Key factors influencing the decision to adopt industrialised building systems technology in the Malaysian construction industry: an inter-project perspective

Akmam Syed Zakaria, Sharifah; Gajendran, Thayaparan; Skitmore, Martin; Brewer, Graham

Published in:
Architectural Engineering and Design Management

DOI:
10.1080/17452007.2017.1298512

Sharifah Akmam Syed Zakaria, Thayaparan Gajendran, Martin Skitmore & Graham Brewer

https://doi.org/10.1080/17452007.2017.1298512

Key factors influencing the decision to adopt Industrialised Building Systems technology in the Malaysian Construction Industry: An inter-project perspective

The factors impacting the adoption of Industrialised Building Systems (IBS) technology is gaining increasing attention in Malaysia, particularly because of the slower-than-expected pace of IBS adoption in construction projects, despite considerable government focus and investment. This paper aims to identify the factors that influence the decision to use IBS in construction projects. The research methodology is embedded in an interpretative phenomenological paradigm that is applied through semi-structured face-to-face interviews with a group of 27 experienced Malaysian construction stakeholders. The 'inter project perspective' is contextualised through an interpretative content analysis that synthesises varied accounts of interviewees across the industry to identify the influence of different factors on the adoption of IBS. The findings group the factors that influence IBS adoption decisions into 'structural', 'contextual' and 'behavioural' themes. The 'structural' and 'contextual' themes have 5 factors impacting the IBS decision, whereas 'behavioural' has four factors. The fourteen factors are Project Condition, Procurement Setup, Management Approach, Communication Process, Decision-making Style, Economics Conditions, Technology Development, Government Involvement, Sustainability Feature, Stakeholders Participation, Experience, Bounded Rationality, Awareness and Attitude. These factors are influenced by 49 'aspects'. It is suggested that the IBS adoption decision is complex and influenced by many interconnected 'aspects', beyond government incentives, cost, attitudes and skills. Moreover, a more integrative approach that considers all factors is needed to make the IBS adoption decision. However, because the intensity of influence of these factors/aspects may differ country to country, as may the nature of the construction industry, any attempt to develop a strategy or policy to increase IBS adoption or integration needs to be targeted.

Key words: decision-making, industrialised building systems (IBS), building projects, construction industry.

Introduction

Industrialised Building Systems (IBS), in addition to mechanised and automated manufacturing processes, can be defined as the application of modern systemised methods of design, production planning and control, with intensive utilisation of various precast elements

(Sarja, 2003). The term IBS is synonymous with prefabrication, precast, off-site construction, modularised construction and modern-method construction (manufacturing aligned process of building methods). The adoption of IBS technology has allowed the construction industry to achieve remarkable productivity gains and is now one of the prevalent and growing building technologies in both developed and developing countries (e.g., Blismas et al., 2010).

Despite the relatively long history of IBS, the goal to have a minimum of 70% IBS in all construction projects in Malaysia is far from reality. The construction industry as a whole remains very reluctant to exploit IBS use (CIDB, 2009). This reluctance is particularly evident among many small contractors, who prefer the use of conventional systems of construction due to their familiarity with such methods (Idrus et al., 2008; Mohamad et al., 2009). The slow uptake of IBS technology (Abdullah and Egbu, 2010; Kent and Becerik-Gerber, 2010; Ofori et al., 2011), the under-performance of IBS building projects (Haller and Stehn, 2010; Vernicos et al., 2011) and the failure to deliver expected returns (Ceylan et al., 2010; Yee and Siti, 2012) have led to a growing research interest in both IBS technology and innovation research.

This slow uptake, which is particularly relevant for Malaysia, prevents any real efficiency from being leveraged across the industry. The objective of this study is to identify the factors influencing the adoption of IBS in construction. This study seeks to answer the question 'what factors are influencing the adoption of IBS in construction?' The objective is investigated by exploring the experiences and perceptions of decision-makers involved in IBS adoption. This paper examines the overall IBS adoption in construction, rather than focusing on a specific stage of a construction project (e.g., design and construction). Although in most cases, the decision of whether to adopt IBS is made during the early stages of a project, the use of IBS can be evaluated at any stage of a project (occasionally as a reflective analysis during its latter stages).

The research method is embedded in the 'interpretative phenomenological paradigm' using qualitative in-depth semi-structured interviews of 27 Malaysian construction-profession stakeholders to gather data from an inter-project perspective. The inter-project perspective provides an opportunity to combine varied accounts of the experiences of interviewers across different projects and identify the influence of different factors in considering the adoption of IBS in construction projects.

Background

There is a growing need worldwide to deliver projects more quickly while maintaining the required quality levels and environmental protection (Akadiri and Olomolaiye, 2012). It is widely recognised that IBS provides a potential solution in improving project delivery effectiveness and efficiency, and the need for its adoption is well established (e.g., Arif and Egbu, 2010). The research to date highlights the need to support government policies to realise the potential of IBS technology in countries such as Hong Kong, Singapore, Malaysia and China, given the characteristics of the construction industry in each country and the advantages to be gained (Arif and Egbu, 2010). In particular, the Malaysian construction industry has the capacity for a much higher usage of IBS technology (Kamar et al., 2009). However, there is a wide variety of factors related to IBS adoption that extends beyond technological and financial factors that have received minimal direct or specific treatment.

Centring on the problem of factors influencing decisions associated with IBS adoption, the focus is shifting to the human aspects (Bouyssou et al., 2013). The literature review is based on peer-reviewed articles published between 1998 and 2016 in both technical and management fields. This period covers the significant breadth of research concepts related to the IBS

conceptual development of the modern methods of construction from the late 1990s (e.g., Slaughter, 1998).

The literature review identifies three main sets of factors or themes, namely, structural, contextual and behavioural, that influence the decision of IBS adoption.

- *Structural factors* are building project and project management-related factors that have the potential to influence IBS decision-making. These factors include the project condition and procurement (Nadim and Goulding, 2009; Faludi et al., 2012; Kim et al., 2012), the management approach and leadership (Ismail et al., 2012; Vernikos et al., 2013), and the communication and cost/investment (Pan et al., 2007; Goodier & Gibb, 2007; Vernikos et al., 2013);
- *Contextual factors* can be defined as any characteristics, situations, forces or circumstances that may exist outside a building project and may influence IBS decision-making including economic conditions (Langford and Male, 2008), government involvement (Arif and Egbu, 2010; Harris and McCaffer, 2013), stakeholder involvement (Ofori et al., 2011; Pryke and Smyth, 2012), sustainability features (Ng et al., 2012; Goulding et al., 2012a), and technology development (Arif and Egbu, 2010; Jones and Saad, 2003); and
- *Behavioural factors* are human or people-related factors that influence IBS decision-making and include cognition (Xue, 2010), culture (Smith, 2011) and perception (e.g., Goodier et al., 2010). The limited number of human-related studies in IBS technology adoption indicates the significance of human-related factors and knowledge management (Abdullah and Egbu, 2010), skills and knowledge (Nawi et al., 2011), readiness (Ern and Kasim, 2012), experience and mind-set (Thanoon et al., 2003), acceptance (Majid et al., 2011) and awareness (Kassim and Walid, 2013).

Contextual and structural factors have been commonly researched in making construction management decisions (e.g., Holt, 2010); however, a limited focus has been provided on the impact of such factors in the context of IBS adoption decisions. Complexity and uncertainty in the decision-making of the adoption of building technology such as IBS have also been an important concern in construction management. Moreover, most of the research concentrates on the effects of project conditions and technical factors (e.g., Eftekhari et al., 2012; Goodier & Gibb, 2007) and focuses less on behavioural factors (e.g., Stanton et al., 2012). Many contemporary researchers have explored various decision-making approaches using quantitative and qualitative models (e.g., Antunes and Costa, 2011) in an attempt to simplify and understand the intrinsically complex and unclear IBS decision-making process (Pan et al., 2012).

The research approach used here is inductive (e.g., Fereday and Muir-Cochrane, 2008). The approach involves the conduct and analysis of a series of in-depth semi-structured interviews with experienced construction-profession stakeholders concerning the key influences on the decision to adopt IBS technology from rich multiple perspectives.

Research method

The qualitative research methodology (Bryman, 2012; Creswell and Clark, 2007) employed in this research is contextualised through a decision-making frame underpinned by behavioural and economics constructs (Wilkinson and Klaes, 2008). The ‘decision making’ is positioned predominantly in an interpretative phenomenology paradigm (Finlay, 2009). The interpretative paradigm, as highlighted by Creswell (2012), strives to understand the social structure and the patterns of interaction between those working within a system (Dainty, 2008), in this case, the

system being the members making decisions on IBS adoption. Interpretative phenomenology focuses on extracting people's understandings of a particular phenomenon (Smith et al., 2009) and offers insights into how a given person in a given context makes sense of a given phenomenon (Smith and Osborn, 2003). Moreover, this paradigm enables us to explain the multiple realities of the world, i.e., to explain the multiple views held by different members (Creswell and Clark, 2012) in the IBS decision-making system.

As a preface to the systematic interpretation of data to identify the contextual, structural and behavioural influences involved, a semi-structured face-to-face interview approach was used to obtain in-depth information about the manner in which a variety of construction professionals across the Malaysian construction industry operate. The advantages of the semi-structured face-to-face interview are reliability, control and speed of data collection, because the same format is used with each respondent (Irvine et al., 2010). This approach allows answers that are more elaborate and detailed via a set of questions in the presence of an interviewee with the interviewer completing the answers based on the interviewees response. This method continues to require genuine human interaction to explore the 'inner world' (feelings, attitudes and perceptions) or the psychological reality of the interviewee (e.g., Knapp, 2012). In support of this qualitative method, Myers and Newman's (2007) also recommend the use of a dramaturgical model to assist researchers in preparing for interviews, to aid disclosures and to improve both the quantity and quality of data gathered.

An inter-project context, where stakeholders construct narratives that are based on their experiences across various projects, provide an opportunity to position via a research perspective associated with knowledge exchange across the industry when the adoption of new technologies or the development of new project routines could be used and applied elsewhere in other projects (Di Vincenzo and Mascia, 2012). Therefore, this inter-project perspective was selected because it was considered important to interview stakeholders who had gained practical knowledge and work involvement in building projects across the construction industry and were thus able to share experiences across the sector.

Several strategies were used to ensure all relevant data were collected. As recommended by Anderson (2011) and King and Horrocks (2010), the interview procedures were well prepared, using the participants' own language and depending on participants' own processes, interpretations and understanding. Coding frames were developed in advance to reflect the emerging themes of the study, with short and specific questions based on the order of pre-coded response categories to enable responses to be matched against each category.

Although the synthesis of literature identified contextual, structural and behavioural factors, direct questions on the topic were avoided to minimise leading question bias. The interview script was organised into four broad sections enabling the respondents to express their experiences and perceptions in a fluid manner. This approach avoided the interviewer steering respondents directly towards the major research themes (see appendix for the questions). Experienced construction professionals were selected as the most suitable stakeholder participants because they had developed knowledge, skills and insights from working in the construction industry (Dainty et al., 2003) and would be able to provide, and elaborate on, the information needed. A purposive participant recruitment method was used. To verify the decision-making of the construction professionals and gather a broad cross-section of perception and opinion across the construction industry, criteria of the hierarchical level, the functional responsibility and the area of responsibility for participant recruitment were applied. Thus, a sample of organisations was first selected based on information obtained from the Malaysian Builders Directory (2011/2012) and were requested to identify potential organisational members to participate in the research. From these submissions, a reduced set of potential participants were selected according to their professional positions and was composed of design architects, quantity surveyors, developers, consultants, contractors, civil

engineers, project managers, manufacturers and client/owners. A final set of 27 participants were selected, with 3 from each type of construction profession. The interviewees were selected from a wide range of backgrounds in terms of their work experience and academic qualifications (Table 1). Confidentiality was assured through a research ethics process.

Table 1 Participant profiles

	Profile	
Priority of decision category	Both group & individual	High
	Group only	Medium
	Individual only	Low
Working experience of construction-profession stakeholders	More than 20 years	9
	10 to 20 years	13
	Less than 20 years	5
Qualifications/ academic background	PhD	-
	Master's	5
	Bachelor's Degree	20
	Diploma	2
	Other	-

Prior to the interviews, the 27 participants were contacted with information statements, consent forms and interview schedules, and a suitable time was arranged for a face-to-face meeting. Interviews were recorded electronically for recollection during data analysis. Detailed notes were made throughout the interview to assist the researcher in determining what words, phrase or ideas should be recorded (e.g., Rapley, 2011). This process also allows the researcher to record tone and speech patterns from the face-to-face interview, which can help clarify or recall the meaning of the words, phrases or ideas raised. Each interview session lasted an average of 50 minutes. The patterns emerging from preliminary thematic analysis of the interview transcripts and evolving around the research's main topic were classified into key concepts by reference to the literature prior to being analysed via content analysis. The emphasis placed by each participant on key phrases, previously identified through the preliminary analysis, was analysed according to the frequency of occurrence or references in the interview text document and within the context of the information gathered. The outstanding factors were then ranked according to their frequency and cross-referenced with extracts from the interviews containing the relevant phrase, to enable the relevant information to be extracted accordingly.

Results and discussion

Content analysis

The content analysis of the data indicates the most dominant factors and themes emerging from the narratives relating to IBS adoption can be aligned to structural, contextual and behavioural factors. These factors and themes are ranked by theme, factors within a theme, and aspects within factors in Table 2 according to the frequency of the associated themes, factors and aspects.

Table 2: Frequency of themes, factors, and aspects associated with structural, contextual and behavioural factors relating to IBS decision-making

CORE FACTORS/ THEMES:	Factors and number of references		Aspects and number of references									
1. STRUCTURAL (4010 references)	Project Condition	1197	Development	341	Operation	300	Risk	278	Information	225		
	Procurement Setup	1117	Costs	420	Clients	267	Resources	136	Supply chain	112		
	Management Approach	1112	Process	393	Planning	281	Goals	103	Strategy	97	Leadership	74
	Communication Process	201	Formal	81	Informal	15						
	Decision-making Style	151	Group	80	Nature	34	Individual	32				
2.CONTEXTUAL (3397 references)	Economic Conditions	1252	Business	398	Demand	166	Opportunity	92	Uncertainty	69	Competition	66
	Technology Development	774	Productivity	230	Quality	175	Innovation	106	Creativity	36		
	Government Involvement	533	Promotion	152	Policy	103	Requirement	78	Rules	65		
	Sustainability Feature	373	Environment	143	Efficient	83	Trends	45	Waste	45		
	Stakeholders Participation	360	Opinion	140	Partnership	136						
BEHAVIOURAL (2899 references)	Experience	917	Failure experience	343	Success experience	316						
	Bounded Rationality	872	Learning	348	Justification	218	Cognition	138	Choice	121		
	Awareness	639	Values	209	Support	150	Culture	101	Personality	61		
	Attitude	403	Positive attitude	265	Negative attitude	51						

The ‘structural’ and ‘contextual’ themes have five factors impacting the IBS decision, whereas ‘behavioural’ has four factors. Each of these factors are influenced by different ‘aspects’. As an example, an IBS adoption decision can be influenced by the factor ‘procurement setup’ under the ‘Structural’ theme. ‘Aspects’ such as cost, clients, resources and supply chain will influence the ‘procurement setup’. Similarly, the other fourteen factors classified under ‘structural, ‘contextual’ and ‘behavioural’ factors are influenced by 49 aspects, as illustrated in Table 2. The remainder of this section provides a detailed account of the factors and aspects influencing IBS adoption decisions. Moreover, the discussion indicates possible complex interconnections and interactions between the ‘structural’ (or project organisation-focused) factors and ‘contextual’ (environmental or external to project) factors and ‘behavioural’ (people focused) factors. Projects (structural theme) generally operates in the external environment (contextual theme) and are driven by people (behavioural theme); therefore, the factors naturally interact. The structural factors are discussed initially with reference to ‘contextual’ and ‘behavioural factors’, presented subsequently (refer to Figure 1).

Figure 1: The interaction between IBS adoption themes and factors

Structural Factors

Structural factors were most frequently narrated in the interviews. Factors are primarily focused situational factors influencing decisions on IBS adoption, based on the nature of project organisation or their characteristics.

Project conditions

The interviewees consider that analysing project conditions is essential because doing so provides inputs to the IBS adoption decision due to both the conditions' relevancy and impact. As one interviewee said, "…we are more involved in operational decisions; some are technical, and some are on the management side. We also act on behalf of the owner to oversee the project implementation..." (Design architect).

Project-development appeared to be frequently referred to as part of the project conditions as this is related to construction industry attractiveness and business position, which influences the IBS decision as an investment opportunity (Ding and Shen, 2010). For example, "Tasks…central to the decision-making process throughout the development of a project from initial inception to final completion…" (Quantity surveyor). Understanding *Project operations* involving several important strategic considerations in project operations, such as measuring performance and the control of time, resources, site activities and quality (Arif and Egbu, 2010) influence the IBS adoption decision.

The aspect of project *risk*s' specially associated adoption of new technology is also perceived as fundamental in the assessment of IBS adoption (Goulding et al., 2012b), specifically in an environment of uncertainty. An interviewee indicated that "… it is important to recognise that incentives must be provided if any of the project members is expected to take a greater risk [in the face of uncertainty…" (Contractor). The aspects of *project development, project operations* and *project risk* interact with the factor '*economic condition*s' (i.e., uncertainty, demand aspects and competition in the industry) under the 'Contextual' theme. Moreover, risk taking is impacted by behavioural factors such as bounded rationality.

The adequacy of *project information* is another consideration (Cavieres et al., 2011). Project information could be viewed as an unconscious and integral component of most other aspects. For example, project information can influence the project development, risk assessment and operational dimensions. Moreover, the project information is also akin to 'behavioural theme', interacting with factors such as *experience and learning,* which leads to the generation of more accurate information.

Procurement setup

Interviewees believe that in the procurement of IBS projects, there are more project members and decision-makers who have different project responsibilities applying different criteria to their procurement decisions. The *cost* (also encompasses terms such as profit, price and return) is a factor influencing decisions (Li et al., 2011) and "…IBS project proposals are often rejected solely on the basis of cost…" (Design architect). Appropriate cost planning and value management, the evaluation of alternative designs against the value criteria project cash flow and the return on investment analysis that provides a means of comparing the attractiveness of investments between IBS projects is critical. This aspect can be impacted by the planning and decision-making style.

Delivering the client requirements is also based on the *availability of resources*, as building-technology choices must consider such resources as funds and the management of time, human skills and materials (Klein, 2000). As stated, "…we decide on what new project to start, what business to start or to abandon, how to allocate resources, whether to expand operations or diversify..." (Client) and "...IBS knowledge is still very much needed for design, fabrication and installation work. Therefore, if the industry can ensure the availability of skilled workers in all three areas…" (Quantity surveyor).

The consideration of IBS components and *supply chain* logistic issues, materials handling and the costs involved are vital (Doran and Giannakis, 2011). The aspects of cost, resources, and supply chain are impacted by contextual factors such as economic conditions, government involvement, stakeholder participation and technology development. Moreover, *Client requirements and views* influence the IBS adoption because this dominates the decisions, regardless of what the other stakeholders may prefer. This aspect is influenced by behavioural factors such as *attitudes, awareness and experience*.

Management approach

The management approach, which ensures the delivery of a construction project through deploying appropriate processes, planning, goal setting, strategy development and leadership, influences the decisions on IBS adoption. The *management processes*, involving activities such as organising, controlling, evaluating and forecasting, impact the IBS adoption decisions (Doran and Giannakis, 2011). The *planning mechanism*, particularly issues relating to the availably/allocation of resources, the extent of the demand for building and the changing nature of the industry (Williams and Samset, 2010) also impacts IBS decisions. Interviews indicated that "…there is a need to improve the integration, planning and control of IBS not only in design but also in IBS production and logistics…" (Contractor); in addition, they must incorporate "…a range of [other] activities, which may include cost planning, feasibility studies, cost benefit analysis, life-cycle costing…" (Quantity surveyor) in the planning.

The *consideration of project goals* is viewed as a factor enabling decision-makers to have a clearer sense of direction and to create a benchmark against which project performance and the effectiveness of IBS technology adoption can subsequently be measured. For example, interviewees indicated that, when "… owners provide the design team with detailed functional requirements and project goals for the proposed building…" (Developer), a level of fragmentation in the decision process is created. The *project strategy* (Langford and Male, 2008) also influences the IBS adoption decisions. The participants indicated that they "conduct cost-benefit analysis to determine whether or not to go forward with each strategy…" (Design architect). The *leadership* is important to the extent that leaders demonstrate their level of commitment, initiatives, directions and support towards IBS technology adoption.

The 'management approach' factors interacts significantly with the behavioural theme. The planning, goals, strategy and leadership are influenced by the experience, awareness, attitude and bounded rationality.

Communication process

Communication, i.e., interacting, messaging, documenting, reporting and activities from a project and organisation perspective, influences IBS adoption. As one interviewee asserted, "…we can control the project development through communication…" (Client). In deciding whether to adopt IBS, project members must engage in effective "…cooperation and communication … to discuss [and share information] on project development…" (Consultant).

Both formal and informal communication are needed to obtain input from various sources. However, *formal communication* is considered the most vital in providing inputs for the IBS decision process, especially when informing about the benefits to be gained. Formal communication channels enable the validation of the source of information, not only for the project in question but also as a reference for future projects. Interviews attested that they " … mostly rely on formal documentations in [their] communication…" (Client). In addition, formal communication channels link internal and external parties effectively to discuss project

developments and technical performance especially "when dealing with authorities, [parties] have to be formal with a lot of written work…" (Developer).

Informal communication is viewed as critical in linking individuals through personal contacts; in certain circumstances, information cannot be obtained by any other means (Gajendran and Brewer, 2012). "...it has to be communicated by telephone only. Its sounds informal but it has to be that way…" (Contractor).

The 'communication process' factors also interact significantly with the behavioural theme. Formal and informal communications are influenced by the attitudes, awareness, and bounded rationality, which are influenced by experience, awareness, attitude and bounded rationality. Moreover, the communication process also interacts with structural factors, the 'decision making style', the 'procumbent setup' and the 'management approach'

Decision-making style

The collective and consensus nature of *Group decision-making* is generally open to multiple information sources and decision tracking processes and assists project decision-makers in the early identification of opportunities/problems (Lahdenperä, 2012). Moreover, this decision-making style can enable the gathering of timely information from experienced team members, particularly information related to project operational measures, project performance and expert advice. Therefore, group decision-making offers proactive conflict or issue resolution relating to IBS technology, with various ideas and options. The interviews suggest that "…most of the decisions … based on client [requirements or] …internal operation of our company…" (Design architect) are best arrived through group decision making. Moreover, firms indicate that "...our decisions are not all ours. Maybe we can decide on [using] IBS, but if it is not really agreed by other project members, then it will not work" (Developer).

Individual decision-making is also referenced as an aspect used in Malaysia, often based on the authority to resolve conflicts. However, some of the interviewees expressed that individual decision-making could reduce the project or IBS information requirements, the number of information sources and the depth of project analysis to accelerate choices or final decisions.

Contextual Factors

Contextual factors were the second most frequently noted in the interviews and included the full spectrum of external project perspectives to understand industry changes, dynamics and their implications on the decision to adopt IBS. The contextual factors are a function of complex economic, technological, governmental, stakeholder and sustainability factors.

Economic conditions

Economic conditions are necessary to understand and evaluate the performance of the construction industry in terms of its economic growth, progress and expansion/contraction. This factor interacts with the factors in the structural theme, specifically during the consideration of project conditions and procurement setup factors in the decision to adopt IBS. For example, in "...economic development leading to a stronger purchase market, rise of 'buy-to-let' market…" (Developer) can impact IBS adoption. Particularly important is assessing the forecasted economic growth rates and income levels for a construction project and other potential markets pertaining to IBS technology adoption. However, the "… increased perception of the negative impact they could have on an IBS project and economy growth

[associated to IBS manufacturing sector] in the year ahead…" (Consultant) and "…the same goes for IBS where it also impacts the national economy…" (Manufacturer) are also important.

The results indicate that *business dynamics* can be influenced by the structure of the industry, which includes the following: the number of IBS suppliers or manufacturers, the ownership IBS project technologies, the cost structures, the IBS technology transfer, the market share and the existence of joint ventures. These items implicitly impact the stakeholders' views in terms of technology strategy, project development and procurement (Brady and Davies, 2004). The dynamics of the IBS product markets can impact adoption (Lim et al., 2010) as "…demand for an industrial product may be short-lived and, if a company does not hit the market first, there may not be demand for its product later" (Developer). These dynamics indicate a project's position in the construction market as favourable, strong, dominant, weak or non-viable.

The *demand for new building technology* (Nawari, 2012) can impact the structure of the construction industry, which then influences industry businesses and subsequently industry performance. The demand forecasts of IBS buildings can have implications for IBS adoption, such as the demand for rapid-build projects increased the focus on addressing issues with onsite construction quality and an offsite construction innovation push. As one participant commented, "…the continuous stability [or increasing demand and repetition] of work is very important to ensure that all of the IBS players can be sustained for a long period…" (Design architect).

The level of *competition* in the supply of IBS can change over time (Halpin & Senior, 2010). As noted, "… the important consideration in the procurement process is to acquire goods and services by competition…" (Client) and with "heightened competition, good project management and improved productivity …" IBS adoption will increase (Manufacturer). Conversely, tracking the economic trends and the development potential is viewed as a means of exploring IBS project *opportunities* for increasing the competitive advantage (Pan et al., 2012) as "...a contracting firm may see their advantage in new technologies and emphasise profit opportunities" (Project manager), and "the IBS market is likely to witness more opportunities…" (Developer).

The attention to *uncertainty* in the economic environment is perceived as essential in conducting evaluations of the economic aspects discussed above. For example, explaining "… uncertainties [that] can create risks [impacting on] the project objectives…" (Client) "will make [stakeholders] less vulnerable to future changes caused by economic uncertainty…" (Manufacturer).

Technology development

The other contextual factor relates to the constantly evolving nature of technology development in the construction industry and emphasises a need to identify and respond to the relevant changes that occur in terms of future growth opportunities and improvements in a more specific and knowledgeable way (Yunus and Yang, 2012). This factor interacts with structural and behavioural theme, especially providing information for learning, evaluating experiences and making sound decisions. The interviewees generally believe there is a need for building projects to adapt to such development, perhaps significantly, or result in the negative consequences of their current position. The potential growth patterns in IBS technology also provides a rationale for its assessment in building project performance, with *productivity* being a particularly influential factor. As one participant commented, "Another issue concerns IBS productivity itself. IBS projects must have a sufficient ratio of production output volume to the input resource volume..." (Quantity surveyor). Many others are also convinced that this volume ratio is the case. As one participant argues, "Besides requiring minimal labour, IBS offers better

quality, increased productivity and faster completion, less wastage with safer and cleaner construction sites..." (Civil engineer).

The quality of technology, as demonstrated by the elimination of defects, the ease of installation or the implementation, complying with building standards, time completions and overall performance, is considered a factor influencing IBS adoption. For example, the "decisions… [are based on] the evaluation of alternative designs against our value criteria for function, quality and durability…" (Client), and interviewees believe "the quality of the IBS is more secured because the manufacturer imposes strict quality control over the materials, production process, curing temperature, etc.…" (Client). *Innovation* aspects, which involve radical new products or solutions through continuous improvement or new-to-market modifications or improvements of existing IBS technology, can also impact IBS adoption. Interviewees suggest that "…collaboration among stakeholders in IBS is vital towards the success of innovation in construction …" (Developer), and "…without these technological innovations, IBS wouldn't have been possible…" (Manufacturer). This aspect interacts with the 'stakeholder participation' factor in the contextual theme. Moreover, *creativity* is perceived as reinforcing innovation and facilitating new IBS technology abilities in that "…considerable initiative and creativity may be required to overcome or exploit…" (Quantity surveyor) and that this "…can reinforce each other…provided that creativity and innovation instead of routine practice are emphasized…" (Project manager).

Government involvement

In Malaysia, the construction industry is moving towards becoming a technology driven sector through the adoption of innovative technologies such as IBS, and the government is forging ahead with this agenda (Lou et al. 2012). The interviewees consider "…the government's role in IBS [as] very important…" (Quantity surveyor) and, specifically "for public projects, … the government can play its role, but the challenge is in private projects, especially housing projects…" (Consultant). The government plays its role through its policies, rules and requirements, the promotion/advocacy as a major construction client, and in determining the competitive directions of the construction industry and in IBS decision-making. This factor interacts with all of the factors in the structural theme.

Government promotion of IBS creates attention, awareness, knowledge, interests and action in the industry (Mohmad et al 2009). This promotion interacts with the behavioural factors such as awareness, attitudes and bounded rationality. As noted, "…the government's concerted effort to encourage both investors and the public to embrace IBS technology has involved it allocating a lot of money…" (Developer), and "the incentives and promotion offered by CIDB and through the government policies look promising …" (Civil engineer). However, according to the interviewees, it is extremely important to determine and evaluate the effectiveness of the government's IBS promotional activities because the interpretation of these promotions may not be translated as it should, thus creating uncertainties or doubts. However, "…government encouragement [may] not be the major consideration if other factors are not [conducive]" for IBS adoption (Design architect). It is also believed that the industry's response to IBS technology was less encouraging, except for public projects, and that there was a need to first identify the *IBS technology policy* likely to have the greatest impact upon the project. An interviewee suggested that he "refer[s] to previous IBS projects to find ways to improve the implementation of IBS in terms of the current policy and guidelines available" (Developer).

Government requirements pertaining to IBS technology adoption need to be clear. Interviewees expressed that a suitable fit between the government's key IBS technology requirements and the characteristics of building design need to align. For example, "The most

important thing in considering IBS are the statutory requirements that IBS building designs have to comply with such as planning and building control, fire, safety and standards" (Contractor), and "Buildings that meet the requirements of our national standards…typically can increase asset value…" (Developer).

The *rules and regulations* concerning standardisation are a particular concern as "…the use of IBS needs government involvement as it costs a lot of money in terms of standardisation of sizes …" (Client), and "The government has to make more progress in terms of standardisation because the lack of uniformity in building projects has serious impact on design…" (Consultant). The regulation of building standards is viewed as the final government factor, although the need for such compliance is currently a component of the project development requirements in Malaysia. For example, "…the CIDB's IBS design guide contains the modular coordination concepts, design rules, drawings and preferred dimensions for architectural finishes…" (Client), and "…the authorities are pursuing power and access in some project rulings" (Developer).

Sustainability features

The *sustainability* discourse also influences IBS adoption decisions (Yunus and Yang, 2012) because "…people are talking about sustainability and green construction, which is understood to be more than just insulation and waste reduction..." (Client). All of the interviewees recognise the role of IBS in *environmental improvement*. Interviewees indicated that "if we are talking about green environment, [we] have to consider if IBS can tackle and handle this problem…" (Consultant). This consideration involves "…several ways to consider IBS for the betterment of our environment and standard of living..." (Civil engineer) such as to "…greatly reduce the usage of conventional timber and therefore the environment will be preserved…" (Client) and "…enable automation processes to perform sequences of tasks onsite by interaction with its environment in a more systematic way" (Developer). However, interviewees acknowledged that IBS adoption decisions are hindered by a short-term preoccupation with project specifications rather than a longer-term consideration of environmental issues.

Improved efficiency is a business sustainability consideration in terms of the faster completion of projects (Arif and Egbu, 2010; Nadim and Goulding, 2010). Interviews indicated that *"*...the government has allocated a lot of money and budget to intensify IBS awareness and to encourage more efficient construction practices…" (Developer). Because IBS involves offsite manufacturing activities in a controlled environment, this has created an efficient working environment with fewer hazards and less congestion. Moreover, the participants acknowledge that IBS could reduce a building project's dependence on more unskilled or imported labour, thus improving the efficiency and reducing the vulnerability in the construction sector.

Living trends are also perceived as an essential sustainability consideration, based on the change in social and demographic environments, as reflected in the popular demand for smarter buildings with a greater emphasis on building methods of convenience. As one participant commented, IBS has the potential "…to change owner's perceptions based on our lifestyle or culture and incentives…" (Design architect).

IBS can improve *waste management* due to the factory-controlled manufacturing/prefabrication environment. As one participant remarked, "…one of the ways IBS enables the betterment of our environment and standard of living is its focus on the reduction of materials and construction waste on site…" (Civil engineer). The 'sustainability' factor can interact with behavioural aspects in terms of bounded rationality; i.e., the changing living trends and improved efficiency can create different justifications for IBS adoption

Stakeholder participation

'Stakeholder participation' tends to concentrate on particular elements of a project as a business in terms of the specific identification of the financial return, the project margin, the accomplishment of project milestones, the market share and the IBS technology quality and reliability. As one participant noted, *"*what is important is for stakeholders to promote a sense of common purpose and direction in IBS use…" (Developer). *Stakeholder opinions* can provide important information for predicting the future potential in adopting IBS technology. One interview suggested: "…we often consider stakeholders' opinions in the areas that involve issues concerning costs…" (Quantity surveyor).

The *partnership development* is becoming increasingly useful in exploring IBS opportunities and entering into IBS markets/projects. Partnerships offer the advantage of access to shared knowledge, improved understanding/experience of IBS technology adoption, and sharing the risks and costs involved in this kind of strategic partnership. As one interviewee commented, "…it is critical that both contractor and government work in partnership to achieve the outcomes sought" (Client).

Behavioural Factors

Decision-making, including decisions on the adoption of IBS technology, inherently involves a human element in the determination of a course of action in a construction project (Walker, 2011). Hence, as perceived by the construction-profession stakeholders, IBS decision-making was also influenced by the behavioural factors in making appropriate choices and judgements. As one participant intimated, IBS "…still requires human skills and experts to establish a stable application" (Developer). These factors are summarised here in terms of experience, bounded rationality, people awareness and attitude. The factors in the behavioural theme significantly interacts with factors in the structural theme.

Experience

The 'Experience' of decision makers is perceived to be because the type of judgements required are driven from a wide variety of experience gathered from building projects. Thus, decisions are influenced significantly by the perceived previous success of IBS technology, broadly across building sectors and on specific projects. "…people want to see a lot success stories. I believe this is important to change people's mind" (Design architect).

However, the experience of *project failures*, such as technical failures, cost overruns, over- or under-estimation, time extensions and operational and management problems, can induce negative reactions. As two participants commented, "…failure of technology transfer also results in the low reception of IBS in the Malaysian market…" (Design architect), and "…those who have faced IBS project failure have different perspectives like growing anxiety and frustration…" (Civil engineer). Similarly, "When a claim is made against one of the project failure, it is difficult for the public to know whether a corrective measure has been taken or simply that a mistake has occurred…" (Contractor) and that "…the downsides are just as evident: clients' fear of the IBS image buildings and memories of past IBS failures..." (Consultant). This observation may not always be the case; for example, "As with many business considerations, people benefit if they really experience [what is involved]…" (Contractor), and "…previous industry experience is very helpful especially when estimated costs are exceeded…" (Manufacturer).

Of particular note, "…all lessons learnt should be shared among interested parties in order to inform future project planning in the light of experience with the project" (Client). This finding is particularly important with *project successes*, where "…we have to look at other IBS projects that are performing well in the industry" (Client). This perspective applies to project failures, which can provide an equally useful insight into their causes. As indicated by one participant, "From those problems and failures, we should improve all aspects of future projects..." (Contractor).

Bounded rationality

The recognition of the limited capability in human thinking, despite the ability to think strategically, plays an unpredictable role in decision-making. In certain circumstances, decisions are not made entirely on managerial and economic rationality (Simon, 1991). While alternative courses of action pertaining to IBS technology adoption are analysed, organised and presented in rational and neutral terms, the choice is necessarily biased in accordance with the decision-maker's personal set of bias, values, attitudes and justifications. As noted, *"...*some designers try to justify their decisions by saying their design just 'looks good'" (Client). This statement explains many idiosyncratic decisions, such as "…owners and contractors having different perceptions on project management for construction" (Consultant) and force of habit, as in "Our operation is basically re-implementing our very own custom production. (Manufacturer) and "We are only into IBS in several aspects… (Civil engineer).

For many of the interviewees, lack of *learning* is the most relevant factor in IBS decision-making, with building-project members tending to make mistakes by focusing on what they have done in the past rather than what they are most likely to improve in a future project. For example, "…learning from experience is very important. If one has to work on an IBS project, we have to analyse the performance of previous projects…" (Contractor). As recognised by the interviewees, it is vital to put a great deal of effort into not only learning about previous experiences in building projects but also developing a detailed understanding of clients' and project members' perceptions and expectations, and the extent to which these could be met. As one participant commented, "…we need to increase efficiency and productivity through continuous learning and training to keep pace with time and survive in a competitive market or else we will be left behind" (Design architect).

A number of participants highlighted that working on building-project technology such as IBS with limited time for problem solving and decision-making could lead decision-makers to appreciate the more efficient use of information to accelerate decision-making through a cognitive process.

Cognition, i.e., the information-processing capabilities of decision-makers based on their knowledge and understanding, is considered to have a significant effect on the IBS decision. The interviews commented that "…we have the ability to implement positive change resulting from our deep understanding of project management resulting from our experience in numerous projects" (Consultant) and that "We have to think what sort of interactions that can help in the transfer and sharing of 'know-how' knowledge and experience are more likely to result in competitive advantage" (Developer).

During the cognitive process, a final *choice* is made based on several alternatives generated from various information inputs. This process is considered crucial when the alternatives are described by many attributes or when a course of action is needed to attain multiple project objectives. Interviewees indicated that "…IBS is definitely an alternative approach of construction that is used together with traditional building methods to save time…"

(Developer), and "extending or altering an existing building could provide alternative and possibly cheaper solutions …" (Design architect).

People awareness

The other behavioural factor that affects IBS decision-making is people awareness. This awareness depends on the culture, personality, support and values. The basic underlying principle is the ability of people to recognise any matter, issue, object, problem or solution by the same, or different, means. Therefore, it is important to have a certain level of awareness and understanding of IBS technology and its related developments in the industry. For example, "...to develop the maturity of project owners, appropriate structures must be created and the awareness of the role must be increased too..." (Client), and "…project owners must be aware of the impacts of the regulations on the costs…" (Manufacturer).

The participants highlighted the need to determine the value system of construction players and their awareness of IBS adoption in the industry. Therefore, by understanding the manner in which people respond to IBS technology and its related developments based on their *values and concerns*, IBS decision-making is also tailored according to people's response and values, as reflected in the comment that: "Our consulting services are coordinated with all parties so everyone can share in the value. It is also the same if we want to value IBS from sustainability perspective" (Consultant).

The next awareness influence is in *support towards IBS technology adoption*. Here, it is maintained that the expectations and support of the project members exert an influence on IBS decision-making, although individuals may well have a variety of personal aspirations. For example, *"*If there was already support in our country to have [a] good view of IBS it would definitely not be that difficult to implement here..." (Design architect).

Culture has a similar influence, with commonly held core beliefs and practices within projects and the construction industry considered essential because industry culture influences the manner in which stakeholders in the construction industry behave towards (Gajendran et al., 2012) and respond to IBS technology adoption. For example, "...architectural design is actually all about representing the cultural and traditions of people in a way based on our society's belief and confidence in its unique characteristics" (Design architect).

Personality provides the final awareness factor, with the comment that "There are some definitive positive traits, which we should possess when doing our tasks. By having these traits, we can do better in project implementation" (Civil Engineer) and "…we have to create a kind of management with influence because a project manager should have a personality or other characteristics to convince others" (Project manager).

Attitude

Attitude regards how different project members think or feel about IBS adoption (Brewer and Gajendran, 2012). Whether the project team members' attitudes towards IBS are positive or negative affects the IBS uptake. The need for a *positive outlook* is also apparent internally in "…developing a team environment where members have the confidence to operate on their own initiative but within clearly defined boundaries in IBS…" (Developer). It is also recognised that with a more positive attitude, construction entities would be more receptive to IBS technology. Moreover, those with positive attitudes are perceived as relatively more subjective in evaluating and considering the IBS technology adoption and can thus provide suitable encouragement and guidance. Obviously, differences in values and attitudes towards

IBS technology adoption are likely to be reflected in the behaviour of those involved, in which case, "…as a manager you must respond to this resistance with patience, confidence and positive support if we really want to adopt IBS" (Client).

In contrast, a *negative attitude* is viewed as the least helpful in IBS adoption. For example, "…some contractors even expressed that they are strongly reluctant in using IBS as they resist changing from their conventional system" (Quantity surveyor). This aspect critically interacts with the 'procurement setup' and 'decision style' factor.

Conclusions

The slow adoption of IBS in general is primarily attributed to cost, skill and customer attitude issues, generating a research gap to identify the broader factors impacting IBS adoption. The findings of this research suggest that numerous structural, contextual and behavioural factors influence IBS-related decision-making by construction profession stakeholders in Malaysia. The 'structural' theme encompasses five factors, namely, Project Condition, Procurement Setup, Management Approach, Communication Process, and Decision-making Style, which are influenced by nineteen aspects. The 'contextual' themes also have 5 factors, namely, Economics Conditions, Technology Development, Government Involvement, Sustainability Feature, and Stakeholder Participation, which are influenced by nineteen aspects.
The 'behavioural' has four factors, namely, Experience, Bounded Rationality, Awareness and Attitude, which are influenced by twelve aspects.

'Project conditions' is the most frequently identified factor influencing IBS adoption decisions; this is followed by the procurement setup and management approach. Moreover, 'economic conditions', which are the business prospects for different construction methods, and the technology development, particularly in productivity and quality, and government involvement also influence IBS decisions. Most of the stakeholders also identified behavioural factors as having an influence on IBS decisions, including the extent of project experience allowing IBS-related information to be gained; in addition, direct involvement in IBS projects could provide the knowledge and understanding required in the decision-making process. The findings provide an empirical account of the wide range of factors that impact IBS decision-making that can lead to further research using quantitative conformity studies.

The implications are, first, that the IBS adoption decision should involve a more integrative process that considers not only project and socio-economic factors but also human-related aspects or behavioural factors. Developing an integrative process requires the generation of a transparent decision frame that consciously evaluates all relevant factors influencing IBS adoption. Thus, many unconcise negative perceptions associated with the factors can be scrutinised, leading to a more effective decision outcome. Second, the influencing factors can be interactive; thus, it is also important to determine the relevancy of each factor to the nature of the project and its decision-making styles. This redevelopment in IBS decision-making factors should foster societal consideration in the construction industry and provide the foundations required to facilitate effective IBS decision-making in building projects. Finally, IBS adoption decision is complex in nature and influenced by many interconnected 'aspects'. However, because the intensity of influence of these factors/aspects may differ across different countries, any attempt to develop a strategy or policy to increase IBS adoption or integration needs to be targeted.

The limitations of this study are that only a partial geographical area is covered; i.e., the results are only representative of the Malaysian construction industry. Additionally, as the information gathered from the organisational representatives is based on the organisational members' perception and interpretations of IBS decision-making, it was only possible to obtain

data on the generalised decision-making process and the mechanism of IBS technology adoption rather than on specific procedures for IBS decision-making. Finally, the issues covered depended on the willingness of a restricted sample of construction profession stakeholders to discuss the IBS decision-making process and the IBS technology adoption issues from personal perspectives.

In addition to resolving these issues, future research would benefit from follow-up studies using a similar methodology. For example, future research may do the following: identify the key intra-project influences involved and expand the research sample to consider other project types such as road and highway projects to improve the generalisability across the construction sectors. In addition, although a high number of interviews (27) was conducted, providing a suitable depth of data from an evenly distributed, multitude of stakeholders, other forms of data collection (questionnaire, workshops, and follow-up interviews/questionnaires) would be useful to increase the breadth and validate the findings. Further, it is recommended that future research investigate related organisations that engage in technology decision-making and specify the changes of dynamics in the manner in which building projects make or perceive IBS decisions and an IBS decision-making framework.

References

Abdullah, M. R., & Egbu, C. (2010) The role of knowledge management in improving the adoption and implementation practices of Industrialised Building System (IBS) in Malaysia. In *TG57-Special Track 18th CIB World Building Congress May 2010 Salford, United Kingdom*, 169.

Akadiri, P. O., & Olomolaiye, P. O. (2012). Development of sustainable assessment criteria for building materials selection. *Engineering, Construction and Architectural Management*, *19*(6), 666-687.

Anderson, R. (2011). Intuitive inquiry; The ways of the heart in Human Science Research, in Anderson, R. and Braud, W., *Transforming Self and Others Through Research: Transpersonal Research Methods and Skills for the Human Sciences and Humanities*, State University of New York Press, pp. 15.

Antunes, F. & Costa, J. P. (2011). Beyond decisions (or to decisions and beyond!): an outline of building blocks for a decision support and reconstruction framework. In *Proceedings of the Recent Advances in Business Administration: 5th WSEAS International Conference on Business Administration (ICBA'11)* (pp. 32-37).

Arif, M., & Egbu, C. (2010). Making a case for offsite construction in China. *Engineering, Construction and Architectural Management*, *17*(6), 536-548.

Blismas, N., Wakefield, R., & Hauser, B. (2010). Concrete prefabricated housing via advances in systems technologies: Development of a technology roadmap. *Engineering, Construction and Architectural Management*, *17*(1), 99-110.

Bouyssou, D., Dubois, D., Prade, H., & Pirlot, M. (2013). *Decision Making Process: Concepts and Methods*. Wiley-ISTE.

Brewer, G. & Gajendran, T. (2012). Attitudes, behaviours and the transmission of cultural traits: impacts on ICT/BIM use in a project team. *Construction Innovation* 12(2): 198 - 215.

Bryman, A. (2012). *Social Research Methods.* Oxford, Oxford University Press.

Cavieres, A., Gentry, R., & Al-Haddad, T. (2011). Knowledge-based parametric tools for concrete masonry walls: Conceptual design and preliminary structural analysis. *Automation in Construction*, *20*(6), 716-728.

Ceylan, M., Arslan, M. H., Ceylan, R., Kaltakci, M. Y., & Ozbay, Y. (2010). A new application area of ANN and ANFIS: determination of earthquake load reduction factor of prefabricated industrial buildings. *Civil Engineering and Environmental Systems*, *27*(1), 53-69.

CIDB (2009). *Industrialised Building System (IBS): Implementation Strategy from R&D Perspective.* Construction Industry Development Board Malaysia (CIDB), Kuala Lumpur.

Creswell, J. W. & Clark, V. L. P. (2007). *Designing and conducting mixed method research.* Thousand Oaks, Sage.

Creswell, J. W. & Clark, V. L. P. (2012). *Qualitative inquiry and research design: choosing among five approaches.* Thousand Oaks, Sage.

Dainty, A. (2008). *Methodological Pluralism in construction management research. Advanced methods in the built environment*. A. Knight and L. Ruddock. West Sussex, Wiley-Blackwell: 1-13.

Dainty, A. R., Cheng, M. I., & Moore, D. R. (2003). Redefining performance measures for construction project managers: an empirical evaluation. *Construction Management & Economics*, *21*(2), 209-218.

Demiralp, G., Guven, G., & Ergen, E. (2012). Analyzing the benefits of RFID technology for cost sharing in construction supply chains: A case study on prefabricated precast components. *Automation in Construction*, *24*, 120-129.

Di Vincenzo, F., & Mascia, D. (2012). Social capital in project-based organizations: Its role, structure, and impact on project performance. *International Journal of Project Management*, *30*(1), 5-14.

Ding, G. K., & Shen, L. Y. (2010). Assessing sustainability performance of built projects: a building process approach. *International Journal of Sustainable Development*, *13*(3), 267-279.

Doran, D., & Giannakis, M. (2011). An examination of a modular supply chain: a construction sector perspective. *Supply Chain Management: An International Journal*, *16*(4), 260-270.

Eftekhari, M., Hatamnia, A., & Bitarafan, M. (2012). Evaluating prefabrication level of shelters using hierarchical analysis method (AHP). *American Journal of Advanced Scientific Research*, *1*(2).

Ern, P. A. S., & Kasim, N. B. (2012, May). E-readiness for Industrialised Building System (IBS) components management: Exploratory study in Malaysian construction projects. In 2012 *International Conference on Innovation Management and Technology Research* (ICIMTR), (pp. 454-459). IEEE.

Faludi, J., Lepech, M. D., & Loisos, G. (2012). Using life cycle assessment methods to guide architectural decision-making for sustainable prefabricated modular buildings. *Journal of Green Building*, *7*(3), 151-170.

Fereday, J., & Muir-Cochrane, E. (2008). Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development. *International Journal of Qualitative Methods*, *5*(1), 80-92.

Finlay, L. (2009). Debating phenomenological research methods. *Phenomenology & Practice*, *3*(1), pp 6-25

Gajendran, T. & Brewer, G. (2012). "Collaboration in public sector projects: unearthing the contextual challenges posed in project environments." *Engineering Project Organization Journal* 2(3): 112-126.

Gajendran, T., G. Brewer, A. Dainty and G. Runeson (2012). "A conceptual approach to studying the organisational culture of construction projects." *Australasian Journal of Construction Economics and Building* 12(2): 1-26.

Goodier, C., & Gibb, A. (2007). Future opportunities for offsite in the UK. *Construction Management and Economics*, *25*(6), 585-595.

Goodier, C., Austin, S., Soetanto, R., & Dainty, A. (2010). Causal mapping and scenario building with multiple organisations. *Futures*, *42*(3), 219-229.

Goulding, J., Nadim, W., Petridis, P., & Alshawi, M. (2012a). Construction industry offsite production: A virtual reality interactive training environment prototype. *Advanced Engineering Informatics*, *26*(1), 103-116.

Goulding, J., Rahimian, F. P., Arif, M., & Sharp, M. (2012b). Offsite construction: strategic priorities for shaping the future research agenda. *Architectonica*, *1*, 62-73.

Haller, M and Stehn, L (2010) Standardizing the pre-design-phase for improved efficiency in off-site housing projects. In: Egbu, C. (Ed) *Procs 26th Annual ARCOM Conference*, 6-8 September 2010, Leeds, UK, Association of Researchers in Construction Management, 1259-1268.

Harris, F., & McCaffer, R. (2013). *Modern construction management*. Wiley Blackwell, New York

Holt, G. (2010). Contractor selection innovation: examination of two decades' published research. *Construction Innovation: Information, Process, Management*, *10*(3), 304-328.

Idrus, A., Hui, N. F. K., & Utomo, C. (2008, June). Perception of Industrialized Building System (IBS) within the Malaysian market. In *Proceeding of International Conference on Construction and Building Technology,* 75-92.

Irvine, A., Drew, P., & Sainsbury, R. (2010). Mode effects in qualitative interviews: a comparison of semi-structured face-to-face and telephone interviews using conversation analysis. *Research Works*, *3*.

Ismail, F., Yusuwan, N. M., & Baharuddin, H. E. A. (2012). Management factors for successful IBS projects implementation. *Procedia-Social and Behavioral Sciences*, *68*, 99-107.

Jones, M. & Saad, M. (2003) *Managing innovation in construction*, Thomas Telford, London.

Kamar, K. A. M., Alshawi, M., & Hamid, Z. (2009, January). Barriers to industrialized building system (IBS): The case of Malaysia. In *BuHu 9th Int. Postgraduate Research Conf. (IPGRC)* (pp. 471-484). University of Salford, Salford, UK.

Kassim, U., & Walid, L. (2013). Awareness of the Industrialized Building System (IBS) implementation in Northern Malaysia - a case study in Perlis. Procedia Engineering, 53, 58-63.

Kent, D. C., & Becerik-Gerber, B. (2010). Understanding construction industry experience and attitudes toward integrated project delivery. *Journal of Construction Engineering and Management*, *136*(8), 815-825.

Kim, S., Nussbaum, M. A., & Jia, B. (2012). The benefits of an additional worker are task-dependent: Assessing low-back injury risks during prefabricated (panelized) wall construction. *Applied Ergonomics*, *43*(5), 843-849.

King, N., & Horrocks, C. (2010). *Interviews in qualitative research*. Sage, London.

Klein, G. (2008). Naturalistic decision making. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *50*(3), 456-460.

Knapp, M. L. (2012). *Nonverbal communication in human interaction*. 8th Edition, Cengage Learnin, Stamford.

Lahdenperä, P. (2012). Making sense of the multi-party contractual arrangements of project partnering, project alliancing and integrated project delivery. *Construction Management and Economics*, 30(1), 57-79.

Langford, D., & Male, S. (2008). *Strategic management in construction*. John Wiley & Sons.

Li, H., Guo, H. L., Skitmore, M., Huang, T., Chan, K. Y. N., & Chan, G. (2011). Rethinking prefabricated construction management using the VP-based IKEA model in Hong Kong. *Construction Management and Economics*, *29*(3), 233-245.

Lou, E. C. W., & Kamar, K. A. M. (2012). Industrialized Building Systems: Strategic outlook for manufactured construction in Malaysia. *Journal of Architectural Engineering*, *18*(2), 69-74.
Lou, E. C. W., & Kamar, K. A. M. (2012). Industrialized Building Systems: Strategic outlook for manufactured construction in Malaysia. *Journal of Architectural Engineering*, *18*(2), 69-74.
Majid, T. A., Azman, M. N. A., Zakaria, S. A. S., Zaini, S. S., Yahya, A. S., Ahamad, M. S. S., & Hanafi, M. H.. (2011). Quantitative analysis on the level of IBS acceptance in the Malaysian construction industry. *Journal of Engineering Science and Technology*, 6(2), 179-190.

Malaysian Builders Directory (2011/2012), Marshall Cavendish Business Information, Kuala Lumpur.

Mohamad, M. I., Zawawi, M., & Nekooie, M. A. (2009). Implementing industrialised building system (IBS) in Malaysia: acceptance and awareness level, problems and strategies. *Malaysian Journal of Civil Engineering*, *21*(2), 219-234.
Mohamad, M. I., Zawawi, M., & Nekooie, M. A. (2009). Implementing industrialised building system (IBS) in Malaysia: acceptance and awareness level, problems and strategies. *Malaysian Journal of Civil Engineering*, *21*(2), 219-234.
Myers, M. D. and Newman, M. (2007). The qualitative interview in IS research: Examining the craft, *Information and Organization*, 17 (1), 2–26

Nadim, W. & Goulding, J. S. 2009. Offsite production in the UK: The construction industry and academia. *Architectural Engineering and Design Management*, 5, 136-152.

Nadim, W., & Goulding, J. S. (2010). Offsite production in the UK: the way forward? A UK construction industry perspective. *Construction Innovation: Information, Process, Management*, *10*(2), 181-202.

Nawi, M. N. M., Lee, A., & Nor, K. M. (2011). Barriers to implementation of the industrialised building system (IBS) in Malaysia. *The Built & Human Environment Review*, *4*.

Ng, T. S., Voo, Y. L., & Foster, S. J. (2012). Sustainability with ultra-high performance and geopolymer concrete construction. In *Innovative Materials and Techniques in Concrete Construction* (pp. 81-100). Springer Netherlands.

Ofori, G., Ai Lin, E. T. and Tjandra, I. K. (2011) Developing the construction industry: A decade of change in four countries In: Laryea, S., Leiringer, R. and Hughes, W. (Eds) *Procs West Africa Built Environment Research (WABER) Conference,* 19-21 July 2011, Accra, Ghana, 3-16.

Pan, W., & Goodier, C. (2011). House-building business models and off-site construction take-up. *Journal of Architectural Engineering*, *18*(2), 84-93.

Pan, W., Dainty, A. R., & Gibb, A. G. (2012a). Establishing and weighting decision criteria for building system selection in housing construction. *Journal of Construction Engineering and Management*, *138*(11), 1239-1250.

Pan, W., Gibb, A. G., & Dainty, A. R. (2007). Perspectives of UK housebuilders on the use of offsite modern methods of construction. *Construction Management and Economics*, *25*(2), 183-194.

Pryke, S., & Smyth, H. (2012). *The management of complex projects: a relationship approach*. John Wiley & Sons, Inc., New Jersey.

Rapley, T. (2011). Some pragmatics of data analysis. In Silverman, D. *Qualitative research*, 3rd Edition, Sage, London, pp 273-290.

Sarja, A. (Ed.). (2003). *Open and industrialised building* (Vol. 222). Taylor & Francis.

Simon, H. A. (1991) Bounded Rationality and Organisational Learning, *Organisation Science*, 2(1), 125 – 134.

Smith, J. A., Flowers, P., & Larkin, M. (2009). *Interpretative phenomenological analysis: Theory, method and research*. Sage, London

Smith, J.A. & Osborn, M. (2003) *Interpretativephenomenological analysis*. In J.A. Smith (Ed .), QualitativePsychology: A Practical Guide to Methods. London: Sage.

Smith, R. E. (2011). *Prefab architecture: A guide to modular design and construction*. Wiley.

Stanton, N. A., Salmon, P. M., Walker, G. H., Baber, C., & Jenkins, D. P. (2012). *Human factors methods: a practical guide for engineering and design*. Ashgate Publishing.

Thanoon, W. A. M., Peng, L. W., Kadir, M. R. A., Jaafar, M. S., & Salit, M. S. (2003). The Experiences of Malaysia and other countries in industrialised building system. In *Proceeding of International Conference on Industrialised Building Systems, Sep* (pp. 10-11). International Conference on Industrialised Building Systems, Kuala Lumpur, Malaysia, 10-11 September, 2003

Vernikos, V. K., Goodier, C. I., Nelson, R., & Robery, P. C. (2013). Implementing an offsite construction strategy: a UK contracting organisation case study. In Smith, S.D. and Ahiaga-Daghui, D.D. (eds.), *Proceedings of the 29th Annual ARCOM Conference*, Reading, U.K., 2-4 September, pp. 667-677.

Walker, A. (2011). *Organizational behaviour in construction*. Blackwell Publishing, London

Wilkinson, N., & Klaes, M. (2008). *An introduction to behavioral economics*. New York: Palgrave Macmillan.

Williams, T., & Samset, K. (2010). Issues in front-end decision making on projects. *Project Management Journal*, *41*(2), 38-49.

Xue, X. (2010). Cognition and decision making in construction engineering management. In *Computer Sciences and Convergence Information Technology (ICCIT), 2010 5th International Conference on* (pp. 748-750). IEEE.

Yee, H. M., & Siti, I. H. I. (2012) An investigation on effect of rebar on structural behaviour for wall-slab system. In *Business Engineering and Industrial Applications Colloquium (BEIAC), 2012 IEEE* (pp. 26-30). IEEE.

Yunus, R., & Yang, J. (2012). Critical sustainability factors in industrialised building systems. *Construction Innovation: Information, Process, Management*, *12*(4), 447-463.

Appendix

Interview Questions:

The questions were categorised into four groups:

(a) I'd like to understand the scope of your normal duties, during normal day-to-day work: (i) What is the nature of the decisions that you routinely must make, in terms of their scope, their influence on design and construction processes? (ii) What are the internal influences on these decisions i.e., influences from within your organisation? (iii) What are the external influences on these decisions i.e., from stakeholders within projects on which you're working? (iv) What is the degree of formality you employ when communicating them i.e., written justification for decisions taken?;

(b) Now I would like to understand the nature of your involvement in decision-making related to IBS: (i) Would you describe yourself or your organisation as enthusiastic supporters/adopters of IBS? Why do you believe this is the case? What is your understanding of the benefits/costs associated with IBS?);

(c) Now I would like to understand the business influences on the decision of whether to use IBS or not in your organisation: (i) What are the business considerations that lead you to decide whether to use IBS or not e.g., financial, technical knowledge, availability of skilled labour, availability of IBS products, risk? (ii) To what extent do you consider government

directives to be an influence on the use of IBS? (iii) To what extent do you consider the project procurement mechanisms to be an influence on the use of IBS on that project?

(d). Lastly, I would like to understand IBS adoption from your personal perspective: (i) What influence does past experience play in your IBS decision-making? (ii) What influence does the experience of others play in your decision-making? (iii) To what extent does the opinion of other stakeholders in a project influence your decision in relation to IBS adoption? (iv) To what extent do you consider the use of IBS in a project to be a decision that increases risk?