the priming effect only lasts for a short time and is not suitable to be added to a VE for training purpose. However, the powers for each of these tests are all less than 0.8, so a larger sample is required.

The same method is used to analyse sound effects on the virtual construction simulator’s training effectiveness (Table XI).

Table XI shows that having sound in the first test has a strong influence on the injury rate in the second test, if the subject was injured in the first test. If the subject was not injured in the first test, then it has no effect. Thus, previous injuries moderate the sound effect on training effectiveness. If the trainees experience injuries in a VE with sound, they will learn from the experience and behave more safely.

**Other observations**

There are other observations found during the experiment. As these findings were not the main aims of this study, they were not analysed statistically. The observations are: some participants walked around or used the plan view to observe the site carefully in their second test after experiencing hazardous situations in their first test; and if people enter a site the first time, the hazards above their field of view are less likely to be considered because they are more likely to observe an environment by turning their “head” left and right, but not up and down.

**Check for sample biases**

As there are five potential confounding variables (gender, age, construction work experience, computer game frequency and computer game experience) that may influence the test results, it is important to validate the results by checking for sample biases. In this study, the sample biases are checked in two aspects: the proportion of participants who used the safe route and the proportion of participants who were injured in their first test.

<table>
<thead>
<tr>
<th>First test</th>
<th>Second test</th>
<th>With priming</th>
<th>Without priming</th>
<th>$p$-value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Uninjured</td>
<td>23.1% ($n = 26$)</td>
<td>28% ($n = 25$)</td>
<td>0.686</td>
<td>0.069</td>
</tr>
<tr>
<td>Uninjured</td>
<td>Uninjured</td>
<td>12.5% ($n = 8$)</td>
<td>28.6% ($n = 7$)</td>
<td>0.438</td>
<td>0.122</td>
</tr>
<tr>
<td>Injured</td>
<td>Uninjured</td>
<td>27.8% ($n = 18$)</td>
<td>27.8% ($n = 18$)</td>
<td>1.000</td>
<td>0.050</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>First test</th>
<th>Second test</th>
<th>With sound</th>
<th>Without sound</th>
<th>$p$-value</th>
<th>Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Uninjured</td>
<td>37.0% ($n = 27$)</td>
<td>20.8% ($n = 24$)</td>
<td>0.204</td>
<td>0.257</td>
</tr>
<tr>
<td>Uninjured</td>
<td>Uninjured</td>
<td>20% ($n = 10$)</td>
<td>20% ($n = 5$)</td>
<td>1.000</td>
<td>0.050</td>
</tr>
<tr>
<td>Injured</td>
<td>Uninjured</td>
<td>47.1% ($n = 17$)</td>
<td>10.5% ($n = 19$)</td>
<td>0.014</td>
<td>0.745</td>
</tr>
</tbody>
</table>

**Table X.** Priming effect on training effectiveness

**Table XI.** Sound effect on training effectiveness
Construction work experience. Most of the participants (excluding some of the final-year undergraduate students) in this study had at least three months’ internship in the construction industry as a basic requirement for their bachelor degrees. Thus, when checking the bias caused by work experience, the participants who have less than three months’ work experience are considered as having a low level of work experience. The results are presented in Table XII.

As shown in Table XII, participants with less construction work experience are slightly less likely to choose the safe route, and the rate of injury is slightly higher than for those with higher levels of work experience. However, if taking the subject grouping into consideration, the overall results do not vary much. The column of "Corrected" data in the table is the weighed percentage assuming when the number of people with low-level construction work experience and those with high-level construction work experience were the same (Huang et al., 2006). Although, there are small differences, the trend presented by the corrected percentage is the same as the overall result from the sample. Thus, construction work experience does not significantly influence the results.

First-person computer game frequency. The computer game frequency was measured by how many hours per week the participants play first-person computer games. When checking the bias caused by first-person computer game experience, the participants who “never or rarely play” first-person computer games are considered as having a low level of first-person computer game frequency. The results in Table XIII compare the participants with high-level frequency with the whole samples in each group. As the participants with different levels first-person game frequency shown in Table XIII do not vary much in terms of the likelihood of using the safe route and being injured, first-person game frequency can be considered as not influencing the results significantly.

First-person computer game experience. The first-person computer game experience was measured by how many months/years the participants have played this type of games. When checking the bias caused by work experience, the participants who have played no more than three months first-person computer games are considered as having a lower level (beginner level) of first-person computer game experience. The results in Table XIV compare the participants with high-level experience with the whole samples in each group.

The sample size of participants with low-level first-person game experience is small, thus the result may lack of accuracy in terms of their likelihood of choosing the same route and

<table>
<thead>
<tr>
<th>Group</th>
<th>&lt; 3-month experience</th>
<th>≥ 3-month experience</th>
<th>p-value</th>
<th>All (%)</th>
<th>Corrected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Used the safe route</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound A</td>
<td>60.0% (n = 5)</td>
<td>77.8% (n = 9)</td>
<td>0.480</td>
<td>71.4</td>
<td>68.9</td>
</tr>
<tr>
<td>Without sound B</td>
<td>16.7% (n = 6)</td>
<td>50.0% (n = 6)</td>
<td>0.220</td>
<td>33.3</td>
<td>33.3</td>
</tr>
<tr>
<td>Without priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound C</td>
<td>40.0% (n = 10)</td>
<td>66.7% (n = 3)</td>
<td>0.416</td>
<td>46.2</td>
<td>53.3</td>
</tr>
<tr>
<td>Without sound D</td>
<td>50.0% (n = 6)</td>
<td>66.7% (n = 6)</td>
<td>0.558</td>
<td>58.3</td>
<td>58.3</td>
</tr>
<tr>
<td><strong>Experienced injury</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound A</td>
<td>80.0% (n = 5)</td>
<td>44.4% (n = 9)</td>
<td>0.198</td>
<td>57.1</td>
<td>62.2</td>
</tr>
<tr>
<td>Without sound B</td>
<td>83.3% (n = 6)</td>
<td>83.3% (n = 6)</td>
<td>1.000</td>
<td>83.3</td>
<td>83.3</td>
</tr>
<tr>
<td>Without priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound C</td>
<td>70.0% (n = 10)</td>
<td>66.7% (n = 3)</td>
<td>0.912</td>
<td>69.2</td>
<td>68.4</td>
</tr>
<tr>
<td>Without sound D</td>
<td>83.3% (n = 6)</td>
<td>66.7% (n = 6)</td>
<td>0.504</td>
<td>75.0</td>
<td>75.0</td>
</tr>
</tbody>
</table>

Table XII. Check for sample bias caused by construction work experience

Table XIII. Check for sample bias caused by first-person computer game frequency

Table XIV. Check for sample bias caused by first-person computer game experience
injury rate. However, it can be seen from Table XIV that when sound was present, the participants with higher levels of first game experience performed much more safely than the other participants. Thus whether first-person game experience has an influence to the participants’ safe decisions or not, and in what circumstances will the influence occur should be further studied over a larger sample size.

**Discussion**

Audio and visual displays cooperate to create high levels of presence. It was hypothesised in H1 that in a VE with sound, obvious stimuli lead people to recognise more hazards. This hypothesis is strongly supported by the results of VE1, while the opposite was found for VE2. The most likely reason for this is that the hazard in VE2 was in the air (above the eye level). As mentioned in the results, the movement of the participants’ “eyes” was more horizontal than vertical. Therefore, the possibility of people identifying the hazards in the air is relatively low. The results of this study stress the importance of the location of the stimuli. Previous research has suggested that if one has been told to focus on a location, the response speed to an object near the location is faster than to an object far from the location.

<table>
<thead>
<tr>
<th></th>
<th>Rarely or never</th>
<th>&gt; 0 hour/week</th>
<th>p-value</th>
<th>All (%)</th>
<th>Corrected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Used the safe route</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>75.0% (n = 4)</td>
<td>70.0% (n = 10)</td>
<td>0.852</td>
<td>71.4%</td>
<td>72.5%</td>
</tr>
<tr>
<td>Without sound</td>
<td>33.3% (n = 3)</td>
<td>33.3% (n = 9)</td>
<td>1.000</td>
<td>33.3%</td>
<td>33.3%</td>
</tr>
<tr>
<td>Without priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>50.0% (n = 6)</td>
<td>42.8% (n = 7)</td>
<td>0.796</td>
<td>46.2%</td>
<td>46.4%</td>
</tr>
<tr>
<td>Without sound</td>
<td>50.0% (n = 6)</td>
<td>66.7% (n = 6)</td>
<td>0.558</td>
<td>58.3%</td>
<td>58.3%</td>
</tr>
<tr>
<td><strong>Experienced injury</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>75.0% (n = 4)</td>
<td>50.0% (n = 10)</td>
<td>0.294</td>
<td>57.1%</td>
<td>62.5%</td>
</tr>
<tr>
<td>Without sound</td>
<td>100% (n = 3)</td>
<td>77.8% (n = 9)</td>
<td>0.272</td>
<td>83.3%</td>
<td>88.9%</td>
</tr>
<tr>
<td>Without priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>83.3% (n = 6)</td>
<td>57.1% (n = 7)</td>
<td>0.308</td>
<td>69.2%</td>
<td>70.2%</td>
</tr>
<tr>
<td>Without sound</td>
<td>50.0% (n = 6)</td>
<td>100% (n = 6)</td>
<td>0.046</td>
<td>75.0%</td>
<td>75.0%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>&lt; 3-month experience</th>
<th>≥ 3-month experience</th>
<th>p-value</th>
<th>All (%)</th>
<th>Corrected (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Used the safe route</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>33.3% (n = 3)</td>
<td>81.8% (n = 12)</td>
<td>0.100</td>
<td>71.4%</td>
<td>57.6%</td>
</tr>
<tr>
<td>Without sound</td>
<td>50.0% (n = 2)</td>
<td>30.0% (n = 10)</td>
<td>0.584</td>
<td>33.3%</td>
<td>40.0%</td>
</tr>
<tr>
<td>Without priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>25.0% (n = 4)</td>
<td>55.6% (n = 9)</td>
<td>0.308</td>
<td>46.2%</td>
<td>40.3%</td>
</tr>
<tr>
<td>Without sound</td>
<td>60.0% (n = 5)</td>
<td>57.1% (n = 7)</td>
<td>0.922</td>
<td>58.3%</td>
<td>58.6%</td>
</tr>
<tr>
<td><strong>Experienced injury</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>100% (n = 3)</td>
<td>45.5% (n = 11)</td>
<td>0.090</td>
<td>57.1%</td>
<td>72.7%</td>
</tr>
<tr>
<td>Without sound</td>
<td>100% (n = 2)</td>
<td>80.0% (n = 10)</td>
<td>0.488</td>
<td>83.3%</td>
<td>90.0%</td>
</tr>
<tr>
<td>Without priming</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With sound</td>
<td>75.0% (n = 4)</td>
<td>66.7% (n = 9)</td>
<td>0.764</td>
<td>69.2%</td>
<td>70.8%</td>
</tr>
<tr>
<td>Without sound</td>
<td>60.0% (n = 5)</td>
<td>85.7% (n = 7)</td>
<td>0.310</td>
<td>75.0%</td>
<td>72.9%</td>
</tr>
</tbody>
</table>

Table XIII. Check for sample bias caused by first-person computer game frequency

Table XIV. Check for sample bias caused by first-person computer game experience
(Rizzolatti et al., 1987). Obvious stimuli attract people’s attention, thus if obvious stimuli had been located in the air near the hazard, they might have helped to attract users’ attention, and subsequently have helped the users to identify the related risks. This should be further studied in the future.

H2 was that priming of safe choices results in people taking fewer risks in a VR simulator. Tables VII, VIII and IX show that this was true in a VE with sound, but priming led to people taking more risks in the VR situations without sound. When sound factors were added to the VE, users behave more safely in the VE with priming factors than those in the VE without priming factors. The reason why a VE with sound triggers the effect of priming on people’s risk perception and safety decisions may be related to how the human brain works. Figure 7 illustrates a conjectured model explaining how the human brain reacts to the sound and priming factors.

When people enter a VE, their attention is attracted by both visual and audio stimuli. In an environment with only visual stimuli, the information people perceived is only limited to a 200 degree arc in front of them (Mather, 2006). The way they observe an environment mostly depends on how they move their “eyes”. Their sense of normality is lower and thus sense of presence is lower. If people do not feel present in a VE, they would not take the consequences seriously, thus they may not be concentrating on detecting the potential hazards when finishing their task. Meanwhile, as there is no sound from the VE, distracting sounds from the real world can be perceived clearly.

On the other hand, when people are in a VE with both audio and visual stimuli, they perceive not only the image information in front of them but also sound information from all directions (Mather, 2006). Thus, the presence of audio stimuli may encourage the subject to look around more, and hence be affected by more of the priming factors. The information received by vision and hearing senses are stored by short-term memory for a few seconds and then are synthesised and processed by the visuospatial sketchpad and phonological loop of working memory (Jarrold and Baddeley, 1997). As the phonological loop and visuospatial sketchpad are parallel processes, the information can be processed at the same time (Baddeley, 1996). Rehearsal of the information in the working memory may help the information to be stored in long-term memory (Baddeley et al., 1998). Thus although the participants cannot see an object/hazard, as long as the related sound is present, they would not forget that the object/hazard is there. Furthermore, the presence of the sounds from the VE can mask some of the sound from the real world, and hence reduce the distraction from the real world.

**Figure 7.**
How human brain reacts to the sound and priming factors
When people are processing the information, their memory is retrieved. Here the memory is divided into explicit memory and implicit memory. Explicit memory refers to a conscious form of retrieval of past information or experiences, whereas implicit memory is unintentional or nonconscious retrieval of information processing (Andersen et al., 2011). As introduced previously, priming is an implicit memory. Knowledge belongs to explicit memory where people deliberately memorise things. In this study, explicit memory also involves the “injuries” the participants had when they were manipulating the simulator. Both implicit memory and explicit memory influence people’s decisions. Meanwhile, the location of their attention determines what information and how much information they recognise from the VE. As mentioned before, it is easier for people to process the information near the stimuli they perceive. The information they perceive affects the decisions they make when doing tasks. However, not all the information they perceive is helpful for them to make decisions. Some stimuli may cause distraction. Previous research has also suggested that an increase in workload reduces people’s ability to process information and increases the chance that they make mistakes (Pierce and Andersen, 2014). Thus whether their ability to make safer decisions is enhanced or impeded should be further studied.

Contrary to H3, the conceptual priming factors did not significantly improve the participants’ safety performances in a subsequent environment. Even repetition priming did not improve the participants’ overall safety performances. One reason of this may be that the two test environments have different appearances and features, which obstructed the participants connecting the two VEs (similar priming factors and site plan). However, the results seem sensible because priming effects generally are short-term effects and may consequently vanish as the experiment continues (Aramaki et al., 2010). Thus for training purposes, adding priming to a VE simulator is not recommended. On the other hand, strong obvious feedback, such as experiencing injuries in the VE simulator that can be explicitly recalled from memory helped the participants to remember their mistakes and act more safely, especially if sound is present. Although not all the participants learned from their mistakes.

Conclusions
Three conclusions can be drawn from this study. First, priming subjects in a safety simulator with hints regarding risks makes those subjects act more safely in regard to those risks in the simulator, if the simulator has appropriate sound effects. If the sound is not present, then the hints are actually likely to result in less safe behaviour. Also the location of the hints compared to the subject’s eye level is important. Stimuli above eye level are less likely to be noticed than stimuli at or below eye level.

Second, the effects of these hints are negligible in a subsequent environment. Thus, it is not advisable to place subtle hints in a training environment. The hints will temporarily elevate the subject’s level of safe behaviour, but this will not carry over into subsequent situations. It would be better to place the hints in the real world.

Third, strong obvious feedback, such as the subject becoming injured from unsafe behaviour, does lead to safer behaviour in subsequent environments. Thus safety simulators should be designed with “traps” that will “injure” the participants. The beneficial effect of experiencing these injuries requires that the environment has appropriate sound effects included. The lack of sound effects in the original simulator may even lead to deterioration in the safety level of behaviour on subsequent exercises.

On the whole, for safety training purposes, virtual construction simulators involving unsupervised interaction should be designed with sound, without priming factors, and should contain “traps” that the trainees will easily fall into when they make unsafe decisions. Further study should be carried out over a larger sample size, and dig into how the human brain reacts to the stimuli in VR simulators.
References


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"We’ve always done it this way" is one of the most infuriating phrases overheard on any construction jobsite. It symbolizes stagnation, an aversion to change and a reluctance to learn from past mistakes. It is an anathema for an industry rapidly being transformed by technology and globalization. Fortunately, the authors of Total Construction Management advance a refreshing alternative. By combining lessons from lean manufacturing and quality management into the idea of "lean quality," John Oakland and Marton Maroszsekely lay out a comprehensive vision for an agile, more value-driven industry. This vision is built quickly at first, then gradually deepened through the use of case studies and the unification of innovative management theories and tools from the past two decades. But, there is a trade-off in this approach. Many of the theories and tools used to build the authors’ vision of lean quality can and do have entire books written about them. Thus, anyone seeking a how-to book on pull planning or total quality management (TQM) should look elsewhere, perhaps to several of the authors’ prior works. Total Construction Management is a more of a primer that brings an extensive breadth of seemingly disparate management ideas together to establish lean quality as a lens for advancing effective management. That said, the variety of ideas being presented is unlikely to be fully appreciated by undergraduate students, making the book more suited for graduate-level study and industry professionals with a few years of practical experience in construction management.

Before delving too deeply into the book’s structure and content, the qualifications of the authors cannot be understated. John Oakland brings his expertise on the quality side of the lean quality equation, having researched, published on and promoted TQM in organizations for nearly three decades. Marton Maroszsekely, on the other hand, brings his knowledge of lean management and production processes obtained firsthand through his work as a Civil engineer, professor and Consultant. Both authors are well-regarded in the field and their combined experiences strike a successful balance between academic and practical perspectives.

The book itself contains 19 chapters, subdivided into six major sections. Each chapter ends with a list of bulleted highlights of important concepts and each major section ends with discussion questions clearly designed to test the reader’s ability to apply those concepts. The first section (Chapters 1-4) provides a foundational background on lean quality that reviews the current state of lean management in construction, defines quality through the eyes of the customer and reviews various TQM models. Section 2 (Chapters 5-8) presents an exhaustive summary of lean planning techniques, ranging from supply chain partnerships to pull planning, building information modeling and the design structure matrix to name a few. Section 3 (Chapters 9-11) discusses perhaps the most important aspect of lean quality: measuring and benchmarking performance. These chapters highlight commonly used measures for efficiency, productivity and
effectiveness. Section 4 (Chapters 12-15) is all about process management and making these measures part of a continuous improvement effort. Section 5 (Chapters 16-18) is dedicated to the human resources and cultural shifts that make lean quality a reality, specifically the communication, leadership, and learning skills needed in project managers. Lastly, Section 6 (Chapter 19) discusses the implementation of lean quality at an organizational level. While short, this chapter has some valuable insights and warnings about forcing too much change, too soon within a construction firm. Throughout each chapter, the writing is approachable, consistent and well-supported by diagrams and other visuals. The authors also make use of descriptive case studies, with roughly 150 pages in the book dedicated to 14 studies.

One limitation in the book’s content is a lack of detail regarding how project delivery methods and their associated contractual arrangements fit within the lean quality framework. Early on, the authors highlight the Lean Construction Institute’s quality triangle and suggest that embracing all three sides – integrated organization, aligned commercial interests and lean operating methods – is crucial to achieving lean quality. However, only integrated project delivery and perhaps some versions of design-build are contractually structured to meet that challenge. Does this mean that lean quality is not attainable in more traditional project delivery methods, such as design-bid-build? Or, is there still value in applying select process improvements and tools? The answer to these questions will almost certainly determine the rate and extent of lean quality adoption in the construction industry.

As stated earlier, the single greatest strength of Total Construction Management is its broad and unifying vision for the industry. The authors successfully expand the concept of quality from a product-centered view of the building, to a process-centered view of the project. Synthesized from the best management theories and tools of the past two decades, this perspective recognizes the importance of waste-reducing management and organizational efforts in creating value for the customer beyond that of the product itself. In other words, lean quality is the antithesis of “we’ve always done it this way.” With this book, John Oakland and Marton Marosszeky have written a roadmap making this vision a reality.

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Volume 25 Number 2 2018

Engineering, Construction and Architectural Management

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