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A PROJECT MANAGEMENT COMPETENCY FRAMEWORK FOR INDUSTRIALISED BUILDING SYSTEM (IBS) CONSTRUCTION

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ABSTRACT

The Malaysian government has been promoting the use of the industrialised building system (IBS) for construction projects since 2003. Worldwide, there are a number of project management competency standards available, but they are generic in nature. This study was conducted to devise a competency framework suitable for industrialised building system (IBS) construction projects. A three-pronged mixed research method comprising qualitative interviews, a quantitative questionnaire survey and face-to-face validation was adopted. The competencies generated were classified as primary and secondary, and assigned to the various initial, planning, implementation, monitoring and closing construction life cycle phases. The proposal fills a gap in the project management landscape by testing and combining academic and non-academic literature with the 'emergent' competencies from the interviews. These are used in conjunction with conventional project management wisdom. IBS is increasingly being applied worldwide, although under different terminologies; therefore, the framework could also potentially be of use beyond Malaysia.

Keywords: Competencies; Industrialised building system; Malaysia; Pareto analysis; Project management

1. INTRODUCTION

The construction industries of advanced economies have long moved away from traditional on-site construction towards the assembly of factory-manufactured components (Lu, 2009; Blismas & Wakefield, 2009; Larsson et al., 2011). This new method is known under different terminologies; for example, offsite construction (OSC) pre-assembly, prefabrication, the modern method of construction (MMC), offsite production (OSP), offsite manufacturing (OSM), and the industrialised building system (IBS). The benefits include the involvement of fewer unskilled workers, higher productivity, better quality, lower wastage, more prudent use of building materials, speedier construction time, increased environmental protection, improved site cleanliness, enhanced health and safety performance, and tighter coordination and

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management (Pan et al., 2004).

Like other developing countries such as China (Gan et al., 2017), the Malaysian government has been promoting the industrialised building system (IBS) to reduce the dependency on foreign site operatives, whilst advancing a more systematic approach to construction. The Construction Industry Development Board (CIDB) developed the IBS Roadmap 2003-2010, thereafter replaced by the IBS Roadmap 2011-2015. Since 2008, it has been mandatory for public building projects to achieve a minimum 70% IBS content.

Among the existing project management competency standards which have become a source of reference for practising project managers are the Project Manager Competency Development Framework (PMCD Framework) published by the Project Management Institute (PMI); National Competency Standards for Project Management by the Australian Institute of Project Management (AIPM); and the Individual Competence Baseline by the International Project Management Association (IPMA). However, these standards are generic in nature. A thorough literature review yielded a limited number of publications on the competencies required for managing IBS construction projects. Indeed, Gan et al. (2017) recently expressed concern over the lack of technical guidelines for IBS construction, which was inhibiting widespread use of IBS in China. Therefore, this research was conducted with the aim to develop a project management framework suitable for IBS construction projects. The specific research objectives were as follows:

1) To identify the competencies required when managing IBS construction projects in the different project lifecycle phases.
2) To separate these into primary and secondary competencies.

The research borrowed Cartwright and Yinger (2007) definition of competencies as “a cluster of related knowledge, attitude, skills, and other personal characteristics that affect a major part of one’s job, correlate with performance on the job, [and] can be measured against well-accepted standards...” This studyis prescriptive in nature, as prescriptive research is at the heart of project management discipline (Ahlemann et al., 2013). Apart from academic material, this research also refers to non-academic documents, thereby bridging the gap between academic theory and practice (Badewi, 2016).

2. IBS IN MALAYSIA

IBS is defined by CIDB (2003) as a construction system in which components are manufactured in a factory, on or offsite, positioned and assembled into structures with minimal additional site work. It divides IBS into six major classifications: precast concrete framing, panel and box systems; steel formwork systems; steel framing systems; prefabricated timber framing systems; block work systems; and innovative product systems. The categorization of off-site systems of other countries are shown in Table 1.

The Malaysian government adopted the term IBS to portray the adoption of industrialization in construction, and the utilization of prefabricated components in building construction (Hashim & Kamar, 2011). Industrialization can be divided into onsite and offsite categories (Alinaitwe et al., 2006). IBS utilises the concepts of manufacturing and applies them to construction (Haas et al., 2000). CIDB (2003) describes IBS as a construction process that is inclusive of the manufacturing process, but which normally excludes conventional construction. Hamid et al. (2008) point out that IBS is an integrated process, involving all subsystems, components, manufacturing and construction processes, and which requires efficient management. Contractors need to keep pace with innovations such as IBS construction to remain competitive (Berawi, 2017).

Table 1 Categorization of offsite system according to selected countries

Countries	Categorization of offsite system	Author
UK	Component manufacture and sub-assembly Non-volumetric pre-assembly Volumetric pre-assembly Modular building	Goodier and Gibb (2004)
Australia	Non-volumetric pre-assembly Volumetric pre-assembly Modular building	Blismas and Wakefield (2009)
US	Offsite pre-assembly Hybrid system Panelized system Modular building	Lu (2009)

Source: Adapted from Majid and Hanafi (2010)

3. RESEARCH METHOD

The study adopted a three-step approach, which provided a sound foundation for this prescriptive research, which sadly many previous studies lack (Ahlemann et al., 2013).

3.1. Stage 1 – Qualitative Approach

In-depth semi-structured interviews were conducted with 14 experienced executives of IBS construction companies, IBS installers and IBS manufacturers. Representing various parties in the supply chain, they provided an all-round view of the subject matter. The interviews also enabled the literature, especially non-academic material, to be validated, and solutions to real problems to be elicited. An abridged list of interview questions is provided in Appendix A. Purposive sampling was used, with project managers of IBS construction companies, IBS installers and IBS manufacturers identified from the IBS contractor register maintained by the CIDB IBS Centre. The data were saturated by the 14th interview. On average, the interviews took one hour to complete, as the initial questions spawned follow-up ones derived from the answers provided. The interviews which were recorded and later transcribed and analysed thematically. Altogether, 50 competences were generated, which were assigned to the appropriate project life cycle phases.

3.2. Stage 2 – Questionnaire Survey

The items generated from the interviews were fed into a questionnaire to elicit their level of significance according to the survey respondents. A five-point Likert Scale (1: not significant, 2: quite significant, 3: significant, 4: very significant, 5: extremely significant) was used for this purpose. Five project managers pre-tested the questionnaire, three academics and two experts from the CIDB IBS Centre. Their feedback on the content and format helped improve the questionnaire design. A pilot test followed to check the reliability of the questionnaire and eliminate any items which could contribute to a low Cronbach Alpha value; the test involved 30 IBS project managers. A reliability test was then conducted on the pilot test results, using the Statistical Package for Social Sciences (SPSS) version 20. The coefficients alpha test were above 0.7 for all the items, indicating that the reliability of the questionnaire was at the 5% significance level and suitable for a full survey (Pallant, 2010).

1,300 questionnaires were distributed online and by post throughout Malaysia, initially only to CIDB-registered IBS contractors, but subsequently to other contractors (but still with IBS experience, based on confirmatory telephone calls) due to the low response from the initial group. 102 completed questionnaires were received (equivalent to a 7.9% response rate). Most respondents (72.5%) had more than 10 years' experience with various IBS systems, including precast concrete (42%), blockwork (16%), formwork (18%), steel framing (19%), prefabricated timber (3.5%) and innovative products (2.0%). The quantitative data were analysed using the SPSS package for descriptive analysis and a ranking test. The Relative Important Index (RII) was used to rank the best practices according to their significance, a method used by Yang and Wei (2010) and Danso and Antwi (2012). The formula to calculate the RII is:

$$\text{Relative Importance Index (RII)} = \frac{\sum W}{A \cdot N}$$

where W is the weighting given by the respondents for each best practice, ranging from 1 to 5 (from 1: not significant to 5: extremely significant), A is the highest weight (five in this case), N is the total number of samples.

The most significant best practices were then filtered using Pareto Analysis. The 80/20 Pareto Principle suggests that the top 20% factors behind a phenomenon account for 80% of it; such analysis has been adopted by previous scholars such as Rosenfeld (2014). Finally, Spearman's Correlation Coefficient test was conducted to identify the relative importance of the competencies. The value of coefficient (r) shows the strength of the correlation between two competencies. A value of p at the 5% level or lower indicates strong correlation between competencies. The null and alternative hypotheses were:

H0: p (two-tailed) > 0.05 – the competencies are not significant
H1: p (two-tailed) < 0.05 – the competencies are significantly correlated

The correlation coefficient for each competence in every phase was lower than 0.05, with the majority being 0.00. Based on the Hypothesis H1, it can be concluded that all the competencies in each phase correlate to each other, and that any changes would have a significant effect on a project.

3.3. Stage 3 – Validation

Five experts agreed to provide non-statistical validation of results, with the validation sessions lasting between 1-2 hours. The credentials of the five experts were as follows:

Panellist 1: Project director/project manager for a contractor with 20 years' experience.
Panellist 2: General secretary of the Malaysian chapter an international association of project managers, with 35 years as a project manager.
Panellist 3: Council member of a local project management association with 33 years' experience and attached to the Public Works Department.
Panellist 4: Manager with 11 years' service with CIDB.
Panellist 5: Freelance project management consultant with 35 years' industry experience.

The panellists unanimously agreed on the appropriateness and coverage of the framework. They stated that it was simple and straightforward to follow (Panellist 3), hence useful for IBS novices (Panellist 2) and for training purposes (Panellists 4 and 5).

4. RESULTS AND DISCUSSION

The competency framework after Pareto Analysis is shown in Table 2. Only primary competences are discussed, which are referred to by their codes. The qualitative information inserted in the text was obtained from interviewees.

Table 2 Project management competency framework for IBS construction

Phase	Primary Competence	Secondary Competence
Initial	1. Notify manufacturers of any deviations in drawings (In:1) 2. Hold coordination meetings with all parties involved (In:2) 3. Integrate IBS drawings with architectural and M&E drawings (In:3) 4. Negotiate cost of components and handling machinery with manufacturers and machinery suppliers (In:4) 5. Brief the scope of work to all parties involved (In:5) 6. Coordinate information so that IBS drawings tally with architectural and M&E drawings (In:6) 7. Select suitable installers and subcontractors (In:7) 8. Identify IBS components for producing IBS drawings (In:8) 9. Integrate conventional scopes of work with IBS ones (In:9)	1. Arrange on-site installation process with manufacturers 2. Ensure converted drawings are approved by the architects, engineers and client, including schemes for handling, transporting and installation 3. Manage conversion of architectural and structural design drawings to IBS drawings
Planning	1. Prepare master work program to include scope of work for installers, manufacturers and subcontractors (P:1) 2. Correct discrepancies between site conditions and drawings (P:2) 3. Integrate work programs of manufacturers, installers, machine suppliers and subcontractors with main contractor's work program (P:3) 4. Integrate master work program for conventional construction with IBS construction (P:4) 5. Approve sequencing of IBS and sub-sequencing of conventional works (P:5) 6. Arrange for component delivery to construction site with installers and manufacturers (P:6) 7. Procure handling machinery, equipment and devices to be used on site (P:7)	1. Assess component load, lateral load, load transfer with handling machinery capacities 2. Choose installers' most appropriate method statements in terms of time and cost 3. Relay necessary information to all parties involved including manufacturers, installers and sub-contractors
Implementa-tion	1.Prepare ground work/ installation area to receive IBS components (Im:1) 2. Integrate IBS work with conventional construction work and parties involved (Im:2) 3. Coordinate IBS work with sub-contractors' work, work program and sequencing activities (Im:3) 4. Coordinate dimensional tolerances at the interfaces of different material (Im:4) 5. Take safety precautions against injury due to heavy components and plant (Im:5) 6. Coordinate materials, handling machinery and people on site (Im:6)	1. Provide protection of works against damage 2. Ensure IBS components are stored where designated 3. Verify remedial works for any discrepancies after installation 4. Rectify minor defects in IBS components upon delivery

Phase	Primary Competence	Secondary Competence
	7. Maintain site access and operating space, especially for heavy machinery (Im:7) 8. Ensure handling machinery, equipment and IBS components arrive as scheduled (Im:8) 9. Confirm component labelling/numbering for sequencing purposes (Im:9)	
Monitoring	1. Monitor coordinates, verticality, horizontality and tolerances during fixing (M:1) 2. Monitor component installation and ensure sequence follows method statements and manufacturers' instructions (M:2) 3. Monitor field connections, such as welding, bolting, post-tensioning, grouting, etc. (M:3) 4. Monitor jointing and positioning of IBS components in relation to conventional trades (M:4) 5. Monitor installation time by IBS installers and conventional sub-contractors (M:5) 6. Monitor construction and supplier delivery schedules (M:6) 7. Check quality of IBS components upon arrival at construction site before unloading (M:7) 8. Check quality of IBS components before installation by referring to pre-installation QA and QC checklist (M:8)	1. Check rectification work done by installer 2. Check production progress at factory or production yard 3. Monitor component delivery to ensure handling machines are fully utilized
Closing	1. Arrange final inspection of installed items with client and consultants (C:1) 2. Ensure submission of warranties for materials and workmanship by installers are certified by consultants and client (C:2)	1. Issue acceptance certificate for items that have been installed satisfactorily 2. Arrange pre-inspection with installers and manufacturers

4.1. Initial Phase

In:1 validates the PCI Erectors Committee (1985); “Notification must be made once defects are detected”, said one manufacturer executive. In:2 supports Haas and Fagerlund (2002). Coordination meetings are crucial for integration purposes; it is important that communication channels are established from the outset for IBS projects (Pozin et al., 2018). IBS construction can only start when design work is completed, unlike conventional projects. Hence the importance of In:3. In:4 is in line with Mao et al. (2016); “Locking the price early helps avert potential disputes”, said one contractor executive. In:5 resonates with Dumont et al. (1997); “There is greater inter-relatedness involving a greater number of parties compared to conventional construction”, according to one contractor executive. In:7 echoes Waddell (1985). Installers and subcontractors must also have the capability to work with project managers in planning the production and delivery of the components as scheduled. Early selection inculcates early commitment to involvement. Regarding In:8, experienced project managers in IBS are able to alert designers to parts of buildings which are suitable for IBS components. In:6 and In:9 are self-explanatory.

4.2. Planning Phase

P:1 supports Kamar et al. (2009). The master program is referred to by all parties, including installers and manufacturers; hence the necessity to incorporate their scopes of work into it. P:2 tallies with Kadir et al. (2005); P:3 resonates with Pan et al., (2004); and P:4 is in line with Blyth and Lewis (2004). P:5 matches the PCI Erectors Committee (1985). Performed properly, the components and trade work are put together as seamlessly as possible. Sub-sequencing of conventional work is no less important, as “many past complications have arisen due to wrong sequencing”, as cautioned by one manufacturing executive. Sequencing requires consultation with manufacturers, installers and conventional trade subcontractors. Project managers must be knowledgeable in plant loading, type of transportation for delivery, timing, sequence of trailers on site, and handling and storage on site (PCI Erectors Committee, 1985). If in doubt, they should not hesitate to seek advice. Equally important, project managers must be aware of ground conditions. Insufficient planning has in the past led to disruptive access and operating space, as mentioned by three executives. P:6 is self-explanatory, and P:7 matches Fotwe and McCaffer (2000). The machinery and equipment must be of suitable capacity and be in good condition. The Just-In-Time (JIT) concept must also be incorporated for efficiency and economy. “There must be contingencies for inappropriate selection of handling machineries and equipment”, said one construction executive.

4.3. Implementation Phase

In relation to to Im:1, failure to do this compromises rapid construction and leads to costly idle time of hired machinery. Temporary works required for the final assembly need to be ready before installation; these include establishing and maintaining control points and bench marks (PCI Erectors, 1989). Im:2 does not require elaboration. Im:3 ensures the smooth running of the project and meeting of the target schedule and relates closely to Im:6, which supports PMI (2013). The right components should be ready for installation according to the work program. “Wrong components delivered to site consume storage space and machinery time”, said one contractor executive. Im:4 resonates with the PCI Erectors Committee (1985) and Kamar et al. (2009). With regard to Im:5, whilst safety is enhanced when IBS components are manufactured in a controlled environment (Haas & Fagerlund, 2002), the nature of IBS components which are large and heavy pose safety hazards on site. “Site safety must be maintained”, said one contractor executive. Im:7 is in line with with the PCI Erectors Committee (1985); the site must be obstruction-free. Im:8 also concurs with the PCI Erectors Committee (1985), relating to the JIT philosophy which helps avoid storage issues and double handling. Temporary bracing should not be overlooked. Im:9 echoes Hamid et al. (2011); the numbering system is important for loading and unloading purposes, as well as for avoiding double handling.

4.4. Monitoring Phase

M:1, M:3, M:4 and M:8 are self-explanatory. With regard to M:2, any deviation from method statements or manufacturers' instructions can potentially lead to latent complications. Pertaining to M:6, close monitoring of schedules "maximises machinery usage and avoids on-site storage", said one construction executive. As for M:5, delays can lead to poor workmanship when everyone is chasing for time. Even though they will have been checked at the factory, the project manager should also undertake a pre-unloading quality check of IBS components (M:7), as damage can arise during loading and even transportation. Any undetected defects after unloading becomes the responsibility of the main contractor, as cautioned by two installer executives.

4.5 Closing Phase

Only two primary competences apply to the closing phase. In connection with C:1, overlooked defects can have grave consequences after handover. This finding gives credence to the PCI Erectors Committee (1985). C:2 requires no explanation: "Make sure the installers submit the warranty of work done", said one construction executive.

5. CONCLUSION

This paper makes three significant contributions to the project management landscape. The first is new project management insights into what competences are required for IBS projects. These can supplement the generic project management frameworks produced by established project management professional bodies. The second contribution is the validation of non-academic literature related to project management competencies for IBS. Third, the research has also tapped into the experiences of project managers.

The competency framework is interesting, in that it reveals that different emphases are stressed in different construction phases: appropriate and timely information flow to the appropriate parties during the initial phase; time management and operational issues in the planning phase; interfacing in the implementation phase; time management, quality control and precision in the monitoring phase; and quality assurance in the closing phase.

As mentioned in the introduction, IBS (often under different terminologies) is gaining popularity around the world. The framework has pragmatic value not only in Malaysia, but potentially elsewhere. For this reason, it has been designed not to be too difficult to follow.

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Appendix A

State the competencies required when managing IBS construction projects for the five construction life cycle initial, planning, implementation, monitoring and closing phases.

Which is the critical part to manage in the IBS construction process? Why?