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Construction in Developing Countries

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The aim of this Commission is to study and effectively disseminate the possible ways and means by which the construction industry of developing countries can be continuously improved to enable them to fulfill the tasks required of them in the nations' drive to achieve social and economic progress.

The objectives of the Commission are:

• to undertake research into areas relating to the construction industry in developing countries, in order to understand its nature, strengths, weaknesses and needs and possible improvement measures.
• to disseminate useful research findings and best practices and monitor and facilitate their implementation
• to provide a forum for the exchange of experiences and information among construction researchers and administrators in developing countries
• to serve as a link between construction researchers and administrators in developing countries and their counterparts in industrialised countries, as well as international agencies involved in the field of construction industry development.
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A Knowledge Based Decision Support System (KBDSS) for Indonesian Contractors to implement Business Continuity Management (BCM)

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Abstract

Throughout the business process, crises may give various consequences to an organization, whether financial, legal or operational impacts. Being in an industry that is complex with high uncertainties, contractors are likely to experience costly errors if they are unprepared when a crisis strikes. As firms located over a vast geographical area, Indonesian contractors have also experienced various crises that have significant impacts on their business activities. To become resilient and capable of providing an effective response to such threats, Indonesian contractors need to adopt a systematic management concept in their organizations. Business Continuity Management (BCM) provides this framework, where it is not only focusing on overcoming crises, but also conducting activities that are needed for keeping the business operations running during a period of displacement or interruption. The initial step in developing BCM for Indonesian contractors is to understand the BCM implementation through its principles and non-technical aspects which are the organizational culture and institutional forces. This phase can be conducted in the form of an implementation guideline that starts with assessing the firm’s BCM level of preparedness, followed by relevant action plan recommendations. A Knowledge Based Decision Support System (KBDSS) can be used for developing this guideline where it is a computer-based system that supports decision making by aiding knowledge storage, retrieval, transfer and application by supporting knowledge access. This system provides quick access to all relevant information and the problem models that are evaluated in the system can be integrated into a logical framework. The objective of the study is to propose a framework for developing a BCM-KBDSS for Indonesian contractors. The study is based on an extensive literature review and benchmarking to BCM best practices. The result of this

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1. Introduction

The business world is currently experiencing an increasing level of uncertainty in its environment, where it can lead to adverse financial implications, damage to corporate reputation, viability and integrity (Marsh, 2007). Events like crises or emergencies can occur unexpectedly during the course of conducting business activities and these cannot be overlooked. A crisis may give various consequences to an organization, whether financial, legal, or operational consequences. It may disrupt the business process from a few minutes up to several months or years in extreme cases. These consequences can impact the business process, and hence may threaten the firm’s sustainability.

In order to overcome a crisis and to continue business as usual, an organization or firm must first have systematic ways and approaches in place. Although some organizations survive such events due to perseverance, but continuity of a business is primarily due to planning and preparation. One of the concepts that can be used is Business Continuity Management (BCM), where it is not only focusing on overcoming any crises that occurred, but also considering thoroughly on how to sustain the business in order to obtain its goals and mission. BCM provides a method for managing any disruption to ensure continuity of service when there is a disruption of business. Moreover, business continuity means to conduct activities that are needed for keeping the business operations running during a period of displacement or interruption (Smith, 2003).

In managing a crisis, decision making is considered as an important part of the process. Critical decisions such as task assignment, resource allocation, guidelines to long-term decisions, training and the control capabilities of the organization are necessary for this situation (Yoon et al, 2008). As part of a decision making process in responding to crises or unexpected events, BCM can be designed into an effective model, which is using computer application for providing faster and reliable decision. Based on the development of advanced computer programming technology nowadays, BCM can be automated by using a Decision Support System (DSS) (Eom and Min, 1999). A DSS can also be developed into a system which utilizes knowledge as its based information, where a knowledge base consists of groups of knowledge from experts which provide any information related to the focused problems (Mockler, 1989). The latter description is called Knowledge Based Decision Support System (KBDSS). The broad benefits from this system are that it provides a quick access for the user to all relevant information, the process is direct and personalized and the problem models that are evaluated in the system can be integrated into a logical framework.

One of the industries that should implement BCM is the construction industry, where it has an important role in a country’s economic growth and development. Considering its characteristics and complexities, overcoming crises and threats in order to continue business in this industry is necessary. As firms located over a vast geographical area, which
is known as the world's largest archipelago (Raftery, Chiang and Anson, 2004), Indonesian contractors have also experienced various threats or crises that have significant impacts on their business activities. Various crises have recently occurred in Indonesia, such as the financial crises in 1997 and 2008, natural disasters that occurred frequently (earthquakes, floods, tsunamis), the political and financial instability, terrorism issues, and other internal events. The crises stated above had resulted in various levels of impacts, where it can start from disruptions to business activities, loss of potential markets, loss of productivity and profitability, to the extreme case such as bankruptcy of a firm. From these cases, it seems that these firms have not developed their crisis responses into a holistic management approach in the organization, and there is a lack of detailed responses for their business stakeholders. To become resilient and capable of providing an effective response to such threats, Indonesian contractors should start to adopt a systematic management concept in their organizations. BCM provides this framework, where based on its definition, it builds resilience and the capability for an effective response that safeguards the interests of its key stakeholders, reputation, brand and value creating activities (Supriadi and Low, 2012).

Adopting a new concept like BCM is not a straightforward process. There are issues to consider before implementing the concept into the firm. Previous studies had shown that the immediate motivation for a firm in adopting a concept or system comes from institutional forces and organizational culture (Liu et al, 2010). Based on these considerations, before implementing BCM, the Indonesian contractor's organizational culture and institutional forces should be identified in order to determine whether these elements support or do not support BCM implementation.

Based on these problems, the objective of this study is to propose a framework for developing a BCM implementation guideline in the form of a KBDSS for Indonesian contractors. The study is based on an extensive literature review and benchmarking to BCM best practices. In developing the framework, a thorough literature review on BCM principles, organizational culture, institutional forces, Indonesian contractor's business characteristics and KBDSS is conducted. The review also highlighted the relationships between these elements that underpin the basis for the framework.

2. Literature Review

2.1 BCM Overview

The Business Continuity Institute (BCI, 2002) defines Business Continuity Management (BCM) as an act of anticipating incidents that will affect mission-critical functions and processes for the organization, and ensuring that it responds to any incident in a planned and rehearsed manner. Foster and Dye (2005) similarly viewed BCM as the process of developing advance arrangements and procedures that enable an organization to respond to an event in such a manner that critical business functions continue with planned levels of interruption or essential change. In this context, top management must take the lead in driving organizational BCM with a view to garnering the collective efforts of all individuals within the organization for this purpose (Low et al, 2008).
Historically, BCM was developed many years ago, where this concept is an evolution of a disaster recovery approach in a firm. Its roots lie in Information Systems (IS) protection although it is argued that it has grown a long way since then. Elliott et al. (2010) developed on these theories in more details explaining that the evolution of BCM has progressed from a focused technical aspect to a broader strategic organizational requirement. BCM is a system that develops a framework of protocols and sets of procedures and instructions which give structure, order and stability to the particular function being managed. It is in line with the definition of a management system, stated by Griffith (2011) that sets out and describes, for a particular management function, the organization’s policies, strategies, structures, resources and procedures used, within the firm to manage the processes that delivers its products or services.

The main aspects in BCM principles are described in Table 1 which shows the BCM concepts being grouped into six categories for BCM implementation.

**Table 1: Main aspects of BCM principles**

<table>
<thead>
<tr>
<th>No</th>
<th>BCM Principles</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1  | Risk analysis and review | • Examine internal and external risk events and impacts (qualitative and quantitative) that can affect the critical operation’s continuity.  
• Using Risk Analysis (RA), Business Impact Analysis (BIA), and Cost benefit analysis (justification for initial treatments to prevent or reduce the effects of risks and potential losses). |
| 2  | Business Impact Analysis | • Examine the impact to the organization (assesses the potential impact of loss from an internal perspective), qualitatively and quantitatively, due to a disruption of business operations and processes.  
• BIA must be conducted on a periodic and systematic basis to assess the impact of losses if the corresponding business operations and processes are disrupted in view of proposed changes. |
| 3  | Strategy development | Examine the possible strategies for maintaining the operation of Critical Business Functions (CBFs). This should cover pre-incident preparedness, response and recovery. |
| 4  | BC Plan development | Examine the BC plan(s) which is an action plan that guides the response and recovery actions of the organization when disaster occurs. It includes an emergency response to stabilize the situation following a disaster, the set up and operation of an Emergency Operations Centre (EOC), and specifies CBFs to be recovered within their established Recovery Time Objectives (RTOs) and Recovery Point Objectives (RPOs) when a disaster occurs. RTO is the period of time in which functions must be recovered after a disruption has occurred, and RPO is the point in time at which systems and data must be recovered after a disruption has occurred. |
| 5  | Test and exercises for BC plan | • Ensure that the BC plan drawn up and implemented by the organization is viable and workable.  
• Tests are intended to verify the capability of the BC plan to attain specified objectives or established criteria.  
• Exercises are intended to train and condition BC team members to improve their coordination and performance in executing the BC plan. Exercises also serve to highlight any weaknesses in the operation and effectiveness of the BC plan, with establishing generic corrective actions if the result falls below assessment criteria. |
| 6  | Program management | • Examine the ongoing efforts and activities of the organization to maintain the effectiveness of its BCM. BCM involves firm commitment of organization’s efforts and resources to safeguard the interests of its key stakeholders, reputation, brand and value-creating activities on a continuous basis. Assessment of an organization’s BCM efforts should therefore be dynamic.  
• The BC plan is operated by staff of the organizations. Staff in the organization should be familiar with the plan via appropriate awareness and training programs prior to any test/exercise of the plan. Periodic and systematic training and awareness programs should be conducted to
2.2 Organizational Culture (OC) and Institutional Forces (IF)

Organizational culture had been defined as the way things are done and operated within the internal environment of the workplace. The features in organizational culture are common beliefs; pattern of behavior, norms; values and rules that are exercised among members of the organization. They viewed that the closer the values and beliefs among members of the organization are, the stronger the culture will be (Kotler and Heskett 1992).

The importance of organizational culture towards adopting a concept or system in the organization can be seen from studies which increasingly push organizational culture as the guide for organizational strategies. It is suggested that organizational culture can impact manager’s ability to process information, rationalize and exercise discretion in their decision-making processes (Hofstede and Hofstede, 2005). Liu et al (2010) found that identifying organizational culture helps its members to understand organizational functioning. It affects how the firm responds to external events and makes strategic choices. Moreover, organizational culture is a key to many change initiatives, where success in implementing a concept depends on the organizational culture.

Institutions are considered as multifaceted, durable social structures made up of symbolic elements, social activities, and material resources. Institutions are inhabited by people and their interactions. Rules, norms and meanings arise in interaction, and they are preserved and modified by human behavior. The essence of the institutional perspective in general resides in the three pillars – the regulative, normative, and cultural-cognitive – which provide meaning and stability for social behavior. The regulative pillar is distinguished by the prominence given to explicit regulative processes; rule-setting, monitoring and sanctioning activities. In the normative pillar, the emphasis is on values and norms which introduce a prescriptive, evaluative and obligatory dimension into social life. The cultural-cognitive elements include widely held beliefs and taken-for-granted assumptions, the rules that constitute the nature of reality and the frames through which meaning is created (Scott, 2008).

2.3 Indonesian Contractors

In delivering a project, a contractor needs to manage the materials, people, and equipment in a project site and assembling the materials in the proper sequence to construct a project that meets the customer’s requirements. In meeting these requirements, the contractor also has to consider their stakeholders, which can vary from the customers, suppliers, creditors, investors, employees, subcontractors, governments and the public, to existing and new competitors. Schaufelberger (2009) also mentioned that each type of construction projects has its unique set of technical challenges, but the following business responsibilities for contractors are similar, which are acquisition of the work, performance of the work, and management of the financial, capital, and human resources of the firm.
The existing conditions of the Indonesian contractors have been analyzed. Suraji (2003) had completed an analysis showing the strengths, weaknesses, opportunities, and threats in general. Based on these findings, the Indonesian contractors have the strengths of delivering more projects due to their many labour resources and the current needs of infrastructures in many cities in Indonesia. There are many opportunities for collaboration with other foreign contractors arising from their recent businesses in Indonesian construction projects. Thus, this can enhance the capability of Indonesian contractors in delivering better projects through technology and knowledge transfer. Some weaknesses identified are the lack of funds and technologies, lack of skilled workers, the high level of competition in the national construction industry, and management inefficiencies. Factors such as the competencies of human resources, research and development, certification and support from other sectors may threaten the firm’s growth and sustainability in the future if not considered comprehensively. Moreover, low skill index and experience of construction workers make the business face difficulties in undertaking new concepts and technologies.

2.4 Knowledge Based Decision Support System (KBDSS)

As a computer-based system that supports decision making by aiding knowledge storage, retrieval, transfer and application by supporting knowledge access, KBDSS provides benefits for the management process. Most scholars viewed the major benefit for the management process is improvement in managerial productivity. Managerial productivity is considered as a function of the time spent in retrieving information, generating value added information and finding problems in the intelligence phase, and developing alternative solutions in the design phase of decision making. A good KBDSS may reduce the time required in this process and thereby improves managerial productivity (Raman and Phoon, 1990). Nonetheless, before using KBDSS for the management process, it is necessary to understand that KBDSS is not designed to make decisions for users, but rather it provides relevant information in an efficient and easy-to-access format that allows users to make more informed decisions (Arain and Low, 2006).

In the construction industry, there are several KBDSSs that have been developed for various functions such as for material and procurement planning in construction projects (Mockler, 1989), integration of AUTOCAD and construction scheduling (Wang, 2001), resource allocation, risk management process and project success forecasting (Mohan, 1990). It can be seen that a DSS or KBDSS is quite applicable in the construction industry, and there could be other processes or concepts that can be applied into this tool.

Yoon et al (2008) also found that KBDSS have been developed for emergency response and management. A KBDSS for emergency response was developed to assess the state of preparation of an agency to respond to emergencies, enable the development of new SOPs, and to better train and empower employees in the decision making process. It is utilized to reduce the time to make critical decisions such as task assignment and resource allocation and to guide long-term decisions, training and the control capabilities of the organization. Considering the function and benefit of this tool, developing a KBDSS can be proposed in order to improve the effectiveness and efficiency of the decision making process in BCM.
3. Results

Based on literature reviews, a framework for developing a BCM implementation guideline in the form of a KBDSS for Indonesian contractors is proposed. The framework consists of aspects which are the Organizational culture (OC) dimensions, Institutional forces (IF) attributes, BCM for Indonesian contractors and KBDSS for BCM. Section 3.1, 3.2 and 3.3 describe the aspects that are part of the conceptual framework, followed by section 3.4 which shows the whole framework proposed for the study.

3.1 Determining Drivers and Hindrances of Implementing BCM through OC and IF

Based on the previous discussion, it appears that institutional forces and organizational culture may work together and interact with each other to affect concept or system adoption. Studies also had suggested that the immediate motivation for concept or system adoption comes from institutional forces. Furthermore, organizational culture, as a stable element of the organization, moderates the effects of institutional forces (Liu, et al., 2010). Based on this understanding, IF and OC attributes can be synthesized with BCM principles in developing a framework for determining the drivers and hindrances of implementing BCM by Indonesian contractors. Figure 1 illustrates the framework for this purpose.

Figure 1: Framework of IF – BCM – OC relationships

There are two relationships that can be described within this framework. Firstly, the relationship between institutional forces and BCM principles is primarily about the contractor’s perspective on BCM principles in the context of the institutional framework. It describes whether the contractor views the BCM principles as regulative, normative or cultural-cognitive forces towards implementation. This relationship can be considered as the
first domain. Secondly, the relationship between organizational culture dimensions and BCM principles (the second domain) is generally to determine whether the BCM principles are part of the contractor’s organizational culture. In answering this, the 14 OC dimensions are used. The relationship between the two domains is to analyze how the contractor views the BCM principle (in the context of institutional forces and organizational culture dimensions) regarding its level of influence (significant drivers) and level of hindrances for the firm. From this relationship, it can further be determined whether BCM principles are supported or not supported by the contractor.

3.2 Developing BCM for Indonesian contractors

In developing the BCM implementation guideline for Indonesian contractors, the main steps that will be involved are based on BCM’s main principles, which are risk analysis, business impact analysis (BIA), strategy development, BC plan development, tests and exercises and programme management. Moreover, BCI (2002) had provided some criteria for understanding the preparedness of the firm towards BCM. These criteria can be used as a benchmark in line with the BCM principles. In this study, some of these criteria will be observed in order to identify the preparedness of Indonesian contractors. Table 2 shows the variables to be used as the benchmark to better understand aspects for BCM preparedness.

**Table 2: BCM preparedness criteria**

<table>
<thead>
<tr>
<th>Variables to be used as a benchmark – BCM good practice criteria</th>
<th>BCM vision and policy statement</th>
<th>BCM training budget</th>
</tr>
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<tbody>
<tr>
<td>• Communicating vision and policy throughout the organization</td>
<td>• Defined BC Plan</td>
<td>• Awareness of the significance and importance of legal privilege in all communication and documentation regarding a crisis or BCM event</td>
</tr>
<tr>
<td>• BCM committee from senior management</td>
<td></td>
<td>• Awareness of the communication and call-out tree</td>
</tr>
<tr>
<td>• Senior and middle management support and strong commitment</td>
<td></td>
<td>• Employment of BCM professionals</td>
</tr>
<tr>
<td>• Monitoring and evaluating BCM implementation and maintenance</td>
<td>• Defined BCM roles and responsibilities at all levels within job descriptions</td>
<td>• Attending external BCM seminars and courses</td>
</tr>
<tr>
<td>• Defined BCM roles and responsibilities at all levels within personal annual performance contracts</td>
<td>• Integration with organization’s performance management and appraisal system</td>
<td>• Provide formal training and professional development plans for BCM personnel</td>
</tr>
<tr>
<td>• Defined KPI for BCM</td>
<td>• Defined BCM roles and responsibilities at all levels within personal annual performance contracts</td>
<td>• Promoting BCM as an issue for continuous professional development for its staffs</td>
</tr>
<tr>
<td>• Integral part of organization’s project management process</td>
<td>• Defined KPI for BCM</td>
<td>• Defined BCM exercising, maintenance and audit programme</td>
</tr>
</tbody>
</table>
| Source: BCI, 2002

3.3 The Application of KBDSS for BCM

For this study, KBDSS will be proposed as a supporting tool for the management team in developing a BCM. According to Crabb (2011), there are parts in BCM that need consistency
of approach, consistency of information and structure and also consistency of process. This type of phase can be supported by a KBDSS. The content for the proposed KBDSS is to develop a BCM preparedness assessment and recommendation (in the form of action plans). It will provide technical guideline or steps to implement each BCM principle. The non-technical attributes that consist of the organizational culture (OC) and institutional forces (IF) that relate with BCM principles will also be included in the system. The answers from the user (the firm) will be assessed to determine the level of its BCM preparedness, and will be followed by recommendations on that specific level. In the proposed system, the level of BCM preparedness is grouped into four levels, which starts from an undeveloped BCM, beginner level, moderate level and comprehensive level. These levels are adapted from various BCM level of preparedness studies (Smit, 2005). Furthermore, all of the knowledge obtained from the BCM implementation guideline will be placed in the KBDSS for developing the assessment process.

Automating this process will provide the BCM information and knowledge in one place that allows the management to take a more rounded view of issues, resources and situations. This allows organizations to develop a much more strategic-based approach for planning its business resilience. Its content is not in providing the exact solution, but supports the decision maker (the user) with information for obtaining the proper solution in that phase. Knowledge will be provided for the decision maker in assisting him to select the decision for developing BCM through the recommended action plans. Figure 2 illustrates the general process in the proposed KBDSS.

![Figure 2: KBDSS process: BCM level of preparedness assessment](image)

In developing the proposed KBDSS, all aspects from the previous phases of the study will be needed, where the data will be compiled and synthesized. Furthermore, the data will be processed as the knowledge base for the system (Mockler, 1989; Turban, 1995). For further illustration, Figure 3 shows the proposed BCM - KBDSS components. KBDSS comprises components such as DSS shell, knowledge base, inference engine, and database. All of the
data from the database will be analyzed to acquire the relevant knowledge needed in the system. Inference engine will be used to develop the knowledge base that will assess inputs from the user and provide the outputs. DSS shell will be the component that structures these processes into a user-friendly interface with the user.

![Figure 3: BCM - KBDSS components](image)

### 3.4 Conceptual Framework

The main conceptual framework for this study is shown in Figure 4. The framework has synthesized the BCM-OC-IF relationships, BCM implementation guideline, and BCM-KBDSS aspects. The constructs needed to understand the Indonesian contractor’s knowledge of BCM are developed, followed by defining the relationships between BCM, OC, and IF. These relationships are considered as the outer layer of the framework. Furthermore, in developing BCM for Indonesian contractors, various constructs are identified that will be developed into a guideline for BCM implementation. BCM principles, BCM preparedness criteria and characteristics of Indonesian contractors are the aspects that will be used in this phase. The role of KBDSS as the automated BCM implementation guideline is the inner layer of the framework that consists of the KBDSS process (BCM level of preparedness assessment and action plans) and components.
4. Conclusion and Expected Contributions

4.1 Conclusion

Due to its vulnerability to various threats and crises, BCM should be adopted by Indonesian contractors. Furthermore, the roles of organizational culture and institutional forces were found to be important in adopting a concept such as BCM.

This research aims to study BCM implementation by Indonesian contractors, which identifies the significant drivers and hindrances for implementing BCM by Indonesian contractors that are related to their organizational culture and institutional forces. Moreover, in order to reach efficient decisions in the process, BCM will be developed as an implementation guideline model that will be automated into a KBDSS.

The conceptual framework for this study incorporates the constructs relating to the Indonesian contractor’s knowledge of BCM; the relationships between BCM, organizational culture (OC) and institutional forces (IF); and aspects that will be used in developing the BCM implementation guideline model such as its principles, its preparedness criteria and the business characteristics of Indonesian contractors.

4.2 Expected Contributions

The BCM implementation guideline model can assist the firms to develop better coordination with their stakeholders that may lead to a competitive advantage and marketing value for the firms. If this model is applied by all the Indonesian contractors for them to become more resilient, the firms may have the ability to absorb, respond and recover from disruptions that will eventually contribute to higher corporate performance. Thus, this may support the role of the Indonesian construction industry in the economic growth plans of the country.
From the academic perspective, along with further understanding about BCM implementation in the construction sector, this study will provide further knowledge on cultural and institutional studies in construction organizations. Last but not least, the development of an automated system (KBDSS) in this study will also contribute to further IT implementation in the construction industry.

References


ANALYSING THE COLOMBIAN LOW-INCOME HOUSING MEGAPROJECTS FROM A MANAGERIAL PERSPECTIVE

Mary Ruth Guevara¹, José Guevara², Clemencia Escallón³, Hernando Vargas⁴

Abstract

Over the last two decades, Colombian government has promoted private low-income housing production through implementing a series of financial and managerial mechanisms. These have sought to increase the participation of non-public firms in providing solutions for low-cost urban households. Despite these efforts, the deficit has not sufficiently diminished. For such reason, since 2008, the national administration has implemented a new policy called the Low-Income Housing Megaprojects (LIHM). These have been proposed mainly to generate improved urban design in city expansion areas and obtain scale economies. This study aims to examine the challenges that project management faces in terms of facilitating social housing production so as to reduce the Colombian affordable dwelling shortage through implementing the LIHM strategy. Since this is an on-going investigation, only preliminary results are presented. Analysis is performed by taking into account two LIHM located in the cities of Soacha (near Bogota) and Cali. Both projects are explored through identifying their main actors based on organisational field and project governance concepts. Our findings are directed towards making clear the real organisational complexity of developing LIHM, and emphasise the necessity of more collaboration among institutions (i.e.: public, private, and non-profit organisations) so as to provide adequate living conditions for the low-income population.

Keywords: low-income housing, megaprojects, organisational field, governance, project management

1. Introduction

One of the most important challenges faced by governments in developing countries is the provision of adequate living conditions for the low-income urban households. Before the 1980s, public institutions were in charge of producing housing solutions for the poor.

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However, over the last three decades, governments have started to address the housing problem by adopting a neo-liberal approach in which they have become a facilitator rather than a producer. Under this economic paradigm, the state seeks to perform fewer public functions and implement private sector practices in order to increase the efficiency of the residential sector. Over the last two decades, the Colombian government has promoted private low-income housing production through implementing a series of financial and managerial mechanisms. These have sought to increase the participation of non-public firms in providing solutions for low-cost urban households. Despite these efforts, the dwelling shortage has not sufficiently diminished. For such reason, since 2008, the national administration has implemented a new policy called The Low-Income Housing Megaprojects (LIHM). This strategy is a central government programme that aims to reduce the Colombian housing shortage and produce large-scale affordable residential initiatives through generating urban soil more efficiently than other regional-based approaches.

LIHM have many features in common with several global engineering projects. Both exert a significant impact on the communities where they are built and require a substantial amount of money to be developed. They also involve the interaction of many actors from many different backgrounds. Additionally, the two types of initiatives are carried out within a neo-liberal economic framework in which the private sector plays a paramount role. Based on these shared characteristics, we argue that LIHM can be examined, from an organizational standpoint by using the concepts of organisational field and project governance. This paper is organised in the following way: first, a description of the Colombian housing policy is presented. Secondly, the concepts of organisational field and project governance are introduced. Based on the national policy and the theoretical ideas shown, the research methodology is explained and the two case studies under examination are described. Subsequently, the actors and organisations involved in the development of the LIHM are identified and examined. Finally, conclusions are presented and recommendations for further analysis are highlighted.

2. A brief review of the Colombian social housing policy

Social housing policies in Colombia have experimented dramatic transformations over the last 20 years. These changes have been intended to diminish the dwelling shortage by incentivising the private sector to take part in providing housing solutions and allowing public strategies to be specifically focused on facilitating access to housing through offering different forms of financial aid. According to these new policies, since 1991 private construction companies have been in charge of developing low-income housing projects and government agencies have been responsible for financing them through supplying bank loans and subsidies to the future homeowners. Thus, government strategies have sought to reduce the deficit through implementing a demand-oriented housing policy for the last two decades.

The new policies required a different institutional framework in order to undertake their transformations. Several new organisations were created so as to manage and grant loans and subsidies: i) the Ministry of Housing, Cities, and Territory, ii) the Housing National Fund (FONVIVIENDA) in charge of proving financial aid to informal workers; iii) the Family Welfare
Agencies (FWA) focused on serving formal employees; iv) FINDETER (a public rediscount bank), a bank responsible for approving social housing construction projects; v) the Military Housing Promotion Agency; and vi) the Public Agricultural Bank for rural households (Arbelaez et al., 2010).

The demand-oriented policy has been directed towards diminishing the housing shortage through implementing drastic budget reforms, changing the State’s organisational structure, and promoting an active participation from the private sector (i.e. banks, construction firms, etc.). However, this strategy has not proven to be successful in terms of improving social conditions for the most vulnerable population. For example, according to the National Department of Statistics (DANE), the housing shortage for 2005 corresponded to more than 3.8 million units both in qualitative (i.e. 2.5 million dwellings with inadequate living conditions) and quantitative (i.e. 1.3 million families without shelter) terms. With these numbers in mind, it is easy to affirm that the mentioned housing policy is neither enough for solving the housing problem in Colombia nor adequate for serving the low-income people (DPU, 2006).

2.1 The Low-Income Housing Megaprojects (LIHM)

Taking into account the increasing housing shortage for the low-income population, in 2006, the national government started to design the LIHM strategy in order to reorganise and streamline the process of getting access to land for affordable housing. Over the last seven years, the new policy has sought to develop housing projects throughout the country by making land available and providing adequate urban infrastructure (i.e. public services, urban facilities, etc.). This is being carried out through establishing a public-private partnership among the national government, local government agencies, and private developers. Under the LIHM scheme, the central government seeks to produce large-scale affordable residential initiatives through generating urban soil more efficiently than other regional-based approaches (Decree 4260-2007).

The execution of the LIHM has not been exempted from problems. Firstly, so far it is not clear how the municipal authorities have to adapt their local urban planning regulations so that a LIHM can be developed. Secondly, since either a private developer or a public agency can promote a LIHM, there have been multiple problems in terms of properly managing such initiatives. Thirdly, taking into account that the final goal of the LIHM policy is to efficiently generate land, there are many megaprojects located in peripheral urban zones with a clear lack of transportation infrastructure.

Currently, there are more than 31 on-going large-scale housing initiatives. In this paper, we are going to analyse two of them: Green City (GC) and Santa Helena Hills (SH). The former is located in Bogota (the Colombian capital) and involves the construction of 40 thousand units in a 107-hectare tract. The latter is situated in Cali (the third most important Colombian city) and comprises the development of 3.5 thousand dwellings in a 35-hectare lot. Additionally, while GC is an initiative led by a private developer, SH has been conceived by the local mayor’s office. Despite the differences, both schemes have similar problems related with the government capacity to ensure not only the construction of low-income
housing solutions, but also the provision of infrastructure and public services for the two projects

3. The concept of organisational field

According to DiMaggio and Powell (1983), the concept of organisational field refers to a group of organisations that constitute a recognised area of institutional life. For instance, key suppliers, consumers, regulatory agencies, and other institutions that produce similar products or services. In other words, the organisations within a field comprise a well-defined social sector and interact in a specific functional area (Machado da Silva, 2010). Based on Carrillo (2009), an organisational field is a collection of actors that belong to a particular social context. For example, an educational system is a field that consists of an aggregation of actors, such as, schools, parent associations, departments of educations, etc. In the same way, the LIHM can be understood as a specific functional sector. For this particular field, the participants are the organisations that work in providing social housing for the poor: construction companies, government agencies (at the local and national level), urban designers, the local community, the landowners, developers, etc.

Jooste (2010) argues that an organisational field has three main components: actors, logics, and arrangements. The actors are the institutions and organisations that belong to the same functional sector. They can influence such functional area at the local, national, and transnational levels. The logics are the beliefs and conceptual maps that guide the actors’ behaviours. The logics among the participants might be in open contradiction if a particular field is comprised by public and private institutions. Finally, the arrangements are the governance mechanisms required for having an adequate coordination among actors and their logics.

4. The concept of project governance

There are many definitions for governance. In this study, we have adopted the one given by Carrillo (2009). According to such author, governance is a concept for describing a set of game rules within a social system. The rules are those formal and informal regulations that belong to a particular social context and are dependent on its specific characteristics. A social system refers to a family, an enterprise, or social communities (at the local, national, or global levels). In terms of urban management studies, the idea of governance plays a key role in explaining how a state (i.e. central government), within a liberal economic framework, has to seek collaboration from other private and public organisations in order to properly implement urban policies and projects. Therefore, Rakody (2003) and Healey (2006) argue that the concept of urban governance is based on the idea that there has to be a regulatory framework (i.e. a set of game rules) so as to properly make decisions and execute programs at the urban level.

The definitions provided by Carrillo (2009), Rakody (2003) and Healey (2006) are useful in terms of explaining the urban complexities. However they are not directly oriented towards examining the difficulties in developing large-scale urban projects. These types of projects have always been a societal challenge due to their great number of participants. Henisz et
al. (2012) propose the concept of project governance as a theoretical framework for understanding the interactions among the actors involved in large-scale initiatives. Since Henisz et al. (2012) work on the basis of the ideas proposed by Scott (1995), they suggest that each project can be analysed from three governance perspectives: regulative, normative, and cognitive.

The regulative perspective refers to the set of formal rules, incentives, and sanctions (i.e. laws, decrees, professional regulations, etc.) that control the project participants’ behaviour (Henisz et al. 2012). Based on regulative mechanisms, project participants tend to do only what the project contract establishes. In other words, from a regulative point of view, actors only do what they are compelled to do. On the other hand, the normative standpoint refers to a series of expectations and exchange processes that are collectively shared by all the individuals involved in the initiative. According to this viewpoint, actors tries avoid social punisheds (i.e. ridicule, isolation, etc.). Finally, the cognitive perspective seeks to create common identities, shared interests, and long-lasting relationships among the participants (Henisz et al. 2012).

Taking into account the three governance perspectives, many authors have analysed large-scale infrastructure projects. For instance, Joose (2010) analyses public private partnership schemes in Australia, South Africa, and Canada. Henisz et al. (2012) show the importance of social exchanges through presenting examples of projects in Argentina and the Philippines. Chi et al. (2012) examines the development of two Chinese projects by employing the concept of relational governance. Since LIHM have many features in common with several global infrastructure projects (e.g. the impact on the communities, the amount of money required, the interaction of many actors from many different backgrounds), we argue that they can be examined, from an organizational standpoint, in a similar way as many infrastructure projects have been previously analysed. In order to do that, the next section shows the research methodology employed for this study.

5. Research methods

The main research question for this study is: how to ensure, since the conception phase, an adequate coordination among the different institutions that participate in the development of the LIHM, in order to benefit the low-income population? This was based on the evolution of the Colombian housing sector, its current neo-liberal organisation scheme, its stakeholders, and its existing difficulties (Jaramillo and Cuervo, 2010; CENAC, 2006).

We sought to answer the research question through employing a multiple-case study approach based on Yin (2003), Eisenhardt (1989), Corvin and Straus (2008), and Jooste (2010). The two cases (i.e. GC and SH) were selected because: (i) they were developed under the LIHM scheme; (ii) the two projects shared similar problems (i.e. lack of coordination among stakeholders); and (iii) they had different execution strategies (i.e. GC was managed by a private company and SH was directed by the City of Cali). The information was collected through a literature review, observation exercises (i.e. site visits), archival analysis (i.e. examination of laws, decrees, local regulations, and project-based information), and two rounds of semi-structured interviews with leading representatives of
organisations involved in the development of the two projects. For each case, 20 interviews (i.e. 10 interviews per round) were conducted with individuals from different institutions, such as local government agencies, national government institutions, project management firms, urban designing companies, main contractors, professional organisations, and universities. The interviews were recorded, transcribed, and analysed by using QSR Nvivo (a total of 20 hours of audiotape were examined).

Based on the literature review, the archival analysis, the first round of interviews, and the concept of organisational field, the data was categorised in three conceptual groups: actors, logics, and institutional arrangements. The analysis was conducted through identifying similarities and differences within the three theoretical classes in the two case studies. Based on this exercise, the information for each project was subsequently grouped in four sub-groups (i.e. public services, accessibility, urban facilities, economic opportunities). Once the conceptual categories and sub-categories were completely defined, a second round of interviews was performed. However, this time, the information was examined through the lens of the concept of governance. Through this approach, conclusions have been directed towards proposing improvements for the types of governance perspectives employed in the LIHM in order to enhance coordination among institutions and benefit the Colombian low-income population. In this paper, we only present a series of preliminary results based on the examination of the organisational field (i.e. the actors that participate in the projects) for the two cases under study. The analysis is supported by the organisational and governance concepts previously presented.

6. Case studies: a basic description

6.1 Green City (GC)

The LIHM of GC is located in Soacha, one of the biggest municipalities that have a border with Bogota. This urban centre has a housing shortage of approximately 36 thousand households. Over the last years, Soacha has experimented an increasing demographic growth due to migrations originated by forced displacement phenomena, expansion of Bogota’s bordering neighbourhoods, and conurbation processes. This rapid increment in the number of inhabitants took place without any formal governmental control and has incentivised the development of several illegal urbanisations.

GC has a total area of approximately 327 Ha, which includes 107 Ha for housing, 18 Ha for urban infrastructure facilities, and 35 Ha for commercial and service land use. The project intends to generate 42 thousand social housing units, it started to be executed in December 2009, and it is expected to be finished by 2018 (Henao, 2011). In terms of its development strategy, the initiative has been led and promoted by private actors (i.e. a housing construction company) and it has been financed through a combination of private funds (i.e. landowners, bank loans, trust funds, etc.) and public mechanisms (i.e. facilitation for changing the land-use).
6.2 Santa Helena Hills (SH)

The LIHM of SH is located in Cali, the third main city in Colombia. Cali is situated in the south-western region of Colombia, it has a population of about 2.5 million people and a housing shortage of approximately 580 thousand households. The project is intended to generate five thousand units and has an area of around 306 Ha, of which 70% corresponds to land for housing use. The initiative has a duration of 60 months and has been led and promoted by the local government (i.e. the local housing agency) and the national administration (i.e. the ministry of housing). Since this project is a governmental initiative, it is important to highlight its funding and managerial mechanisms. On the first hand, the project’s funds are controlled through a trust scheme. A committee that consist of representatives from the national and local administrations manages such scheme. On the other hand, a local FWA (i.e. Comfenalco) undertakes the project management tasks related with institutional, commercial, financial, and technical aspects (i.e. marketing activities, subcontractor hiring procedures, etc.).

The following table presents a comparison between the two projects under analysis.

Table 1: A comparison between Green City and Santa Helena Hills

<table>
<thead>
<tr>
<th>Category</th>
<th>Green City (GV)</th>
<th>Santa Helena Hills (SH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Soacha (border with Bogota)</td>
<td>Cali (third main city in Colombia)</td>
</tr>
<tr>
<td>Size</td>
<td>327 Ha – 42 thousand units</td>
<td>31 Ha – 5 thousand units</td>
</tr>
<tr>
<td>Urban context</td>
<td>Housing shortage: 36000 households</td>
<td>Housing shortage: 85000 households</td>
</tr>
<tr>
<td></td>
<td>Lack of urban facilities and public service</td>
<td>Illegal urbanisation processes</td>
</tr>
<tr>
<td></td>
<td>infrastructure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Illegal urbanisation processes</td>
<td></td>
</tr>
<tr>
<td>Developers</td>
<td>Private construction company</td>
<td>National and local administrations</td>
</tr>
<tr>
<td>Financial</td>
<td>Trust scheme</td>
<td>Trust scheme</td>
</tr>
<tr>
<td>mechanisms</td>
<td>Integration among 7 construction firms</td>
<td>Project management contract</td>
</tr>
</tbody>
</table>

7. The organisational field for the LIHM: actors and organisations

As it was mentioned before, an organisational field consists of an aggregate of organisations that forms a recognised area of institutional life (DiMaggio and Powell, 1983). We argue that the Colombian LIHM can be analysed from an organisational-filed point of view because the development of such projects involves multiple institutions with formal and informal relationships at different levels. Although an organisational field has three main components (i.e. actors, logics, and governance arrangements) (Jooste, 2010), in this paper we only discuss the actors that participate in developing the megaprojects. Since there are many organisations involved in the delivery of the housing initiatives, we only focus on those who exert the greatest influence.
7.1 The national government

The Ministry of Housing and the Housing National Fund (Fonvivienda) are the two main governmental agencies in charge of developing the LIHMP throughout the country. The ministry focuses on analysing the project conceptual phase, examining the feasibility and technical studies, producing the decrees that regulate the initiatives, and participating in the trust scheme committee. Fonvivienda is in charge of managing the resources for developing the project. Such resources comprise the funds required not only to build the housing units, but also to build the urban infrastructures.

In the case of GC, the Ministry of Housing, in conjunction with a private company (i.e. the project developer), developed the conceptual phase, undertook the feasibility study, and approved the initiative submitted by the private firm. Additionally, it was in charge of obtaining the environmental approvals for the project. Although that was not competence of the national government, one of the interviewees claimed that was a necessary step in order to streamlining the feasibility and approving procedures. On the other hand, in terms of transportation accessibility to the project, the Ministry also committed to make agreements with the local municipalities so as to build an extension of one of the current lines of the Bogota’s mass transit system. In the case of SH, the national government was specifically in charge of approving the project and giving resources for the construction of both housing units and urban infrastructure facilities. Since the local housing department led the initiative, the national agency had to sign an inter-institutional agreement with them in order to establish the trust scheme for the project. Although, at the beginning, there were high expectations regarding the national government participation, there have been severe delays in delivering the promised urban facilities. This has deteriorated the relationship between the local and national levels.

In short, it is clear that national agencies are in charge of generating the decrees that regulate the housing initiatives and take responsibility for approving the project concept and its feasibility and technical studies. These procedures may vary depending on who is the project leader. In GC, for instance, the main project sponsor is a private company; in SH, the main promoter is the local administration.

7.2 The local administrations

The analysis of this actor took into account elements, such as its role for ensuring an adequate public services provision and a satisfactory construction and operation of the urban infrastructure facilities. In the case of GC, the municipality of Soacha is an extremely weak urban centre in terms of the maturity of its institutions. For example, such city does not even have an agency specialised in housing issues. These are managed jointly by the local planning and infrastructure offices. In respect to public services provision, Soacha is not responsible for the project’s water and sewage systems (this is responsibility of the developer). Regarding the development of the urban facilities, the municipality does not have resources for financing the amenities. For such reason, it established an agreement with the developer through which the sponsor may finance them in exchange of tax exemptions or urban land.
In contrast to Soacha, the City of Cali has a housing agency. Its role in the development of
the SH project has consisted in providing funding for developing the initiative through
supplying urban land and offering subsidies for the future households. Based on that, the
Cali’s city hall is, in conjunction with the Ministry of Housing, the main sponsor of the
megaproject. The local housing agency has been in charge of the conceptual phase, it has
undertaken the technical and feasibility studies, and it has established a management
contract with a local FWA so as to administer the design, procurement, and construction
stages of the megaproject. Furthermore, The regional housing department has also been
responsible for the public services provision and the construction of the required urban
infrastructure (i.e. access roads, facilities, etc).

7.3 The public utilities

The Bogota Water and Sewerage Company (BWSC) and the Cali Public Services Provider
(CPSP) are the two main state-owned firms that exert a great level of influence in the
development of GC and SH, respectively. On the one hand, taking into account that the
BWSC provides its services to Soacha, such company has played a key role in the
development of the GC project. For instance, before beginning construction, the private
developer had to obtained a certificate of technical feasibility in order to show that the BWSC
could provide water for the 42 thousand housing units. However, currently, there are still
some discussions about how to provide the services. While the promoters (i.e. an aggregate
of private construction firms) argue that they can build the water and sewerage infrastructure
and operate it through paying a fee to the BWSC, the BWSC wants to design, build, and
operate the system by itself.

On the other hand, the CPSP is in charge of providing services related with water,
sewerage, energy, and telecommunications. Although over the last years the state-owned
company has had budget difficulties and problems with its Union, it continues to be the main
public services provider in Cali. In the same way than the BWSC, the CPSP had to give a
certificate of technical feasibility in terms of supplying the water and sewerage infrastructure
for the SH megaproject. Although, during the project’s conceptual stage, the company
ensured the services viability, it was later on discovered that the water supplier did not have
the capacity to build the required infrastructure for ensuring an adequate service provision.
This caused time delays and cost overruns.

7.4 The Family Welfare Agencies (FWA)

The FWA have played a key role in the development of the housing megaprojects. In Cali for
example, a local agency (i.e. Comfenalco) has been in charge of managing the project. In
other words, Comfenalco has participated in the conceptual, design, procurement, and
construction phases. It has also been involved in selecting the future residents, supervising
the contractors, and ensuring an adequate financial administration of the project trust
scheme. In contrast, the FWA in Soacha have only been limited to provide urban facilities
when required. For instance, a local FWA has won the contract for developing a school in
the GC premises. This is because a private company has managed the GC project since its
conception.
7.5 The private sector

In Soacha, a private construction company has been the main sponsor of the project. The company conceived the idea, established an association with the landowners, and presented the proposal to the Ministry of housing. The same company has been also responsible for funding the project through bank loans and forming a consortium with other construction firms in order to build the 42 thousand units. In this case, a single enterprise has directed the whole initiative and been responsible for linking the interest of both public and private entities. Conversely, private firms did not participate during the conceptual and feasibility phases of the SH project. They did not provide any form of funding and have been involved in the initiative after the procurement stage.

8. Key issues in the organisational field

Taking into account the main actors within the organisational field, there is a series of critical issues that hinder the generation of low-income housing to the poor through the LIHM.

8.1 Lack of administrative capacity of the local administrations

The LIHM initiative represents a real challenge to the traditional public sector capacity. For the Soacha administration, the development of GC highlighted the necessity for having a better institutional framework so as to manage large-scale projects. It is clear that the municipality was not prepared for supervising a megaproject. For instance, there are not local agencies specialized in housing-related issues. This would have helped to have better control mechanisms in order to ensure that the private actors respond not only to their own interest, but also to the city’s concerns. Conversely, Cali was very prepared for big housing initiative because its local administration had not only a local housing agency but also a special office to deal with the megaproject’s issues.

Despite having public organisations for dealing with the LIHM, the Cali administration has shown capacity-related weaknesses due to constant changes of city’s directives. For example, there was a change of mayor between the project conceptual and construction phases. In other words, the mayor that initially sponsored the initiative was not the same than the one who was in charge of its construction. This implied diverse changes in the project scope due to political differences.

8.2 Leadership

Neither in GC nor in SH, there has been a clear project leader. Although a private actor has led the initiative that takes place in Soacha, this has not been able to properly negotiate with the Bogota utilities about the provision of public services, such as water, sewerage, and transportation. The mentioned negotiations have not been successful due to political differences between the utilities’ general manager (i.e. the mayor of Bogota) and the owner of the construction company that conceived GC. In the same way, the local administration in Cali has not been able to manage the SH project due to a lack of coordination among its own agencies and deficiencies in communication procedures with the national government.
8.3 Urban facilities and public services

Urban facilities and public services are one of the most important concerns in terms of stability of the LIHM in the long-range. Based on the two cases under analysis, it is not clear who is going to be the sponsor of the several amenities required for both initiatives. So far, GC has made an agreement with a FWA in order to build a private school; in Cali, the project manager has also established an association between the national and local governments so as to develop a kindergarten institution. The development of any other kind of amenities remains unknown. On the other hand, for both projects is clear that there is not a strong relationship between the project managers and the local utilities for ensuring and adequate service provision. Neither of the two local public utilities (i.e. the BWSC and the CPSP) has strongly supported the LIHM development.

9. Conclusions

Based on account the information collected from the GC and SH projects, it is clear that the main participants in the LIHM are: the Ministry of Housing, the private sponsors, the local administrations, and the FWA. Unfortunately the relationships among them are primarily based on formal regulations. The lack of a formal regulation for controlling the communication among two or more actors creates conflicts, project delays, and in some cases, cost overruns. This is case of the public service provision for both projects because there is not an adequate communication channel between the local administration, the national government, and the public utilities. It is evident that it is necessary to implement governance mechanisms related with the normative and cognitive perspective. Additionally, there is not an adequate integration among the institutions within the organisational field. As it can be seen in Figure 1, there is not a single institution in charge of the whole lifecycle for both projects. Such diagram shows that Green City (see GC boxes on figure 1) has been primarily controlled by a private sponsor; and Santa Helena Hills (see SH boxes on figure 1) has been managed by the local administration. Further studies are required in order to show how to implement relationships based on relations (i.e. relational governance) instead of always relying on formal regulations.

<table>
<thead>
<tr>
<th>ACTORS</th>
<th>THE ORGANISATIONAL FIELD IN THE LIHM LIFECYCLE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>IDEA</td>
</tr>
<tr>
<td>Ministry of Housing</td>
<td>GC SH</td>
</tr>
<tr>
<td>Local Administrations</td>
<td>SH</td>
</tr>
<tr>
<td>Private Sponsors</td>
<td>GC</td>
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<tr>
<td>FWA</td>
<td>SH</td>
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<td>Public Utilities</td>
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<tr>
<td>Banks</td>
<td></td>
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<tr>
<td>Contractors</td>
<td></td>
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<tr>
<td>Residents and Neighbours</td>
<td></td>
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</table>

*Figure 1: The organisational field in the LIHM lifecycle*
10. References


A Review of the Performance of the Malaysian Construction Industry

Toong Khuan Chan¹, May Chuan Theong²

Abstract

The Malaysian construction industry developed the Construction Industry Master Plan 2006-2015 to achieve world class status by 2015. Industry stakeholders identified seven strategic thrusts together with twenty one strategic recommendations, eighty two action plans and 453 activities to achieve this vision. Six years have elapsed since the launch of the master plan in 2006 and it is now prudent for the stakeholders to review the outcome of all its strategic thrusts and activities towards achieving the goals set earlier. A set of performance measures were developed previously resulting in a list of some 34 unique indicators. Tentative targets were set by benchmarking the performance of the local industry to other national initiatives and modified to suit local conditions. The objectives of this study are to determine the performance measures for the 2011, to compare the performance with the 2005 base year and to assess the achievements made in the last six years. Results of this study indicate that although construction demand has increased substantially, worker productivity remained sluggish, safety performance did not improve, export of construction services declined as many companies reduced their presence overseas. The only encouraging observation was a marked increase in construction quality. These results indicate that a thorough reassessment of the construction industry master plan in now necessary to ensure that the strategic actions produce the required outcomes.

Keywords: Benchmarking, Performance evaluation, Malaysia

1. Introduction

The Malaysian construction industry has largely been supported by substantial public spending to fund the construction of basic infrastructure in order to enhance economic activities and to provide affordable public housing. Due to a decline in public spending in 2003 and 2004, the construction sector value added dropped 0.9%, 1.8% and 0.5% in 2004, 2005 and 2006, respectively. Towards the end of 2007, the Malaysian Construction Industry Development Board (CIDB) published a ten-year master plan (CIDB, 2007) that will be implemented from 2006 to 2015 with the objective of refocusing the strategic position and charting the future direction of the industry. The main driver for the strategic plan was the

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fact that the industry has recorded an average annual growth of only 0.7% during the period between 2000 and 2007 compared to an average annual gross domestic product growth of 5.5% over the same period. There were concerns that the construction industry, being a main pillar of industrialisation and major contributor to economic growth, was not performing at its best and thus not able to meet the dual challenge of open markets and greater global competition. The master plan was therefore initiated to establish an innovative, sustainable, professional, profitable and world-class construction industry.

The objectives of this study are to determine the performance measures for 2011, to compare the performance with the 2006 base year and to assess the achievements made in the last six years. A list of 34 performance measures were previously suggested for the master plan by examining similar national initiatives in Canada, Chile, Denmark, New Zealand and the UK (Chan, 2009).

Previous studies (Landin and Nilsson, 2001; Kagioglou et al., 2001; Mohamed, 2003; Takim et al., 2003; Beatham et al., 2004; Bassioni et al., 2004; Lin and Shen, 2007; Nudurupati et al., 2007; Yu et al., 2007) have mainly been focused on evaluating project outcomes or company performance and implemented primarily for the construction companies, consultants and managers of construction projects. Other stakeholders, such as clients, suppliers, regulatory authorities and the community were not assessed or taken into account.

2. Performance Measurement Framework

Many performance measurement frameworks have been suggested and adopted for the purpose of improving performance over the last decade. Good overviews of performance measurement frameworks in construction together with discussions and critiques of the deficiencies can be found in Kagioglou et al. (2001), Bassioni et al. (2004) and Costa et al. (2006). These frameworks include performance measures which can be implemented at the project, company or industry level where the measures for the project perspectives are sub- sets of the measures for the company performance, and the aggregation of company measures evolve into measures for the industry. Kagioglou et al. (2001) extended the framework for an organisation to the construction industry by adding the ‘project’ and ‘supplier’ perspectives. Bassioni et al. (2004) reviewed the three main performance measurement frameworks in the UK construction industry – the key performance indicators (KPI), Balanced Scorecard, and the EFQM Excellence Model, and highlighted a range of issues that requires further research. These include how existing performance measurement systems interact with newly developed systems, the setting of targets and standards for performance measures, aggregation of measures, hurdles to implementation, and using performance measures to take managerial action. Some of these concerns were addressed by Costa et al. (2006) which highlighted the role of performance measurement to enable a company to benchmark its performance against that of other similar organisations in key business activities. Five performance measurement initiatives, some implemented with the intent of establishing a benchmarking programme, were discussed in a previous publication (Chan, 2009)
The review above has given a broad overview of the various performance measurement and benchmarking initiatives at various stages of implementation, beginning with the UK which has a mature system of reporting KPIs since 1998, the Chilean initiative, and more recently the Danish (BEC, 2006), New Zealand (NZCAE, 2007) and Canadian efforts (Rankin et al., 2008) have made significant progress although initiated only in the mid-2000s. These programmes have indicated that the performance measures for the construction industry necessarily include a combination of metrics for projects (time and cost target, quality), companies (profitability, turnover, return on capital) and the industry (safety, growth, labour productivity, innovation, training, construction demand).

3. Methodology

The list of performance measures was designed to focus on the seven strategic thrusts described in the master plan. A number of measures were adopted from other initiatives, mainly from the UK, Danish and Singapore performance measures. Other measures were created to reflect the specific foci of the industry: e.g. percentage of contracts awarded to local construction companies, number of companies with quality assurance programmes, number of construction patents and spending on information and communications technologies. Ideally, this mid-term review should encompass the entire set of performance measure but as the industry has not collected sufficient data to produce a comprehensive account of its performance, this study will be limited to publicly available data and information. The performance measures examined in this review is therefore limited to (a) annual construction demand, (b) percentage of projects awarded to local contractors, (c) export of construction services, (d) worker productivity (measured as value-added per worker), (e) building quality, (f) occupational safety and health, and (g) investments in IT. Data on project values, exports, quality and safety was obtained from the CIDB, while worker productivity and investments in IT were obtained from the Department of Statistics.


Annual construction demand from both the public and private sectors are important measures of the financial viability and sustainability of the construction industry. The total value of construction projects awarded in 2006 consists of RM 22.5 billion from the public sector and RM 38.5 billion from the private sector, leading to a total of RM 61.0 billion. A marked increase was observed in 2007 (see Figure 1) when the government announced significant investments for infrastructure to boost construction demand. The government through its five-year economic development plan for 2006-2010 and Economic Transformation Programme (ETP) has increased total construction demand to RM 93.3 billion in 2007, an increase of more than 50%. Construction demand remained high in 2008 to 2011 with private sector spending contributing an ever increasing share of the total demand due to the government’s efforts to enhance development projects under the Public-Private Partnership Programme (PPP). In 2011, the public sector share of construction demand has dropped to a mere 23% (DOSM, 2012).
Figure 1 Construction Demand reported as value of projects awarded (Source CIDB Quarterly Information Bulletins)

The ratio of value of contracts awarded to Malaysian contractors compared to foreign contractors has consistently exceeded 80% since 2000 as shown in Figure 2 and is expected to remain above 80% indicating that local contractors were able to effectively compete against foreign contractors operating in Malaysia. One perturbing observation was the sudden increase in the proportion of work won by foreign contractors to 18.5% in 2011.

The total value of overseas construction activities directly measures the export potential of the construction industry and its efforts to penetrate markets overseas. It was reported that Malaysian construction companies won a total of RM 18.5 billion worth of contracts overseas in 2007 and another RM 19.5 billion in 2008 (see Figure 3). These figures seem to indicate that the industry is well on its way to realise its target of RM 45 billion in overseas project value by 2015. However, the global financial crisis which hit many of the countries in the Middle East and South Asia severely affected this overseas expansion. The overseas projects won by Malaysian companies only totalled RM 4.0 billion in 2011.

The construction sector in Malaysia has long been perceived as a low productivity sector due to the employment of a large number of migrant workers and the lack of investment in technology and equipment. A major strategic thrust of the CIMP was to encourage the use of Industrialised Building Systems (IBS) reduce the industry’s reliance on migrant workers and to improve quality and productivity. Productivity (value-added per worker) is obtained by dividing the total construction sector value-added by the total number of workers in the sector. Based on the data for value-added shown in Figure 4, the value-added for the construction industry when reported in constant 2000 prices was observed to increase at an annualised rate of 5.6% from 2006 to 2010. However, when this figure is divided by the number of workers in the industry the value-added per worker for 2005 was RM 26,615 whereas the figure for 2010 dropped drastically to RM 18,697. This significant drop in
productivity was due to a large increase in the number of workers from 602,694 in 2009 to 974,488 in 2010.

**Figure 2** Percentage of project value awarded to local and foreign contractors (Source CIDB Annual Reports)

**Figure 3** Export of Construction Services reported as value of projects won overseas (Source CIDB Quarterly Information Bulletins, BCA Annual Reports)
In 2001, the CIDB introduced the QuaLity Assessment SyStem In Construction (QLASSIC) to evaluate the quality of a completed building and covers workmanship in three components; structural, architectural and external works. Existing projects which have been assessed in accordance with QLASSIC have achieved a median score of 60-65 in 2006 and improved to a median of 70-75 in 2011. The number of projects evaluated remained low at 73 projects in 2006 and only 120 projects in 2011 which may not be representative of the quality of the output of the entire construction industry. The distribution of QLASSIC scores is shown in Figure 5 below.

Figure 4 Value-added per worker of the Construction Sector in Constant 2000 Prices (Source DOSM, 2005, 2012a, 2012b)

Figure 5 Distribution of QLASSIC score between 2006 and 2011 (Source CIDB Annual Reports)
Industry stakeholders have insisted on major improvements in occupational safety and health performance. Data on benefits claimed from the Takaful Insurance Scheme organised by the CIDB and the Social Security Organisation (SOCSO) can be classified into fatal accidents, accidents resulting in permanent disability and hospitalisation. The Department of Occupational Safety and Health (DOSH, 2008, 2009, 2010) also investigates accidents at construction sites and provides the accident data shown in Table 1. The data from these three sources, although vastly different because of distinct member profiles, does not seem to indicate any improvement in safety performance at the worksite.

**Table 1: Summary of Accident statistics from CIDB, SOCSO and DOSH**

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatality</td>
<td>23</td>
<td>25</td>
<td>76</td>
<td>88</td>
<td>63</td>
<td>51</td>
</tr>
<tr>
<td>Permanent Disability</td>
<td>75</td>
<td>61</td>
<td>618</td>
<td>815</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Hospitalisation</td>
<td>69</td>
<td>108</td>
<td>3948</td>
<td>4813</td>
<td>66</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>167</td>
<td>194</td>
<td>4642</td>
<td>5716</td>
<td>136</td>
<td>99</td>
</tr>
</tbody>
</table>

In order to leverage on information technology to improve the design process and to increase the efficiency of the building approval process, measures such as total IT spending by construction companies on computer hardware and software may be tracked; data for which is compiled during the census or surveys of construction industries. Data for 2005 and 2010 (DOSM, 2006, 2012b) shows that capital spending and net book values for computer hardware and software approximately doubled in this period.

**Table 2: Detailed capital expenditure and fixed assets for construction companies**

<table>
<thead>
<tr>
<th>Type of fixed assets</th>
<th>Net Book Value: 1-Jan</th>
<th>Capital Expenditure</th>
<th>Net book value: 31-Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 Total Assets</td>
<td>7,598,075</td>
<td>1,294,220</td>
<td>7,486,517</td>
</tr>
<tr>
<td>2005 Computers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer hardware</td>
<td>(1.0%) 73,130</td>
<td>(1.3%) 16,356</td>
<td>(0.9%) 63,876</td>
</tr>
<tr>
<td>Computer software</td>
<td>(0.4%) 27,868</td>
<td>(0.3%) 3,906</td>
<td>(0.3%) 23,962</td>
</tr>
<tr>
<td>2010 Total Assets</td>
<td>14,368,220</td>
<td>2,197,803</td>
<td>14,476,140</td>
</tr>
<tr>
<td>2010 Computers:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer hardware</td>
<td>(2.2%) 310,919</td>
<td>(0.8%) 18,097</td>
<td>(1.9%) 292,854</td>
</tr>
<tr>
<td>Computer software</td>
<td>(0.5%) 76,078</td>
<td>(0.1%) 3,202</td>
<td>(0.5%) 73,876</td>
</tr>
</tbody>
</table>
5. Discussion

The surge in domestic construction demand from RM 60.7 billion in 2007 to RM 91.3 billion in 2011 resulted in only a minimal increase in the percentage share of contribution to the gross domestic product from 2.9% to 3.0%. A consequential increase in gross output for the construction industry was only observed in 2010 indicating that there is generally a 2 or 3 year delay for the increase in demand to be converted to an increase in output. Even though the construction value added increased from RM 16.1 billion to RM 21.4 billion in constant 2005 prices, the national economy increased from RM 544 billion to RM 709 billion. As such the contribution from construction remained small.

It is worthwhile to note that this large increase in demand was met largely by local contractors, with foreign contractors picking up less than 10% each year until the sudden spike to 18.5% in 2011. The value of the projects won by foreign contractors amounted to RM 17.4 billion in 2011. There is currently no information from the industry whether the award of these projects to foreign contractors is due to the technical complexity or if the demand has exceeded the capacity of the local contractors.

Malaysian contractors were very successful in winning projects from overseas in 2007 and 2008 but these activities have been curtailed substantially with overseas projects at RM 4.0 billion each in 2010 and 2011. The major thrust for local contractors to venture overseas was the lack of opportunities within the local market in the 2004 to 2006 period. The government was also very aggressive in exporting construction services to India and South-East Asia with a number of government-to-government projects initiated during that period. Once the effects of the 2008 global financial crisis were felt in the Middle-East, construction demand slumped and many successful contractors returned to focus on the local market. In contrast, the Singapore contractors have remained mainly in their local market as the government attempts to smooth out the spikes and troughs of the construction market by bringing forward or delaying large scale infrastructure projects. The export of construction services by Singaporean contractors has risen gradually in recent years as shown in Figure 3.

The large increase in construction demand was met with a surge in the number of construction workers in 2010. It is now clear from the data that the increase in output is not due to an increase in worker productivity but met by putting additional manpower resources to work. This increase in the number of workers, many of whom are migrant workers from Indonesia or Bangladesh now poses a serious concern to the government as a large proportion enter the country illegally or are poorly trained.

Quality has improved substantially since 2006 although the number of projects that are currently being assessed using the QCLASSIC scoring system is still small. It is indeed encouraging to note that large increases in construction quality can be achieved in a short period of 5 years.

Safety in the construction industry remains a major concern to stakeholders. Data from three separate sources seem to indicate that the overall safety performance has not improved. It is possible that with the accident rate reported by CIDB and SOCSO increases due to a rise in
reporting to collect compensation benefit whereas the accident rate reported by DOSH decreased due to the punitive measures applied to the contractors when an accident occurs at their worksite.

Data on IT spending indicates large increases in the purchase of hardware and software by construction companies to support their operations. This bodes well for the increased utilisation of software tools for the design, quantification and planning of construction works.

6. Conclusion

All available data for 2011 was collated and analysed to determine the performance of the Malaysian construction industry. The performance of the industry in 2011 was compared with its previous performance in 2006. The findings indicate that although construction demand has increased significantly from approximately RM 60 billion in 2006 to RM 90 billion from 2007 onwards, this increased demand was delivered through the employment of more workers and resulted in lower overall worker productivity. Building quality has improved significantly but the industry’s workplace safety performance remains unsatisfactory.

Malaysian contractors have also drawn back from their initially aggressive ventures overseas after the local construction market recovered from the lack of investments in the period from 2004 to 2006. Spending on both IT hardware and software has increased. Other aspects of industry performance could not be analysed due to a scarcity of data.

These findings indicate that a number of initiatives may have to be reviewed and revised to ensure that the outcomes envisioned in the construction industry master plan are achieved. The implementation plan will have to be substantially strengthened and intensified in the next phase as Malaysia experiences the full effects of trade liberalisation and global competitive pressures.

References


Abstract

Although International Construction Joint Venture (ICJV) projects are believed to be beneficial with regard to aiding capacity building in the local construction industry, it is still debatable whether such skills and technology transfer effectively occurs in the hosting companies. South African construction companies are therefore not immune from these undesirable trends. This paper reports on a research project which was carried out in South Africa to identify salient challenges in ICJV environments, and proposes a conceptual structure of international construction joint venture at projects delivery stage that can appropriately assist to accelerate the transfer of expertise from the international JV partners to the host companies in South Africa.

Keywords: International construction joint venture, projects, capacity building, South Africa.

1. Introduction

The performance and capability of the industry is pivotal to transport and communication, import and export, industry development, and to all the logistics of a growing economy that increasingly supports an integrated and economically active population [Construction Industry Development Board (CIDB) (2004)]. Furthermore, the SACI is considered as one of the few African advanced construction industries and thus its role extends beyond the borders of South Africa to other countries across the continent, and the current African infrastructure backlog strongly suggest that the SACI’s role is more prominent across the continent to-day than ever before.

According to Infrastructure Consortium for Africa (ICA) (2010), inefficient and insufficient infrastructure holds back Africa’s economic growth per capita by 2% each year, and reduces firms’ productivity by as much as 40%. Thus, Africa will need to invest approximately 40 Billion US Dollars of annual investment in infrastructure over the coming decade and a further 40 Billion US Dollars, worth of upkeep on existing networks (Emerging 2008).
In order to meet the South African and African infrastructure demands, the SACI needs to possess sufficient competent skills, technology and resources capacity. However, Merrifield (2006) indicates that the industry is currently operating at close to capacity limits and there are concerns that the current capacity is already showing strains of not coping. The SACI is lacking experienced skills and technology to meet the demand for successful delivery of these projects both within South Africa and across the continent. Unless serious efforts are made to address capacity constraints, cost escalations and poor quality are likely to stifle growth going forward (Merrifield 2006 and Rwelamila 2007). Hence, the need to overcome the shortage of domestic skills, technology through joint ventures with overseas partners (Sewapaul 2007).

Although ICJVs are believed to be beneficial with regard to aiding capacity building in the hosting construction industry, it is still debatable whether such skills and technology transfer effectively occurs in the hosting South African (SA) companies. Lowitt (2007) argues for research on technology and skills transfer from developed country construction companies to their less developed counterparts.

The research project reported in this paper involved a case study of an international joint venture between Group Five (Pty) Ltd (a SA company) and Spiecapag (a French company) within the New Multiproduct Pipeline Project (NMPP). The NMPP comprised the construction of approximately 700 km of welded steel pipeline with new pump stations and storage terminals throughout the KwaZulu-Natal, Free State, Mpumalanga and Gauteng provinces in South Africa. The client of the NMPP project is Transnet Pipelines, a division of Transnet Ltd, which currently operates over 3,000 km of pipelines in South Africa. At the time of commencing this study, the NMPP project was valued at approximately 5 Billion Rands (approximately 650 Million US Dollars). The construction of the NMPP project was undertaken by an integrated international construction joint venture partnership known as Spiecapag/G5 JV and it was established so that the partnering companies could assist one another in their fields of expertise in order to deliver the NMPP project, which was considered challenging. Spiecapag provided its technical expertise in pipeline installation while Group Five (Pty) Ltd provided its South African local knowledge, and the administration and financial support necessary in facilitating a project of this scale. The implementation of the project commenced in August 2008 and at the inception of the research study, progress was at 60% with final completion in May 2011. As Group Five (Pty) Ltd., seeks to build its standalone capabilities in pipeline construction, especially in petrochemical pipelines, the establishment of a joint venture with Spiecapag in the NMPP project was viewed as an opportunity to acquire knowledge and technology.

This paper is organised as follows: literature review of theory and practice of knowledge and technology acquisition in ICJV; research methodology; research results and their synthesis and analysis; and finally, a conceptual structure that is suitable for speedy knowledge and technology acquisition in ICJV is proposed.
2. Theory and practice of capacity building in ICJV projects

An International Construction Joint Venture (ICJV) involves one or more local construction companies teaming up with one or more foreign construction companies to undertake a construction project (Vaughan 2010). However, in other cases, an ICJV may involve two or more foreign companies undertaking a construction project in abroad territories without partnering with a local company. Vaughan (2010) stresses that regardless of the scope of the undertaking, the nature of the ICJV or the respective degrees of equity or management involvement, a joint venture must possess the following features: (a) It must be a separately identifiable entity; (b) It must have an ownership interest in such entity by joint venture partners (JVPs); and (c) It must have an active management involvement or deliberate rejection of the right to such involvement by each joint venture partner.

2.1 The drivers and benefits of ICJV

Several factors have been acting as catalysts for ICJV throughout the world including Africa. The construction industry in most developed countries, e.g. European countries, is operating in maturity stage as the new construction demand has slowed and de-industrialization has occurred (Lowitt, 2007). The subsequent fierce competition has compelled construction companies in these countries to seek markets in other geographical areas (Africa being the emerging market due to its high infrastructure demand) to strengthen their strategic positioning, competitiveness and performance. Dlungwana and Rwelamila (2004) indicate that Africa, particularly Southern Africa, is increasingly experiencing globalization in construction works. While African construction companies seek external expertise and technology to execute large complex infrastructure projects, foreign companies perceive teaming up with local companies via joint ventures as an ideal option to overcome government-mandated barriers to entry in Africa (Boateng & Glaister, 2003). Among those African countries seeking external expertise and technology to execute large complex infrastructure projects is South Africa (Sewpaul 2007). Rowan (2005) identified the following as the motives to formation of ICJV:

(a) A foreign contractor takes a project that is larger than it normally would undertake outside its country and therefore teams up with a competent local contractor with a view toward spreading the risk.

(b) A foreign contractor teams up with a competent local contractor to generate bonding capacity that each contractor would not have individually.

(c) Two or more contractors with special expertise e.g. a civil and mechanical contractor, team up to undertake a project that requires diverse expertise e.g., a power plant.

(d) A contractor that has an established organization in a country teams up with a contractor with little or no experience in the country but with specialized engineering knowledge or technology.
A foreign contractor teams up with a local contractor that may have political or other valuable relationships in the country where the project is executed.

Therefore, the foreign companies benefit the feasibility of entering new geographical markets in pursuit of strengthening their strategic positioning, competitiveness and performance while the local companies gain from the expertise and technology brought in by the foreign companies which can vitally contribute to the performance improvement of local companies.

2.2 Types of ICJV and agreements

According to Rowan (2005), International Construction Joint Ventures can take any of these three forms:

- **Integrated joint venture:** This type of joint venture’s primary characteristic is that it can represent a true partnership in that the parties share profits and losses.

  - **Non-Integrated joint venture:** In this type, there is no sharing of profit and losses between the parties.

  - **Combination joint ventures:** These joint ventures present a combination of an Integrated and Non-Integrated joint venture partnership. Each member takes on a specified scope of work and is responsible for that scope of work.

While the joint venture is not a partnership (usually the JV agreement will expressly stipulate that it is not), its structure and form closely resemble a partnership (Rowan, 2005). Vaughan (2010) alerts that structuring international construction joint venture agreements may pose challenges due to the fact that, parties are from different jurisdictions and various cultural backgrounds. After parties have decided on fundamental issues such as the commercial nature, scope and mutual objectives of the joint venture, the JVP must determine what legal structure the joint venture will take (Vaughan, 2010). Usually and particularly where the JV involves a local partner, the legal structure of the ICJV follows the laws of the host nation. Vaughan (2010) and Rowan (2005) suggest that, the joint venture contractual agreement should at least define and address the following:

- **Specific Limited Purpose and Duration:** Joint ventures are formed for a specific business objective and can have a limited life span or long-term.

- **Sharing of Profits and Losses:** Whether the joint venture is an integrated or non-integrated joint venture.

- **The Project Leader:** When there is a non-integrated joint venture in which each party is undertaking its own separate scope of work, it is critical that all joint venture agreements contain provisions that either specify that the party is the Leader of the ICJV or identify who is the project manager or provide a mechanism to appoint the project manager.
- **Working Capital:** Regardless of whether the joint venture is an integrated or non-integrated joint venture, provisions must be included that address the responsibility of the parties for working capital contributions.

- **Default:** As in any main contract or subcontract, the joint venture agreement must address default by one of its members. Default must be defined as clearly as possible and the remedies for default must be included.

### 2.3 Structure and management of ICJV projects

An international construction joint venture project structure refers to formal and informal framework of policies and rules, within which an ICJV arranges its lines of authority and communications, and allocates rights and duties. Graham and Englund (2004) argue that structure influences behavior of the project team members. Thus the objective in designing a project structure should be to provide a formal environment that the project manager can use to influence team members to do their best in completing their assignment and duties (pm4dev, 2007). Vaughan (2010) further highlights that some JVs are dominant partner enterprises in which projects are managed by one parent like wholly owned subsidiaries. Management normally will be in two tiers, i.e., project level and board level (Rowan 2005).

- **Management Board:** This forms the top layer of ICJV management. The management board usually comprises senior management personnel from head offices of the respective members and not project staff.

- **Project Level Management:** The project-level management often is left to a project manager, with or without the support of a project board. Generally, unanimity is not required of the Project Committee and frequently the project manager will be given the right to break tie votes.

### 2.4 Knowledge and technology acquisition in ICJV

IJVs are viewed as a practical vehicle for knowledge and technology transfer, and such knowledge transfer can contribute to the performance improvement of local companies (International, 2010). Such transfer of knowledge and technology from the foreign company to the local partner is not guaranteed. Hence the need to firstly understand the terms, technology and knowledge in order to have a better view on the dynamics of their acquisition in ICJVs. These terms from various sources are articulated in Table 1.

#### Table 1: Understanding technology and knowledge acquisition

<table>
<thead>
<tr>
<th>Researcher(s)</th>
<th>Arguments, definitions and assertions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen and Levinthal (1990)</td>
<td>Aspects that make absorptive capacity distinctly organizational include structure of communication between external environment, and the organization and the character and distribution of expertise within the organization itself.</td>
</tr>
<tr>
<td>Grant (1996)</td>
<td>Knowledge classified based on transferability as tacit (knowledge which is only known by an individual and that is difficult to communicate to rest of the</td>
</tr>
</tbody>
</table>
organization) and explicit (knowledge which can be codified, articulated and easily communicated). Knowledge transfer involves both transmission and receipt. An organizational structure that promotes interaction between individuals is highly pivotal to knowledge and technology acquisition among other factors.

Toukas (1996) Knowledge acquisition or transfer, results from participation and interactions with task, technology, resources and people within a particular context. Individuals acquire knowledge but an organization creates a context for acquiring that knowledge.

Meschi (1997) An ICJV structure that can facilitate mutual interaction between employees can enhance the foreign employees’ successful adjustment to the cultural differences.

Davenport and Prusak (1998) Knowledge is a fluid mix of experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experience and information.

Lane, Salk and Lyles (2001) Ability to learn directly reflects the ability to assimilate new knowledge and cultural distance serves as the context that facilitates or inhibit this ability.

Anh et al. (2006) Investment in training is critical in determining the level of knowledge acquisition.

2.5 Previous research on knowledge and technology acquisition ICJV

Learning from foreign partners is considered to be a determinant of success of the IJVs especially IJVs in transitional economies, hence the importance of learning from foreign partners in international joint ventures (Lane, Salk & Lyles, 2001). Some factors that affect successful technology and knowledge acquisition by local partners from the foreign partners in IJVs, include, internal environment of the firm, external environment of the firm and the process of consultation (Wallender III 1979), and absorptive capacity (Cohen & Levinthal 1990). Of all these factors, absorptive capacity has attracted the most attention. Based upon Cohen & Levinthal (1990), Lane et al. (2001) and Minbaevs et al. (2003) studies which point out that both human and organizational mechanisms are important aspects of organizational absorptive capacity, Anh et al. (2006) reaffirm the important role of absorptive capacity in inter-organizational learning context and further argue that different absorptive capacity components contribute to knowledge acquisition from foreign partners in different ways.

2.6 Synthesis of theory and practice – identifying the gap

The synthesis of literature above indicates that there is no research or any significant documented work that has been conducted in South Africa and across Africa and other
developing countries generally on knowledge and technology acquisition by local partnering firms, specifically in international construction joint venture projects.

3 Expertise acquisition in ICJVs in practice – the case study

The research project was carried out in order to partly fill the gap described above, by carrying out a case study of the NMPP project in South Africa as briefly described in Section 1, above.

For lack of space and brevity, only case study salient information is provided and extensive case study details are found elsewhere (Rwelamila and Mkandawire 2010).

- The main hypothesis:

$$H_{\text{main}}: \text{The ICJV structure that promotes joint participation of local personnel with experttriates in shared activities of the international construction joint venture project is positively correlated with the local company’s level of skills and technology acquisition from the foreign partner.}$$

- Sub-hypotheses:

Two sub-hypotheses were formulated from the main hypothesis and tested:

On the relationship between interaction at work place and collaboration in job tasks (Question 26)

$$H_0: \text{There is no significant relationship between collaboration in job tasks and the foreign employees’ willingness to share their knowledge and technology with local employees.}$$

$$H_1: \text{There is a significant relationship between collaboration in job tasks and the foreign employees’ willingness to share their knowledge and technology with local employees.}$$

On the relationship between collaboration in job tasks and sharing and sharing of knowledge and technology (Question 27)

$$H_0: \text{There is no significant relationship between interaction at work place and collaboration in job tasks.}$$

$$H_1: \text{There is a significant relationship between interaction at work place and collaboration in job tasks.}$$
3.1 Design of research method

The case study incorporated both qualitative and quantitative research methods via a two-phase design, in which quantitative study was followed by qualitative study. The quantitative research method was aimed at assessing the extent to which knowledge and technology acquisition occurs in the ICJV project. The quantitative research approach was purposed to profoundly describe and analyse the common drivers of knowledge and technology acquisition or lack thereof in the ICJV project in relation to its structure. This led to identification of the critical success factors for speedy acquisition of knowledge and technology. This is supported by Eisenhardt (1989), Tellis (1997) and Lee (1999) as a leverage to the weaknesses inherent in each.

3.4 Design of research instruments and profile of respondents

3.4.1 Research instrument

A 44 questions structured questionnaire was administered to the project participants and the philosophy and details of the instrument (including its administration) are described elsewhere (Rwelamila and Mkandawire 2010).

Follow-up interviews were conducted to simple sampled focus groups of not more than 20 people, in which open-ended questions were asked.

3.2.2 Profile of respondents

A total of 125 randomly selected employees in the Spiecapag/G5 JV within NMPP project were involved in the case study. As expected from a typical construction project in South Africa, the majority of respondents were male (82%) and the rest were female (18%).

On the job level, the sample was stratified into non-management, middle management and senior management levels. The non-management strata, was made-up of 58% of respondents, while middle and senior management represented 33% and 9% respectively. For a typical organisation or project, the sample was deemed to be fairly distributed across job levels.

3.5 Summary of research results

For lack of space and brevity, summary of questionnaire and interview results are presented here and detailed results are reported elsewhere (Rwelamila and Mkandawire 2010).

The following key findings from the research project are fundamental to ensuring that these critical success factors materialize, and that the local partner acquires enough knowledge and technology from the foreign partner:

- **The structure should enhance project success**: project success which is determined by factors such as cost, time, quality, utility, stakeholder management, health and safety,
etc., should not be hampered at the expense of knowledge and technology acquisition. JV partners were concerned with this.

- **The structure should help minimize the cultural shock period:** the study discovered that regardless of whether the employees are foreign or local, they all go through a cultural shock period when mobilized together in a project.

- **The structure should emphasize sharing of same project objectives:** it was found from the study that knowledge and technology sharing may become feasible when employees share the same project objectives. When employees share the same project objectives they bear the responsibility of achieving those objectives, as a result they find it compelling to collaborate in tasks and share information, knowledge and technology.

### 3.6 Conclusions and recommendations

#### 3.6.1 Conclusions

- **The importance of the JV structure:** even though the primary rationale for adoption of the section-based structure is to facilitate knowledge and technology acquisition in an international construction joint venture project, the structure is also perceived to be pivotal to enhancing project success.

- **The need for integration:** with the integration of local and foreign employees in one project section, the foreign and local employees will feel compelled to collaborate in jobs tasks and share knowledge and technology.

- **The importance of risk mitigation:** in any international JV, the foreign partner is more likely to be risk averse than the local partner and hence will incline more toward adopting a structure that is more capable of mitigating project risks.

- **The importance of local partner commitment to knowledge and technology acquisition:** the local partnering company should also show commitment to knowledge and technology acquisition to its employees.

#### 3.6.2 Recommendations

Overall, it is recommended that where international construction joint venture projects are involved and that knowledge and technology acquisition from the foreign partnering company becomes one of the objectives of a local company, a section-based structure should be adopted as indicated in Figure 1.
Figure 1: Section-based joint venture project structure

A section-based structure should be supported by a conceptual framework (Figure 2).

Figure 2: A conceptual framework for effective adoption of section-based structure
Other recommendations include:

- **Induction of project team on project objectives**: induction should involve orienting employees to the project partners, the reasons for the international joint venture, the different cultures, and what they should expect from the partnering companies and their employees.

- **Identification of required knowledge and technology**: unless the local company identifies the knowledge and technology it needs to acquire from the foreign partnering company, it may not acquire sufficient knowledge and technology in the ICJV even if a section-based structure is adopted.

- **Training and monitoring of employees**: it is not enough to induct employees on ICJV project objectives, identify required knowledge and technology, and single-out potential employees. It is important that the above is coupled with training of employees and continuous monitoring of their progress.

**References**


Community Directed School Infrastructure Development in Vanuatu

Lawther, Peter

Abstract

The demand for primary level education in Vanuatu continues to rise driven by strong population growth and the introduction of fee-free schooling. This in turn places pressure on supply side educational requirements, of which school infrastructure is a significant one, and more broadly places achievement of relevant Millennium Development Goals at risk. School infrastructure includes classrooms, toilets, staff houses, dormitories, furniture etc.

The commonly used method for the provision of school infrastructure in Vanuatu is through a centralised (inside out) model implemented by the Ministry of Education, with international donor support. However, geographical and institutional constraints has resulted in an under supply of school infrastructure which is unable to meet increased demand for education.

As a result, a community directed school infrastructure pilot program was implemented in 2011/12, with the objective being to trial an alternative (outside in) delivery mechanism. In addition, a refined building design, which more aptly captures local knowledge, skill and maintenance requirements was developed, whilst retaining some deference to “imported” disaster risk reduction engineering principles. With support from the Ministry of Education and Donors, the new “hybrid” classroom building was constructed by “the community” of Takara, on Efate Island, Vanuatu and opened in May 2012.

This paper documents the rationale and implementation of the project, concluding that it represents a realistic methodology to address required school classroom provision in Vanuatu.

Keywords: Vanuatu, School Infrastructure, Community Directed Development, Hybrid

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1 Introduction

Increasing demand for primary level education in Vanuatu is being driven by strong population growth and the introduction of fee-free schooling. This demand is placing pressure on supply side educational requirements, including infrastructure. It is estimated that some 200 school classrooms per year are required to be either refurbished or reconstructed to keep pace with enrolment demand. Whilst this figure has not been verified, it is clear that the current output of classrooms (approximately 30 – 40 per year) will not cater for this demand. Further, the current double classroom block design reinforced concrete is comparatively slow and expensive to build.

2 Current Method of Education Infrastructure Delivery

The design and delivery of school infrastructure in Vanuatu is the responsibility of the Ministry of Education (MoE). A standard double classroom design is used throughout the country. This design comprises a reinforced concrete frame with solid concrete block infill walls, and a timber framed metal deck roof. The MoE utilises a centralized approach to school infrastructure delivery throughout Vanuatu. Historically, this has operated with the MoE procuring materials centrally and distributing them to school sites on an “as needed” basis. Installation of the materials is in turn done by local contractors whom are sourced through competitive local bidding. This is essentially an “inside-out” control paradigm of infrastructure delivery which broadly places the Authorities at the centre of delivery, and communities at the periphery as per Figure 1 below.

![Figure 1: The Control Paradigm of Infrastructure Delivery (Lankatilleke 2010)](image)

However, institutional capacity constraints (predominantly in the form of human resourcing) associated with this method of delivery currently result in an undersupply of classrooms
(approximately 30-40 per year), which clearly will not deliver the identified required output of 200 classrooms per year as stated above. As such, an alternative approach to school infrastructure procurement is required.

3 A Community Driven Development Approach

A Community Driven Development approach (CDD) is an alternative procurement option which has been used successfully in the Pacific (Lawther 2009), South Asia (Edstrom 2002, World Bank 2003), as well as a number of African countries (Theunynck 2009) to deliver school infrastructure on a large volume basis.

CDD essentially decentralizes the provision of school infrastructure from the MoE to the communities. The emphasis shifts from the current government provision of infrastructure to the community, to the community provision of infrastructure. In practice, the community is paid a stage based grant to deliver a facility that they identify as necessary for their local school, within an holistic school development plan. CDD leverages off existing capacities within communities and provides the necessary resources (usually money and technical expertise) to augment these capacities. In addition, communities are encouraged to think strategically about the immediate and longer term infrastructure requirements for their schools. Such an approach is commensurate with accepted development theory (Chambers 1997) which seeks to empower communities to identify and achieve their own development objectives, and thus delivery infrastructure through an outside in, or support paradigm, as shown in Figure 2 below.

![Figure 2: The Support Paradigm of Infrastructure Delivery (Lankatilleke 2010)](image)
International experience (World Bank 2003) has shown that the transfer of responsibility from government to community for the delivery of small scale infrastructure, such as school buildings;

- leads to substantial cost-savings, community empowerment and ownership, increased speed of the execution of large programs of scattered small facilities, and in the case of school construction, increased participation of the community in the school life.
- community-based contracting is feasible and particularly desirable in remote areas.
- Governments consistently underestimate the capability of rural communities to mobilize and manage projects. Nonetheless communities need properly targeted mobilization and support, in order to succeed.

In addition, a CDD approach to school construction typically delivers the following benefits (Lawther 2009):

- reduced costs, through the increased use of lower cost rural labor, material and management capacities.
- greater maintainability, as the skills and materials needed to maintain the building are both sourced and developed locally.
- greater ownership, as the community sees the finished building as something they created rather something belonging to the Government.
- greater empowerment, as Villages successfully undertake the task of producing quality school buildings.
- better dialogue and relationships between Government and Village, through the process of working together.
- great economic benefits, as more of the work and money associated with school infrastructure investment flows through the Village, rather than directly to urban contractors and suppliers.

Success of CDD (World Bank 2003) depends upon the following principles:

- Investment in an awareness program to socialize the concept of CDD within communities.
- Use of local knowledge and having the local community participate in the design and ongoing review of the program.
- Working within existing community governance structures.
- Paying the community properly for the service they render the Nation through managing the construction of schools.
- Proper investment in the planning and management of the program.
- Use of financial incentives so that producing school buildings that are well built, and built quickly, delivers the greatest rewards for the community.
- Use of pro-active Quality Assurance systems that prevent mistakes before they happen, and help the communities to succeed, rather than identifying mistakes after the fact.
• Develop designs that are appropriate and attuned to the local skills and materials base, for ease of local production.
• Delegation of responsibility. It is better to give the community too much responsibility, and later pull back, than to be timid, and never know how much they are capable of.
• Maintaining simplicity by using minimum paperwork and procedures at the community level.
• Ensuring transparency and accountability by all members of the community being aware of where and how the finances are being spent.

Thus a CDD approach to the delivery of school infrastructure was piloted. This pilot required the design and construction of a “hybrid” classroom building. This is now considered.

4 The Hybrid Design

The overarching design philosophy of the project was to involve the local community as much as possible. This required the use of local materials to the full extent possible, coupled with the integration of discreet specific “western” seismic and anchoring details. This fusion of local and external technologies gave rise to the “hybrid” nomenclature. The spatial layout of the classroom building was based upon the MoE’s existing double classroom layout, but with scalable flexibility as shown in Figure 3 below. In this sense the floor plan replicated the existing classroom facility.

![Hybrid Building Floor Plan](Source: Kaunitz 2011)

Figure 3: Hybrid Building Floor Plan (Source: Kaunitz 2011)

However, the reinforced concrete frame was replaced with a timber frame to facilitate the use of local materials in construction. Structural connection and tie downs were included for
earthquake and cyclone resilience (hence the term “hybrid). Design options considered and chosen by the community included:

- the type of flooring being either reinforced concrete slab, or traditional crushed coral. The community chose reinforced concrete.
- the type of walling infill panels, such as timber or stone. The community chose local stone.
- the type of roofing, typically either metal deck roof sheeting, or traditional thatch. The community chose thatch on the basis of its deference to traditional local building design. This was interesting as metal sheeting is often considered as having lower maintenance requirements (Lawther 2009).

Additional consideration was also given to lighting and ventilation to facilitate user comfort as shown in figure 4 below.

![Figure 4: Lighting and Ventilation considerations (Source: Kaunitz 2011)](image)

A comparison of salient design features between the pre-existing reinforced concrete frame and the hybrid design is shown in table 1 below:
From Table 1 above, the following can be gleaned:

- The hybrid design is approximately 5\% larger than the reinforced concrete design in terms of internal floor area.
- The hybrid design has approximately 4\% less classroom area than the reinforced concrete design. However, the hybrid has a separate common classroom storage area, which should assist user efficiency of classroom space utilization, as items will be capable of being stored adjacent to, rather than within, the classroom.
- The hybrid design is approximately 50\% larger in terms of the office, storage, verandah area.
- The ventilation area provision of the hybrid design is approximately 3 times that of the reinforced concrete building, and should provide greater thermal comfort for users.
- The lighting area provision of the hybrid is approximately 20\% greater than the reinforced concrete building, and should provide enhanced visual comfort for users.
• The floor to truss height of the hybrid design (at the external wall) is 200mm lower than the reinforced concrete building. Whilst the hybrid design roof is therefore effectively 200mm closer to users, and some impact upon thermal comfort might be expected, it is considered that this will be compensated for by the significant increase in ventilation provision, as above. In addition, a thatch roof covering (if chosen) will also assist in defraying any adverse thermal impact.

5 Construction

The construction of the hybrid building was undertaken by the community of Takara, Efate island. This community was chosen as they expressed interest in undertaking the project, and were within proximity of MoE and donors (approximately 1 hour from Port Vila). In order to simplify the piloting process, it was decided to use milled timber sourced from Port Vila, rather than milled on site, which is the ultimate objective of the CDD, particularly given the importance of timber to the building. As stated, however, the Takara community opted for a concrete slab flooring, stone wall infills and a thatched roof in accordance with traditional local design principles.

A pictorial record of the construction is presented in Figure 5 below:
Figure 5: Construction (Kaunitz 2012a)
The final construction report (Kaunitz 2012b), highlighted the following key issues from the construction component of the project:

• The project took eight months to construct, which is longer than that experienced for the reinforced concrete design (3-5 months generally). However, a substantial component of these delays resulted from procurement delays in the MoE. When these (and holiday periods) are removed, the construction period is 5 months, which is comparable with the reinforced concrete design. However, future local milling of timber would add to this timeframe.

• A group of twelve local men predominantly undertook the majority of the construction work on the project. The Takara and surrounding communities also supplied the necessary sand, gravel, thatch and woven bamboo window hatches. Local timber species were used in construction.

• The cost of the hybrid was 5.45 million Vatu. This represents an approximate 50% saving of the reinforced concrete designed classroom building. If locally milled timber were be used, it is estimated the cost of the hybrid would decrease to approximately 30% of the reinforced concrete design meaning that school classroom production could theoretically be increased threefold – clearly a significant achievement in addressing demand for education in Vanuatu.

• Additional MoE support to the community is required, particularly in terms of procurement and on-site supervision. This could be achieved through outsourcing to the private sector and thus overcoming inherent capacity constraints.

The overall success of the community directed development approach is summarised in the following communiqué from the MoE supervisor of the project to the designer:

“Thank you very much everything.

It's been a very big pleasure been working with you to put all our theories into PRACTICAL so now people of Takara, Efate, Shefa and all Vanuatu have witnessed and enjoyed so much the complete product.

It has help me a lot too in my building capacity or carrier in hybrid construction and also shows me more creative ideas & techniques of mixtures of natural to artificial materials to develop schools and communities around all Vanuatu.

This MODEL will grow so fast in the other island I can tell you, as now I am already having problems in working on the designs of the staff houses, classrooms, libraries and schools halls and all at one go, by using parts of our takara models for EPI ISLAND and EFATE ISLANDS following so many requests, and soon or later you will see some of them built.”
6 Conclusion

The increasing demand for primary level education in Vanuatu has placed pressure upon school infrastructure delivery mechanisms. The existing inside-out government controlled procurement paradigm of school infrastructure has proved incapable of catering for such demand.

This has resulted in the trialling of a community directed development (outside in) procurement paradigm comprising the design and construction of a “hybrid” double classroom building. The hybrid label is derived from a predominantly local based technological solution laced with some discreet deference to Western style engineering principles vis a viz earthquake and cyclone resistant principles.

The hybrid building was successfully piloted in the community of Takara on Efate island, Vanuatu in 2011/12. The project was constructed in comparable time to the mainstream reinforced concrete design, although at half the cost. Further economies could be expected as the process is refined through further implementation.

Subject to a detailed evaluation of user satisfaction which is yet to be undertaken, the hybrid pilot project provides a workable model of a community driven development approach that can be implemented on a broader scale to address current infrastructure supply constraints that potentially restrict access to primary education in Vanuatu.
References


CONSTRUCTION WASTE MANAGEMENT SYSTEM: A CASE STUDY IN A CONSTRUCTION PROJECT IN CHILE

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ABSTRACT

Construction waste forms the majority of waste disposed in landfills. It originates from various sources and is produced throughout the duration of the construction projects. The Chilean Chamber of Construction has taken actions to reduce waste generation through mechanisms such as the Clean Production Agreement and the Guide to Good Environmental Practices, among others. However, they have had poor results in terms of reducing the rate of waste generation. For this reason, it is important to view construction waste management as a series of procedures to improve production methods and not just as a process of classification, collection and disposal of waste. This article describes a waste management system (WMS) at a construction operations level and the results of its implementation during the execution of the structural work on a real project. While the procedures that make up the WMS were the result of a series of interviews with construction experts, some of the support elements necessary for its implementation in the field were the authors' own developments. The results show a high participation and involvement of all who took part in the project. The implementation of the WMS raised awareness towards waste minimization and its effectiveness was demonstrated by the amount of waste reduction achieved. Preliminary findings indicate that some of the most important components for a good performance of the WMS are staff training, leadership by the project manager and control through the partial measuring of the performance of its components.

Keywords: system, management, waste, construction, case study.

1. INTRODUCTION

Construction is the industry that generates the greatest quantity of solid waste in the world (Xiao-shuang, et al., 2010; Spoerri et al., 2009; Kourmpanis et al., 2008, Deng et al., 2008 and Wang et al., 2004). With the current population growth rate, the demand for construction will continue to rise, thereby causing a significant increase in the rate of waste generation.

According to Chile’s Environment Ministry (2010), 5 million tonnes of construction waste are generated annually. According to the Chilean Chamber of Construction, building permits in

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2011 increased by 55% in comparison to 2010, in a year which saw the highest number since 1992 (Report Mach-35, April 2012). In many cases the waste produced by this construction is being taken to illegal landfills located mainly in poorer peripheral neighborhoods in the metropolitan area, generating increasingly greater environmental and social impacts. In January 2010, the Ministry of Health recorded more than 70 illegal dumps in the metropolitan region of Chile alone, not counting all of the micro landfills. The vast majority of these are located in peripheral municipalities of Santiago where there are scarce resources for control and management.

Construction waste comes from various sources involved in the execution of building projects (Shen et al., 2004). Waste management on site is becoming an important part of the construction process (Wimalasena et al., 2010). In the construction phase, specific plans have been put forth for waste management, such as those proposed by McDonald and Smithers (1998). Additionally, McGrath (2001) developed a project called SMARTWaste, Chen et al. (2002) used barcode technology and Shen et al. (2004) employed the Waste Management Mapping Model (WMMM). Furthermore, Cha et al. (2009) have proposed utilizing the Waste Management Performance Assessment Tool (WMPAT) to assess waste management in advance from four perspectives: labor, equipment and materials, construction methods and management practices. However, a WMS is not currently available for construction operations that incorporate management actions for waste that has already been generated or for the management hierarchy of waste avoidance, reduction, reuse and recycling, as proposed by Deng et al. (2008), Shen et al. (2004) and Kartam et al. (2004). Therefore, in this study a WMS to support construction operations has been developed and implemented in a construction project of a Chilean company.

This article describes a WMS for a construction project in Chile, at a construction operations level, with all of the involved processes, activities and records. The results of the WMS implementation are also shown to demonstrate its benefits in terms of reducing the amount of waste its contribution to economic utility of the project.

2. PREVIOUS RESEARCH

The literature review focused on three major topics: waste management plans and case studies, manuals of good waste management practices and public initiatives in Chile developed for construction waste. The following chapter describes the findings in each of these cases.

2.1 Waste management plans and case studies

McDonald and Smithers (1998) implemented a waste management plan for the construction site of a two floor building with a floor space of 10,600 m². The plan's objectives were to reduce, reuse and/or recycle waste. The main strategies used to achieve the objectives were: to prepare an inventory of wasted materials and to assess their potential for reuse and recycling, to evaluate the costs of waste disposal, to develop a practical method for the collection of waste and to use recycled materials in temporary work. Although waste
reduction costs were estimated, the only the management operations studied were those concerning the handling of waste. Additionally, specific practices implemented in the project, such as the use of cranes, workers, trucks, and waste handling facilitators, among other details, were not explained.

McGrath (2001) proposed a using piece of software called SMARTWaste (Site Methodology to Audit, Reduce and Target Waste). Its purpose is to identify sources of waste generation and quantify the amounts generated. The system is based on collecting information by periodically analyzing waste disposal containers. It analyses the possible causes of waste generation by entering information such as type, size and quantity of waste, as well as the location it was collected, among other data. SMARTWaste requires a person on site once or twice a week, whose task is to collect the details of waste generation and to talk with workers and project managers to determine the origin of this waste. The implementation costs and efficiency of the plan with regards to the reduction of waste were not evaluated.

Chen et al., (2002) presents a rewards program based on giving incentives to building site workers (IRP - Reward Incentive Program). It uses a bar code system to identify materials and obtain real time information on the amount of material exchanged between the warehouse and the workers. In this way the consumption of each type of material is controlled and it can be identified whether a material has been either saved or consumed excessively. Workers can then be rewarded according to the quantities and values of the materials they have saved when carrying out their work. Although this incentive program is able to reduce the amount of material consumed, it does not identify which waste management procedures have been implemented by the workers, nor does it calculate the economic benefit of this reduction.

Shen et al., (2004) propose using a program known as the WMMM, which was employed to implement good waste handling practices in Hong Kong. The proposed model focuses on strategies to deal with waste on construction sites once it has been generated. The idea is to reduce costs by minimizing and simplifying handling processes, cutting back on staff (by using mechanical waste handling methods) and abolishing the double handling of waste products, among other strategies (Shen et al., 2004). While this model proposes specific action to minimize the generation of waste at the handling stage, it does not quantify the economic impact of such action.

Cha et al. (2009) propose employing the WMPAT. This is an application developed using Excel and Visual Basic to facilitate the evaluation process of waste management in projects concerning labor, materials and equipment, methods of construction and management practices. The WMPAT gives a total index that indicates the level of performance of the project in terms of waste management (Cha et al, 2009). This index has been classified into four levels: excellent, good, fair and poor. For example, for a project classified as “poor” waste management is of little importance to the workers and they have little training in this area. In terms of materials, the recycling of materials is rarely implemented. Regarding building methods, little effort is made on the site to decrease waste. Finally, from a management perspective, there is no incentive for waste reduction. While the WMPAT is a
tool that evaluates the performance of waste management, it does not evaluate each factor influencing the economic impact of construction waste.

2.2 Manuals of Good Environmental Practices

The United States Environmental Protection Agency (EPA) has proposed strategies and practices to reduce construction waste and demolition debris from buildings. It has published the results of a series of cases where there is an emphasis on cost/benefit and has made suggestions for the use of such results in other projects. One strategy is to educate contractors and workers in material recovery techniques. Another is to make subcontractors responsible for the recovery of materials through the inclusion of contractual clauses which can be paid only after it has been certified that the outsourcer has made efforts to recover materials. Finally, incentives are provided for the recovery of materials.

The Master Builders Association of Victoria and Ecorecycle Victoria, also in the United States of America (2004), have published a brochure to provide guidance to reduce waste. They propose six ways to work smarter, to reduce waste and to save money. These are: (1) To prepare a waste management plan, (2) to design and order only what you need, (3) to use pre-manufactured products, (4) to work together with other builders to recycle, (5) to provide waste recipients, and (6) to separate waste for recycling. Additionally, they provide a template to check each of the above components before, during and after construction.

Laquatra and Pierce (2002) propose using spreadsheets to audit waste. These will help control the disposal of waste by volume and by weight, identify companies that recycle specific materials and their costs, calculate the rate of waste generation per material, register the organizations involved in waste recycling, register identify the current costs of waste disposal, and take note of other important observations.

The Chilean Chamber of Construction, specifically the Commission on Sustainable Development, has prepared a guide to good construction practices that is especially oriented towards the erection of buildings. It proposes mitigation measures to moderate the following effects that may be generated by construction activities: air emissions, noise, waste and complaints by neighbors (Chilean Chamber of Construction, 2010). Regarding the waste issue alone, there are 13 mitigation measures that have been proposed for building constructions. Only 5 of these aim to prevent the generation of waste, while the others focus on its handling once generated. However, these measures are only outlined. Some are generic and it is not shown in detail how they would be executed. Each requires operational planning for its proper implementation in the field.

2.3 Public initiatives in Chile

On 28 January 2000, the construction sector’s Clean Production Agreement (CPA) for the metropolitan region of Chile was signed. It came into effect on May 1 of that year and ended on April 30 2002, adhering to the 34 construction company members of the Chilean Chamber of Construction. The CPA’s study of the environmental and economic impact
determined that the goals of the CPA in relation to solid waste had not been completely accomplished. However, it did show that average waste generation was reduced by 20% through the use and acquisition of standardized or precast products and the reuse of excavation waste as fillers in other building work. The study also determined that it is not possible to say whether this reduction is due to the CPA or not because the total construction area developed by the companies who signed the agreement in 1999 (the year of the initial signing of the agreement) and 2005 (when the study of the environmental and economic impact of the agreement took place) is not known. This is due to the fact that companies tend to treat such data as confidential information. Therefore, the true effectiveness of waste management in construction projects cannot be identified. Secondly, other good environmental practices that would indicate how to avoid, reduce, reuse and/or recycle waste before it ends in a landfill were not incorporated.

3. FRAMEWORK AND METHODOLOGY

The generation and management of waste in a project are closely related to production processes and support activities (procurement management, quality control system, material control and cost control, among others.). Previously, when thinking about procedures to reduce waste and emissions from certain activities, the first thing that was focused on were tactics like the replacement of materials and equipment. The possibility of reducing waste by implementing simple and inexpensive measures to improve operations management in a project had not been considered. For this reason, in this study a WMS was designed that proposes some changes to the traditional patterns of management operations and also articulates some of the activities that support the implementation of a project. In this way it is hoped that the generation of waste can be reduced and environmental and economic benefits for construction projects can be obtained.

Based on the list of the sources and causes of waste generation and the procedures and/or waste management strategies proposed by Aldana et al., (2011), a list of 33 measures was generated that can be implemented in construction projects and contribute to the reduction of waste. Additionally, by reviewing the literature regarding materials wasted in construction projects, a list of 34 waste materials was obtained. Subsequently, interviews were given to 11 professionals from 6 construction and real estate companies. These people were asked which 10 procedures and/or strategies they considered most relevant to implement in a construction project that would contribute to a reduction of waste. Finally, they were asked which 5 materials are wasted the most on such projects. The professionals surveyed consisted of builders (7) and civil engineers (4) who have an average of 19 years experience in the industry and who currently hold the following positions: technical manager (1), project manager (2), site manager (6), construction manager (1) and technical inspector (1).

After an analysis of 123 publications on construction waste management, it was found that only 26 of them talk about waste management procedures and/or strategies. Based on this, a ranking was performed taking the frequency that these strategies were mentioned in the literature (see Table 1) as a parameter. This frequency ranking was taken from Aldana and Serpell (2012).
Table 1. Waste management procedures and/or strategies most cited in the literature.

<table>
<thead>
<tr>
<th>Procedures and/or strategies</th>
<th>Number of citations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorting waste at construction sites, assigning locations and recipients for each type.</td>
<td>9</td>
</tr>
<tr>
<td>Use of precast materials.</td>
<td>8</td>
</tr>
<tr>
<td>Training and educating staff on management tools and on-site waste management.</td>
<td>8</td>
</tr>
<tr>
<td>Buying and ordering materials efficiently.</td>
<td>7</td>
</tr>
<tr>
<td>Establishing centralized cutting areas to identify parts that can be reused.</td>
<td>4</td>
</tr>
<tr>
<td>Storing materials in good condition.</td>
<td>4</td>
</tr>
<tr>
<td>Making orders and receiving deliveries in good time</td>
<td>4</td>
</tr>
<tr>
<td>Encouraging subcontractors and workers to save materials.</td>
<td>3</td>
</tr>
<tr>
<td>Requiring the reuse of materials to be stated in contracts, demanding the amount of waste to</td>
<td>2</td>
</tr>
<tr>
<td>be recorded and the generated levels to be reported as the construction process is carried</td>
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<tr>
<td>out, requiring materials to be ordered with the correct sizes by adequately reviewing supplier</td>
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<tr>
<td>catalogs, changing the design of construction processes, using metal formwork.</td>
<td></td>
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<tr>
<td>Cutting steel in the factory not on site, using modern technologies, committing workers to</td>
<td>1</td>
</tr>
<tr>
<td>use good material handling, requiring subcontractors to purchase their own materials,</td>
<td></td>
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<tr>
<td>maintaining machinery and equipment, handling materials correctly, reviewing materials when</td>
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<tr>
<td>workers arrive on site and returning deteriorated materials to the supplier, preparing</td>
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<tr>
<td>transport systems suitable for each material, unloading materials at their final site and</td>
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<tr>
<td>avoiding stacking and double handling, locating warehouses near the construction site,</td>
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<tr>
<td>limiting the quantity of stockpiled materials to avoid excess inventory, returning material</td>
<td></td>
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<tr>
<td>packaging to suppliers for reuse, negotiating the return of unused materials with suppliers,</td>
<td></td>
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<tr>
<td>avoiding suppliers that over package materials, providing recipients that separate trash</td>
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<tr>
<td>(food, drink containers, etc.), carrying out material inventories as planned, buying</td>
<td></td>
</tr>
<tr>
<td>materials that have reusable packaging, using technologies that generate little waste, using</td>
<td></td>
</tr>
<tr>
<td>materials before their expiry dates, requiring subcontracts to dispose of their own waste.</td>
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</tbody>
</table>

After analyzing the results of the interviews and the ranking in the literature, it was possible to conclude that of the 14 procedures most frequently listed in the literature, 12 of them were selected by experts in the interviews. An analysis was also done considering the specific influence of the experts' responses, leading to the conclusion that of the 15 procedures most mentioned in the literature, 12 were selected by experts. Finally, an incremental revision of the interviews was carried out to verify the stability of the answers and to determine whether more interviews were needed to select the procedures that would be the basis of the WMS. It was concluded that of the 15 procedures mentioned in the literature, between 10 and 13 were selected by respondents in all the iterations analyzed. Therefore, it was decided to take the procedures identified by the experts as a reference point for planning the WMS. The results of the survey yielded the following order of importance of waste management actions:
(1) committing workers to use good material handling, (2) encouraging subcontractors and workers to save materials, (3) training and educating staff about management tools and waste management, (4) sorting waste on site by assigning locations and recipients for each type, (5) buying and ordering materials efficiently, (6) using precast materials, (7) establishing centralized cutting areas to identify parts that can be reused, (8) handling materials correctly, (9) providing garbage containers, (10) cutting steel in the factory rather than on site, (11) recording the amount of waste and reporting generated levels as the construction process progresses, (12) requesting appropriately sized materials through the study of supplier catalogs, (13) using metal formwork, (14) changing the designs of construction processes, and (15) using modern technologies and those that generate little waste.

Based on the 15 procedures selected, aspects that were applied at the operational level required for their successful implementation in the field were reviewed. This included taking a performance measurement for the WMS implementation to control its execution in the field, as proposed by Aldana et al., (2011). Finally, once the system had been designed, verification of the project support activities was carried out (quality control system, procurement system, cost control system, etc.) to see which were common to the WMS. In this way, the same work was not done twice and information was not over-recorded.

The WMS was validated by the technical manager of the construction company who provided the building project and two project managers for the case study. The particularities of the project and restrictions made by the person in charge resulted in minor changes to some records and the incorporation and/or elimination of some of the proposed procedures.

According to Aldana and Serpell (2012), the construction waste most widely reported in the literature is: concrete, wood, brick, plastic, metal, steel, and gypsum board. According to the interviews with the experts, the most frequently generated waste is: concrete, wood, steel, and gypsum board. Based on this, the materials selected for the implementation of the WMS were those reported by both the experts and the literature, and which are present during the structural stage of the project.

4. FINDINGS

An overview of the case study project, the WMS, some specific aspects of the WMS process, a performance measurement of the WMS implementation, and the effectiveness of the WMS are presented below.

4.1 Overview of the case study project

The case study project chosen for the WMS implementation was the construction of a preschool with a building area of 12,603 m². The structure is of reinforced concrete, with foundations and roof beams in concrete runs and vegetation cover. To measure the effectiveness of the project, the WMS was divided into four areas, each having the same
distribution. Rhythmic planning was used. In zone 1 the amount of waste was measured without having implemented the WMS. In zone 2 the deployment had already begun and served as a transition for zones 3 and 4 where the effectiveness of the WMS was measured once implemented.

4.2 Waste Management System

The 15 measures selected for the WMS were grouped into the following ten processes: (1) 3D modeling, (2) training, (3) efficient purchasing of materials, (4) steel prefabrication, (5) materials handling, (6) donating materials, (7) rewarding workers, (8) recycling time, (9) material storage areas, and (10) recording and reporting residue levels. Each process was planned in such a way that all the elements necessary for proper execution and implementation in the field were developed. This included a flowchart, forms, records and supporting documents.

4.3 Description of the WMS processes

The following section will explain some of the processes that generated the most significant WMS changes at an operational level when compared to how the company was run before.

4.3.1 Efficient purchase of materials

Before implementing the WMS, products offered by the material suppliers were verified by reviewing their catalogs. Through measurements in the plans of the amount of material theoretically needed for each activity and considering the supplier's recommended performance, the amount of material required was calculated. This is a procedure known as scaling. Previous to scaling, providers were consulted on the possibility of producing materials that specifically fit the project to avoid excess waste in the cuts. After finding out the dimensions made available by the manufacturers, optimization of the material was performed through the use of the appropriate software (Length Cutting Optimization 2D and 1D). Subsequently, modulation plans were generated of the activities that required the material studied. In this way, materials and cuts could be optimized. The plans indicated to the fitters how to make the cuts and where the materials should be installed. Finally, a cost analysis was carried out to compare buying materials with standard sizes with those cut to project specifications.

4.3.2 Waste control

Before implementing the WMS, the number of waste trucks leaving the site were counted in order to obtain the total waste volume. The goal was to create a methodology for measuring the amounts of materials wasted daily in project activities and to deliver information for decision-making without having to wait a considerable time. This helped control productivity and the performance of the materials.
After the implementation of the WMS, a material control table was designed (see Table 2) based on the scaling obtained after developing the modulation plans. Table 2 shows the quantity of each material to be delivered to locations in each of the preschool areas. Later, the store manager recorded the amount of each material received, following the inspection protocols of these materials. The delivery of materials to the workers was allowed only through permission slips given by the site managers. When the requested quantity exceeded the amount permitted by the control table, a warning was generated and a message was sent to the project manager to report on what had happened and initiate a procedure to identify the reason an excess amount of material had been requested.

**Table 2. Example of material control box**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Compound</th>
<th>Material</th>
<th>Materials stored</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone</th>
<th>Compound</th>
<th>Material</th>
<th>Unit</th>
<th>Amount allowed to be delivered (A)</th>
<th>Quantity delivered to workers (B)</th>
<th>Difference (A-B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Finally, in order to maintain control over the volume of waste of each material for each location, the site managers carried a notebook where they recorded day by day activities with their respective units of measurement (see Table 3). In this way, by looking at the amount of material delivered and the amount used, it was possible to accurately find out the quantity of waste generated at each location and for each activity.

**Table 3. Example of notebook of measurements**

<table>
<thead>
<tr>
<th>Compound:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Activity</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Measuring unit:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Measurement date</th>
<th>Length (m)</th>
<th>Width (m)</th>
<th>Height (m)</th>
<th>Total</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.4 Performance measurement of the WMS implementation

To evaluate the performance of the WMS implementation, a weekly indicator was used based on that proposed by Aldana et al., (2011). This evaluation consisted of a weekly visit to the project to find out where there was compliance with each of the control variables of the WMS processes. The structural work stage of the project lasted 14 weeks, in which time an
average of 50% of the WMS implementation was achieved, with a maximum of 60% in week 6 and a minimum of 17% in week 10.

4.5 WMS effectiveness

Below are the results of the measurements of material waste in the structural work stage.

**Table 4. Level of material waste in the structural work stage**

<table>
<thead>
<tr>
<th>Material</th>
<th>Without WMS implementation (Zone 1)</th>
<th>With WMS implementation (Zone 3)</th>
<th>With WMS implementation (Zone 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Steel</td>
<td>10</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Wood</td>
<td>15</td>
<td>11</td>
<td>9</td>
</tr>
</tbody>
</table>

5. DISCUSSION AND CONCLUSION

Implementing the WMS required cultural and behavioral changes for workers and professionals that were part of project. Initially some resistance to the changes that were implemented was shown by certain participants. However, following procedures such as training and incentives, and after the support of the senior management of the company and project managers, this changed and a high degree of worker motivation was generated. Behavioral changes were especially apparent in the carpenters. This was due to the implementation of wood recycling collection centers, where before removing material from the stores, workers went to the collection centers to select materials that could be reused.

The integration of the WMS with processes such as cost control, procurement management and quality control were instrumental in its implementation. This is because overly long records with unnecessary information did not have to be generated. Therefore, people did not have a negative disposition towards the WMS and in return a more useful information was obtained. This helped decision making and led to improvements in construction operations.

When measuring the performance of the WMS implementation, a maximum and a minimum were presented. The maximum was due to motivational factors that coincided with system processes, thereby resulting in a proper WMS implementation. The minimum coincides with activities that were more difficult to execute and with problems of labor shortage where new workers had to be incorporated, trained and taught the WMS principals.

As a result of the implementation of the WMS, savings of approximately US $ 400,000 were achieved. This figure consists of savings on materials, with an approximate value of US $
300,000, and savings on waste collection and removal, with an approximate value of US $100,000. It should be noted that the project budget was US $4 million.

ACKNOWLEDGEMENTS

The authors wish to thank the AXIS Construction Development Company S.A for providing a project with which to implement the WMS. Also, gratitude is given to all participants of the project (about 200 workers) for their good reception and hospitality.

References


Cámara Chilena de la Construcción, Abril de 2012. Informe Mach No 35.


Delay Analysis Methods and Factors Affecting their Selection in the Construction Industry in Gaza Strip

Adnan Enshassi ¹, Asmahan Jubeh ²

Abstract

Delay in construction projects is a global phenomenon. The contracted parties resort to a variety of delay analysis methods (DAMs) to determine the parties responsible for delays. The delay analysis methods have various capabilities and requirements that limit their use in the construction industry. This paper aims to survey the commonly used DAMs and to determine the factors that influence their selection according to contractors and consultants perspectives in Gaza Strip. A total of 100 contractors and consultants were approached, of which 33 participated. The results indicated that, the most commonly used DAM in Gaza Strip is "As-planned vs. As-built". It has been found that, the most important factors which affect DAMs are: records availability, baseline programme availability and updated programme availability, while dispute resolution forum and applicable legislation are the lowest factors that affect the selection of DAMs. This paper stressed the importance of obtaining full records throughout the project life cycle in order to assist the disputed parties to select the appropriate DAM that gives relatively correct results. Training courses covering delay analysis methods and their requirements are recommended.

Keywords: Delay analysis methods, construction, disputes, life cycle, training.

1. Introduction

Most construction projects are executed through contracts which are not easy to comprehend even by professionals. As the size of project increase, the contract becomes more complex and ambiguities causing the project to undergo cost and time overrun, which in turn create ground for claims and disputes (Iyer et al., 2008). Construction projects are composed of many interrelated elements of labour, material, cost, schedule, and other resources, that make it difficult to decide the proximate causes of delay, and the parties responsible for delay (Kim et al., 2008).

Parties to dispute may seek compensation by submitting a claim. The equitable allocation of responsibility for project delays is essential to resolve most construction disputes and claims. Analysis of schedule delay is conducted to find out what happened in the project, when and how delay events impact schedule and which party causes that delay in order to settle the delay claim or dispute without litigation. For this, there are different methods available for schedule delay analysis methods (DAMs) in construction industry. The DAMs produce

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results of different levels of accuracy and the analysts have differences in the way they deal with the issues often in disputes. Hence the selection of the appropriate DAM is paramount (Palaneeswaran and Kumaraswamy 2008).

For this reason, Iyer et al. (2008) developed expert system that could give guide lines to owners and contractors to evaluate their claims before they are pursued. Palaneeswaran and Kumaraswamy (2008) formulated a knowledge-based decision guidance system to help all disputed parties to rationalized their approaches towards the preparation and evaluation of extension of time claims due to delay. Arditi and Pattanakitchemroon (2006) established a selection guide lines for the DAMs by comparing the most common DAMs under different circumstances. Braimah and Ndekgri (2008) have studied the factors that influence the analyst's selection from the DAMs. Adhikari et al. (2006) used the analytical hierarchy process to select the appropriate DAM.

In Gaza Strip no previous researches were conducted on the factors that control the selection of the appropriate DAM. This modest research is an attempt to survey the most commonly used DAMs in Gaza Strip and the factors that influence the analyst's selection from these DAMs. The objective of this paper is to survey the widely used delay analysis methods in Gaza Strip with respect to contractors, consultants and overall, and to determine the factors that influence analyst's selection from these delay analysis methods with respect to contractors, consultants and overall.

2. An overview of common delay analysis methods

The task of investigating the events that cause the project to delay in order to determine the financial responsibilities of the contracting parties arising from the delay is referred to as delay analysis (DA) (Braimah and Ndekgri, 2008). Delay analysis is a formidable challenge since the contracted parties each prone to view most delays as the responsibility of the others which give rise to disputes. Responding to such challenges, the industry has developed techniques used to prove or disprove the claims either in the course of the project, or after completion under arbitration or any other form of dispute resolution mechanisms (Arditi and Pattanakitchemroon 2006). Yang and Kao (2007) reviewed 28 articles regarding construction delay analysis techniques and developed a knowledge map for delay analysis.

The popular and comparatively acceptable delay analysis methods (DAMs) include As-Planned vs. As-Built; Impacted as-Planned; Collapsed As-Built; Window Analysis and Time Impact Analysis (Braimah and Ndekgri 2008, Palaneeswaran and Kumaraswamy 2008, Yang et al. 2006 and Zack et al. 2006). However, no one method is accepted by project participants and suitable for all situations. Arditi and Pattanakitchemroon (2006) excluded the Window Analysis from being a common method, while Conlin and Retic (1997) excluded the Collapsed As-built and Window Analysis methods. The following is a brief discussion of the common DAMs:
2.1 As-planned vs. as-built method

This method compares the activities of the original critical path method baseline programme with those of the as-built programme, assesses the impact of delays on the project, identifies the sequences that actually define the duration of the project and determines the causes and the parties responsible for that delay. The advantages of this method are inexpensive, simple and easy (Braimah and Ndekugri, 2008). Arditi and Pattanakitchamroon (2006) concluded that as-planned vs. as-built relies on common sense, the analysis incorporates both as-planned and as-built schedules, and both contractor and owner delay events which facilitates the ability for recognizing concurrent delays and acceleration. He suggested using it as a starting point in relation to other complex DAMs.

Among the disadvantages, it assumes that both schedules are correct in activity duration and logic relationships sequences, failure to consider changes in the critical path and inability to deal with concurrent delays and complex delay situations (Braimah and Ndekugri, 2008). It lacks a systematic procedure to evaluate the impact of delay events individually (Arditi and Pattanakitchamroon, 2006). This method should not be used by itself except in the simplest cases (Zack et al., 2006).

2.2 Impacted as-planned method

The method uses only an as-planned schedule for delay analysis where delays and disruption are considered as activities into as-planned critical path schedule to demonstrate how schedule completion date is affected by those delays. The difference between schedules completion dates before and after the addition of delay activities will produce the amount of project delay due to each delay event. This method does not need as-built information to operate since it assumes that the planned construction sequences remain the same and does not consider any changes in critical path (Braimah and Ndekugri, 2008). Arditi and Pattanakitchamroon (2006) concluded that impacted as-Planned Method is the least favored method since it has theoretical flaws.

2.3 Collapsed as-built method

This method does not need as-planned schedule where an as-built critical path schedule with all the delays encountered should be created. Subtracting the delays from the schedule to create collapsed as-built schedule will indicate what would have occurred but for those events. It produces results of good accuracy (Braimah and Ndekugri, 2008). It is easy to understand by triers of fact and can determine delay impact in case of limited time and resources available for analysis (Arditi and Pattanakitchamroon, 2006). Great effort is required in identifying the as-built critical path, failure to consider changes to critical path and inability to deal with concurrent delays and complex delays (Braimah and Ndekugri, 2008).

2.4 Time impact method

This method depends on the assumption that running a series of analysis on schedule updates can assess the delay impacts to projects. This method is probably the most reliable
technique when data and source documents are available in the required format and in the required time frame (Braimah and Ndekugri, 2008). Although it provides both parties to dispute to an opportunity to scrutinize the delay and reduce disputes, it is considered costly to operate particularly when large number of delaying events is involved and consumes lots of time (Arditi and Pattanakitchamroon 2006).

2.5 Window analysis method

Using as-built critical path schedule, the total duration of project is divided into number of time periods, which are updated chronologically from the as-built information including all delays encountered to get the project delay that occurred during a certain period. The project completion dates resulting from any time period under review is subtracted from that prior to the review. This method takes care of the dynamics nature of the critical path but it is considered as time consuming, costly to operate particularly when large number of delaying events is involved (Arditi and Pattanakitchamroon 2006, Braimah and Ndekugri, 2008).

3. Factors influencing the selection of the appropriate DAM

In the construction industry there is no single, standard and accepted procedure to determine the impact of schedule delay. However in given circumstances, one method can be more beneficial than another (Bubshait and Cunningham 1998. The selection of the suitable DAM depends on the ability of scheduling data, the familiarity of the analysts with the capabilities of the software used in the project, clear specification in the contract concerning concurrent delays and float ownership and time, fund and effort allocated to the analysts (Arditi and Pattanakitchamroon, 2006). Braimah and Ndekugri (2008) identified 18 factors that affect the selection of the appropriate DAM. These factors are: records availability, baseline programme availability, nature of baseline programme, updated programme availability, time of the delay, reason for the delay analysis, the other party to the claim, applicable legislation, the form of contract, cost of using the technique, size of project, duration of the project, complexity of the project, nature of the delaying events, skills of the analyst, the amount in dispute, dispute resolution forum, and the number of delaying events.

4. Methodology

Quantitative research strategy involving the use of a cross sectional survey was adopted. The first stage in questionnaire design process was an extensive review of the literature relevant the most commonly used DAMs in Gaza Strip, and the factors influence their selection. The questionnaire design was composed of three sections to accomplish the aim of this research. The first section is general information about the respondents. The second section is a survey of the most commonly used DAMs in Gaza Strip. The third section requires respondents to score on 5- point likert scale (1 for “very important” and 5 for “not important”) the listed factors on their degree of importance in their decision making as the appropriate DAM to adopt in any given situation.

The targeted sample that consists of contractors and consultants was chosen randomly. 100 questionnaires were distributed (50 for consultants and 50 for contractors) and 33
questionnaires were returned (18 for consultants and 15 for contractors). The data was measured at ordinal level. Non-parametric statistics involving frequencies and relative important index was conducted for each selection factor to facilitate their ranking with respect to contractors, consultants and overall.

The relative importance index (RII) of each selection factor was computed using Eq. (1) to facilitate their ranking (Braimah and Ndekugri, 2008).

$$RII = \frac{100\%}{n} \times \sum_{i=1}^{n} w_i f_i$$  \hspace{1cm} \text{Eq. (1)}

Where $f_i$ is the frequency of response; $w_i$ is the weight for each rating (given by rating in scale divided by number of points in the scale which is 5; and $n$ is the total number of responses.

The degree of agreement between the contractor group and the consultant group in their ranking was investigated using Kendall’s coefficient of concordance ($W$) as defined by Eq. (2) (Legendre, 2005).

$$W = \frac{12 \times s}{k^2 (N^2 - N)}$$  \hspace{1cm} \text{Eq. (2)}

Where $s$ is the sum of square of deviations of ranking sum of the factors from the mean, $k$ is the number of respondent groups, which is 2 in this case and $N$ is the number of factors ranked.

Eq. (3) is used to determine the significance of $W$ using a chi-square approximation of the sampling distribution with $(N - 1)$ degrees of freedom (LEGENDRE, 2005).

$$\chi^2 = k(N - 1)W$$  \hspace{1cm} \text{Eq. (3)}

5. Analysis and discussion

5.1 Characteristics of the respondents

The contractor's response was 30%, while the consultant's response was 36%. Figure 1 shows the distribution profile of respondent's designation. The contractor's respondents lack the existence of claim consultant and about 60% of them have been acting as project managers and site engineers. About 60% of the consultant's respondent's have been acting as firm managers and office engineers. Besides 10% of them are claim consultants.

Figure 2 shows the distribution profile of respondent's experience. About 60% of the consultant's respondent's have more than 15 years experience, while less than 30% of contractors have more than 15 years experience.

Figure 3 shows the distribution profile of respondent's education. The education of the consultant's respondents is better than contractor's respondent. 92% of contractor's respondents have just Bachelor's degree and none of them have PhD. Degree. 33% of the
consultant's respondents have Master degree and 14% of them have PhD. degree. The results reveal that the consultant's respondents have higher experience and education and hence are more suited than contractors to comment on the delay issues covered in the questionnaire.

**Figure 1: Respondent's designations**

**Figure 2: Respondent's experience**

**Figure 3: Respondent's education**
5.2 The common used DAMs in Gaza Strip

Figure 4 Shows that 80% of the contractor’s respondents have consent that the As-Planned vs. As-Built Method is the most widespread method in Gaza Strip. The other methods used in rare situations. 20% of them are recognizable with impact as-planned method and Time impact method.

![Figure 4: The percentage of the common used DAMs by contractors](image)

Figure 5 Shows that 56.3% of the consultant's respondents agreed that the As-Planned vs. As-Built Method is the most common method in Gaza Strip while the Collapsed as-built method ranked the second common DAM in Gaza Strip according to consultant's respondents. The results indicated that, contractor’s and consultant’s respondents have consent that the As-planned vs. as-built is the most used method in Gaza Strip. The reason for this is the simplicity of this method since it relies on common sense and the environment of construction projects in Gaza Strip where approximately no complex projects were executed that could force practitioners to resort to the other DAMs.

![Figure 5: The percentage of the common used DAMs by consultants](image)
Due to the higher level of education and experience to consultant's respondents 44% of them are recognizable with the other four DAMs compared with 20% of contractor's respondents recognizable with Time impact method and Impact as-planned method.

5.3 Relative importance index of factors influencing DAMs selection

Table 1 shows the relative importance index (RII) and ranking of the factors that affect the selection of DAMs for contractors, consultants and overall. The degree of agreement between contractor's and consultant's respondents equal 0.925 and this was statistically significant at 98% confidence level. The ranking of the "records availability" as the most important factor according to contractor's and consultant's respondents was expected, since regardless of the method adopted the analysis depends on the available data, although the amount of records required varies for various DAMs. For example Window analysis and Time impact analysis methods required the existence of certain records to operate, the lack of these project information will enforce practitioners to resort to less reliable methods. The ranking of record availability in the first position is confirmed by Braimah and Ndekugri (2008).

Table 1: RII and Ranks of DAM selection factors

<table>
<thead>
<tr>
<th>Selection factor</th>
<th>Contractors (RII)</th>
<th>Consultant (RII)</th>
<th>Overall (RII)</th>
<th>Contractors Rank</th>
<th>Consultant Rank</th>
<th>Overall Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Records availability</td>
<td>0.666</td>
<td>0.880</td>
<td>0.788</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Baseline programme availability</td>
<td>0.574</td>
<td>0.810</td>
<td>0.708</td>
<td>5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Nature of baseline programme</td>
<td>0.48</td>
<td>0.750</td>
<td>0.622</td>
<td>16</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Updated programme availability</td>
<td>0.6</td>
<td>0.760</td>
<td>0.702</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Time of the delay</td>
<td>0.546</td>
<td>0.680</td>
<td>0.622</td>
<td>8</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Reason for the delay analysis</td>
<td>0.56</td>
<td>0.740</td>
<td>0.662</td>
<td>7</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>The other party to the claim</td>
<td>0.546</td>
<td>0.640</td>
<td>0.600</td>
<td>8</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Applicable legislation</td>
<td>0.506</td>
<td>0.560</td>
<td>0.538</td>
<td>15</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Type of contract</td>
<td>0.574</td>
<td>0.700</td>
<td>0.646</td>
<td>5</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Cost of using the technique</td>
<td>0.48</td>
<td>0.700</td>
<td>0.606</td>
<td>16</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Size of project</td>
<td>0.534</td>
<td>0.800</td>
<td>0.686</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Duration of the project</td>
<td>0.52</td>
<td>0.760</td>
<td>0.658</td>
<td>13</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Complexity of the project</td>
<td>0.546</td>
<td>0.740</td>
<td>0.658</td>
<td>8</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Nature of the delaying events</td>
<td>0.6</td>
<td>0.740</td>
<td>0.680</td>
<td>3</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Skills of the analyst</td>
<td>0.654</td>
<td>0.750</td>
<td>0.708</td>
<td>2</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>The amount in dispute</td>
<td>0.52</td>
<td>0.750</td>
<td>0.652</td>
<td>16</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Dispute resolution forum</td>
<td>0.48</td>
<td>0.590</td>
<td>0.542</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>The number of delaying events</td>
<td>0.534</td>
<td>0.670</td>
<td>0.612</td>
<td>11</td>
<td>15</td>
<td>14</td>
</tr>
</tbody>
</table>

W=0.925  \chi^2 = 31.35  \text{df=17 ; } \chi^2 \text{ critical } = 31.7
Baseline programme availability has been ranked by contractor's respondents in the fifth position, while ranked in the second position by consultant's respondents. Both of them have ranked it within the top five factors. The difference in the contractor's and consultant's respondents ranking is due to the variation in their level of education and experience. In the absence of base line programme the DAMs that rely heavily on it cannot be used. Braimah and Ndekugri (2008) have ranked this factor in the second position as consultant's respondents do in this research which confirms in general the importance of this factor.

Nature of baseline programme has been ranked by contractor's respondents in the sixteenth position, while ranked in the sixth position by the consultant's respondents. As mentioned the As-planned vs. as-built method is the most common method used by contractor's respondents which rely on common sense and doesn't require the baseline programme to exist in the CPM format, thereby the contractor's respondents rank it in the sixteenth position. Braimah and Ndekugri (2008) have ranked this factor in the forth position in the neighborhood of consultant's respondents ranking which confirms in general the importance of this factor. Updated programme availability has been ranked by contractor's respondents in the third position, while ranked in the forth position by the consultant's respondents. Braimah and Ndekugri (2008) have ranked this factor in the fifth position. This corroborates the importance of this factor that enable the use of certain DAMs more than the others.

Time of delay refers to occurrence of delay relative to the stage of the project. The delay analysis can be carried out prospectively or retrospectively. Prospectively refers to analyzing delays when they start brewing or began to occur in order to determine their likely impact on the project performance. Impacted as-planned method is best suited for this situation. On the other hand retrospective analysis required the delay analysis to be done after their occurrence. Collapsed as-built is best suited for this situation. Time of delay has been ranked by contractor's respondents in the eighth position, while ranked in the fourteenth position by the consultant's respondents and Braimah and Ndekugri (2008).

Reason for delay analysis may be either to get extension to project duration or to get compensation. Reason for delay analysis has been ranked by contractor's respondents in the seventh position, while ranked in the ninth position by the consultant's respondents. Braimah and Ndekugri (2008) have ranked this factor in the tenth position. The other party to claim is related to behavior of the opposing party to the claim. When the opposing party to claim is capable to deal with delay issues fairly, the parties to claim usually resort to less expensive methods of DAMs and vice versa. Reason for delay analysis has been ranked by contractor's respondents in the eighth position, while ranked in the sixteenth position by the consultant's respondents. Braimah and Ndekugri (2008) have ranked this factor in the seventeenth position which is too near to consultant's ranking.

Applicable legislation has been ranked by contractor's and consultant's respondents in the fifteenth and eighteenth position respectively. Braimah and Ndekugri (2008) confirm this result by ranking this factor in the eighteenth position as did the consultant's respondents revealing that this factor has a minimum influence on the methodologies that could be used to analyze delays. Type of contract; contract clauses may require the availability of specified type of baseline programme and its updating which facilitate the use of certain DAMs to a
great extent than others. This factor has been ranked by contractor's respondents in the fifth position while the consultant's respondents ranked it in the twelfth position. Braimah and Ndekguri (2008) confirm the consultant's respondents by ranking this factor in the eleventh position.

Cost of using the technique; sophisticated DAMs such as window analysis required the use of powerful planning software which is expensive and a skill person is essential to operate it. When the amount in dispute is relatively small compared to project cost, the parties to claim may resort to use less expensive DAMs. This factor has been ranked by contractor's respondents in the sixteenth position while the consultant's respondents ranked it in the twelfth position. Braimah and Ndekguri (2008) confirm the consultant's respondents by ranking this factor in the twelfth position too.

Size of project; as the size of project increase the number of activities increase. This factor has been ranked by contractor's respondents in the eleventh position while the consultant's respondents ranked it in the third position. Duration of project also influence the methodologies that could be used to delay analyses. This factor has been ranked by contractor's respondents in the thirteenth position while the consultant's respondents ranked it in the fourth position. Braimah and Ndekguri (2008) rank size of project in the fifteenth position and rank duration of project in the sixteenth position. The relatively high ranking of these two factors by consultant's respondents is surprising and need more investigation.

Complexity of project; in complex projects innovative procedures with overlap of phases are often used thereby necessitating the use of certain DAMs to a greater extent than others in case of delay occurrence. This factor has been ranked by contractor's respondents in the eighth position and the consultant's respondents ranked it in the ninth position. Braimah and Ndekguri (2008) confirm the consultant's and contractor's respondents by ranking this factor in the seventh position. Nature of delaying events; the existence of concurrent delays influence the methodologies that could be used to analyze delays. This factor has been ranked by contractor's respondents in the third position while the consultant's respondents and Braimah and Ndekguri (2008) ranked it in the ninth position.

Skill of the analyst; sophisticated DAMs require skill analysts to operate. This factor has been ranked by contractor's respondents in the second position, which is surprising and require further investigation. The consultant's respondents ranked it in the sixth position. Braimah and Ndekguri (2008) rank this factor in the eighth position. The amount in dispute; as the amount in dispute increase, the parties to claim resort to more sophisticated DAMs in order to recover their losses. This factor has been ranked by contractor's respondents and Braimah and Ndekguri (2008) in the second position while the consultant's respondents ranked it in the sixth position.

Dispute resolution forum has been ranked by contractor's respondents in the sixteenth position while the consultant's respondents and Braimah and Ndekguri (2008) ranked it in the seventeenth position. The three parties have consensus on the minimum effect of this factor in selecting the appropriate DAM. The number of delaying events; as the number of delaying events increase, the delay analysis become more complex thereby, necessitating
the use of certain DAMs to a greater extent than others. This factor has been ranked by contractor's respondents in the eleventh position while the consultant's respondents ranked it in the fifteenth position. Braimah and Ndekugri (2008) rank this factor in the sixth position. The insufficient appreciation by contractor's and consultant's respondents of the importance of this factor is attributed to the environment of construction in Gaza Strip.

6. Conclusion

The aim of this paper is to survey the commonly used DAMs and to determine the factors that influence their selection according to contractors and consultants perspectives in Gaza Strip. The most commonly used DAM is As-planned vs. as-built, this is attributed to the lack of complex construction projects in Gaza Strip. Eighteen factors that could assist the disputed parties to choose the appropriate DAM have been ranked according to their relative important index. According to contractor's respondents the top five factors are "Records availability, Skills of the analyst, Updated programme availability, Nature of the delaying events and Baseline programme availability, while the consultant's respondents exhibit that the top five factors are" Records availability, Baseline programme availability, Size of project, Updated programme availability, Duration of the project". The contractor's and the consultant's respondents rank record availability in the first position and agreed on the importance of "Baseline programme availability and Updated programme availability", this is not surprising since programmes are now considered the vehicle for analyzing delays. But they both failed to address "Nature of baseline programme" as an important factor, this is attributed to the fact that most of them are using Microsoft project for scheduling were bar chart and CPM are available. Both contractors and consultants agreed that "Dispute resolution forum and Applicable legislation" are the lowest factors that affect the selection of DAMs. According to contractor's respondents the lowest five factors are "Nature of baseline programme, Cost of using the technique, Dispute resolution forum, Applicable legislation, Duration of the project" while the consultant's respondents stated that the lowest five factors are" Applicable legislation, Dispute resolution forum, The other party to the claim, Cost of using the technique, The number of delaying events".

Both contractors and consultants agreed that "Dispute resolution forum and Applicable legislation" are the lowest factors that affect the selection of DAMs. Ranking the "Nature of baseline programme" as the least important factor by contractors is surprising because bar charts are unable to show critical paths, interrelation and interdependencies between activities which enforce analysts to select certain method of DAMs. The rank of "The amount in dispute" is the sixth according to consultant and the thirteenth according to contractors.

This research stressed the importance of obtaining full records throughout project life cycle or at least at time where a delay dispute is brewing in order to empower the disputed parties to select the appropriate DAM that gives relatively correct results. Training courses covering delay analysis methods and their requirements are recommended. A comprehensive survey should be carried out to confirm the findings of this research and to provide more reliable ranking to guide contractors and consultants how to select the appropriate DAM.


Effectiveness of Construction 21: Enhancing Professionalism in Singapore’s Construction Industry

George Ofori¹, Evelyn Teo Ai Lin², Imelda K. Tjandra³

Abstract

The Construction 21 report (C21), prepared by a government-appointed high-level committee, aimed to transform the construction industry in Singapore from a Dirty, Demanding and Dangerous (3D) industry to a Professional, Productive and Progressive (3P) industry. To achieve this intended transformation, the report proposed 39 recommendations under six strategic thrusts. Specific targets were set under each recommendation. The report was adopted as a blueprint for developing Singapore’s construction industry, and most of the recommendations have been implemented.

A research project was undertaken to review the effectiveness of C21. This paper reports on a segment of the study; it focuses on the first strategic thrust of C21, which was to raise the level of professionalism in the construction industry. A questionnaire-based survey of the main stakeholders of the industry, including clients, consultants and contractors, was undertaken. On the whole, the change programme was viewed by the respondents to be only moderately effective. The industry considered the programmes for enhancing the level of professionalism in Singapore’s construction industry to be the most effective among the six thrusts. The findings also indicate that all the groups of stakeholders are of the view that more needs to be done. Moreover, despite the many improvements which have been realised, the image of the industry has not been much improved.

Keywords: Construction 21, industry improvement, change programme, professionalism

1. Introduction

In Singapore, the initial mandate of the Construction 21 Steering Committee was appointed by the Ministry of Manpower (MOM) and Ministry of National Development (MND) to conduct a thorough investigation into many key aspects of the construction industry, from Processes (including practices, techniques, and integrated approach to construction) and Players (including professionalism and skills) to Products (including the exporting of construction expertise). (Construction 21 Steering Committee, 1999). The Committee proposed the

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following vision for the Singapore construction industry: “To be a World Class Builder in the Knowledge Age”. It suggested that this would involve a change in public perceptions of the industry from a Dirty, Demanding and Dangerous (3D) industry to a Professional, Productive and Progressive (3P) industry (Construction 21 Steering Committee, 1999).

The C21 Steering Committee made 39 recommendations under six strategic thrusts. The thrusts were: (i) enhancing the professionalism of the industry; (ii) raising the skills levels; (iii) improving industry practices and techniques; (iv) adopting an integrated approach to construction; (v) developing an external wing (i.e. building up a strong capability to export construction services); and (vi) a collective championing effort for the construction industry (Construction 21 Steering Committee, 1999). The Building and Construction Authority (BCA) (a statutory agency for developing the construction industry, set up in 1984) was identified as the champion agency. Some of the tasks were also assigned to the Construction Industry Joint Committee (which embraces all the professional institutions and trade associations in construction). The report highlighted the following desired outcomes: (i) a professional, productive and progressive industry; (ii) a knowledge workforce; (iii) superior capabilities through synergistic partnerships; (iv) integrated process for high buildability; (v) contributor to wealth through cost competitiveness; and (vi) construction expertise as an export industry.

The C21 report has been used as a blueprint to develop the construction industry in Singapore (Ofori, 2002). The proposals in the C21 report have been used to formulate action programmes for, and to manage, the industry since 1999, and many achievements have been realized. Examples include: (i) information and communication technology (ICT) adoption, stimulated by the need to submit building proposals on-line through the Construction and Real Estate Network (CORENET) and to submit tenders via the government’s business portal, GeBiz; (ii) greater consideration of buildability during design as a result of statutory minimum levels; (iii) the widespread adherence to the construction quality programme; and (iv) greater recognition of continuing professional development.

The literature relating to the C21 report was published in the first few years after publication of the report. The studies evaluated the programmes and focused on the factors and strategies to enable implementation of the recommendations (Ofori, 2002; 2003; De Silva et al., 2004; Dulaimi et al., 2004). However, there has not been any comprehensive evaluation of the level of success of the implementation of the change agenda. The premise of the research is that, some ten years after the publication of the C21 report, it is pertinent to evaluate the progress made, in order to assess its achievements and the continuing challenges facing the industry. The main objective of the study is to ascertain and evaluate against their original objectives, the outcomes from the implementation of the construction industry performance improvement programmes in Singapore since 1999. This paper reports on the segment of the research project which relates to Strategic Thrust One of the C21 report: “Enhancing the professionalism of the industry”.

2. Enhancing professionalism in the industry

2.1 Professionalism at individual level
The C21 report recommended that the curricula of programmes on construction at the tertiary institutions should be restructured. Common modules for engineering and architecture students should be introduced in order to develop multi-disciplinary skills in students, and build a foundation for future co-operation among them. Following this recommendation, at the National University of Singapore (NUS), for example, common modules were introduced in the curricula for the first degree programmes in Architecture, Building and Real Estate. The report also recommended that soft skills, such as professional ethics and management skills, be included in the educational curricula of construction-related programmes at the tertiary institutions. Again, at the NUS, soft skills were included as a part of the curriculum for the engineering, building and architectural students.

Another C21 report recommendation was that the universities and polytechnics should collaborate with the professional institutions and BCA to design academic programmes and training courses which meet the needs of the industry, and attract more professionals to attend these courses. New training programmes for professionals and technicians have been introduced by the professional institutions and trade associations such as the Singapore Contractors Association Limited (SCAL) and Singapore Institute of Surveyors and Valuers (SISV). Some of the institutions have set up their own academies. They often collaborate with the academic institutions to provide courses for professionals. In 2007, the then Construction Industry Training Institute (CITI), the training arm of BCA which undertook trades training, was re-structured with an expanded scope of professional education, and renamed as the “BCA Academy of the Built Environment”. The academy offers short courses and executive development programmes, as well as a number of diploma, first degree and master’s degree programmes (the latter in partnership with overseas universities).

2.2 Professionalism at professional body/trade group level

The C21 report recommended that Continuing Professional Development (CPD) programmes should be made mandatory for the renewal of professional and trade membership. In Singapore, the law requires architects and engineers to be registered before they can practice as professionals. Prior to the C21 report, BCA had initiated a study on CPD for architects and engineers, together with the two professional registration boards, the Board of Architects (BOA) and the Professional Engineers Board (PEB).

The professions have responded to the C21 report recommendation. Participation in CPD programmes was made mandatory for the renewal of practicing certificates by the Board of Architects and Professional Engineers Board. Previously, Singapore Institute of Architects (SIA) and Institution of Engineers Singapore (IES) had encouraged their members to undergo CPD on a voluntary basis. Since 2003, all licensed architects must obtain 20 Credit Points in order to renew their practising certificates annually, with relevant reductions for those above 60 years old (SIA, 2009).

As examples of the professions not subject to statutory control, the Singapore Institute of Planners (SIP) and SISV require their members to attend minimum numbers of hours of CPD in order to maintain their memberships. Since 2006, members of SIP are required to attain a minimum of 20 CPD points over a period of two years for assessment (SIP, 2007).
SISV believes that CPD enables members to stay ahead with developments in the profession (SISV, 2005). Instead of points, SISV requires its members to record the number of hours of participation in CPD activities, and members must attend 60 hours of CPD activities over three years.

2.3 Professionalism at industry level

At the industry level, the C21 report recommended that professionalism can be achieved through the giving of awards, development and application of information technology (IT), and licensing of builders.

BCA recognises to companies and practitioners by giving four kinds of awards (BCA, 2010): (i) Built Environment Leadership Award recognises outstanding industry firms demonstrating excellence and leadership in shaping a safe, high quality, sustainable and friendly built environment in Singapore; (ii) Construction Excellence Awards acknowledges projects on which the participating teams have attained high standards of management, technical expertise, and workmanship; (iii) Green Mark Awards for buildings with high performance in energy efficiency, building management, water conservation, indoor environmental quality, and environmental protection in a building; and (iv) Green and Gracious Builder Award for builders addressing environmental and public concerns arising from construction works, hence enhancing the image of the industry.

The C21 report recommended that the level of application of IT in construction be raised to help re-engineer the work processes in the industry. The goal of the Construction and Real Estate Network (CORENET) is to “re-engineer the business processes of the construction industry to achieve a quantum leap in turnaround time, productivity and quality.” The development of CORENET was accelerated following publication of the C21 report. CORENET became a major IT initiative led by the MND and driven by the BCA in collaboration with other public and private organisations. The government committed itself to invest S$44 million to develop the infrastructure after C21 (Framework, 1999). One of the first steps was to revamp the website to make it more user-friendly. Next, the One-Stop Submission Centre (OSSC) was developed immediately after C21 and was to be ready in 2001 (Framework, 1999). The OSSC enabled the industry to submit planning and building plan applications on-line, and also make submissions for structural designs, temporary occupation permits, certificates of statutory completion and fire safety certificates. The submitted information would be validated, and routed to the relevant authorities or applicants for processing or action. Costing some S$7.7 million, the OSSC brought about savings in manpower, material and time in dealing with the 13 building and planning authorities.

CORENET has undergone a number of development phases. Currently, the effort is focused on developing a set of infrastructure and industry projects in order to: (i) provide information services to allow businesses to speed up business planning and decision making processes; (ii) provide government to business infrastructure to facilitate electronic building plans submission, checking and approval processes; and (iii) provide a set of standards to improve business communications. The CORENET project has been a success story that is inspiring similar developments in other countries. In 2008, Singapore was ranked by the World Bank
as the top economy globally in terms of the ease of doing business (IFC, 2008). CORENET was highlighted as one key reforms that sped up the process for dealing with construction permits, reducing the time from 102 days to 38. Almost 99% of applications are now submitted through CORENET.

BCA and other public agencies such as SPRING Singapore and Singapore Workplace Development Authority, offer several incentive schemes to assist construction companies to deepen the application of IT, such as the Investment Allowance Scheme (IAS), Training Assistance Scheme (TAS) and Local Enterprise Technical Assistance Scheme (LETAS) (BCA, 2010). BCA, together with the Industry Foundation Classes (IFC) Implementers Work Group (IIWG) of buildingSMART Singapore Singapore), have been promoting the use of building information modeling (BIM) as the platform to facilitate the integration of knowledge in design and construction, and handing over to facilities management.

The C21 report recommended that all contractors (including sub-contractors) should be licensed in order to improve their standards and professionalism. In 2005, it was announced that a licensing scheme for contractors would soon be launched (Mah, 2005). To be licensed, firms must be financially sound; have good safety records; and employ qualified and experienced personnel to manage the firm and supervise its construction works. The licensing started on 16 December 2008, with the coming into effect of Part VA of the Building Control (Amendment) Act 2007 on Licensing of Builders. There was a six-month grace period for builders to apply for the license. All builders who have been granted or to be granted a permit to carry out building works, as well as builders carrying out work in six specialist work areas, must possess a license issued by the Commissioner of Building Control (Pillars, 2009).

3. Research method, sample and response

3.1 Interviews

Nine in-depth, face-to-face, interviews were conducted with 12 key construction practitioners (from the public and private sectors) as shown in Table 1. The interviews were intended to gain a better understanding of the C21 process and the implementation of the C21 report, from the practitioners and administrators who were involved in the preparation of the report, or have been active in the implementation of its recommendations. The knowledge gained in the interviews would enable the questionnaire for the survey to be drafted.

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Position</th>
<th>Organisation type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>Director</td>
<td>Government</td>
</tr>
<tr>
<td>1B</td>
<td>Deputy Director</td>
<td>Government</td>
</tr>
<tr>
<td>2</td>
<td>Executive Director</td>
<td>Consultancy firm</td>
</tr>
<tr>
<td>3</td>
<td>President</td>
<td>Professional body</td>
</tr>
<tr>
<td>4A</td>
<td>President and Chief Executive Officer (CEO)</td>
<td>Consultancy firm</td>
</tr>
<tr>
<td>4B</td>
<td>Executive Vice President</td>
<td>Consultancy firm</td>
</tr>
<tr>
<td>4C</td>
<td>Executive Vice President</td>
<td>Consultancy firm</td>
</tr>
<tr>
<td>5</td>
<td>Chairman</td>
<td>Consultancy firm</td>
</tr>
<tr>
<td>6</td>
<td>Past President</td>
<td>Professional body</td>
</tr>
</tbody>
</table>
After a review of the literature relating to the C21 process, lists of questions (based on the strategic thrusts of C21) were prepared to guide the interviewers and interviewees. The interview questions sought to find out the interviewees' perceptions towards the C21 report in general. They were mainly asked to comment on the relevance of C21 in the present context and whether it was necessary to refresh the reform programme. They were also asked for their perceptions of the results of the C21 recommendations, in terms of the progress of the process of transformation and its achievements.

3.2 Questionnaire survey

The survey questionnaire sought to ascertain how senior personnel in Singapore’s construction industry would rate the effectiveness of the various initiatives based on the 39 C21 recommendations. A five-point Likert scale was used. The respondents were requested to indicate the level of familiarity with, the effectiveness of, their agreement with, and the necessity of, the various statements, as relevant. For example, when respondents were asked to rate each of the statements on the effectiveness of a measure based on the recommendations, 1 represented “very effective”, 2 stood for “effective”, 3 indicated “neutral”, 4 represented “not effective” and 5 stood for “not effective at all”.

Three groups of respondents were identified. They were: clients, consultants and main contractors. Two groups of clients were identified: public-sector clients and private-sector property developers. The public-sector clients were selected on the basis of the relevant portfolio of the particular organisations. The private-sector property developers were selected from the list of members of the Real Estate Developers Association of Singapore (REDAS). A total of 174 clients were selected, as shown in Table 2.

**Table 2 Distribution of questionnaires and response rates**

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Sent out</th>
<th>Wrong addresses</th>
<th>Sub total</th>
<th>Usable responses</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clients (public and private)</td>
<td>174</td>
<td>18</td>
<td>156</td>
<td>22</td>
<td>14.10%</td>
</tr>
<tr>
<td>Architectural firms</td>
<td>337</td>
<td>2</td>
<td>335</td>
<td>45</td>
<td>13.43%</td>
</tr>
<tr>
<td>Quantity surveying firms</td>
<td>44</td>
<td>1</td>
<td>43</td>
<td>11</td>
<td>25.58%</td>
</tr>
<tr>
<td>Engineering firms</td>
<td>143</td>
<td>7</td>
<td>136</td>
<td>29</td>
<td>21.32%</td>
</tr>
<tr>
<td>Main contractors</td>
<td>1,671</td>
<td>11</td>
<td>1,660</td>
<td>150</td>
<td>9.04%</td>
</tr>
<tr>
<td>Total</td>
<td>2,369</td>
<td>39</td>
<td>2,330</td>
<td>257</td>
<td>11.03%</td>
</tr>
</tbody>
</table>

The consultants, consisting of firms of architects; structural engineers, mechanical and electrical engineers (M&E) (grouped together as “engineering firms”); and quantity surveyors, were identified from lists published by SIA, Association of Consulting Engineers of Singapore (ACES) and SISV respectively. Some 524 consultants were selected.

The target population for main contractors was drawn from companies registered with the BCA under registration heads CW01 (general building) and CW02 (civil engineering). The
contractors are classified by tendering limits into A1, A2, B1, B2, C1, C2 and C3. The smallest firms, C3 contractors, can bid for projects of value no more than S$650,000 (US$494,000). A1 contractors are the largest firms; they are allowed to bid for projects of any size. A total of 1,671 contractors were identified.

Within two months of sending out some 2,369 questionnaires, 267 hard copy questionnaires were returned. Of these, 39 were returned because the firms have changed their addresses. Two questionnaires were not used because they were substantially incomplete. In total, 226 usable responses were received in hard copy format. In addition, 31 firms filled up the online version of the questionnaire. In total, 257 responses were usable, reflecting a response rate of 11.03% (Table 2).

The majority of the respondents were holding senior positions, such as managing directors, directors, partners, Chief Executive Officers (CEOs) and chairmen, which were defined as upper management. Upper management was accounted for 58.77% of the respondents. The middle management level, which comprised general manager, project manager, contracts manager, operation manager, business development manager, and administrative manager, was accounted for 28.51% of the respondents. The professionals, which included engineers, quantity surveyors and architects, accounted for 10.96% of respondents. Administrative staff formed 1.75% of the respondents. Most respondents (79.82%) have worked for more than ten years. This means that they had been working in the industry during the implementation of the initiatives in the C21 report. The high number of senior people with many years of working experience responded to the questionnaire gave validity to the survey results. These factors made the questionnaire ratings dependable, and the views expressed by the respondents noteworthy.

There were 85 responses from the consultants. Of these, more than half (52.94%) were architectural firms, 18.82% were civil and structural engineering firms, 12.94% were quantity surveying firms, 9.41% were multi-disciplinary firms and 5.88% were M&E engineering consultancies. The number of staff of companies ranged from one to 420 (in a multidisciplinary firm). Most consultants responding to the survey were small firms employing one to ten persons. The turnover of the consultants ranged from S$30,000 to S$40 million.

Of the 150 contractors who responded to the questionnaire-based survey, only 135 contractors filled up their BCA grades. Of these, the C3 category took up 41.48%. A1 and A2 contractors accounted for 8.15% and 2.22% respectively. Among the 143 contractors who provided information about the number of staff, 84.51% employed 100 persons or less. The largest contractor employed 1,300 staff. Average turnover was S$22.98 million, with turnover ranging from S$80,000 to S$600 million.

3. Analytical methods applied

Reliability of the questionnaire was examined to determine internal consistency; which is whether all items in the questionnaire measured the same thing. Cronbach alpha (\(\alpha\)) is a measure of reliability; it typically varies between 0 and 1. The closer alpha is to 1, the greater
is the internal consistency. In the study, the Cronbach alpha was 0.943, which is very high. It indicates strong internal consistency among the items in the questionnaire.

Mean ratings were calculated from the feedback received, first the overall mean and then mean ratings for the three different categories of respondents: clients, contractors, and consultants. The purpose was to ascertain whether different construction industry participants had different views about the various initiatives presented. Statistical t-tests of the mean were carried out to check the entire likely response to the issues raised in the questionnaires, based on the sample’s ratings. Analysis of variance (ANOVA) was undertaken to test equality of different population means. The test was undertaken to identify whether the views from different groups of respondents on various initiatives were similar.

4. Results and discussion

5.1 Interviews

As encouraged by the C21 report, BOA and PEBoard made CPD compulsory as a pre-requisite for renewing the practising certificates. SIP, SISV and others also require members to undertake minimum CPD. However, it is important to strike a balance. As Interviewee 2 explained, “If you enforce it strictly, you may lose some members, but gain some respect as an institution.” Interviewee 6 noted that CPD may be more effective for certain professions than others; for example, he felt it is more effective for architects than for quantity surveyors.

The interviewees agreed that CORENET has been the most significant achievement of C21. The C21 report recommended that all contractors, including sub-contractors, be licensed to influence their standards and professionalism. According to Interviewee 8, who was involved in the preparation of the C21 report, there had to be many compromises along the way.

C21 recommended that an industry-wide code of conduct spelling out industry standards with regard to the working relationships among the various players be developed. The interviewees disclosed that the codes of conduct were drafted, but they were not implemented, because, according to Interviewee 2, who took part in drafting the codes, the codes were considered by the members of the CIJC to be too general and so the document was considered to be unnecessary. Interviewee 6 noted that it is unreasonable to attempt to formulate an industry-wide code of conduct. In the opinion of that interviewee, it would not possible to enforce such a code as there could be no sanctions; he suggested that regulation of the industry should not go to that extent.

In summary, the interviewees agreed that the level of professionalism in the industry has improved. They also noted that there is scope for further progress. Interviewee 4A noted: “If you want professionalism, then you must downplay regulation, or have regulation with a lighter touch, and allow peer pressure to raise standards. We can say that professionalism has been achieved when the industry does the right thing without too many regulations.”

5.2 Questionnaire survey
Respondents were asked to express their views of the effectiveness of the C21 report in addressing the problems of the construction industry on a scale of one to five (1 = “very effective”, 2 = “effective”, 3 = “neutral”, 4 = “not effective”; and 5 = “not effective at all”). The results (Table 3) show that the respondents gave a moderate vote of confidence (average of the means of 2.77). Although there were no significant differences among the scores of the three different groups in the sample, the clients (average of the means of 2.68) and the main contractors (average of means of 2.71) gave a slightly stronger vote of confidence than the consultants (average of means of 2.89).

Table 3 Mean rating and ANOVA for effectiveness of C21

<table>
<thead>
<tr>
<th>Mean rating</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole sample</td>
<td>Clients</td>
</tr>
<tr>
<td>How effective do you think the C21 initiatives have been in addressing all the problems of the construction industry?</td>
<td>2.77</td>
</tr>
</tbody>
</table>

Comparing all the results on the six strategic thrusts, the highest rating in terms of effectiveness was accorded to Strategic Thrust One: “Enhancing the professionalism of the industry”, with an average of the means of 2.39. This average of the means showed that the respondents agreed that the implementation of Strategic Thrust One had been more effective than that of any of the other thrusts and the C21 programme in general. Also, among all the particular measures, the increase the use of IT in general (average of means of 2.26) was considered most effective.

For Strategic Thrust One, all the means were between 2.26 and 2.50 (Table 4). It indicated that the firms moderately agreed that the measures had improved the professionalism of the construction industry. However, the clients had different opinions from the contractors and consultants on the degree of effectiveness of different measures. For the clients, it was the licensing of all contractors that had contributed the most to enhancing the professionalism of the construction industry. For contractors and consultants, it was the increase in the use of IT that played the most significant role.

Clients perceived industry awards to have the lowest rating in terms of effectiveness. Consultants gave lowest rating to the same measure, and the mandatory requirement of the CPD programmes. Main contractors gave the lowest rating to the increase use of CORENET programmes, while consultants gave it a high rating.

Table 4 Mean rating and ANOVA for Strategic Thrust 1

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean rating</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>To what extent do you believe the following measures have improved the professionalism of the industry?</td>
<td>Whole sample</td>
<td>Clients</td>
</tr>
<tr>
<td>Various courses offered by the educational</td>
<td>2.34</td>
<td>2.18</td>
</tr>
</tbody>
</table>
institutions, professional bodies, and BCA Academy, designed to meet the needs of the industry.

<p>| | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>The mandatory requirement of the Continuing Professional Development (CPD) programmes for the renewal of professional and trade membership.</td>
<td>2.50</td>
<td>2.18</td>
<td>2.61</td>
<td>2.49</td>
<td>0.087</td>
</tr>
<tr>
<td>Industry awards to promote and recognise achievements such as quality of work, productivity, innovation, and green performance.</td>
<td>2.45</td>
<td>2.36</td>
<td>2.60</td>
<td>2.38</td>
<td>0.104</td>
</tr>
<tr>
<td>The increase in use of IT in general.</td>
<td>2.26</td>
<td>2.32</td>
<td>2.21</td>
<td>2.27</td>
<td>0.750</td>
</tr>
<tr>
<td>The increase in use of CORENET programmes.</td>
<td>2.39</td>
<td>2.23</td>
<td>2.20</td>
<td>2.53</td>
<td>0.004</td>
</tr>
<tr>
<td>Progressive strengthening of Contractors Registration System.</td>
<td>2.42</td>
<td>2.23</td>
<td>2.45</td>
<td>2.43</td>
<td>0.460</td>
</tr>
<tr>
<td>The licensing of all contractors (including sub-contractors).</td>
<td>2.34</td>
<td>2.14</td>
<td>2.33</td>
<td>2.38</td>
<td>0.391</td>
</tr>
</tbody>
</table>

5. Concluding remarks

Efforts to improve professionalism in the construction industry in Singapore have included actions by individual professionals, professional institutions and trade associations, and at the broad industry level, following specific recommendations outlined in the C21 report. The respondents to the field study agreed that C21 had been effective in addressing some of the problems of the construction industry. In their opinion, measures taken to enhance professionalism had been effective. The initiatives under Strategic Thrust One were adjudged by the respondents as being the most effective in the C21 programme. The study also showed that practitioners consider CORENET to have been the most significant achievement resulting from the recommendations of the C21 report.

The findings from the study also indicate that much more can be done in the effort to enhance professionalism in the construction industry. There is a need for holistic co-ordination of the training programmes for professionals. The industry and academic institutions should work together to develop syllabuses that are in line with developments in industry practices and procedures. The implementation of CPD programmes for construction practitioners was considered by the respondents to have been successful. However, there is a need to ensure that the practitioners do not participate in CPD programmes just simply to collect the points, or amass the hours necessary for registration or membership renewal. There should be a system within each firm and institution to ensure that the practitioners retain, actually apply and also share the knowledge gained from such programmes.

The awards given at the industry level in Singapore construction have motivated construction firms to achieve excellence in many aspects. The development and application of IT in the industry has been greatly deepened, and has moved ahead with the use of BIM as the platform to facilitate the integration of knowledge and information. Here, Singapore is among the world’s leaders. The licensing of all contractors (including sub-contractors) has also been useful for raising the standards of professionalism of the contractors.
To build on the achievements in enhancing professionalism in construction in Singapore, there should be continuous monitoring and periodic review of initiatives and policies as circumstances change. There should also be effective multi-stakeholder collaboration on performance improvement, involving the industry, government, clients and universities.

6. References


Integration of Saudi Arabia’s Conservative Islamic Culture in Sustainable Housing Design

Mohammed Al Surf¹, Connie Susilawati², Bambang Trigunarsayah³

Abstract

The cities of Saudi Arabia have perhaps the largest growth rates of cities in the Middle East, such that it has become a cause in shortage of housing for mid and low-income families, as is the case in other developing countries. Even when housing is found, it is not sustainable nor is it providing the cultural needs of those families. The aim of this paper is to integrate the unique conservative Islamic Saudi culture into the design of sustainable housing. This paper is part of a preliminary study of an on-going PhD thesis, which utilises a semi-structured interview of a panel of nine experts in collecting the data. The interviews consisted of ten questions ranging from general questions such as stating their expertise and work position to more specific question such as listing the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia. Since the participants were selected according to their experience, the answers to the interview questions were satisfactory where the generation of the survey questions for the second stage in the PhD thesis took place after analysing the participant's answers to the interview questions. This paper recommends design requirements for accommodating the conservative Islamic Saudi Culture in low cost sustainable houses. Such requirements include achieving privacy through the use of various types of traditional Saudi architectural elements, such as the method of decorative screening of windows, called Mashrabiya, and having an inner courtyard where the house looks inward rather than outward. Other requirements include educating firms on how to design sustainable housing, educating the public on the advantages of sustainable methods to housing construction. This paper contributes towards the body of knowledge by proposing initial findings on how to integrate the conservative Islamic culture of Saudi Arabia into the design of a sustainable house specifically for mid and low-income families. This contribution can be implemented on developing countries in the region that are faced with housing shortage for mid and low-income families.

Key Words: Islamic culture of Saudi Arabia, housing for Mid and Low-income Families, Sustainable Housing, Semi-Structured Interview, Saudi architectural elements.

1. Introduction

Since the development of the concept of sustainability, nations worldwide have adopted the concept of sustainability and evolved it dramatically since it’s conception in 1987 by the U.N. World Commission on Environment and Development (UNWCED). It’s well known that the
main factor behind the development of sustainability is to make sure that natural resources are not jeopardized for future generations. There are three basic factors that define sustainability: environmental factors, economical factors and social factors; these three factors formulate the sustainability triangle.

Saudi Arabia is a harsh dry climate country where water is a scarce natural resource. Environmental in addition to social factors of Saudi Arabia make the application of sustainability a challenging task that requires the collaboration of all key stakeholders in the country. Several reasons validate the need of applying the concept of sustainability in Saudi Arabia that include, limited natural resources, rapid urbanization rate, growing social awareness, environmental impacts and economical impacts (EL-Batran, 2008, Gamboa, 2008, Garba, 2004, Henderson, 2002, Karam, 2010, Stensgaard, 2008, Swain, 1998)

Saudi Arabia is experiencing a huge housing crisis (Abdulaal (2011). In Jeddah, for example, the draft of the Jeddah Strategic Plan indicates the severe shortage of adequate housing for low and mid-income residents. Abdulaal (2011) goes on to declare that, although there are no sound or scientific statistics to back up this claim, continued growth of unplanned settlements is evidence enough of this increasing shortage of adequate housing for this sector of the public, with nearly one million residents currently living in unplanned areas of Jeddah. “It was estimated that the supply of housing units in Jeddah included 697,000 units in 2007, and there is currently a shortfall of 283,000 homes in Jeddah, including 80,000 in the low income sector. The Jeddah Strategic Plan calls for 151,600 new units to be built to accommodate those people currently living in unplanned settlements, with a further 47,500 units to be built annually to meet the demands of population growth. With regard to future requirements, the strategic plan foresees the need for 953,000 units, and an investment of US$640 billion, over the next 20 years.”(Abdulaal, 2011)

This tremendous growth caused strain in various sectors of the Saudi Arabian economy (Mubarak, 1999). Housing is one of the affected sectors, especially among low and mid-income earners (Gamboa, 2008). According to Gamboa (2008), even when one managed to secure housing, it was neither sustainable, nor efficient in the provision of cultural needs of the occupants. And according to Hamed (2003) designing sustainably is no longer a luxury addition to a building, it is now vital to the survival of the present generation and those yet to come.

Compounding the growing housing crisis in Saudi Arabia is the lack of regulations from the government sector concerning the application of sustainable methods. Karam (2010) enforces the lack of regulations by saying that there are no enforceable building codes, nor are there any regulations to follow that integrate the principles of sustainable architecture in the country. He goes on in recognizing the fact that several researchers have debated that

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one of the most significant and cost-effective ways to foster the prevalent use of sustainable practices is setting a comprehensible set of these codes and standards, specifically with regard to diminishing household energy and water consumption (Karam, 2010). These regulations will need to follow the laws of Islam and incorporate the conservative Islamic culture of Saudi residents.

Saudi Arabia is a conservative Muslim country that follows the laws that are transcribed in the Holy Quran and the Sunnah (sayings and living conducts of the prophet Mohammed). In addition, to understand the economic system of Saudi Arabia, one must comprehend that the economic system is based on the Quran and Sunnah, the accumulated knowledge of Islamic jurisprudence generated by consensus (ijma), analogy (qiyas) and independent interpretation (ijtihad) (Astrom, 2011).

As a preliminary study, which was carried out as part of an ongoing PhD research, this paper’s focus is how to achieve sustainable housing in Saudi Arabia, with special emphasis or interest on the conservative mosque community. It is based upon this groundwork that this study concentrates in particular on the multifamily detached housing units. It begins with a discussion of challenges that were faced in developing sustainable housing in Saudi Arabia – such as climate, economic and social. It then moves on with the description and discussion of the results from the semi-structured interview, and then finally culminates with some concluding remarks.

2. Challenges Facing Sustainable Housing in Saudi Arabia

High cost of living has discouraged people to implement new ‘expensive’ sustainable housing. The public perception about this ‘new concept’ is expensive, and some of the public are still unaware of this ‘New Concept’. Although the financial benefits are remarkable in the long term, concerns are sometimes voiced about the initial cost of green projects (Cityscape 2010). Munton in Eden (2000) argues that what will determine the success or failure of this international call to arms, will be the local responses that will make it a practical programme (Eden, 2000). Eden goes on and states that local governance in addition to the planning process and the involvement of citizens are critical to the success of the sustainability programme. But to incorporate the local public, they must first of all be educated on sustainability and they should be persuaded on why they should want to participate (Eden, 2000). With the large estimated population in Saudi Arabia, it is no easy task to apply a new concept to a country that has developed from living in tents as recently as the 1930’s. The challenge is not in applying a sustainability scheme to the housing sector, magnificent as this is, but rather in initially educating the public and government sectors about sustainability, and convincing them that this is the right way to go for the sake of the future as well as strengthening the present.

2.1 Climate Challenges

Harsh dry climate of Saudi Arabia in addition to pollution and global warming raised environmental challenges facing the housing construction industry in the country. The climate in Saudi Arabia is generally harsh, dry desert conditions with extreme temperature
differences ranging from -11°C to 51.1°C (Piccolo, 2010). Another environmental challenge that faces Saudi Arabia and other Arab countries is the scarcity of water. In order to react to the increasing demand of water, several Arab countries relied on non-renewable groundwater provisions to amplify their scarce water supply (Swain, 1998). In addition, due to the extremely limited conventional water resources such as fresh surface water and renewable groundwater, alternative sources such as wastewater reclamation and desalination have been adopted since the 1960’s (Stensgaard, 2008). In addition to climate challenges and water scarcity, the ecological footprint in Saudi Arabia is approximately 4.5 hectares/capita - almost two times the global average. Compounding this is the fact that Saudi Arabia is among the top 20 countries that are most environmentally challenged (Al Fadi, 2010).

2.2 Economic Challenges

Saudi Arabia has the largest oil reserve in the world, which has been the main catalyst of the economic growth of Saudi Arabia since the 1930’s. This is confirmed by the U.S. Department of State when it states that prosperity from the oil industry has made rapid economic development achievable in the country. (U.S. Department of State, 2011). The near-to-non-existence of mortgage financing is the main factor for the current disequilibrium in the Saudi residential property market. Although there is a substantial pent-up demand for mid or low-end residential real estate, the actual demand – in other words potential investors able to purchase this type of housing without assistance of a mortgage – is quite limited. Therefore, Saudi property developers are reluctant to even build such projects, hence a further increase in the housing deficit as compared to the needs of the community. Independent economist Saud Jleadan reports that with an annual increase of 150,000 units, the country has a current deficit of two million housing units. Experts of the housing industry such as REFCO (Saudi-based mortgage lender “Real Estate Financing Co.”) and Clayton Holdings (U.S. consultancy) have estimated that Saudi homeowners are only 30% of the population – a decrease of more than half of the percentage of the Saudi population, which were homeowners only 20 years ago.

For the world’s largest oil exporter, these are striking numbers signifying an alarmingly uneven distribution of wealth and benefits. (Karam, 2010). And what makes matters worse is that there are no regulations or a set of standards that that would safeguard the safety, health and security of tenants (Colvin, 2006, 23). The tendency of Saudi residents to rent over owning originates from the fact that they simply cannot afford to buy a house in the current real-estate market. Houses are being provided by developers at more than SR1 Million ($270,000), but demand is strongest within the SR500,000 – SR750,000 range – evidence resulting from the fact that the average income of Saudi households ranges most generally from 5,200 to 6,000 Saudi Riyals monthly (Savard et al., 2010).

2.3 Social Challenges

The Saudi culture is defined by the teachings of Islam and is governed by what the Qur’an and the Hadith of the prophet Mohammed (PBUH) state. The culture of Saudi residents is a family oriented culture where all family members are close and the elderly are respected and
are considered the wise members of the family. It is not uncommon to find extended families reaching to three or four generations may living in the same house (North and Tripp, 2009). With this multigenerational household in mind, it is evident that the Saudi house would be larger in scale as opposed to those where a single family live in a two bedroom unit or similar.

One of the major social challenges facing sustainable housing in Saudi Arabia is achieving privacy. Privacy is crucial in the design of a Saudi house, and the concept of privacy is perceived from three different areas as stated by Daneshpour (2011), between the neighbours dwelling as well as the street, between the sexes and privacy between individual family members (Daneshpour, 2011). Abu-Gazzeh (1996) states, “The concept of privacy has become a subject of growing concern for people, architects, urban designers, landscape architects and social scientists involved in development projects in Saudi Arabia.” Al Surf and Susilawati (Al-Surf and Susilawati, 2011) further discuss that unplanned distribution of the residential areas has been the instigating factor resulting in a potentially dangerous mixture of foreign single labour forces living in or nearby previously designated family residential areas. This has led to many serious security issues across the city of Riyadh in addition to the rest of the Kingdom.

The house design should separate private and public life, maintaining their independence. Alhazmi and Nyland (2010) point out the importance of gender segregation where it is fundamental to most people’s educational, social and political activities. To incorporate this fundamental requirement in housing design, the housing designer should divide the house into three distinct areas: private areas for the inner family members such as the father and the mother, semi-private areas for the whole family, such as the living room. And finally, public guest zones for men and guests. According to El-Shorbagy (2010) the traditional Islamic-Arab house layout segregated the house between what is public, semi-public and private areas of the house. He also adds that the design of the house is an inward looking design where the outside walls are generally featureless, which discourage strangers from looking inside.

3. Semi-structured Interview

This research pursues to investigate and interpret the theoretical and practical knowledge of challenges facing sustainable housing in Saudi Arabia. Above and beyond that, this research aims to construct meaning through an interpretation and understanding of the participant’s theories, experiences and knowledge. The participant’s views are critical to forming the findings of this research and stipulate a specific and locally constructed reality. This paper utilizes a semi-structured interview with experienced professionals as the main research method for its primary data. Careful selection of the panel is necessary to the success of the semi-structured interview. The following criteria were used to correctly identify eligible participants for the interviews:

- Established practitioners/stakeholders considered knowledgeable by the housing construction industry and have extensive working experience in housing construction for Low and Middle-income households in Saudi Arabia.
• Experts directly involved in housing projects (either currently or recently) with a sustainability focus, and
• Experts who are in decision-making roles in organizations or companies associated with sustainable housing projects.
• Knowledge of the local capabilities; and
• Objectivity with respect to sustainable housing policy options and criteria.

3.1 Semi-Structured Interview Background

A total of nine professionals agreed to participate in the semi-structured interview. There were a total of ten questions ranging from broad themes to more specific issues, the first of which was of very general nature, asking of the participant’s work experience and relation to the construction industry. Only five questions are discussed in this paper, including one about culture and privacy, due to its significance to the outcomes of this paper. There were a total of ten questions that started from very broad themes, as in discussing the participant’s work experience, to very specific issues related to the research. The following were the questions that all nine participants answered to where only the first five questions are discussed in this paper including a question about privacy due to its cultural significance to the findings and outcomes of this paper:

1. What is your interpretation of Sustainable Development, specifically in the housing industry (sustainability definition)?
2. What parameters/factors of sustainability do you account for when dealing with a housing project (the triple bottom line of sustainability)?
3. What are the critical success factors and/or barriers for applying sustainability to housing in Saudi Arabia and how can barriers be managed?
4. In your opinion, does the Saudi Building code discuss or relate to the cultural needs of the Saudi population and their unique cultural characteristics?
5. One of the crucial elements in the design of a Saudi house is it must provide a private environment and out of the sight-range of passing pedestrians. In your opinion how can privacy be achieved in a sustainable way in a Saudi house?

The participants were approached by email invitations that were sent a few times to get their approval to participate, the duration of which took more than one month. The participants ranged from academics to architects to government workers to private contractors, as can be seen in the following table.

Table 1 Participant Profiles

<table>
<thead>
<tr>
<th>ID</th>
<th>M/F</th>
<th>Age</th>
<th>Current Position</th>
<th>Education</th>
<th>Job Sector</th>
<th>Years of experience</th>
<th>Worked with sustainable projects</th>
<th>Have Knowledge about the subject</th>
<th>Knows the Saudi Building Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>M</td>
<td>30-40</td>
<td>Director of Research and Assessment</td>
<td>Master</td>
<td>Private</td>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>A-2</td>
<td>M</td>
<td>30-40</td>
<td>Architect</td>
<td>Bachelor</td>
<td>Public</td>
<td>12</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A-3</td>
<td>M</td>
<td>40+</td>
<td>Architect</td>
<td>Master</td>
<td>Public</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ID</td>
<td>M/ F</td>
<td>Age</td>
<td>Current Position</td>
<td>Education</td>
<td>Job Sector</td>
<td>Years of experience</td>
<td>Worked with sustainable projects</td>
<td>Have Knowledge about the subject</td>
<td>Knows the Saudi Building Code</td>
</tr>
<tr>
<td>----</td>
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<td>------------</td>
<td>---------------------</td>
<td>---------------------------------</td>
<td>-------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>A-4</td>
<td>M</td>
<td>30-40</td>
<td>Architect (Academia)</td>
<td>PhD</td>
<td>Public</td>
<td>10</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A-5</td>
<td>F</td>
<td>30-40</td>
<td>Architect</td>
<td>Bachelor</td>
<td>Private</td>
<td>3</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A-6</td>
<td>M</td>
<td>30-40</td>
<td>Architect (Academia)</td>
<td>Master</td>
<td>Public</td>
<td>6</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A-7</td>
<td>M</td>
<td>30-40</td>
<td>Consultant (Academia)</td>
<td>PhD</td>
<td>Public</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A-8</td>
<td>M</td>
<td>50-60</td>
<td>Contractor</td>
<td>Bachelor</td>
<td>Private</td>
<td>32</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A-9</td>
<td>F</td>
<td>50-60</td>
<td>Consultant/Advisor</td>
<td>Bachelor</td>
<td>Private</td>
<td>15</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

### 3.2 Results and Discussion

Due to the constraints of this paper, not all the results are revealed. Only the important results that were controversial or had a great impact on the researcher’s expectations are presented and discussed.

For the first question, the participants had the chance to tell the researcher about their work experience and if they had any contact with sustainable housing projects. The outcome of the question was that three of the nine participants had been in contact with sustainable construction projects, and they were A-1, A-3, and A-7 as illustrated in table 1, while the remaining six have not been in any contact with any sustainable project.

All the participants had a great deal of knowledge when it came to answering the second question, which was about how would they define sustainable development. Al Surf and Susilawati (Al-Surf and Susilawati, 2011) discussed such awareness by stating although “the sheer new-ness” of the concept is the main barrier, still there is a marked rise in awareness among the public as well as professionals, as we see from the following responses:

- Sustainable housing is any housing, which proves to be environmentally friendly, has low-cost long-term maintenance and is affordable to the consumer.
- A sustainable housing development is a development that is built from local material, which is suitable for the local environment and culture while employing (absorbing) the local weather for its advantage in energy efficiency.
- Sustainable development is mainly the conservation of resources for future generations. It is concerned with the conservation of energy resources for the longest possible period of time.

For the third question, the participants agreed on most of the sustainable design factors, which demonstrated that the participants are aware of the factors that should be incorporated into the design of a Saudi house. The following table illustrates the response rate in relation to the sustainability factor descending from the highest selected factor to the lowest:
### Table 2 Sustainability factors in housing projects

<table>
<thead>
<tr>
<th>Category/ Theme</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Management</td>
<td>8</td>
</tr>
<tr>
<td>Resources (Materials)</td>
<td>7</td>
</tr>
<tr>
<td>Day Light</td>
<td>6</td>
</tr>
<tr>
<td>Energy</td>
<td>5</td>
</tr>
<tr>
<td>Cost</td>
<td>5</td>
</tr>
<tr>
<td>Natural Ventilation</td>
<td>5</td>
</tr>
<tr>
<td>Quality</td>
<td>4</td>
</tr>
<tr>
<td>Recycling</td>
<td>3</td>
</tr>
</tbody>
</table>

Responses to the fourth question highlighted barriers in applying sustainable methods to housing construction in Saudi Arabia, as revealed in table 3:

- Lack of public awareness of the positives of sustainable housing.
- Lack of stakeholder interest in applying sustainable housing.
- Shortage in sustainable construction material.
- High cost of sustainable housing and long period of return of investment.
- Low levels of investment in sustainable housing.
- Lack of alternative designs of housing and focusing only on the villa typology.
- Lack of awareness from designing firms of how to design sustainable housing.

### Table 3 Barriers to applying sustainability on housing

<table>
<thead>
<tr>
<th>Critical Success Factors</th>
<th>Worked in Sustainable Projects</th>
<th>Never Worked in Sustainable Projects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of stakeholder interest</td>
<td>X X             X X X X</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>High cost</td>
<td>X X X X</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Lack of public awareness</td>
<td>X X X</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Shortage in sustainable construction material</td>
<td>X X</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Low levels of investment</td>
<td>X X</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Lack of alternative designs</td>
<td>X</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Designing firms lack of awareness</td>
<td>X</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Barriers selected</strong></td>
<td>3 4 3 2 2 2 2 1 2</td>
<td></td>
<td>2</td>
</tr>
</tbody>
</table>

The results deducted from Table 3 makes it clear that those having direct contact or real experience with sustainable projects are more inclined to understand the barriers, as these participants are the ones which selected 3 or more of these selections. It is therefore imperative that such persons should be consulted for formulation of a sustainable rating system unique for Saudi Arabia.

On the other hand, the following statements were considered to be critical success factors (CSFs) to applying sustainable methods to housing construction in Saudi Arabia, which can also be found in detail in table 4:

- All designing firms should be educated on the Saudi building code
- Take advantage of local media to create public awareness of Saudi building code.
- New housing projects must use the Saudi building code
- Renovate Old housing projects to reach the minimum level of the Saudi building code
- The Saudi building code should address and solve local environmental problems

**Table 4 Comparison between participants regarding CSFs**

<table>
<thead>
<tr>
<th>Critical Success Factors</th>
<th>Worked in Sustainable Projects</th>
<th>Never Worked in Sustainable Projects</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementing new laws</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Educating firms</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Educating the public</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Environmental comfort</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Grey water treatment</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Using solar energy</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Rainwater collection</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td><strong>Total CSF’s Selected</strong></td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

From table 4 it is evident that participants who worked with sustainable projects have selected five or more critical success factors (CSF’s) while the other participants who did not have any interaction with sustainable projects have selected less CSF’s, illustrating the fact that exposure to sustainable projects greatly impact their judgement of CSF’s and how they apply to sustainability on Saudi housing. One of the noticeable results from this table is that the utilisation of solar energy is one of the least selected CFS’s. This can be due to the high cost of installing solar panels as well as the high maintenance cost of such a system.

In relation to the fifth question, which was asking the participants to discuss the Saudi building code (SBC), it was shocking to see that six of the nine participants did not know that there was even such a building code. But it is not surprising to find out that the three participants who have had some interaction with sustainable projects have knowledge of the SBC as it is illustrated in the table 1.

In response to this reaction, the first thing is that the Saudi building code was not introduced until 2007, which means that is relatively new in the construction industry. The second reason is that the Saudi Building Code National Committee (SBCNC) did not introduce itself to the construction industry well enough so that all the construction industry was informed of the Saudi Building Code. The following outcomes from the participant’s responses should be considered as a guideline for the SBCNC:

- All designing firms should be educated on the Saudi building code
- Take advantage of local media to create public awareness of Saudi building code.
- New housing projects must use the Saudi building code
- Renovate Old housing projects to reach the minimum level of the Saudi building code
• The Saudi building code should address and solve local environmental problems

The question regarding the adaptation of privacy in current and future sustainable Saudi housing design had an agreement across the board, which indicates that all the participants agree on the importance of this aspect, both culturally and religiously. Several methods of achieving privacy have been outlined by some of the panel members, which include:

• Refrain from the design constrictions of fenced villas.
• Employment of Mashrabiya concept
• Provision of clearstory fencing along the room walls instead of typical windows
• Designing a house with an introverted concept (looking inside a court).
• Introduce camouflage and pattern in the house, in addition to the idea of a courtyard.

Overall, the concept of privacy can be achieved in the design process of a sustainable Saudi house, which can serve both the cultural and religious needs of its occupants. Designers should incorporate a minimum level of privacy that can fulfil the occupant’s needs and any additions or alterations can be done according to the extent and willing of the homeowner.

4. Concluding Remarks

High cost of living has discouraged people to implement sustainable housing concept. The public perception about this ‘concept’ is expensive, and some of the public are still not aware about this ‘concept’. With the large estimated population in Saudi Arabia, it is no easy task to apply a sustainable housing concept to a country that has developed from living in tents in the 1930’s to having a sustainable scheme applied to the housing sector and convince them that this the right way. The findings from the interview suggest accommodating the conservative Saudi Culture in design requirements for sustainable houses. The following points are also derived from the interview:

• Enlightening architectural and construction firms on sustainable designs
• To implement regulations resulting in enforcement of application of sustainable methods in housing construction.
• Encourage Saudi government to erect affordable sustainable housing units.
• Promotion of green energy to become the main energy source for housing.
• The importance of rainwater collection.
• The value of grey water treatment systems

This discussion of the applicability of sustainable methods on the housing construction industry in Saudi Arabia can be utilised for other developing countries in the region that are faced with similar housing shortage especially for mid and low-income families.

Further research is on-going as part of the researcher’s PhD, and results from the first and second Delphi rounds, which are additional research methods used in the PhD thesis, will be available as they arise along the timeframe of the PhD thesis that will discuss further agreement between participants on the research topic.
References:


Mechanisation in Construction – A Malaysian Perspective

Toong Khuan Chan

Abstract

Many developing countries have suggested policies to increase mechanisation or prefabrication in their respective construction industries to improve on quality and to increase construction productivity. Mechanisation is widely acknowledged to significantly reduce the reliance of the construction industry on labour; a problem particularly acute in developed economies where skilled labour is increasingly scarce, expensive or both. The trade-off between capital and labour in the production function is clearly illustrated by investments in plant and machinery to produce precast concrete components as compared to employing labour to manually carry out the concreting works in-situ. There is evidence that the low wages of migrant construction labour may preclude the use of the more capital intensive precast concrete technology in developing countries. This paper examines a number of precast systems currently in use in Malaysia and attempts to characterize the factor inputs to support the decision for a semi-mechanised approach. Various constraints against the adoption of precast concrete technology is exposed and discussed. The impact of current labour policy, employment of migrant labour, training, and technology is discussed to identify appropriate policies and incentives that could increase the adoption of mechanised construction systems into the building industry. The current financial incentive for the adoption of mechanised construction system in Malaysia is clearly deficient.

Keywords: Mechanisation, Precast concrete, Malaysia

1. Introduction to Mechanisation

The primary objective of mechanisation or prefabrication in general is to enhance productivity at project, company and industry level, reduce construction time, reduce wastage and improve quality. In many developing countries, it may be proposed as one of a suite of strategies for the construction industry to adopt advanced systems and technologies to enable construction companies to penetrate global markets and export professional services and construction expertise. The introduction of greater mechanisation and prefabrication was also proposed in developed countries to improve the performance of their respective construction industries (NAO, 2001)

In 1999, the Malaysian government initiated a program to introduce prefabrication methods into the construction industry with the aim of improving productivity, quality and safety. An

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eight-year road map to drive the adoption of industrialised building systems (IBS) in order to reduce cost, improve quality and reduce the dependence on migrant labour was introduced in 2003 (CIDB 2003). The main IBS systems proposed include pre-cast concrete, advanced formwork system, steel framing systems, prefabricated timber frames, and block work systems (such as interlocking concrete masonry units). Key targets to be achieved include a gradual reduction of the percentage of migrant workers in the construction industry from the existing level of 75% in 2003 to 15% in 2009, and to increase utilisation of IBS from 30% of total public housing in 2004 to 70% in 2008.

A survey carried out in 2003 indicated that the utilisation of IBS in building construction was extremely low at approximately 15% (Shaari, 2003). Earlier efforts by the government to encourage greater mechanisation in the industry have not gained traction as the construction companies continue to practice conventional methods of in-situ construction. It was reported by Hamid et al. (2008) that only 10% of the completed building projects utilised IBS in 2006; less than 35% of total construction projects used at least one IBS product, compared with the projection of utilising IBS 50% of all building projects by 2006 and 70% by 2008, as recommended in the IBS road map.

Financial incentives such as the abolition of a 0.25% levy on low, and medium cost houses, and a 50% levy reduction for building incorporating more than 50% IBS components were announced in 2003. In 2005, buildings with at least 50% IBS components were exempted from this levy altogether to further encourage adoption of IBS components. In October 2008, the government (Ministry of Finance, 2008) further advanced the full utilisation of IBS in government projects by stipulating that the use of IBS components in public projects must not be less than 70% and that the IBS had to be specified for all public building works.

The aim of this study is to characterise the cost structure of the mechanised and conventional methods of concrete construction in Malaysia to enable construction managers and cost engineers to gain a deeper understanding of the drivers behind the adoption of mechanised building systems in Malaysia. Material and labour costs, as inputs to these forms of construction, are estimated and analysed to identify and recommend appropriate policies and reforms that could promote the greater use of mechanisation in Malaysia or in developing economies in general. The main focus of this paper is to review the extent to which a semi-precast panelised wall system may be utilised for residential construction to replace the conventional reinforced concrete frame with brick infill walls. This semi-precast wall panels may be produced with simple flat moulds and hence a smaller capital investment in plant and machinery. The ability to cater for complex shapes and designs with the use of a cast in-situ column or section is an added advantage for designers and builders who are not well versed with the methods of installing fully precast components. This semi-precast system may allow for the numerous benefits of precast construction such as greater productivity, shorter construction programmes, and improved quality to be achieved at a lower cost compared to a fully precast system.
2. Literature Review

Many developing economies have been reported to be looking towards improving the quality of the products of construction and increasing the productivity of the sector with greater use of mechanisation, prefabrication technology and upgrading the skill of workers. Various precast concrete building systems were created in the early 1970s by construction companies in Europe and the US to cope with increasing demand for housing. High levels of precast utilisation were reported in Denmark, Netherlands, Sweden and Germany in the 1990s (Construction 21 Steering Committee, 1999).

In many countries, prefabrication is applied in the building sector to enhance productivity, improve quality, and cope with a shortage of skilled labour. However, in land scarce Hong Kong, the Housing Authority had advocated the usage of precast concrete methods since the mid-1980s and contributed to major precasting innovations in the industry. Although the Hong Kong Construction Industry Review Committee (CIRC) recommended a wider adoption of prefabrication to improve the quality and to reduce the generation of construction waste, Jaillon and Poon (2009) reported that the private sector still relies heavily on cast in-situ methods of construction involving the use of timber formwork, in-situ concreting, substantial amount of wet trades and bamboo scaffolding. In the same article, Jaillon and Poon reported major advances in precast construction techniques involving volumetric and modular precast elements, and large increases in number of precast elements used in public housing projects. It is interesting to note that incentive schemes were required to encourage the private sector to promote the use of prefabrication such as prefabricated non-structural external wall in the Joint Practice Note 2 (Government of Hong Kong, 2002).

Similarly, precast concrete was introduced in the early 1980s in Singapore, and have resulted in volumetric precast elements being used to provide additional space to existing high rise apartment blocks for the Public Housing Upgrading Program. The main driver for adopting prefabrication technology was to reduce Singapore’s dependence on foreign labour and technology through increased construction productivity. Given the many technical and social constraints of operating in a highly built-up environment, Lau and Tay (1996) reported that prefabrication has improved the efficiency and cost effectiveness of concrete construction while at the same time minimise disruptions for their upgrading programs.

A survey on the use of precast concrete systems in Turkey and the US (Polat, 2010) indicated that American respondents considered restrictions on transportation, poor communication, and the lack of qualified specialised contractors as the three most important barriers to the extensive use of precast concrete systems in the US market. On the other hand, Turkish respondents ranked poor communications amongst parties and the lack of structural engineers and specialised contractors as the most important factors in Turkey. Polat suggested that the cost of exploiting labour-intensive methods of construction may be much lower than the cost of implementing advanced technologies such as precast concrete systems in a developing country.

Precast concrete construction in Australia took off in the 1990s when designers and building owners realised that the economics and speed of construction of precast walls and floors
were favourable compared to conventional in-situ systems. Benefits of precast flooring such as the long-spanning ability to eliminate conventional concrete beams and therefore the need for formwork during construction was recognised early (National Precast Concrete Association Australia, 2009). Reports of cost savings of 10% of the structure costs by using precast walling and flooring were common.

More recent studies by Lou and Kamar (2012) identified a series of critical success factors for the adoption of mechanisation in construction but had not fully considered the economics of the precast versus cast in-situ option in detail. Elliott (2002) had previously pointed out that precast cannot compete with cast in-situ concrete where the ratio of labour-to-materials or plant is low, say one man-hour pay is less than 1/50 tonne of cut-and-bent rebar, or one man-hour pay is less than 1/500 daily hire of a large mobile crane. This observation clearly lends weight to the discussion on the two opposing policies of greater mechanisation and the continued employment of cheap migrant labour by the construction industry in Malaysia.

3. Methodology

Based on the review presented above, the case for promoting pre-cast technology as a means of mechanisation in a developing country is obvious and has been proven in many instances to bring about immediate gains in productivity, shorter construction periods, improved quality and safety performance, and in specific cases a reduction in overall construction cost. There is clear evidence to indicate that the concept of greater productivity with large-scale precast buildings can be achieved in Malaysia (Lai, 2005).

The relative cost of the cast in-situ, precast and semi-precast systems was examined by either studying the precast manufacturer’s bid submitted to the builders or by estimating the cost of each system from published cost guides. The cost comparisons for cast in-situ and precast construction systems were previously conducted by Yong (2010) to assess the effects of wages and material costs on the price of each system. The cost for the semi-precast system was obtained from a precast manufacturer and was valid for projects in the states of Selangor, Perak and the Federal Territory of Kuala Lumpur.

4. Comparison of Construction Costs

Conventional building construction in Malaysia consists of reinforced concrete frames with brick in-fill walls, timber or cold formed metal trussed roof with either clay or concrete tiles, or sheet metal roofs. Concrete is cast in-situ into timber moulds while steel reinforcement is generally fabricated off-site but may still be bent on-site in less developed areas. This method of construction is very labour intensive, involving many wet trades on the work site: carpenters to fabricate the moulds and scaffolding, bar benders to cut, bend and place steel reinforcements, concreters to place, vibrate and finish the concrete, and brick layers to build the walls.

A case study was conducted by Yong (2010) on proposed hostel blocks for an institution of higher learning in the state of Perak, Malaysia where the builder was obligated to construct 4 blocks with the use of precast components while the remaining blocks were to be
constructed with conventional in-situ technology. Each hostel block provided a total area of 3,088 square metres of floor space. As both precast and in-situ construction methods were to be employed, it was possible to obtain construction drawings and cost estimates for both these modes of construction. A reinforced concrete structural frame was the proposed structural form with a slab and beam arrangement. The walls were all in clay brick with cement render on both faces. In comparison, the proposed prefabricated system was precast columns, precast inverted-T beams supporting hollow core precast prestressed planks. The hollow core planks were eventually topped up with an 80 mm structural screed.

4.1 Material and Labour Costs for In-situ Construction

A close examination of the builder’s cost for cast in-situ slabs indicated that the supply and installation of sawn timber formwork cost approximately RM 7 (12%) whereas the materials (supply and fix concrete and steel reinforcements) cost RM 47, or 88% of the total cost of a suspended reinforce concrete slab.

The concrete structure complete with reinforced concrete slabs, beams and columns worked out to a cost of RM 250 per square metre for the cast in-situ option. This conventional construction method necessitated the deployment of a large number of workers to fabricate and install sawn timber formwork and timber props to support the fresh in-situ concrete. Materials now constitute 70% of the total cost with site labour and machinery accounting for 24% and 6%, respectively, as shown in Table 1.

Table 1: Comparison of concrete structure cost

<table>
<thead>
<tr>
<th>Case Study Items</th>
<th>MALAYSIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-situ Suspended Slab and Beam</td>
<td></td>
</tr>
<tr>
<td>- Supply of Materials and Forms</td>
<td>RM 250 (100%)</td>
</tr>
<tr>
<td>- Site Labour</td>
<td>RM 175 (70%)</td>
</tr>
<tr>
<td>- Crane Rental</td>
<td>RM 59 (24%)</td>
</tr>
<tr>
<td>- Crane Rental</td>
<td>RM 16 (6%)</td>
</tr>
<tr>
<td>Precast System (Slab and Beam)</td>
<td></td>
</tr>
<tr>
<td>- Manufacture &amp; Supply of Materials</td>
<td>RM 411 (100%)</td>
</tr>
<tr>
<td>- Site Labour</td>
<td>RM 360 (88%)</td>
</tr>
<tr>
<td>- Crane Rental</td>
<td>RM 23 (6%)</td>
</tr>
<tr>
<td></td>
<td>RM 28 (7%)</td>
</tr>
</tbody>
</table>

4.2 Manufacturing and Labour Cost for Precast Construction

In comparison, a fully precast solution with hollow-core slabs and planks, beams and columns, cost RM 411 per square metre, an increase of more than 60% over the cost of the cast in-situ concrete. The supply cost of the manufactured precast components was more than double the supply cost of materials and forms for the cast in-situ option as shown in Table 1. The reduction in site labour from RM59 to RM23 per square metre did little to mitigate this large increase in material supply cost. There was also a significant increase in
the cost of crane rental as larger capacity cranes were required for the heavier precast components.

These results indicate two important observations in the cost structure: (a) the supply of precast components is clearly more expensive than the supply and fixing of concrete, steel reinforcement and forms, and (b) the cost of site labour for cast in-situ construction is double that of precast construction. It is clear that the saving in site labour costs cannot compensate for the higher material cost incurred by adopting a fully precast solution. Construction labour in Malaysia consists of migrant workers from neighbouring countries, often working illegally and unregistered, and earning RM 50 and RM 100 per day as unskilled and skilled workers, respectively (CIDB 2009). The presence of these migrant workers in large numbers naturally put downward pressure on the wages for local workers in the same industry leading to a situation where local workers shun working as skilled workers in the construction industry. This observation confirms the assertions by Shaari (2003) that construction firms in Malaysia have continued to adopt labour intensive practices due to the availability of cheap migrant labour instead of investing in plant and equipment for the manufacture of prefabricated components.

5. Semi-Precast Construction

A semi-precast system comprising of a series of precast wall panels that are interconnected with cast in-situ joints or columns were developed in 2002 for residential construction. This method of construction was particularly suited for detached, semi-detached or multi-storey commercial buildings with complex architectural designs. The semi precast system allowed various sizes of wall panels to be erected and fully adaptable to most existing designs and provides sufficient versatility for architect’s design intent to be expressed. The cast in-situ joints or columns are reinforced with conventional reinforcements, provide stability to the building, and eliminate the possibility of ingress of water. These in-situ columns can also act as load carrying members to support heavily loaded beams and allow a hybrid system of conventional and precast systems to be achieved.

Figure 1 shows typical wall panels being cast flat with openings for windows and doors predetermined. The edges of the precast wall panels are cast with a shear key joint providing a strong interlock with the in-situ concrete. This method of casting allows wall panels of various thicknesses to be easily cast. Figure 2 shows the shear keys and continuity bars at the edge of each wall panel. Figure 3 illustrates how a plastic tube is used as backing for the sealant between the wall panel and floor slab. Figure 4 shows a partially completed double storey house built using this semi-precast system. The entire semi-precast panelised system can be demonstrated by the model shown in Figure 5 where the wall panels are shown in grey and the cast in-situ sections are shown in white. The model shown here has a revised shear key for improved vertical shear resistance. The size of the in-situ columns can be easily increased or reduced depending on the structural requirements.
5.1 Manufacturing and Labour Costs

The precast panel walls were generally 100mm or 120mm thick with a layer of mesh reinforcement placed mid-thickness. A local precast manufacturer quoted a price of RM 110 per square metre to supply and install these panels with approximately 30 pieces 3 metre by 3 metre panels to construct a double storey townhouse. These wall panels were 40% more expensive compared to the cost of a conventional 260mm brick wall which comprises RM 38 per square metre for the brick wall and an additional RM 40 for the cement render on both faces (total brick wall = RM 78 per sq.m). The proposed floor slab was a half slab (80mm thick semi-precast slab with an additional 70mm in-situ concrete) supported on the edges of the wall panels. When compared on a per unit basis, the estimated cost for the panel wall system worked out to be RM 42,460 whereas the conventional RC framed with brick wall was costs RM 23,917. The panel wall system was 78% more expensive as tabulated in Table 3.

![Precast wall panels at the casting yard](image)

**Figure 1: Precast wall panels at the casting yard**

The installation rate of 40 panels per day for a team of installers indicate that the construction schedule can be shortened considerably with the associated cost savings making up for the marginally higher cost of these panels. This semi-precast system has several advantages over a fully precast construction: the panels are connected with wet cast in-situ joints providing full structural connection at a low cost, wet-joints for all floor slabs to prevent water ingress or leakages, ability to allow for large tolerances due to wide cast in-situ joints, able to create complex shapes and configurations to comply with architect’s design intents, adaptable to last minute design changes, and excellent quality finishes.

These large prefabricated panels create potential for transportation, handling and temporary stability hazards which must be adequately addressed. Suitable braces must be installed to provide stability during installation. These additional items combine to increase the total cost.
of the semi-precast system but the overall productivity, quality and schedule benefits far outweigh these costs.

6. Discussion

The cost comparison of the semi-precast panelised wall system indicates that it may be feasible for large scale residential housing construction in Malaysia. This system, although not fully mechanised and require substantial labour input to construct the in-situ joints may bridge the path between a conventional cast in-situ construction and the more capital intensive fully pre-fabricated precast slab, beam and column system.

The comparison between conventional cast in-situ against a fully precast solution indicates that the availability of cheap migrant labour in Malaysia generates an artificially low cast in-situ cost that is hard to beat. The cost of precast components is generally higher to cater for the additional capital investment in plant and machinery. If one considers the additional financial risk involved with investing in a precasting plant whilst having to compete for projects on a continuing basis, the total financial viability of the investment may not be feasible.
Table 3: Comparison of Panel Wall and RC Frame with Brick In-fill Wall

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Unit</th>
<th>Qty</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Double Storey House – Panel Wall System</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Panel Wall (external &amp; internal)</td>
<td>cu.m</td>
<td>29.37</td>
<td>1,100.00</td>
<td>32,307.00</td>
</tr>
<tr>
<td>2</td>
<td>Column – Car Porch</td>
<td>cu.m</td>
<td>0.08</td>
<td>1,100.00</td>
<td>88.00</td>
</tr>
<tr>
<td>3</td>
<td>Beam – Car Porch</td>
<td>cu.m</td>
<td>0.55</td>
<td>1,100.00</td>
<td>605.00</td>
</tr>
<tr>
<td>4</td>
<td>Floor Slab (150mm thick)</td>
<td>cu.m</td>
<td>8.60</td>
<td>1,100.00</td>
<td>9,460.00</td>
</tr>
<tr>
<td></td>
<td>Total per unit</td>
<td></td>
<td></td>
<td></td>
<td>42,460.00</td>
</tr>
<tr>
<td></td>
<td>Total gross floor area</td>
<td>sq.m</td>
<td>136.94</td>
<td></td>
<td>310.06</td>
</tr>
<tr>
<td>1</td>
<td>Double Storey House – RC Frame &amp; Brick Wall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Brick walls</td>
<td>sq.m</td>
<td>244.78</td>
<td>38.00</td>
<td>9301.64</td>
</tr>
<tr>
<td>2</td>
<td>Plastering</td>
<td>sq.m</td>
<td>489.56</td>
<td>20.00</td>
<td>9,791.20</td>
</tr>
<tr>
<td>3</td>
<td>Column – Car Porch</td>
<td>sq.m</td>
<td>0.08</td>
<td>280.00</td>
<td>22.40</td>
</tr>
<tr>
<td>4</td>
<td>Beam – Car Porch</td>
<td>sq.m</td>
<td>0.55</td>
<td>280.00</td>
<td>154.00</td>
</tr>
<tr>
<td>5</td>
<td>Floor Slab</td>
<td>sq.m</td>
<td>8.60</td>
<td>280.00</td>
<td>2,408.00</td>
</tr>
<tr>
<td>6</td>
<td>Structural Frame</td>
<td>sq.m</td>
<td>8.00</td>
<td>280.00</td>
<td>2,240.00</td>
</tr>
<tr>
<td></td>
<td>Total per unit</td>
<td></td>
<td></td>
<td></td>
<td>23,917.24</td>
</tr>
<tr>
<td></td>
<td>Total gross floor area</td>
<td>sq.m</td>
<td>136.94</td>
<td></td>
<td>174.65</td>
</tr>
</tbody>
</table>

Figure 4: Completed precast wall panel with in-situ columns

Pan et al. (2007) identified through their survey of the UK’s leading house builders that significant barriers against the use of off-site and other modern methods of construction in the house-building industry were considered to be higher capital cost, difficult-to-achieve economies of scale, complex interfacing between systems, lack of ability to freeze the design early on, and the nature of the UK planning system. Sadafi et al (2012), on the other hand, reported that factors preventing the wider application of IBS components in Malaysia were skill shortages and design conflicts were the two most challenging categories for the
respondents, followed by installation issues, manufacturing and cost difficulties and lack of knowledge. The disadvantages pointed out by participants included prohibitive cost and maintenance issues and limitations in architectural and detail design.

Lou and Kamar (2012) also reported that barriers to a greater IBS adoption in Malaysia include the following points: not popular among design consultants; lack of knowledge among designers; the need for mind-set change; the chicken-and-egg dilemma; lack of support and slow adoption from the private sector; lack of push factor from responsible bodies; volume and economy of production in scale to IBS components; monopoly of big boys, limiting opportunities to other contractors; low IBS construction components available in the market; IBS requires on-site specialized skills for assembly of components; lack of special equipment and machinery; lack of local R&D on technologies and testing facilities; mismatch between readiness of industry with IBS targets; insufficient capacity for contractors to secure project; and a sustainability issue, with the government to lead during a downturn.

With the prevailing conditions in Malaysia, it may be worthwhile considering the lower investment in a semi-precast panelised wall system combined with increased utilisation of labour to complete the in-situ connections. This semi-precast system seem to require little specialised skills for the assembly of the wall panels, fully adaptable to complex designs and shapes, and may be able to address many of the concerns mentioned above.

If mechanisation or off-site construction is to make a sustained positive contribution in the marketplace, research is needed to identify the pervading issues that constrain the uptake of this, or conversely, can promote this in a more reasoned and defendable way, especially taking into consideration the existing societal, cultural, and current business models associated with conventional thinking and practice (Arif et.al. 2012). The core finding here is that as far as mechanisation is concerned, the semi-precast system seem to be the logical way forward for Malaysia at this stage of its development and taking into account the large
number of migrant workers in the country at this point in time. Once a clearer policy with regards to the reduction of these migrant workers is outlined, the economics of the various systems of construction may evolve leading to a different system being optimal once the number of migrant workers is substantially reduced.

7. Conclusion

The case studies presented here have illustrated the trade-off between capital and labour in the production of reinforced concrete buildings. Construction firms in a developing economy like Malaysia with access to cheap migrant labour can choose to keep construction costs down by utilising greater labour inputs. On the other hand, construction firms in a developed economy, e.g. Australia, with high labour wage rates can easily opt to increase capital input and decrease labour input to minimise costs.

The cost comparisons clearly indicate that the choice of inputs for construction is market driven, and that financial incentives to increase mechanisation in construction must be coupled with a reduction in the supply of cheap migrant labour.

The semi-precast system seem to be the logical way forward for Malaysia at this stage of its development and taking into account the large number of migrant workers in the country at this point in time. Once a clearer policy with regards to the reduction of these migrant workers is outlined, the economics of the various systems of construction may evolve leading to a different system being optimal once the number of migrant workers is substantially reduced.

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Perception of Procurement on Successful Infrastructure Project Outcomes in Pakistan

Muhammad Ali Noor, Farshid Rahmani, Nawaf Alshanbri, Malik M. A. Khalfan, Tayyab Maqsood

Abstract

In Pakistan, the need for infrastructure is immense while resources, capitals and commodities are scarcely found. This paper explores the methods used in Pakistan to procure infrastructure projects. With the help of archival analysis, in-depth case interviews and in light of the literature it discusses the advantages and disadvantages of the methods of procurement used in the public sector in Pakistan. The findings reveal that there are two distinct methods of infrastructure project procurement in the public sector in Pakistan i.e., the traditional method and the non-traditional method (Public Private Partnership (PPP)). The driving forces for the non-traditional method in comparison to the traditional method are also limited. This paper also discusses the perception of procurement in the delivery of successful project outcomes in Pakistan. In addition, it provides an analysis of the challenges a developing country like Pakistan faces while adopting modern procurement methods and systems; how enabled is the environment in Pakistan to accept new and innovative forms of procurement.

Keywords: Infrastructure Projects, Procurement, Pakistan.

1. Introduction

In Pakistan the need and demand for infrastructure is massive while the resources in Pakistan are not ample to meet this demand (Noor et al., 2012). Not only there is limited fiscal space, there are also huge gaps in public sector capacity to build and operate infrastructure (IPDF, 2010). Procurement of infrastructure projects poses challenges that are not found in other areas of public procurement, the primary reason is that infrastructure is highly complex and customized therefore it requires not only economic but also political, social and environmental...
considerations from a long term perspective (World Bank, 2009). How to use the limited public resources wisely remains an important challenge for governments especially under fiscal pressure (Estache and Limi, 2011). The Government of Pakistan (GoP) estimates that less than half of the infrastructure investment needs can be met with public funds under the Medium Term Development Framework (MTDF) of the Government of Pakistan (IPDF, 2010). The country needs to embark on implementing different forms of procurement to meet its infrastructure needs (Noor et al., 2011). The public sector in Pakistan has taken some steps but there is still more to be done (Noor et al., 2012). A combination of policy reforms, institutional support, incentives and financing modalities are required to encourage private-sector participation in financing, constructing and managing infrastructure projects (IPDF, 2010). In Pakistan, construction sector is an important sector and although it is not working to its fullest potential, it is still of prime significance to the country (Azhar et al., 2008). They state that it is among the largest sectors that generates employment within the country as well as a key driver for economic development of Pakistan. Furthermore, according to them, similar to many other developing countries, Pakistan is also facing critical project management related issues. They also suggest that procurement is a major factor for cost overruns in projects in Pakistan. Saqib et al. (2008) found out that procurement related factors such as project delivery system, project bidding method and project contract mechanism were rated as most significant factors and procurement related factors were rated among the top five critical success factor categories in Pakistan. They suggest that there is a need for further study on procurement in Pakistan which will be useful in implementing projects successfully. Much research remains to be done on the links between procurement of projects and its effective implementation in Pakistan (Khan et al., 2008). They expect that further research within Pakistan could reveal more prospective information on the existing mechanisms of procurement of projects in Pakistan and the means for improving the implementation of projects to achieve successful outcomes for the benefits of all the stakeholders and general public (Noor et al., 2012). The aim of this paper is to give a holistic view of the types of procurement of infrastructure projects in Pakistan, the perceptions about procurement and its impact on successful delivery of project outcomes and the challenges a developing country like Pakistan face in implementing new and innovative forms of procurement as well as how enabled is the environment to accept these new forms of procurement.

2. Methodology

The methodology for this research employed qualitative research techniques. The research was carried out in two stages. In the first stage, archival analysis was conducted of government documents and reports including reports by international organisations, policy documents and literature. As a result, it was found that there are two different methods of procurement used for procuring infrastructure projects in public sector in Pakistan i.e. the traditional and the non-traditional methods. This also facilitated in identification of potential case study projects based on the type of procurement method used. During the second stage, case studies were selected based on archival analysis. A total of 6 public sector organisations had been selected as organisational case studies and 8 projects had been selected among these organisations as
project case studies. A total of 24 respondents participated from these 6 organisations. The case studies were analysed using qualitative content analysis techniques of the in depth interviews. Cross case analysis had also been carried out based on looking at the similarities and differences across similar as well as different methods of procurement.

3. Types and Use of Infrastructure Procurement in Pakistan

Figure 1 below provides a diagrammatic explanation of the different types of procurement arrangements and methods for infrastructure projects in Pakistan.

The infrastructure procurement in Pakistan can be broadly classified in two distinct methods of procurement i.e. the traditional method and the non-traditional method. Within the traditional method the normal practice in public sector in Pakistan is to use the general contracting i.e. Design-Bid-Build. In case of non-traditional methods of procurement for infrastructure projects in the public sector in Pakistan the three main types of contractual arrangements are BOO which is under policy recommended for procuring thermal power projects in addition to it being used by the first private sector airport in Pakistan. BOT is most widely used for infrastructure projects across the public sector in Pakistan especially in case of transport sub-sector as almost all the case study projects in this sector have been procured through this arrangement. The only one BOOT project is in the hydropower sector in Pakistan and it is the only BOOT project so far in infrastructure projects in public sector in Pakistan. From the respondent responses, it was quite evident that the predominant method of procurement in case of infrastructure projects in almost all the organisations was that of traditional method of procurement. This is illustrated in the Figure 2 below that all organisations utilise traditional form of procurement except Organisation 2 which employed only non-traditional method of procurement as per government and policy guidelines and is specialised organisation in case of non-traditional form of procurement in Pakistan (Noor et al., 2012).

![Figure 1: Types of Infrastructure Procurement in Pakistan - Source: Noor et al. (2012)](image-url)
4. Advantages and Disadvantages of Different Types of Procurement in Pakistan

The following sections have been adapted from a study conducted by Noor et al. (2012) which discusses the advantages and disadvantages of traditional and non-traditional methods of procurement in light of literature and in the context of Pakistan based on interview responses during case study interviews.

4.1 Traditional Method

General contracting or as it is usually known as design-bid-build is the traditional approach to procurement in construction. The advantages of the traditional method in Pakistan have been reported to be the relative comfort with the approach and ease of use for the public sector organisations, with relative price certainty and targeting at least cost, having fair amount of competition and to a degree transparent which are mandatory for public procurement under the government regulations. The disadvantages have been reported to be cumbersome, time consuming, often resulting in delays in project execution and resulted in adversarial relationship often ending in legal disputes. Both advantages and disadvantages broadly conform to the literature on traditional method of procurement such as Francis and Sidwell 1996; Hughes et al. 2006; Morledge et al. 2006; Walker and Hampson 2003 and Murray and Langford 2009. This can also be depicted in the force field analysis diagram such as in figure 3 below. Considering the advantages being the forces driving the traditional method and the disadvantages being the restraining forces, also evident from section 3 and figure 2 above, the traditional method of

Figure 2: Predominant Use of Method of Procurement across Cases - Source: Noor et al. (2012)
procurement is the predominant method and is in high use hence it can be inferred that the driving forces are stronger than the restraining forces.

4.2 Non Traditional Method (PPP)

Duffield (2008) defines Public-Private Partnerships’ (PPPs) as a contracting arrangement in which a private party, normally a consortium structured around a Special Purpose Vehicle (SPV), takes responsibility for financing and long term maintenance or operation of a facility to provide long term service outcomes. In Pakistan as stated earlier in section 3, Public-Private-Partnership (PPP) is considered as a non-traditional procurement method. The driving forces and advantages of the non-traditional method of procurement and especially Public Private Partnerships in Pakistan have been reported to be the need for efficiency and finances. The restraining forces and disadvantages to this particular method have been reported to be lack of understanding of the method of procurement, the project revenue issues, the long gestation period of PPP projects, resistance to change and the suitability to the present environment of the country. These factors broadly conforms to the literature by authors such as Hughes (1989); Walker and Smith (1995); Merna and Smith (1996); Chu (1999); Walker and Hampson (2003); Hughes et al. (2006); Morledge et al. (2006); Miller et al. (2009) and Murray and Langford (2009). Regarding the issue of lack of understanding as explained by authors such as Nahapiet and Nahapiet (1985); Naoum(1994); Nam and Tatum (1997); Slaughter (1998); Luu et al. (2005); Shields (2005) and Miller et al. (2009), stress is on the need and the importance of understanding of procurement as well as the increase in the level of understanding with experience and expertise. This lack of understanding as reported was not specific to clients alone but also contractors, consultants and private parties have exhibited the same in case of Pakistan which corresponds to what Naoum (1994) and Luu et al. (2005) have stated. It is also interesting that resistance to implement change (Shields, 2005) has also been observed in case of Pakistan. Suitability to the specific environment and the influences of environmental factors such as regulatory, legal, political, economic, cultural, financial etc in which it is being administered conforms to the literature. Although the literature does not particularly elaborated these in the context of developing countries, the findings do confirm that these issues are having a profound negative impact on the applicability of this type of procurement in Pakistan. Considering the above the same can be depicted using a basic force field analysis as done in figure 4 below. Considering section 3 and figure 2 above, non-traditional method of procurement is seen as a sparingly used method. Hence it can be inferred that the restraining forces are stronger than the driving forces in the case of non-traditional method in Pakistan.
Driving Forces

- Comfort and Ease of Use
- Relative Price Certainty
- Least Cost
- Competition
- Relative Transparency

Restraining Forces

- Cumbersome
- Time Consuming
- Causes Delays in Project Execution
- Results in Adversarial Relationship & Legal Disputes

Figure 3: Force Field Analysis of Traditional Method in Pakistan - Source: Noor et al. (2012)

Driving Forces

- Need for efficiency
- Need for finances

Restraining Forces

- Lack of understanding of the method
- Project revenue issues
- Long gestation period of PPP projects
- Influence of environmental factors
- Resistance to Change

Figure 4: Force Field Analysis of Non-Traditional Method in Pakistan - Source: Noor et al. (2012)
5. Perception of procurement practices in delivering successful project outcomes

Success was defined and perceived as meeting all the major objectives of the project as envisaged prior to execution when the project was constructed and completed. In totality the respondents perceived that procurement had a direct impact on successful outcomes of the project. As it was unanimously stated that the project procurement processes and methods directly impacted the successful outcomes of the projects in the organisations investigated, it was perceived that all the criteria, guidelines and rules etc. were designed to achieve successful project outcomes. It was felt if the process of procurement is followed in letter and spirit there would be no problems in its effective implementation. The criteria for pre-qualification and award of contracts in theory was perceived to be tailored in such a way that these are built in the process for one reason alone i.e. to achieve successful project outcomes. The procurement systems in the organisations studied had a direct relationship and impact on performance and success of the project.

In addition procurement planning and project planning were perceived to be instrumental in achieving successful outcomes. If project planning and especially the prime governmental project document i.e. PC-1 (stands for Planning Commission template 1) was properly prepared in their experience, such projects usually reached successful conclusions. It was felt that for successful implementation both political and organisational will and loyalty including personal will and loyalty to the project, were imperative i.e. how loyal and willing all the project stakeholders are to the project. It was reported that there was much room for improvement in the process and rules which would lead to successful implementation of projects. The due diligence of the process of procurement was also reported to help in identifying who is best suited to handle the project.

6. Challenges in adopting modern procurement methods for developing countries

As Riley and Lewis (2008) state that uncertainty results in large part from imperfect information, the institutions in a society are those that reflect the quality of the information that is available. They further state that adopting new and different procurement processes has a direct relationship with uncertainty. They assert that the greater the uncertainty, the more rigid and limiting the institutional arrangements tend to be, and in the context of construction, the more difficult it becomes to adopt a new and different procurement process that minimizes transactional and enforcement costs. They further state that “the smaller the uncertainty facing the decision maker, the more flexible the institutional arrangements, and the greater the scope for initiative. Hence, developing countries tend to limit the scope for initiative in public sector contract letting (almost always to the lowest competitive bid) whereas more developed countries experiment with various of the newer formats that even allow negotiation (PPP, PFI, BOOT, BOLT etc)” (Riley and Levis, 2008: P?). The same can be inferred from this research in case of Pakistan that the external environmental uncertainties are quite extensive and massive.
Infrastructure procurement has been found in Pakistan to have forward and backward linkages to a range of external environmental issues and barriers identified during this research. It has been found and can be summarized to state that the current situation of the economy, the instability of the political scenario, the immaturity of organizations and institutions, law and order situation or security situation, legal and institutional frameworks, risks and contract management practices, the level of understanding of other procurement form all are not conducive at the moment towards effective implementation of other forms of procurement. There is weak rule of law and justice; economic situation, policy, political instability, decision making abilities etc; all of these have increased the cost of working with public sector in Pakistan. Although it may be noted that these factors and higher uncertainty affects of the above mentioned factors have had a negative impact on the public sector, they have, on the positive side, pushed the organisations to find other innovative methods of financing and procurement. There is limited number of enablers for implementation of other forms of procurement and large number of impediments. A study funded by the Asian Development Bank in 2007 was targeted in Pakistan for finding private sector constraints to infrastructure investment and resulted in finding of substantial impediments, however efforts for removal of these impediments have had limited success till date.

Overall, there is a need to investigate and explore processes of infrastructure procurement in Pakistan as according to the World Bank study (2007) which states that in Pakistan different processes need to be explored which focus on efficient delivery of the end product, especially large mega infrastructure projects at cost, in time, with quality and functionality (World Bank, 2007).

7. Conclusion

Infrastructure procurement is a fairly complex phenomenon and requires innovation, specialty of skills, expertise including policy, regulatory, financial and governance instruments in place to tackle different eventualities. Although most of the factors driving infrastructure procurement process are common across the globe, it should be granted that local solutions to local problems should be pursued. There is a dire need to innovate in the procurement of infrastructure projects in Pakistan. The Government of Pakistan realises that all infrastructure needs of the country cannot be with public funds, but the fact of the matter remains is how to attract, retain and build investor confidence from the private sectors; how to get the knowledge and understanding of the principles and prerequisites of project finance; what policy measures are required and how to maintain a consistency in policies; how to increase the efficiency regarding management and governance of procurement processes; how to develop a regulatory framework that addresses every aspect of procurement; etc. The policy, regulatory, financial and governance instruments at present in the country are at the stage of infancy regarding new and different procurement forms. They need to evolve to the growing needs of the time. Merely incorporating what has been successful in other countries will not bare fruitful results. A longitudinal study investigating and comparing costs for traditionally procured projects and non-traditionally procured projects might be also worth further investigating. Further research is
required that might more rigorously explore the policy environment on how procurement is supposed to be and how currently it is actually being procured in Pakistan. At policy level, stability and clarity in policy frameworks is required. The unstable political environment of the country, instability in policies, use of political pressure and influence are impediments to the procurement and successful implementation of projects. Measures are needed to reduce the impact of negative political factors and increase the impact of positive political factors such as political will.

There is a need to reduce the higher uncertainty of environmental affects as there are limited number of enablers for implementation of other forms of procurement and large number of impediments which need to be reversed. The concept of partnering, alliances and principles of supply chain management need to be explored, understood and adopted within the context of Pakistan in public sector infrastructure procurement.

References


Prevision of Delay in Brazilian Residential Unit Construction Contracts

Estacio Siemann Santos Pereira¹, Antônio Edesio Jungles², Cristine do Nascimento Mutti³

Abstract

Delays in the delivery of residential units create numerous problems, not only for the homeowners, but also for society. This is due to the legal actions necessary to adjudicate disputes between the parties. The aim of this paper is twofold: firstly, to verify the existence of a clause in Contracts of promise of property sale which defines the consequences of delay in the delivery of property; and secondly, to discover whether owners demanded any compensation for delays occurred. The total number of buildings delivered after the scheduled deadline in the cities of Balneário Camboriú and Itajai in the period between December 2009 and January 2011 was found (n = 542), and a sample of 82 residential units was taken. In order to obtain the data, a semi-structured questionnaire was given to the homeowners. It was observed that only 35% (n = 29) of the Contracts of promise of property sale included a penalty clause for delay in delivery. However, in 19 of the 29 contracts the clause regarding delay came with other clauses that allowed the company to delay the delivery of the building for up to six months. This clause is considered null in Brazilian legislation. As for compensation, only one (1.82%) owner demanded that the company provide a rental property during the period of delay. The others (n = 98.18%) did not demand any compensation. It could be concluded that contractors are not observing Brazilian legislation regarding the delay in the delivery of residential units. They prepare contracts according to private interests. In addition, a certain conformism is perceived in the attitude of the homeowners as to the delay in delivery of the property. They don’t insist on the compensation that they are entitled to, in accordance with current legislation.

Keywords: Delay, contracts, buildings

1. Introduction

In the past, the delay in completion of the buildings was deemed acceptable by consumers. But nowadays, tight budgets mean that delays are more significant and costly. As a result of construction delays, many customers have been demanding compensation from construction companies (Kaliba, Mumba, Muya, 2009).

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Delays in completion of construction can cause a lot of damage to civil construction companies, such as higher costs, cash flow problems (Assaf, Alhejji 2006), unavailability of staff, loss of credibility in the consumer market, loss of customers, plot returns and indemnities (Kaliba, Mumba, Muya, 2009).

Delays can also cause loss of revenue when production facilities or rental units are not completed on time. As well, higher overhead costs may be incurred due to the longer work period and the inflation in the price of materials (Alaghbari, Kadir, Ernawati, 2007).

1.1 Contracts

In the construction industry, construction companies generally work in an environment of risk and uncertainty caused by economic factors such as fluctuations in the costs of materials, labour, and equipment. Contractors and suppliers working in today’s volatile materials market find that estimating, bidding on, and financing construction projects are challenges (Maram, Rajendran, Kalidindi, 2011).

A well-prepared contract reduces business risk. In countries under European jurisdiction, construction contracts are considered to be independent contracts regulated by the laws to which they are bound. Construction contracts also differ from other types in having great and long-term financial responsibilities. Contract conditions define the rights and responsibilities of the parties (Mitkus, Trinkūnienė, 2006; Lordi, 2004).

Fong and Choi (2000) have analysed methods of contractors’ selection and observed that some methods are not comprehensive and are generally tendentious. In accordance with this, it is sometimes difficult for owners to consider at once all variables such as price, time, quality and security.

The obligation of the contract is based on the concern that goes beyond private interests to serve the interests that are collective. Whoever, for free expression of will, promises to give or do creates an expectation in the social environment that the law should guarantee. Thus, the contract should not be viewed from the individual angle, but from the social angle, since these consequences could affect the balance of society (Rodrigues, 2007).

One type of contract according to Brazilian law is the Contract of promise of property sale. The Civil Code (Brasil, 2002) cites in article 481 that: "According to the Contracts of promise of property sale, a contractor undertakes to transfer to the domain a certain thing and the other, to pay a certain price in money."

1.2 Brazilian law about contracts during or before the construction phase

In a Contract of promise of property sale, the seller undertakes to transfer the domain, and this effectively moves with the transcription of the title in the registry of property. The three basic elements that constitute a purchase and sale agreement are the price, the date of delivery and the object (e.g. homes, apartments).
The Civil Code, Article 439, states that whoever promises to deliver a product to a consumer must offer compensation when said product is not delivered according to the agreement between the two parties (Brasil, 2002).

If construction companies do not fulfil their obligations, or fail to comply by the way and in due time, homeowners can sue the builders for damages (Civil Code article 1056). These damages may include rental costs (or an equivalent value) incurred by homeowners during the delay and a reasonable value for the lost profit that the building could have generated for its owner (Civil Code article 1059) (Brasil, 2002).

The purchase of an object is also regulated by the Consumer Protection Code (CDC). According to this law, contractors can delay for a maximum period of 180 days. However, in article 18, paragraph 2, the CDC states that both the owner and the contractors may agree to reduce or increase the period specified in the preceding paragraph, though not less than seven or more than one hundred and eighty days (Brasil, 1990).

The contractor, however, must pay a price for this delay. The only exceptions permitted are: a) the existence of a fortuitous event or force majeure or b) the proof that the delay is the exclusive fault of the consumer. Proving these exceptions is the joint responsibility of the contractor and consumer, who respond objectively according to article 14 of the CDC.

The aim of this paper was to verify if there is a clause that defines the consequences of delay in the delivery of Contracts of promise of property sale and assess whether the owners demanded any compensation for the delay occurred.

2. Methodology

To obtain the data for the building units delivered in the period between December 2009 and January 2011, a survey was conducted among the construction companies registered in the Construction Union in the municipalities of Balneário Camboriú and Itajai (Brazil). The participants owned buildings that were over 10 floors or had more than 20 apartments.

During this period 30 buildings were delivered. Of this total, 16 were delivered late. In relation to the number of buildings, 973 residential units were delivered, with 542 being late.

The number of observations required is defined by Equation 01 (Gil, 1999). With these values, the numbers needed for sampling were 82 residential units. For a better distribution of the number of interviews per building, these were listed according to the number of properties of each one (Table1).

\[
n = \frac{N \cdot \hat{p} \cdot \hat{q} \cdot (Z_{\alpha/2})^2}{\hat{p} \cdot \hat{q} \cdot (Z_{\alpha/2})^2 + (N - 1) \cdot E^2}
\]

Eq. 01

Where:

\[n\] – Number of residential units delivered with delay in the sample (82)
N – Total of residential units delivered with delay (542)

p – Population proportion of individuals who belong to category (50%)

q – Population proportion of individuals who do not belong to category (1-p)

Z_{a/2} – Critical value that corresponds to the desired degree of confidence (95%)

E – Margin of error or maximum error of estimate. An error of 10% was adopted in this research.

**TABLE 1 – Sample of properties per building delivered with delay.**

<table>
<thead>
<tr>
<th>Building delivered with delay</th>
<th>Quantity of residential units</th>
<th>% of the total residential units delivered with delay</th>
<th>Sample by building</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>3,14</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>3,69</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>3,32</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>28</td>
<td>5,16</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>18</td>
<td>3,32</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>45</td>
<td>8,30</td>
<td>7</td>
</tr>
<tr>
<td>15</td>
<td>30</td>
<td>5,54</td>
<td>5</td>
</tr>
<tr>
<td>16</td>
<td>48</td>
<td>8,86</td>
<td>7</td>
</tr>
<tr>
<td>17</td>
<td>80</td>
<td>14,76</td>
<td>12</td>
</tr>
<tr>
<td>18</td>
<td>22</td>
<td>4,06</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>42</td>
<td>7,75</td>
<td>6</td>
</tr>
<tr>
<td>25</td>
<td>29</td>
<td>5,35</td>
<td>4</td>
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<tr>
<td>26</td>
<td>28</td>
<td>5,17</td>
<td>4</td>
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<td>27</td>
<td>54</td>
<td>9,96</td>
<td>8</td>
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<td>29</td>
<td>45</td>
<td>8,30</td>
<td>7</td>
</tr>
<tr>
<td>30</td>
<td>18</td>
<td>3,32</td>
<td>3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>542</td>
<td>100</td>
<td>82</td>
</tr>
</tbody>
</table>

Three municipal construction companies were consulted to verify the instrument used in the delivery of the residential units to homeowner when the building was finished. From this instrument, the questionnaire was elaborated which contained the questions regarding:

- The performance of the contract;

- The form of communicating the delay to the homeowner;

- The satisfaction of the homeowner with the residential unit and the company.
The interviews took place in person or by telephone.

3. Results and Analysis

Only 35% (n=29) of the contracts had clauses that defined possible damages because of the delay in delivery. However, in buildings 17, 18 and 26 (totalling 19 contracts) clauses were added to the delay clauses that allowed the company to deliver the residential units within six months, for reasons of force majeure.

Contracts of promise of property sale should provide conditions for the completion and delivery of the residential unit. They should specify the circumstances in which the construction company might be exempt from meeting the agreed period of delivery of the unit and thus extend the contract term. However, none of the companies gave details explaining the force majeure responsible for the delay. Thus, the clause concerning the extension of the delivery period is null and considered unfair in accordance with the Consumer Protection Code (Brasil, 1990) and the Civil Code (Brasil, 2002).

Only 28% of homeowners (n=23) were informed about the new date of delivery of their residential units. For the 72% (n=59) of homeowners who were not informed of the new date of delivery, the discovery occurred as follows: 56% (n=33), through visits to construction sites, and 44% (n=26) through telephone contact with the construction company. It is possible to observe that most construction companies violate Brazilian Federal Law No.4.591/64, complemented by Law 8.078/90. These laws regulate the activity of real estate development and cite that homeowners must be informed at least every six months of the progress of the building.

Neglecting the client can create many problems for the construction company, such as customer dissatisfaction which may result in law suits and retaliation.

The residential units were delivered completely finished for 91% (n=75) of the homeowners. For the other 9% (n =7) there were still some outstanding issues in the building. In buildings 4, 11 and 29 the common area was not completed at the time of the delivery of the residential units (19%). In building 16, two homeowners said the common area was not completed.

This difference between the percentage of common area and residential units delivered complete can be explained because some companies deliver the residential units before having completed the whole building, due to pressure exerted by homeowners.

According to Pereira et al (2011), in a research conducted with construction companies, the main causes for delay occurrences are: changes ordered by the client, lack of compatibility in design, lack of skilled labour, and unskilled labour.

It can be noted that almost all the above mentioned causes are not valid excuses to delay according to Brazilian laws. Only the change ordered by the client can be an excusable
delay. But, in this scenario, it is very difficult to determine which delays were caused by the owner and which were caused by the construction companies.

### 3.1 Compensation demanded by consumers or offered by construction companies due to the delay.

Only one (1.82%) homeowner demanded that the company provide them with a rental unit during the period of delay. The others (n = 98.18%) did not demand any compensation. None of the respondents received monetary compensation from the company because of the delay occurred.

For 30% (n=25) of homeowners, delay affected the construction companies’ image. However, if we consider only those buildings that were delivered with more than six months delay (buildings 1, 4, 11, 16, 17, 20, 26, 29, n=50), the delay would have affected the image of the construction company by 46% (n =23). Thus, we can deduce that the greater the delay in delivery of residential units, the worse the image of the construction company held by homeowners.

Concerning the issue of whether homeowners would recommend the company to others, 80% (n=66) said yes and 77% (n=63) would buy another property from the same company. In buildings that were more than six months late in delivery, 29% (n=14) did not recommend the construction company to others. An increase of 9% of homeowners who do not recommend the company to others can be noted in buildings with six or more months delay. Only one company (building 1) was rejected by 100% of the homeowners.

Through the analysis of answers collected, it appears that the delay in delivery of the residential units is not the only factor responsible for client satisfaction. Other factors, such as perceived quality and documentation, can interfere with the positive assessment of the construction company by homeowners. But for Silva, Brasileiro and Duarte (2011), delays may generate higher recoveries of homeowners regarding the quality of the building units because the homeowners become more demanding.

In a research conducted by Medvedovski et al. (2005) regarding a building located in Pelotas (Brazil), 13.13% of the homeowners were dissatisfied with the units received. The biggest complaints were about the numerous entries to the building and the size of the corridors. According to Cardoso (2003), in a survey conducted with homeowners of a building in Belém do Pará (Brazil), the main items that generated dissatisfaction were the design and construction of the building’s facade, the security relating to the building’s entrances, the dimension of the garages, and the condominium costs. The reasons for customer dissatisfaction were numerous.

It can be concluded that delay is only one of several factors affecting customer satisfaction; however, companies should be concerned about unhappy customers since they can produce negative publicity for the construction company, reducing the reliability of the brand. 77% (n=63) of the homeowners considered themselves demanding clients.
3.2 Considerations made by homeowners

In interviews with homeowners, it was possible to observe other factors that could account for the satisfaction of consumers whose residential units were delivered late. One of the owners said that he had been considering the possibility of litigation against the company because of the delay (seven months). However, when he received the completed unit, it exceeded his expectations which resulted in a change of heart. Another homeowner whose unit was delivered after a four-month delay was considering legal action against the construction company because it was below his expectations. He claimed that the tiles used were of poor quality, causing a depreciation of the property.

From these interviews, it can be inferred that delay is not the only factor responsible for the satisfaction of the homeowner. According to Chauvel (2000), satisfaction is a psychological state resulting from the comparison of internal references to the reality of ones circumstances.

Another topic mentioned by the home owners was the cultural acceptance of delay. A homeowner whose residential unit delivery was delayed for four months, said: "This is common and happens to all construction companies." Another homeowner, who is a lawyer, pointed out that despite being aware of his rights, he would not take any action against the construction company, because "they are nice people."

This attitude on the part of homeowners demonstrates conformity. The subject conformed not only accepts what is presented, but also puts into practice actions that demonstrate conservative actions by the homeowners (Chauvel, 2000).

There are also some inconsistencies on the part of construction companies. Sometimes they feel abused because of the tax burden imposed by the government, but in other circumstances, they abuse their clients by failing to respect the law of the country.

4. Conclusion

In Contracts of promise of property sale that had clauses defining the delay, it was perceived that this was unfair according to Brazilian law, because it permitted the construction companies to delay the delivery of residential units without having to compensate owners for damages. Only one homeowner demanded compensation from the construction company, demonstrating that delay is culturally accepted in the study area. However, it was observed that the longer the delay, the more chance of dissatisfaction with the residential unit received.

Moreover, some properties were delivered without being fully completed. This may generate additional costs and subsequent disputes, since the occurrence of defects can be difficult to attribute the responsibility to the client and/or the construction company.
Regarding informing customers of the new delivery date, companies may have had difficulty in determining it because there may have been simultaneous delays during the building construction phase.

It is also important to state that Brazilian law should clarify the meaning of events of force majeure, in order to avoid disputes between homeowners and construction companies.

References


Product platform considerations on a project that develops sustainable low-cost housing for townships

Michael Wörösch¹, Martin Bonev², Niels Henrik Mortensen³

Abstract

Construction companies in Denmark are often working with profit margins as little as 1-3% in situations where they deliver high-end buildings to the local market. Even though customers are willing to pay a premium price for high quality, construction companies earn very little on their products. Consequently one Danish company took the decision to produce sustainable low-cost houses and to sell them to developing countries that have township housing programmes. But why would this company believe it could make a profit in the low-cost housing segment abroad, when there is almost no profit in the high-end segment at home? As the research described in this article shows there are three main reasons for their optimism: 1) The successful introduction of a product platform for low-cost houses, 2) a modular approach to the design of low-cost houses, and 3) the application of requirements management as described by INCOSE. 1) to 3) have been studied using action research on a case project.

The case company’s success contributes to people currently living without decent housing by providing insulated, low-cost houses based on the latest technology. The fact that those low-cost houses are solid gives their new owners the possibility to take a loan out on their building which is expected to contribute to more businesses being started up and thereby strengthening the domestic economy. As a consequence of this, additional research is needed in how to further optimise the economy of sustainable low-cost housing based on life cycle considerations. Moreover, it has to be examined how the experience gained can support in maximising the high-end segment in countries like Denmark.

Key words: Low-cost housing, product platform, construction industry, practical implementation, action research

1. Introduction

This section will introduce the trend of population growth and the concept of product platforms which are core to the business opportunity of the research case detailed in this paper.

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1.1 Population growth in developing countries

It is estimated that about 1.6 billion people around the world live in sub-standard housing and over 100 million are homeless. If no serious action is taken the number of slum dwellers is expected to rise from one billion people today to two billion within the next 30 years (Habitat for Humanity, 2013). This leaves many developing countries with a problem that is hard for them to overcome. South Africa is one of the countries that are taking action, as it tries to solve its housing problem by means of a centrally planned housing programme. Through this programme, since 1994 more than 2.3 million housing units have been made available to nearly 11 million people, where in 2010 alone about 219,000 housing units have been made. The goal for the coming years is to create 220,000 housing units a year. Despite such a tremendous number of erected units, the housing backlog has grown from 1.5 million units in 1994 to 2.1 million units today. This means that 12 million South Africans – a quarter of the population – are still in need of a better shelter (Ministry of national housing and social amenities, 2011).

Inspired by the housing programme of the South African government, the case company described in this article examined whether and how it would be possible to contribute to the housing problem of developing nations with its knowledge and technology. After a careful examination of the National Housing code (2009), the decision was taken to develop a low-cost product platform that could co-exist with both the existing, high-end and re-insulation panel product platforms and to make an offer to the South African housing programme.

1.2 Product platform definition and strategy

The product platform concept has widely been discussed in literature, where accordingly a number of definitions have been introduced by e.g. Muffatto and Roveda (2002). Halman et al. (2009, page 151) for example, refer to McGrath’s definition of a product platform: “a set of subsystems and interfaces that form a common structure from which a stream of related products can be effectively developed and produced”. The authors base their research on this definition, as it incorporates both the physical and economical aspects of a platform concept. An overview of the product platforms that exist in the case company can be seen in Figure 1.

![Figure 1: The product platforms that exist in the case company](image)

As illustrated in Figure 1, the insulation panels aim to cover all business segments, while the other two product platforms address only parts of the market, but still keeping the possibility
of expanding open. The reasons for believing in the success of a product platform that did not even exist at the time the offer was made were:

- The product platform approach had been rooted in the organisation and the staff of the case company had been trained in product platform thinking for several years
- The successful implementation of requirements management in the case company
- All the desired European safety and product approvals had already been received
- The technology the case company wanted to use had successfully been tried out in several buildings in Denmark (see Figure 2 for an example)
- The senior staff have a long history of successfully executed building projects

The above listed points indicate that a strong base had indeed been established which made it possible for the case company to continue building upon. At the same time the case company was also aware of the main obstacles that had to be overcome. To begin with, the government subsidy for a 40 m² stand-alone house only amounts to 55.706 ZAR (= 4.926,87 € using exchange rates from December 25th 2012) (Coetzer, 2010), which is considerably less than what a house based on the high-end product platform costs. Moreover, unskilled labour is to be used, whereas the usual approach of the case company is one of automation and efficiency in combination with a skilled work force. There is also a risk of facing problems using the local building materials with unknown properties and quality. However, the management of the case company had full confidence in being able to produce 40 m² low-cost houses at a price that did not exceed the government subsidy. Working with unskilled labour and having to use local building material were treated as risks. Therefore, risk mitigation plans were made for those two points as described in the PMBOK (2008).

**Figure 2: A building based on the high-end product platform**

Studying the situation resulted in the main hypothesis that creating and introducing a platform concept to low-cost markets would support both, developing countries in overcoming their housing problem in an effective manner, and construction companies to improve their performance in the domestic markets. To this end, this article in particular addresses the following aspects:

a) It is possible and beneficial to develop a low-cost product platform that can be used for making low-cost houses
b) It is possible to make several variants of houses based on that low-cost product platform
c) The new knowledge gained by developing and implementing a product platform for low-cost housing will contribute to improved efficiency and reduced prices in the high-end platform.

This paper therefore deals with the question on how to successfully introduce a product platform that supports modularity to the low-cost housing segment of the construction industry. To answer this question, after a literature review (Section 2), an explanation of the applied research and design methods (Section 3) and a description of the case (Section 4) will be provided. Section 5 then gives a brief overview on the key observations that have been made when developing the low-cost product platform and building houses. In Section 6 the thereby achieved results have been analysed. A final conclusion is drawn in Section 7, where the most important findings are summarised and recommendations for future research are given.

2. Literature review

Even though the work on the case project was mainly of a practical nature, a lot of knowledge has been drawn from literature, where both academic publications as well as literature from seasoned practitioners have been consulted. Table 1 below gives an overview showing the main references considered for this article and what they cover in the context of this research:

| Table 1: Main literature considered in this research |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Product platform               | X                | X                | X                | X                | X                | X                | X                | X              |
| Product platform in construction| X                |                  |                  |                  |                  |                  |                  | X              |
| Product platform in construction – low-cost housing |                  |                  |                  |                  |                  |                  |                  | X              |
| Product variants / family      | X                | X                | X                | X                | X                | X                | X                | X              |
| Modularization of products     | X                | X                | X                |                  | X                | X                | X                | X              |
| Requirements management        |                  |                  |                  |                  |                  |                  |                  | X              |

The concepts of product modularization (Ulrich and Tung, 1991) and product platforms have extensively been discussed in literature. Huang et al. (2005) for example have studied several companies in different industries using product platforms. In addition, Hvam (2011), Mortensen (2008), and Simpson (2011) provide a number of publications on the application
of product platforms, where the approach of using product platforms has mainly been put in
the context of consumer electronics, car, aerospace, and software industries. However, at
the same time very little theoretical contribution could be found on how to apply product
platform principles to the construction industry (Roy et al., 2003). As of today, there are in
particular no published attempts to practically implement a product platform which facilitates
modularity and product variants for low cost housing in this industry.

3. Research and design methods

The research described in this article makes use of action research (AR) defined by
Coughlan and Coghlan (2002) as well as Checkland and Holwell (1998) for creating the
needed models and tools. The approach was applied to a case project, where full access to
all key people and complete access to all documents relevant to this research, including
minutes of meetings in addition to documents containing the future strategy of the case
company and its products, existed (Voss et al., 2002 and Yin). In order to cover all parts of
the case project’s value chain (see Figure 3), including the sub-projects described in Section
4 “Description of case”, several interview rounds with key persons from the construction
industry and the case project have been conducted.

![Figure 3: The value chain of the case project](image)

For reasons of comparability and consistency interviews were conducted using a question
template from previous research for all participants, resulting in a master document that
covered a wide range of different requirements: from functional, non-functional, technical,
market and organisational requirements, to requirements towards the project manager and
finally to requirements of the stakeholders themselves. This was used to implement
requirements management on the case project and was actually (at that time unconsciously)
the first step towards a low-cost product platform. During the analysis of the second out of
four AR cycles it became clear that requirements management on the case project worked
well (Wörösch, 2012), as it significantly contributed to having a clearly defined scope of the
case project, its sub-projects, and the different product platforms – the two existing ones as
well as the one that needed to be developed.

When linking the requirements of the low-cost product platform to the company and product
strategies, modularity of the houses based on this platform could be ensured. In an
architectural perspective, a definition of the term modularity that fits well with this research
has been described by Ulrich and Tung (1991). The authors refer to “the construction of a
building from many instances of standardised components. In manufacturing the term often

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refers to the use of interchangeable units to create product variants” (Ulrich and Tung (1991, page 73)). Examples of the hereby achieved modularity will be given in Section 6.

4. Description of case

Despite of operating in construction, the case company is unique within its industry in several aspects. Firstly, it produces sandwich elements and insulation panels from High Performance Concrete (HPC) that are used to build and renovate houses to have greater energy efficiencies. Secondly, the company constantly develops new technologies and products resulting in patents. Therefore, already today, it offers buildings that live up to the European Union’s 2020 energy saving requirements, covering the complete value chain (see Figure 3), where responsibility is not pushed down to sub contractors. The uniqueness of this case is reflected in the structure of the case project that consists of four different types of sub-projects, which will in the following section be shortly introduced:

1. Technology development used to develop new insulation and HPC material as well as different mounting systems
2. Product development with the goal to develop new sandwich elements, insulation panels, and jointing in different dimensions
3. Development of low-cost, high-end, and insulation panel product platforms
4. New building projects (such as the erection of 40 m2 prototype buildings in Delft, Cape Town, South Africa)

1) to 4) deliver and share human and financial resources as well as processes, which simultaneously results in constraints, where 4) depends on the success of 1), 2), and 3).

5. Observations

When developing the low-cost product platform and building the houses, a series of key observations, that are further grouped and described in detail, has been made.

5.1 The low-cost product platform

- On a conceptual level there were many elements that could be re-used from the high-end product platform; e.g. the basic methodology when describing a platform structure and how to phrase requirements. Previously, there was not much reuse between the two other product platforms
- A solution for the design of the HPC elements has been found that required only few tools for assembly. Buildings can even be assembled without using power tools, since stable electricity sometimes is absent on some building sites. An assembly where only few tools are needed also makes teaching of staff easier and leaves less room for error
- Even though unskilled labour and no high technology production are being used, many houses can be produced during a year. This is due to the production of only few different kinds of elements, which are strongly standardised and can be used across the product variants. Using unskilled labour and no high technology also changes the
description of requirements from being database and specification focused to being expressed in photographs and drawings wherever possible

- Once the HPC elements with their pre-mounted windows and doors are ready for assembly, a Type 1 house (see Figure 4) can be assembled within one working day. This fast assembly also contributes to the possibility of building many Type 1 houses in the course of a year and at the same time it prevents theft or unauthorised occupation, as the houses are closed in the evenings.
- The local building materials (about 99%) can be used without any quality problems. The only exception to the use of local material is a special concrete binder that is sent from Denmark. In result, the use of local material creates domestic jobs and reduces CO₂ emission that otherwise would have been caused by transportation from abroad.
- The scalability of the low-cost platform is high. This means that when, for example, the production has to be doubled or halved it can be done relatively fast at low cost.
- The price of a 40m² stand-alone house (basic model) based on the low-cost product platform does not exceed 55,706 ZAR. This means that the case company can continue building the low-cost houses without generating losses and the housing programme can accordingly achieve its yearly targets.

5.2 Modularity

Modularity has been achieved in several facets. For the customers this means that they can upgrade their houses with extra rooms, a veranda or a bigger kitchen at a low price at the time of ordering. Upgrading is possible in all situations where the housing programme facilitates a contribution of the end user. Besides, modularity can also be achieved by using additional means; e.g. by giving the customer or resident the possibility to enhance the house by adding a rainwater collector that gathers rain water from the roof facilitating cultivating a garden for the house. Another benefit of achieving modularity is that it also is possible to improve the houses with solar panels for generating power for hot water, lighting, charging computers, cell phones, and other consumption. Also, here the housing programme has to allow this kind of improvement.

5.3 Knowledge transferred back to the high-end product platform

- The high degree of standardisation contributes to a high throughput in production. The high-end product platform needs to be examined for possibilities to increase standardisation and to get away from the current high level of uneconomic flexibility.
- The use of prototype elements, drawings, and verbal explanations instead of lengthy documents has been very successful. This method of controlling the scope for a product platform could also be introduced to the other product platforms, which, however, would mean to go away from a systems engineering best practice approach as described in the INCOSE Systems Engineering Handbook (2011). It has to be examined to what degree this could be done while still maintaining sufficient documentation and living up to described processes.
- The rather effective way of teaching new local staff and the team, created a very inspiring feeling during the teaching sessions and should further be applied to staff working on the other platforms as well. Flying the key personnel of the case project to
South Africa in order to participate in building low-cost houses could be one way of transferring the new knowledge and a positive team spirit back to Denmark.

- This new knowledge gained by developing and implementing a product platform for low-cost housing will contribute to improved efficiency and reduced prices in the high-end platform, as many decisions that had been taken on the high-end product platform have been seriously challenged. An example is the very high focus on the factor cost for the low-cost platform that has never been enforced to such a degree on the high-end product platform.

Having summarised the main observations, in the next section the results of implementing a low-cost product platform into the case project are discussed.

6. Discussion of results

By the end of action research cycle two, the research conducted in the case project had given a series of theoretical and practical results. The main results have been listed below.

6.1 High level results of making a low-cost product platform

As anticipated, from a technical and process point of view, it was indeed possible to develop the low-cost product platform and build houses based on it within the estimated time. Due to the active use of requirements management, the scope of the new product platform was clearly defined, while market segment-wise there was no overlapping with the existing product platforms. From a societal point of view, building low-cost houses at high speed helps ensuring that more people have decent housing and thereby producing an increase in quality of life. Furthermore, a relatively fast, cheap and secure assembly, contributes to reducing the large backlog in the low cost housing area. Thus, as demonstrated by the case company, local job opportunities together with relevant education and training are created. This increases the standard of living and improves future chances for personal development.

Houses made from HPC are solid and have according to Danish Standard (2001) a minimum life expectancy of 50 years, while in practice concrete companies often calculate with 70 or more years. This is much higher than what most housing objects currently have. This longer life expectancy makes it possible for a house owner to take a loan out on their house, which in turn can contribute to starting up financial businesses and thereby to strengthening the domestic economy.

6.2 Results related to the main hypothesis

6.2.1 The low-cost product platform and the use of modularity

The low-cost product platform currently supports three types of houses, of which two will be explained further in this paper. All houses based on this platform can only be ordered in a light or in a dark version. Each of them comes with two different surface structures, a smooth and a brick-like one. Altogether the customer is offered a limited number of choices, as all concrete elements, windows, doors, materials, sizes, and interfaces are completely standardised. This radical standardisation is the main difference from the high-end product
platform, for which more variety and a higher degree of customisation is available. Figures 4 (Type 1) and 5 (Type 2) show two types of 40m2 houses, that are based on this new low-cost product platform.

**Figures 4 and 5: Two different 40 m2 buildings made from HPC – Type 1 and Type 2**

Modularity on the low-cost product platform exists on two levels. On the element level, the HPC elements are prefabricated and scaled to approximately 1.2m in width. Figure 6 illustrates the conceptual assembly of a Type 1 house based on those elements. On the building level, several variants of the Type 1 and Type 2 house exist. The Type 1 house can be produced as basic 40 m2 model or as one of four variants, where modules like a veranda or extra rooms can be added. Depending on what modules are added, the size of a Type 1 building can go up to 56 m2, as depicted in Figure 7.

![Figure 6: A Type 1 house assembled from prefabricated HPC elements](image)

<table>
<thead>
<tr>
<th>Plinth panel</th>
<th>Floor and wall panels</th>
<th>Gable and wall panels</th>
<th>Roof beam</th>
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<table>
<thead>
<tr>
<th>Roof panels</th>
<th>Integrated solar cells</th>
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**Figure 6: A Type 1 house assembled from prefabricated HPC elements**

<table>
<thead>
<tr>
<th>40 m2 basic model</th>
<th>+ 2 modules veranda 40 m2</th>
<th>+ 2 modules veranda, extra room 50 m2</th>
</tr>
</thead>
</table>
+ 2 modules veranda, larger kitchen 50 m²  + 2 modules 2 extra rooms 56 m²

**Figure 7: The five variants of the Type 1 house (Figures 6 and 7 have been taken from a sales offer to the South African Housing Programme)**

6.2.2 Knowledge transferred back to the high-end platform

A lot of knowledge has been gained when making the low-cost product platform. Some of the key learning points were:

- Even though there were only a few choices the customers could make, when ordering a house, the offered variety appeared to be suitable for this market segment. This will result in a review of the high-end product platform, to ensure that customers are not offered an infinite degree of variety and that the financial contribution per variant is high enough. Non-profitable variants should be removed from the platform.
- Starting the low-cost product platform from scratch, rather than trying to take the high-end product platform as a starting point for scraping off layers, turned out to be the right decision. In hindsight, it is our belief, that it would not have been possible within the given timeframe to achieve the cost goal per unit using this approach.
- This was the third product platform the case company developed. Since the high-end and insulation panel product platforms were well defined and linked to the company strategy, developing a third product platform took considerably less time. The experienced staff and the right software tool support, such as the use of product configuration systems (Bonev and Hvam, 2012), contributed strongly to the fast development of this platform.

7. Conclusion

In this article it has been described how a low-cost product platform has successfully been developed and implemented in the low-cost housing segment within the construction industry. The houses based on this platform are built up in a modular approach, where modularity has been achieved both on element and on building level, resulting in buildings which can be delivered in several types and variants. The main difference compared to a coexisting high-end product platform is the high degree of standardisation and the limited number of commercial variants, which has been adapted according to the requirements of this market segment. Besides, the application of requirements management as described by INCOSE has resulted in working descriptions containing much less text, but with more pictures and drawings instead. This positive attempt to use product platforms in the low-cost segment of the construction industry confirmed the main hypothesis of this research (Section 1) and shows that the product platform approach is a valid strategy for meeting the low cost
housing demand of developing countries. Hopefully the described case inspires other construction companies to introduce a product platform concept for their products.

Despite the promising results, further research is needed in the following vicinities: Since there is a high need for decent housing, smart solutions have to be found for quickly producing a high amount of houses, which are cheap and long lasting. If companies find a way of addressing this issue in a profitable manner, they are more likely to participate in this enormous task. At the same time it is important that the applied housing solutions are sustainable, as according to EU, 2010, residential and commercial buildings are responsible for about 40% of the total energy consumption and 36% of the total CO₂ emission in the European Union. Other parts of the world will soon face similar situations to those described above, if there is no sufficient focus on sustainability when producing such a vast amount of buildings. To this end, further research is needed in how product platforms, by means of effective development and production, can further contribute to the low-cost housing segment and to the construction industry in general. Finally, it is necessary to further optimise the economy of sustainable low-cost housing based on life cycle considerations. Once this has been done, it has to be examined how the gained experience can support in maximising the high-end segment in countries like Denmark.

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Sustainable Construction in Malaysia: A Consultants’ Perspective

Leong Boon Tik, Soon Lam Tatt, Theong May Chuan

Abstract

The government of Malaysia recently introduced the National Green Technology Policy together with a proposed RM 1.5 billion (USD 500 million) Green Technology Financing Scheme to promote green and sustainable technologies. This policy is predicated on the belief that regulatory change is a key driver of innovation as local firms compete to develop new products that are more efficient, greener and safer. For the construction sector, the National Green Technology Policy complements the previous thrust to adopt Industrialised Building System (IBS) as a means to deliver high quality building and to reduce the reliance of the sector on migrant labour. The abundance of cheap low-skilled migrant labour has hindered investments in mechanisation and innovation. The current exemption levy for building with 50% IBS elements is 0.125% of construction cost. In order to encourage the construction industry to deliver high quality and environmentally sustainable housing, the government in 10th Malaysia Plan (2011 – 2015) stated to review tax incentives for the design of buildings that are built in a more sustainable manner. This study aims to investigate the influence of government policies toward the use of sustainable technologies and Industrialised Building System (IBS) in the Malaysian construction industry. Primary data has been collected by questionnaire survey of design consultants. The responses on how these policies affect design and construction decisions were analysed by employing descriptive and analytical methods. The findings of this study concluded that government policies play an important role in influencing the adoption of IBS in the construction industry. The most significant way of promoting the use of this innovated method is through incentives.

Keywords: Sustainable Technology, Industrialised Building System (IBS), Design Consultant, Government Policies, Malaysia

1. Introduction

Climate change is a great challenge to all countries. The world is experiencing the melting of polar ice, drying of Amazon rainforest, flooding of many coastal cities and increase of climate refugees. Being a member of the Intergovernmental Panel on Climate Change (IPCC), Malaysia voluntarily, aim to reduce the carbon emission up to 40% in terms of emission intensity of Gross Domestic Product (GDP) based on year 2005 level by year 2020.

One of the efforts initiated by the Malaysian government is the introduction of green and sustainable technologies (ST) which minimizes the degradation of the environment, promotes the use of renewable resources and conserves the use of energy and natural resources. The National Green Technology Policy launched on 24th July 2009 by the Prime School of Architecture, Building and Design Taylor’s University, Malaysia
Minister spurred demand for green industry as the priority in providing products and services. The policy is designed to minimise the problems of destruction of the environment and depletion of natural resources which have brought to climate change. As a result, green technology is expected to be a driver in accelerating the national economic growth and at the same time promote sustainable development (Kamarul et al, 2010).

One of the listed government initiatives in the policy emphasize on building aspect or the construction industry. It is because the built environment uses huge amount of non-degradable resources, produces wastes and emits around half of the carbon dioxide gas. Almost 40% of the world’s consumption of materials converts to the built environment and about 30% of energy use is due to housing development (Kamarul et al, 2010). As a result, the construction industry has great challenge to deliver economic buildings that reduce the social and environmental negative impacts.

A supportive effort towards green technology has been made by the Work Ministry as the ministry had decided that Industrialised Building System (IBS) is adopted for building construction. Hence, the industry links IBS to the issue of climate change and claimed that IBS industry is able to contribute the sustainable development. Kamarul and Zuhairi (2011) suggested that the fundamental idea of IBS is to shift on-site to a more controlled environment.

Thus, sustainability can be achieved through the application of IBS by transforming the 4D – difficult, dirty, dangerous and dusty construction industry into a controlled production environment. Via this, IBS promotes minimisation of waste generation, effective usage of energy, efficient building materials, etc (Kamarul and Zuhairi, 2011). This can be achieved by the reduction of wastage in the construction industry due to prefabrication of building component. Various sizes of components can be produced in mass volume to suit the requirements of buildings. This reduces the number of trips of transportations.

Allocation of RM1.5 billion in the 10th Malaysia Plan (MP) to stimulate the use of green technologies demonstrates Malaysian government concerns the global climate change issue. With the environmental advantages offered by IBS, the government made compulsory of 70% IBS components in public building project. Tax incentives are offered to buildings that are built in a more sustainable manner. The paper aims to investigate the influence of government policies toward the use of sustainable technologies and IBS in the construction industry.

2. SUSTAINABILITY IN MALAYSIA CONSTRUCTION INDUSTRY

Wet construction method has been adopted in the Malaysian construction industry. Activities carried out in the industry have been considered as one of the major contributors to the environmental pollution (Augenbroe et al, 1998). These activities not only consuming large portions of raw materials (Ding, 2005), but also creating wastes to the earth. As a result, the construction industry causes the depletion of non-degradable resources, destruction of landscape and creation of health and safety issue to the nation (Azapagic, 2004).
Environmental issue has started to gain wider attention by the construction industry players. The industry is currently shifting from its conventional approach with little regard on the ecological consequence to a development process with wider concern of the environmental agenda. The change is inevitably leading the industry towards ‘green’ or ‘sustainable’. (Das Gandhi et al, 2006).

The concept of sustainable is not new. The philosophy of “Sustainable Development” was introduced in 1987 in Brundtland Report and since then, a lot of strategies and positive efforts had been prompted by many countries. Sustainable construction which plays a critical role of the philosophy is expected to contribute to the protection of environment. Figure 1 mimics the tree diagram of the concept of sustainability in construction. According to Nazirah (2005), sustainable construction concern about environmental protection, social well-being and economic prosperity. Activities carried out in the built environment and uses of natural resources exert an obvious impact to the environment. Builders help in protecting the environment by demanding less non-renewable natural resources and more recycled material in their productivity. Social well-being concerns with workers feelings which relate to security, satisfaction, safety and comfort (Lombardi, 2001) and their contributions of skills, health, knowledge and motivation (Parkin, 2000). Sustainability in construction leads to benefits in both micro and macro economy of the country.

![Diagram of Sustainability in Construction](image)

**Figure 1: The diagram of sustainability in construction (Nazirah, 2005)**

According to Ofori et al (2000), practitioners in the construction industry must be willing to change their attitudes and culture in adopting new ideas and approaches. Construction Industry Development Board (CIDB) plays a vital role in directing the Malaysian construction sector towards sustainability. Many efforts have been carried out in the area of waste minimization and management, environmental management plan and construction hazard...
identification (CIDB, 2007). The subject of sustainability had been highlighted in the Construction Industry Master Plan (CIMP) 2005 -2015. Environmental practices as well as occupational safety and health are included in Strategic Thrust 3 of CIMP. The Malaysian Green Building Index (GBI) has been developed in year 2009 to promote sustainability in built environment. The introduction of the rating system provides a platform of assessment for sustainable construction and creates new challenges for the industry players.

At present, several sustainable projects are initiated in Malaysia. The projects revolve energy saving housing that blends man-made and natural elements, community development which introduces eco-tourism to the world, zero energy office buildings that promote sustainable from the aspect of economic and social, etc. Nevertheless, the sustainability in the Malaysian construction industry is at its infancy stage (Nazirah, 2005) and a lot more efforts are required to increase the level of awareness among the industry players.

3. INDUSTRIALISED BUILDING SYSTEM (IBS) IN MALAYSIA

As part of the effort in promoting sustainable construction, the Malaysian construction industry has been urged to shift from the traditional wet method of construction to IBS method. The urge is highlighted in CIMP under Strategic Thrust 5 which relates to innovative construction method.

There are plethoras of definitions of IBS found in many literatures. Dietz (1971) for example, described IBS as total integration of all subsystem and components into overall process fully utilizing industrialized production, transportation and assemble techniques. Warszawski (1999) on the other hand, defined IBS as a set of interconnected elements that joint together to enable the designated performance of a building. Lew et al (2003) provided a simpler definition by describing it as a system in which concrete parts and components, pre-fabricated at site or in factory are assembled to form the structure with minimum in-situ construction process. All seem to have some common denominator - it is about pre-fabrication i.e. off-site production and mass production of standardised building components that are taken to site for assembly. IBS can be said to be an assembly industry. CIDB defines an IBS project as that which uses 70% IBS components (for government projects) or 50% IBS components for private sector project. IBS is a method of transferring the on-site production processes to the factories and while the on-site works are limited to the assembly of factory made parts and components only. It is about the assembling of pre-fabricated building parts or components (whether standardised or non-standardised).

The concept of IBS is not new as it was introduced since mid-60s. According to Din (1984), in 1964, the government has identified two pilot projects to try out the precast construction. The first project was in Kuala Lumpur to construct a 7 blocks of 17 storey flats and 4 blocks of 4 storey shop lots. This project comprised about 3,000 units of low cost flats and 40 units of shop lots. It is awarded to the Gammon / Larsen Nielson using the Danish system of large panel industrialised prefabricated system. The second pilot project was located in Penang with the construction of 6 blocks of 17 storey flats and 3 blocks of 18 storey flats. The project [Type text]
consisted of 3,699 units of flats and 66 shops along Jalan Rifle range. It was awarded to Hochtief / Chee Seng using the French Estiot System.

While the sustainable technologies are still relatively new concept in Malaysia, IBS has its potential role in sustainable and green construction. The system components are mostly manufactured in the factory before delivering to the site. The productions take place in a controlled environment and this also helps in reducing construction waste in the site. Majority of IBS components have longer life span than the conventional building components. Ability to produce and assemble the components in large quantities reduces the number of trips of transporting to the site. Thus, waste produced by the transportation system is also lesser.

CIDB has been putting its effort in promoting the use of IBS in the construction industry. Despite the publication of the 2 roadmaps which documented the benefits of IBS, the adoption of IBS is still low especially in the private sector. Majority of the industry players feel reluctant to shift and the root cause is low labour cost (Kamarul et al, 2010). In order to increase the adoption of IBS in Malaysia, the Malaysian government had taken a number of initiatives.

During the 9th Malaysia plan period (2006-2010), the government pledged for the construction a total of 709,400 new houses. Special emphasis will be given to housing for the lower-income group where 38.2% of total new houses constructed will be for low-medium cost houses. These were built by utilising IBS in order to deliver the huge number of houses on time. As an incentive to private sectors, construction projects that adopt 50% or more IBS components in the building works are entitle to receive an exemption of construction levy. Generally, levy is imposed by CIDB at 0.125 % of total cost of the project. The new circular by the Ministry of Finance (MOF) emphasized on the full utilization of IBS for all government’s projects. The circular emphasised that the use of IBS components in government projects should not be less than 70%. As in 2009, 320 government projects worth RM 9.43 billion have been identified to be carried out using the IBS (Bernama, 2009). Moreover, CIDB had allocated RM 100 million to train skilled workers in IBS (Bernama, 2009). Trained skilled workers play an important role in assembling the IBS components on site. By March 2011, there are 136 manufacturers registered with CIDB and 328 types of products are produced. There are a total of 671 IBS contractors in Malaysia and this builds up of merely 1% compared to 64698 contractors registered in 2009. It shows that only a very tiny portion of contractor firms adopted IBS method of construction.

4. RESEARCH METHODOLOGY

Online questionnaire surveys were employed as a major tool for this research. The questionnaire surveys comprised of three major sections. The first section contains questions that defined the influences of Malaysian policy on the usage of sustainable technologies and industrialised building system (IBS) in Malaysia. The second section defines the positive and negative factors influencing the usage of sustainable technologies and IBS in Malaysia. The third section contains two questions on respondents’ information, general suggestions and comments about the research topic.
4.1 Design and content of questionnaire

Table below depicts design and content of questionnaires based on the tackled and investigated issues.

**Table 1: Design and content of questionnaires**

<table>
<thead>
<tr>
<th>Question(s) number(s) and type(s)</th>
<th>Issues tackled/ investigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 1: Yes / No question</td>
<td>Determination of influence of Malaysian policy to sustainable technology and Industrialised building system (IBS)</td>
</tr>
<tr>
<td>Question 2: checklists/ multiple choice</td>
<td>The constraints for Malaysian construction to implement sustainable technology and Industrialised building system (IBS)</td>
</tr>
<tr>
<td>Question 3-4: checklists/ multiple choice</td>
<td>Factors influencing the usage of sustainable technologies and IBS in Malaysia</td>
</tr>
<tr>
<td>Question 5: checklists/ multiple choice</td>
<td>The influence of Malaysian policy to sustainable technology and Industrialised building system (IBS)</td>
</tr>
<tr>
<td>Question 6: checklists/ multiple choice</td>
<td>Factors discouraging the implementation of sustainable technologies and IBS in construction industry</td>
</tr>
<tr>
<td>Question 7: checklists/ multiple choice</td>
<td>The benefits of sustainable technology and IBS to country development in Malaysia</td>
</tr>
<tr>
<td>Question 8: checklists/ multiple choice</td>
<td>Classification of IBS reducing environment pollution</td>
</tr>
<tr>
<td>Question 9-10: Open-ended (optional)</td>
<td>Respondent’s information and general suggestion and comments about the topic</td>
</tr>
</tbody>
</table>

4.2 Data Collection

Respondents for this survey were selected from the list of registered architect under Board of Architect (Lembaga Arkitek Malaysia, LAM) in Malaysia. Architects were selected as respondents as they are generally leader of the consultant team in construction Malaysia. The sample for this study was selected using systematic sampling from the list available online on the Board of Architect Malaysia website. From the list of 1845 registered Architects in Malaysia, 50% of respondents from an existing population were selected to ensure significant responses and representative results. This online questionnaire allowed professional architect to respond to questions and give suggestions and comments according to his or her experiences.

This online questionnaire survey was prepared by a web-based survey tool. It comprised of 10 qualitative questions consisting of 8 compulsory questions and 2 optional or open-ended questions. Each of the closed-ended questions included an option ‘Other’ to allow respondents to give comments or suggestions in the actual questions about this topic.
5. DATA ANALYSIS, RESULTS AND DISCUSSION

5.1 Analysis of Data

A total of nine hundred and twenty two (922) questionnaire surveys were distributed to registered professional architects in Malaysia. Twenty eight (28) architects responded to the survey, making the response rate 3.04%. This low rate had been expected for an e-mail questionnaire. On the other hand, the high percentage of invalid e-mail addresses, which is 14.21% or 131 invalid e-mails further corrode the response rate.

Figure 2: Can Malaysian government policies significantly influence usage of ST and IBS

Refer to Figure 2, out of 28 responses, 60.7% of respondents think the Malaysia government policies can significantly influence the usage of sustainable technologies, primarily Industrialised Building System (IBS) in Malaysia. 39.3% do not agree with the statement. Design consultants believe that government policies play important roles in promoting the usage of sustainable technology.

Figure 3: Constraint of implementing IBS in Malaysia

The government take IBS as a strategy to deliver high quality building and to reduce the reliance of migrant workers, the questionnaire requested the respondents to identify the factor that constrains implementation of IBS in Malaysia. 92.9% identify that cost is the constraint of implementing IBS, 7.1% show their worry in quality and none of the respondents take time as a constraint factor.
Incentives are employed as a preferred tool of policies in many areas (Ruth, 2004). The survey shown 42.9% of respondents think as long as incentive is given the usage of sustainable technology and IBS will increase. 28.5% think the incentive should be at least 0.2% of the total construction cost. Anyway, 14.3% of respondents believe that incentive doesn’t encourage sustainable technology and IBS. Finally, 14.3% agrees, the usage will increase only upon the government enforcement but not incentive. Hence, a total of 71.4% of respondents agree that different level of incentives can encourage sustainable technology and IBS and 28.6% disagree that incentives works.

![Figure 4: Factors significantly influence the usage of ST and IBS](image)

As for the question on factors that can significantly influence the usage of sustainable technology and IBS in Malaysia, 64.3% of the respondents felt that government policies can bring significant influence. Among others, materials cost (60.7%), construction period (60.7%), labour cost (57.1%) and building quality (57.1%) are factors that supported by more than 50% respondents. 42.9% of respondents think intention of developer brings influence, and only 3.6% supported construction accident rates is the factor that significantly influence usage of sustainable technology and IBS. It is found that the government policies is the major factor influence the usage of ST and IBS, following by time, cost and quality.
Figure 5: Factors discourage the design consultant from implementing ST and IBS

More than half of the respondents (57.1%) think poor sustainable and IBS knowledge is the main factor of not implementing sustainable technologies and IBS in Malaysia. 50% support lack of integration in the design stage will discourage the implementation. 46.4% think lack of local R&D on technologies leads to discouragement of implementation. 39.3% think the factor is lack of specialised skill for assembly of components. Other factors include lack of support and understanding from professional (35.7%), low sustainable technologies and IBS construction component availability (35.7%), lack of government support and opportunities (35.7%), lack of push factors from responsible bodies (32.1%), misunderstanding and misinterpreting of building regulations (25%). 21.4% think the factor is monopoly by big company, 17.9% support that lack of equipments and machineries is the factor, 17.9% think contractor do not have capacity to secure project.

Figure 6: Benefits of ST and IBS
With reference to the above chart, three quarter of respondents agree that sustainable technology particularly IBS will ensure sustainability development. While 64.3% agree that sustainable technology and IBS will reduce energy usage. 64.3% responses they agree with long term cost saving and 42.9% think it can leads to healthy living environment. 39.3% believe this can increase innovation in country development and a quarter supports one of the benefits is enhance public awareness. Only 17.8% of architects think IBS can reduce construction accident rate.

When ask upon which classification of IBS can significantly reduce environment pollution, more than three quarter (85.7%) agree precast concrete framing, panel and box systems will reduce environment pollution. 57.1% think steel frame system can reduce environment pollution, 53.6% agree steel formwork systems can do the same thing. Half of the respondents support that prefabricated timber framing systems is useful in reduce pollution and finally only 42.9% agree block work systems is good in reduce pollution.

As for the optional questions that allow respondents to voice out their suggestions on increasing the usage of sustainable technologies and IBS, the answers were categorised into two categories.

i) Suggestions toward the government

ii) Suggestions toward the construction players

The suggestions toward the government were divided into two parts, the policies and the incentives.

As for policies, there were 3 suggestions to urge the government to make compulsory for all government projects to adopt sustainable design and technology. There is a proposal to have a scoring system as part of the development approvals. One suggestion wishes government to set up policies in collective manner, which this respondent thinks only a few departments championing the technology won’t encourage the advancement of the technology. Another suggestion suggested anti-corruption in government project, and this will improve the implementation of government projects.

Total of five respondents wish more incentives can be given in order to gain momentum of the technology adoption. They suggested reducing taxes significantly on imported IBS materials, to provide subsidies to developers which use recyclable components or materials, to offset cost like reduced contribution costs, development charges and Improvement Service Fund (ISF), to subsidise the cost of applying for Green Building Index (GBI) certification. There is a proposal to request government to financially support selected contractors to perform sustainable technology and design. Lastly, there is also a suggestion to increase levy and tighten rules for employment of migrant workers, in order to reduce the migrant workers hence encourage sustainable technologies and IBS.

The suggestions to industry players are as follows.
All agencies or players have to coordinate and work together to achieve a common goal, which is to increase the usage of sustainable technologies and IBS. More engineers should be trained to specialise in precast, IBS and jointing system. Industry players, including engineers and architects should do more research and development (R&D) in the local context instead of relying on imported technologies. The professionals need to have more knowledge on IBS costing and the characteristics of waste reduction. Finally, there are respondents who hope the suppliers can prepare more catalogues, manufacture more standard and customised IBS parts and offer IBS certified or GBI certified products.

6. CONCLUSIONS AND RECOMMANDATIONS

The study concludes that the architects as design consultants have the awareness that sustainable technology, particularly IBS will bring benefits to sustainable development, reduce energy usage and save cost in long term. They are also aware of the impact of different classification of IBS in reducing environment pollution.

Anyway, in Malaysia context, the main reasons of not using sustainable technologies and IBS include poor sustainable and IBS knowledge and lack of integration during the design stage.

As a conclusion, most respondents agreed that government policies are able to influence the usage of ST and IBS. Majority of them responded that incentives offered by the government encourage the usage of IBS in construction projects. Therefore, it is suggested that further financial aid by the government become the catalyst in promoting the adoption of sustainable technologies and IBS in the construction industry.

References


The Brazilian Design Manager Role and Responsibilities after the BIM Process Introduction

Flavia Souza¹, Mariana Wyse², Silvio Burratino Melhado³

Abstract

The introduction of Building Information Modelling (BIM) in the Brazilian construction industry has raised a discussion about various topics through forums organized by professional associations, unions and universities. The design management topic has been discussed by a group led by researchers of the University of Sao Paulo and senior professionals. This group verified the growth in the number of interfaces between players and tasks related to design production in BIM, which have generated an increase in management responsibilities for the design coordinator. These realizations raised questions regarding the current management and communication practices, required to evolve to a collaboration scenario with the implementation of BIM.

In this context, we present the development of “The Design Manager Responsibilities Guide” (DM Guide) and its structure. The guide is based on IDDS four pillars: Collaborative Process; Enhanced Skills, Integration and Automation Systems and Knowledge Management. The design manager responsibilities are approached in the context of the Real Estate Developer. The development methodology for the DM Guide is a discussion by a panel of specialists comprising construction players, facilitated by the academy through regular meetings.

Keywords: Design Management, Building Information Modelling, BIM initiatives.

1. Introduction

In the last 10 years, papers and discussions about BIM (Building Information Modelling) and its associated technologies have increased significantly, both in academic and industry contexts. However, most of the discussions and references have focused on technological aspects, such as software and interoperability tools, information flow, strict language, parametric objects, etc. Even though all of these themes are relevant, the discussion about process and design management in the BIM context has been set aside.

According to Fox and Hietanen (2010), several researchers focused their studies on interoperability issues for BIM software and tools. However, more recently, there has been a number of researchers realizing the relevance of design process improvement, especially

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inter-organisational work handbooks, in order to make technology application more feasible. Owen, Palmer et al. (2009) advocate that technology exists to support processes, which exist to support the creation and maintenance of coherent and important information, which in turn supports the collaboration in the project team. Therefore, the definition of process protocols and standards is required to achieve full collaboration and BIM highest potential.

To illustrate this discussion, a review is made of BIM implementing initiatives in countries such as USA, Finland, Norway, Denmark, Singapore, Hong Kong and UK. Regarding Brazil, the discussion focuses on the importance of defining policies and strategies to implement BIM in the construction sector.

According to Wong et al. (2010), in Finland, AEC researches found that companies are disappointed with technology adoption due to the high costs of investment and the low immediate benefit return. For the authors, this is verified in contexts in which project processes were not reviewed for the adoption of BIM. In this sense, they conclude that, for achieving a successful BIM implementation, efforts towards technology, people and processes should be equivalent. Another aspect emphasized by these authors is the importance of discussing processes and work handbooks preferably in inter-organisational environments, involving most of the project players throughout the project lifecycle.

In this context, this paper reports the process of writing a “Design Manager Responsibilities Guide” (DM Guide). The aim of the guide is to define all the design manager’s responsibilities and tasks throughout the building project life cycle with BIM application. The guide is currently being developed by the Design Management Workgroup of Escola Politécnica, University of São Paulo, and it is a part of the PhD research named “Guidelines to the Design Management area of Real Estate Developer Companies - structure, people, technology and processes” as of the Master’s research named “Models of Collaborative Contracts for Integrated BIM Projects”. The workgroup comprises AEC professionals from architectural firms, construction firms and clients as well as software developers that discuss the BIM project process as it has been implemented in Brazil, under the coordination of this paper authors.

2. Literature Review

2.1 Integrated Design and Delivery Solutions

For Owen et al. (2010), due to the construction sector inefficiency, from product development to construction and building operation, concepts and tools issued from Lean Construction, Lean Design and Information Technology have been undertaken to improve processes and add value to construction projects. Nevertheless, according to the authors, these practices and technologies have been applied singly, and until 2010, initiatives to integrate them had not been proposed.

As an example of low integration, BIM introduction practices have been similar to the introduction of CAD (Computer Aided Design); however, BIM could change the current practices, since its associated technologies improve building project management practices.
along its life cycle. In this context, to potentiate the use of BIM, a critical analysis to the current implementation practices should be performed.

Aiming at integrating actions and good practices, such as Lean, BIM, IPD and others, the International Council for Research and Innovation in Building and Construction (CIB) elected the IDDS (Integrated Design and Delivery Solution) as a priority theme, through the framework for an integrated and coordinated merge of people, process and technology issues in order to conduct a radical and continuous transformation in the construction industry.

According to the authors, several elements of the IDDS are currently being explored in largely isolated parts of the academy and of the industry. The IDDS approach also challenges traditional industry structures and contractual process, as it both highlights current inefficiencies and facilitates their resolution, making the most of the workforce collaborative intelligence. The implementation of IDDS will move the industry towards an ongoing and iterative way at each of the projects phase: conceptual planning and making business case, all the design parts, supply chain management, construction, commissioning, operation, retrofit, and decommissioning.

For Gray and Hughes (2001) and Hjelseth (2010), design management complexity increases as the number of specialists grow. Analysing the design process from the information exchanged point of view, the greatest design manager challenge is to provide timely information and within the requested quality, aiming to meet the design team needs and the final client demands, through collaborative approaches and tools throughout the project life cycle.

As an example of low integration in the construction sector, Nederveen and Ridder (2010) emphasize that due to the construction sector fragmentation, building projects are characterized as multifunctional structures, with high level of risk tied to cost management, inefficiencies in communication processes, among others, which often trigger stakeholders’ dissatisfaction. To Hjelseth (2010), information exchange in the construction sector has been conducted with a low level of formalization, once in general the building information is scattered in various documents, such as descriptive memorials, blue prints, contracts and legal documents, which raises questions on information quality and availability.

In this context, Nederveen and Ridder (2010) proposed LBC (Living Building Concept) as an approach to the requested paradigm shift. In most cases, the construction product development occurs through demand-driven supply approach conduct, since the initial contact occurs between the client and the architect, who is responsible for translating the clients’ needs into construction information. In the LBC approach, the suppliers are active players during the construction product development, since clients choices must be met within the library of components and systems previously developed. These components must be organized into a parametric object library, since the condition to apply LBC is the similarity between virtual and real world. From the components and system choices, a building information model should be built aiming to evaluate the performance and design solutions quality, from the clients’ point of view.
3. METHODOLOGY

For the development of this paper, the authors conducted a literature review based on the IDDS (Integrated Design and Delivery Solutions) agenda. Also, having Succar’s (2009) BIM Initiative field model in mind, a research through papers and publications in these themes that classified initiatives around the world was developed, and the same classification concepts were applied to Brazilian and the UK scenario.

The second part of the paper presents the work by the Design Management Workgroup from the University of Sao Paulo, on one of its current research themes, the production of a Design Manager Guide for BIM in Brazil. The workgroup methodology is presented in item 3.1.

3.1 Design Management Workgroup Methodology

This research group was an initiative of the design process management research group from the University of Sao Paulo, and consisted in regular meetings with the participation of the researchers and market players, such as designers, design coordinators, software industry representatives, and members of construction building companies.

The meetings took place every two weeks and the discussion was based on the Brazilian Design Manager Scope (2006), and on several international BIM guidelines and handbooks as references, as well as on the participants’ experiences. The discussion involved the Design Manager tasks and responsibilities, and the analytic process was guided by a division of management tasks domains in four different fields: product management; design process management; communication management and modelling management.

At a second stage, specialists in specific AEC themes (planning, sustainability, constructability) will be invited to discuss the group production and evaluate its results; workshops in different Brazilian regions and with the academic community are going to be organized by the workgroup.

Figure 1: Workgroup Method
4. BIM SECTORIAL INITIATIVES: STRATEGIES AND MOBILIZATION

According to Wong et al. (2010), the BIM knowledge domain is expanding with its implementation in various countries. The authors present a review of BIM implementation process in six different countries (USA, Finland, Norway, Denmark, Singapore and Hong Kong), and classify their initiatives into the fields of policy, process and technology (Succar, 2009), where they identify the players and deliverables for each field. The six countries evaluated have developed more initiatives in specific fields (Wong, 2010), shown in Figure 2.

The USA have developed BIM initiatives within the three fields, which can be explained by the players from different sectors, such as government associated institutions, such as GSA (General Services Administration, responsible for BIM implementation in the public sector), NIST (National Institute for Standards and Technology) and many others, including research institutes, organizations and associations from the private sector.

In Denmark, public sector clients defined specific modelling standards and guidelines; in Finland, the effort dedicated to the development and use of IFC standards stands out in government initiatives. Also, BIM guidelines emerged as the result of an R&D project developed within industry players, ProIT.

Norway also developed BIM guidelines from a state client pilot construction project using BIM, and also has strong initiatives along the implementation of IFC standards and the definition of information exchange requirements. Within the process field, the building SMART initiative has a number of cross department projects working on converting and implementing BIM in building projects.

In Singapore, the use of an automated code checking system that reads IFC for project approvals has a strong influence in Policy initiatives, and also process initiatives have been implemented since 2007. In Hong Kong, the public sector have applied BIM technology for design, sustainability studies and construction coordination of its public housing projects.
the process field, several companies have implemented BIM in their projects and have been using the technology for clash detection, design visualisation and evaluation, and also have a number of consultants providing implementation services.

Succar’s classification model used in the six countries above, allows the identification of each country’s strategy for BIM implementation, the probable responsible players and deliverables, and, by exclusion, helps identify the fields that are not being developed equivalently. This review methodology is used in this article to evaluate UK and Brazilian BIM initiatives, as follows.

4.1 BIM INITIATIVES IN THE UK

In 2011, the United Kingdom Government, through its Plan for Growth, highlighted the critical importance of an efficient construction industry for the economy. According to the Cabinet Office Report (2011), the construction industry in UK is highly fragmented, with over 300,000 businesses, of which 99.7% are SMEs and over 2 million workers. The sector has contributed, on average, with 7% of GDP and is worth about £110 billion per annum, through three main sub sectors:

a) Commercial and social infrastructure: (45% - public: 18%, private: 27%): projects are typically traditional construction with a mix of new building and refurbishment;

b) Residential (39% - public:13%, private: 26%): the public sector has a relatively small new building program compared to repairs and maintenance;

c) Infrastructure (16% - public: 6%, private: 10%): is typified by civil engineering works, long overall project durations and major programs are renewal/maintenance.

As the scenario which forced the UK Government to rethink the construction sector strategies were based on studies which highlighted that the construction sector activities usually under-performs in terms of its capacity to deliver value, and that there had been a lack of investment in construction efficiency and growth opportunities, the prevalent inconsistent procurement practices, particularly in the public sector, aligned with low level of standardization and fragmentation of the sector had led to waste and inefficiency. As a solution, the UK Government proposed a four-year program to modernize the Construction Sector with two key objectives: reducing capital cost and carbon burden from the construction and operation of the built environment by 20%.

One of the strategy objectives was related to Building Information Modelling and was detailed in the Building Information Modelling Working Party Strategy Paper (March, 2011), which recommended a strategy to deliver a structure Government/ Sector capability to increase BIM adoption over a five-year horizon. For this, a Client BIM mobilisation and implementation group to drive the adoption of BIM across government was established to meet the requirement to attain fully 3D BIM collaboration (with all project and asset information, documentation and data being electronic) as a minimum by 2016. This group was named Building Information Modelling (BIM) task Group.
The working group recommended the “Push-Pull” as the strategy to adopt, supporting the “push” supply side of the industry to enable all players to reach a minimum performance in the area of BIM use, balanced by a “pull” from the client side to specify, collect and use the information derived in a value-adding way. The working group team was formed by construction player representatives, academics and software manufacturers. Its objectives were related to adopting BIM methodology benefits in construction as post-occupancy management, identifying the UK Government as a client who would need to encourage a number of BIM approaches as well as assess the potential of the government policy regarding BIM.

4.2 BIM INITIATIVES IN BRAZIL

The Brazilian AEC sector has only recently started BIM implementation, and the companies which have invested in this initiative in the past few years belong to the private sector. A number of Brazilian institutions have been developing study and workgroups aiming to discuss the implementation of BIM, and to promote its concept within the AEC community by promoting events and courses, but the concept of BIM is still not widely spread in the market.

Figure 3 shows a map identifying a number of BIM initiatives per region, identified in Brazilian research institutions with publications on BIM initiatives, some of them connected in a knowledge network for defining parameters and promoting BIM in the country. The data refers to papers published by Brazilian researchers on BIM in the Brazilian Information Technology Conference (TIC) in 2009 and 2011. The papers were organized into the following subjects: Design Process, Academic Diffusion, Technology and AEC Sector Diffusion. A total of 46 papers were analysed and 8 papers (16.7%) were classified as Design Process, 7 papers (14.6%) as Academic Diffusion, 28 (58.3%) as Technology and 5 (5.4%) as AEC Sector Diffusion.

![Figure 3: BIM initiatives in Brazil](image-url)
There are five specific initiatives which have connected a significant number of researchers and AEC associations with specific purposes of BIM development in Brazil. They are described in Table 1.

**Table 1: BIM Initiatives in Brazil**

<table>
<thead>
<tr>
<th>BIM Initiative</th>
<th>Initiative Description</th>
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<tbody>
<tr>
<td><strong>BIM Interdisciplinary Group</strong></td>
<td>In 2009, a regular discussion group was created on the initiative of AEC associations, opened to research institutions participation, AEC associations, institutions and private companies. This group was responsible for the development of those private companies knowledge of BIM and its processes, which led to the first real BIM project cases known in Brazil, further developed within the companies with consulting from members of the Interdisciplinary group.</td>
</tr>
<tr>
<td><strong>BIM BRASIL NETWORK</strong></td>
<td>This network is financed by CAPES, the Brazilian Federal Agency for the Coordination for the Improvement of Higher Education Personnel, and counted on the participation of four Brazilian Universities (USP, UFF, UFBA and UFPR). It was responsible for the inclusion of BIM disciplines in those universities graduate programs, and for promoting BIM research projects through scholarships. The production related to this group will be available for public access in their website, redebimbrasil.org.br.</td>
</tr>
<tr>
<td><strong>SINDUSCON – SP (Sao Paulo State Contractors Union)</strong></td>
<td>Sinduscon - SP is responsible for the annual BIM seminars, hosted in their headquarters since 2010. This event is known for bringing together representatives of all roles in the AEC chain, from designers to suppliers, clients and construction companies, investors and consultants. Its themes are compatible with the BIM scenario in Brazil, and companies implementing BIM often present cases with results, the positive and negative aspects of their implementation processes. The participation of international researchers and BIM consultants is also regular. These seminars are considered an annual event for every company and professional interested in BIM, a valuable opportunity for creating connections and sharing knowledge, and also discussing real case studies of implementation, preventing them from making the same mistakes as the companies who started the innovation curve.</td>
</tr>
<tr>
<td><strong>BIM Standard Committee</strong></td>
<td>The growing discussion and dissemination of BIM concepts led AEC institutions to identify the need of developing national standards, leading to the formation of a committee for developing BIM first standard in Brazil, NBR 15965-1 – Construction Information Classification System – Part 1.: Terminology and Structure, and Part 2.: Construction Objects Characteristics. These Standards define the vocabulary, the principles of the classification system and groups of classification for planning, design, management, construction, operation and maintenance, and should be observed in the elaboration of other standards which may rule and concern Building Information Modelling. The first part is in force since August, 2011, and the second part since August, 2012.</td>
</tr>
<tr>
<td><strong>FINEP’s TICHIS</strong></td>
<td>FINEP – Project and Research Financer is a public company associated to the Brazilian Ministry of Science, Technology and Innovation (MCTI). In December 2010, a cooperative research network was formed with seven of the largest public universities in Brazil (USP, UNICAMP, UFMG, UFRGS, UFPR, UFBA and UFC), financed by FINEP, called TICHIS: Information Technology and Communication Applied to Social Housing. The cooperative research network aims at developing innovative solutions for improving the quality and productivity of social housing constructions, focusing on BIM solutions, comprehending six main themes: (1) Web management, (2) Open standards for interoperability, (3) Digital design and conception, (4) Information technology and communication in construction management, (5) Integrated project management and IPD and (6) Information technology and communication for usage. These themes are reflected in the research subprojects, described in Table 2 herein and classified into BIM fields.</td>
</tr>
</tbody>
</table>
There are also isolated BIM implementation and development initiatives identified in professional associations and private companies. These initiatives, despite having a minor range, have helped the formation and shaping of Brazilian AEC professionals and, therefore, the implementation of BIM in the country. In this category, there are a few professional associations such as Agesc (Association of Design Managers and Co-ordinators), AsBEA (Brazilian Architectural Firms Association), SindusCon (Contractors Union), and software developers, such as Autodesk, Bentley and PINI. These associations and companies are responsible for several initiatives, such as BIM workshops and courses, promotion and sponsoring of BIM congresses, and contributing to the development of BIM national practices.

Table 2: Brazilian university research themes and BIM fields

<table>
<thead>
<tr>
<th>University</th>
<th>Research project themes</th>
<th>BIM Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>USP – University of Sao Paulo</td>
<td>Construction site prototyping, multi-dimensional performance analysis, masonry modulation generative techniques for BIM, handbook for creating BIM components, BIM project management and collaborative contracts</td>
<td>Process, Technology and Policy.</td>
</tr>
<tr>
<td>UNICAMP – State University of Campinas</td>
<td>Augmented Reality, 4D simulation, project cost vs. performance analysis model, participatory design, BIM technology for decision making, design prototyping, model control parameters.</td>
<td>Process and Technology</td>
</tr>
<tr>
<td>UPM – Mackenzie Presbyterian University</td>
<td>Digital fabrication, model for multi-dimensional analysis of risk areas occupation, generative systems for design modulation, components library production, collaborative process methodologies</td>
<td>Process and Technology</td>
</tr>
<tr>
<td>UFRGS – Federal University of Rio Grande do Sul</td>
<td>Modelling of client requirements, augmented reality, construction control automation, 4D simulation implementation</td>
<td>Process and Technology</td>
</tr>
<tr>
<td>UFPR – Federal University of Paraná</td>
<td>Multi-dimensional performance analysis, environmental performance tool analysis, semi-immersive collaboration environment development, handbook for construction of BIM components by suppliers, augmented reality for simulating construction site, BIM and Lean for public projects, communication management through BIM.</td>
<td>Process and Technology</td>
</tr>
<tr>
<td>UFBA – Federal University of Bahia</td>
<td>Business model/project management model for social housing, procedures for complex geometric shaping in BIM, thermal performance analysis methodology development, laser scanning, collaborative project methodology model.</td>
<td>Process, Technology and Policy</td>
</tr>
<tr>
<td>UFC – Federal University of Ceará</td>
<td>Post-occupancy evaluation through BIM models, strategies for improving integrated management in social housing.</td>
<td>Process and Technology</td>
</tr>
</tbody>
</table>

4.2.1 Design Management Workgroup

The Design Management Workgroup is an initiative of the Research Group on Construction Technology and Management of Escola Politécnica (USP). It is an integral part of the PhD research named “Guidelines to the Design Management area of Real Estate Developer Companies: structure, people, technology and processes” as of the Master research named “Models of Collaborative Contracts for Integrated BIM Projects”. The workgroup gathers AEC professionals from architectural firms, construction firms and clients, as well as software developers, aiming to discuss the BIM process as it has been implemented in Brazil, under the coordination of this paper authors.

The first meeting was held in March 2012 and aimed to discuss the responsibilities of the Design Manager in the BIM context with a panel of design management specialists. Aiming
to attain the Design Management Workgroup objective and its context, the Brazilian Design Manager Scope (2006) was chosen to base group discussions.

This Scope service had been part of an initiative to develop a set of Design Services Scope, in the context of Brazilian Construction Policies which had aimed to improve the services quality into the construction chain as well as to maintain an ethic and reliable relationship in design contracts.

Since the first meeting, the Design Manager Workgroup has met 10 times and developed a document called “The Design Manager Responsibilities Guide” (DM Guide). The guide is structured throughout the Building Project Life Cycle and uses the four IDDS pillars to define design managers’ tasks. It is worth emphasizing that the DM Guide structure is addressed to the context of Real Estate Development projects.

5. The Design Manager Responsibilities Guide in Brazil: DM Guide

Before presenting the DM Guide, it is important to understand The Brazilian Design Manager Scope (2006) development context and its structure. In this handbook, BIM is slightly approached, since when it was developed, there had been few discussions about BIM in Brazil, most of it only in the academic field.

The Brazilian Design Manager Scope (2006) is a handbook structured upon design building life cycle phases: a) Product Conception; b) Product Definition; c) Design Interfaces Identification and Solution; d) Post-Design and e) Post-Construction. Each phase was divided into three services categories: i) essential services, which are applicable to all types of building projects; ii) specific services – applicable only to some specific building projects; iii) optional services, which are not part of the design manager basic responsibilities, but can be hired in order to add value to the project.

The development of the DM Guide is not a review of the Brazilian Design Manager Scope (2006). It is the result of a research that re-organises the Design Management tasks based on practitioners’ experiences, BIM literature review, and the analysis of international guides, such as the BIM Project Execution Plan Guide and BIM overlay to the RIBA outline Plan of Work.

5.1 DM Guide Structure

The DM Guide aims to define and to organize the Design Manager responsibilities in a context in which the design is developed by modelling processes. Additionally, the tasks are structured for planning and organizing the necessary information to design activities, making it available in time and with the quality required. It also aims to maintain information integrity along the building project life cycle. The guide is structured into 5 phases: a) Product Conception; b) Product Definition; c) Product Development and Detailing; d) Construction; e) Post-Occupancy.
Considering the design process evolution, some of the design phases proposed by the Brazilian Design Manager Scope (2006) were suppressed (Design Interfaces Identification and Solution and Product Detailing), as demonstrated in Figure 4.

**Figure 4: Adjustment of Traditional Project Phases to the BIM context**

Product Conception tasks aim to support the Real Estate Developing Company to conceive the Building Design. For this, the Design Manager must understand what the developer’s resources and needs are, including performance, quality costs, time and sustainability objectives, among others. This phase tasks help define product briefing and support the multidisciplinary design team conceptualize physical and occupational characteristics through geometric conceptualization. The identification of stakeholders as well as their demands and expectations is part of the design manager responsibilities.

After Product Conception, Product Definition tasks aim to support the feasibility studies. Once the Business Plan is approved, it supports modelling development to extract documentation for legal approval purposes, since the Brazilian government agencies responsible for building design and construction approval still work on a paper/document basis. Also, tasks referring to multidisciplinary design management support technological analysis and building construction system choices, considering cost, time, risk, quality, communication, sustainability and procurement.

In the Design Product Development and Detailing phase, the tasks aim to consolidate all the information required for building execution through the model and to support the modelling process in decision making as to construction strategies and methods. For the Preparation for Construction Execution phase, the Design Manager must support the construction team at operational and production plans, procurement process, and quality process plan, defining the resources and team responsibilities.

During the Construction phase, the DM Guide tasks support resolving construction managers’ doubts, management of design changes and production simulation. The Preparation for Operation tasks aims to support the model preparation for facilities management.
Finally, Post-occupancy tasks support the post-occupancy evaluation and allow the feedback for the knowledge management system of the Real Estate Developer Company as well as the knowledge asset of the AEC players involved.

In each phase, management tasks were organized into four categories: a) Product Management; b) Design Process Management; c) Collaboration and d) Modelling Support.

Product management tasks aim to support the decisions referring to the building product from the aesthetic, functional and technical point of view, based on the developer and stakeholders constraints and cost requirements, time, quality, usability, operation, sustainability and constructability criteria. As to design process management, the tasks refer to the setting, contracting and evaluating the multidisciplinary design team, managing the design team activities, following costs and quality controls and other KPIs (product and management).

Collaboration tasks must enable communication and provide information integration for the decision-making marks along the design process and among all the agents from the design team and real estate developing company to the construction and facilities managers.

Design knowledge management tasks are part of the collaboration process along the project life cycle; even in the post-occupancy phase, the design manager must collect and organize the lessons learned through post-construction research, involving all the teams who participated in the project cycle different phases. The knowledge accumulated along the design phase must be fed into the Real Estate Developing company knowledge system. Modelling Support tasks aim to provision the BIM manager with all the necessary information for the modelling process.

At this point, the development of the Design Manager Responsibilities Guide is still in phase 1, and the tasks and process workflow defined so far are available at (http://www.iau.usp.br/pdconhecimento/melhorespraticas/?categoria=3).

The workgroup intends to continuously publish its results and production in academic meetings and scientific journals.

6. DISCUSSIONS

Analysing the BIM initiatives in Brazil, it is verified that there is low articulation among them. The discussion about BIM in Brazil, both in the Academy and in the Industry, started less than 10 years ago, and the existence of isolated initiatives is reasonable. However, it is important to highlight that, although the initiatives are not articulated, they are all relevant. Compared with the data presented by Wong et al. (2010) and the UK Government Strategy, the approach of these countries started with construction policies establishment as well as government requirements - as a major client of BIM implementation -, which does not correspond to the Brazilian reality.
The second interesting aspect of BIM initiatives in Brazil refers to academic researches. According to data shown in Part 4 and Figure 3, the Brazilian academic production in BIM is concentrated in the South, South-West and North-West states, and in four priority themes: Design Process, Academic Diffusion, Technology and AEC Sector Diffusion. Most of the papers (58.3%) published by TIC (2009 and 2011) were about technology.

For Fox and Hietanen (2010) and Owen, Palmer et al. (2009), processes and technology are co-dependent. In the BIM context, process protocols and standards are fundamental to achieve collaboration. Following this logic, it is important for the Brazilian Academic Community to re-evaluate their research strategies to include processes as well as AEC Sector Diffusion and Academic Diffusion themes.

The DM guide was developed under these assumptions and that in Brazil the BIM Manager and Design Manager responsibilities and skills must be better understood and defined. Through the DM Guide development, we perceived that both professionals are part of the Project Building Manager staff and they should work together in the BIM context process management to comply with stakeholders and clients constraints and requests.

7. CONCLUSIONS

The development of the Design Manager Responsibilities Guide is an important BIM initiative in the Brazilian scenario, given the few cases in which processes have been approached for the implementation of BIM in this country. As discussed in item 4, most Brazilian initiatives are towards the implementation of BIM technology, creating an unbalanced score for process and policy initiatives, recreating the Finn experience, which has shown high levels of disappointment by AEC companies.

Both academic researches that incited the creation of this workgroup emphasized the importance of defining the role of the design manager in the design process. They also emphasized the definition of project phase tasks and of the players involved, proposing a detailed workflow for the design process that can be used as a generic model for BIM implementation by Brazilian AEC companies.

Aiming to apply the DM Guide as a resource for BIM process implementation in Brazil, the next steps of the workgroup grow in importance, as they will validate the document as a referential set of guidelines for the AEC sector. After the discussion and first draft of the design process and design management tasks (Phase 1 of the DM Guide), the workgroup will promote three other phases for analysis and validation of the Design Manager Responsibilities Guide: Phase 2) Discussion with AEC specialist at each process phase; Phase 3) Promotion of workshops in different Brazilian regions; Phase 4) validation of the reviewed Guide with the academic community.
References

BIM Overlay to the RIBA Outline Plan of Work (2011) (available online http://www.bimtaskgroup.org/ [accessed on 01/11/2012])

Brazilian Design Manager Scope (2006) (available online http://www.manuaisdeescopo.com.br/ [accessed on 01/11/2012])


The ecomaterials. Science and Innovation to Tackle Housing in Developing Countries.

Fernando Martirena H

Abstract

Housing, health and food are the most urgent problems that developing countries face. Tackling housing deficit in poorer countries prompts for an innovative approach in order to meet the massive demand for land, building materials and technology. The Latin American Network for the Sustainable Habitat, EcoSur (www.ecosur.org) has developed a model for the decentralized production and use of “ecomaterials” based on (a) use of locally available materials, preferably wastes, (b) small scale of production, tapping a local housing market, (c) labor intensive technologies. Universities in Cuba and Europe have engaged in innovation projects, whose aim was to close the loop fundamental-applied-research-technology-implementation in a pioneer’s work of cooperation with local governments, NGOs and the civil society in general. A technology for the local production of binders out of agriculture wastes is presented as exampled of the implementation of the ideas. 20 years of successful implementation in developing countries have proven the potential of the new approach to tackle housing problems in a sustainable way. Only in Cuba there are over 50 production units spread throughout the island producing ecomaterials for the construction of approximately 3000 houses per year. The model has been embraced by the Cuban government as a sustainable solution for providing houses to the poorer sectors of society. This model has also been replicated to other countries like Haiti, where disasters have posed a severe burden to the already existing housing needs. This contribution aims at discussing the model and its main contribution to meet social goals.

Keywords: social housing, science & innovation, building materials, disaster mitigation

Introduction

More than two thirds of the world’s population lives in the so-called “developing countries”, where most of the basic needs are not yet properly fulfilled. The gap between poor and rich nations is most visible in areas like food provision, mobility or housing. Tackling housing problems in poorer nations, where a weak infrastructure and structural economic problems create resistance to progress, prompts for radical innovation; in order to meet the massive demand for land, building materials and technology for the construction of houses, while preserving Mother Nature.

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The building materials industry is amongst the most dynamic areas for modern development. A wide variety of new products has overwhelmed the international market for construction in the XXI Century. However this impressive development has not equally benefited industrialized and developing countries, being the latter often affected. The “global market” in building materials often causes great constrain to local industry which can only opt for becoming a “franchised business” of international trusts to locally distribute the international products.

This phenomena becomes a burden for the lower income sectors of population in developing countries, who cannot afford to have access to products having a foreign exchange share in its price. The other side of the problem deals with the discouragement of local productions, which leads to decrease in job opportunities, above all in rural areas far distant from industrial regions.

Ecology is also a problem of great concern. Modern technologies are the major responsible for the negative ecological impacts created by the increasing amount of wastes generated by industrial and agriculture production. Environmental awareness and damage prevention is currently addressed with some success in industrialized countries, mainly because of the existing infrastructure, the well-organized society and the law enforcement system to preserve the environment.

The goal is to find an appropriate solution for the poorer sectors of population in under-industrialized countries, where the capital cost is high and labor costs are low. This approach, basically denominated as “appropriate technology” or “intermediate technology” has proved to be a sound solution in many cases; however a larger social impact must be sought by improving the efficiency of such technologies without abandoning the original concepts.

This paper aims at presenting the experiences of a joint collaboration between an academic institution and an international Non Governmental Organization in the pursuit of solutions to tackle housing problems in developing countries.

The model for decentralized production of ecomaterials

The International Network for Sustainable Habitat, EcoSur (www.ecosur.org) has triggered an intensive exchange among academics and researchers, mainly based in Cuba, and experienced practitioners who worked in social projects throughout Latin America in the areas of production of building materials and housing issues in general on the search for new paths to the solution of housing problems at community level in developing countries.

The model embraced by EcoSur becomes an alternative to production carried out in large industries with automated processes, where the products have to be distributed at long distances and quite often raw materials have to be sourced from distant places. This brings unemployment at the short term, while it increases dependency from foreign technology and raw materials import.
The manufacture of reasonably priced building materials is among the most important issues, since it allows people to have access to affordable housing. The cost of building materials represent a high percentage of total construction costs for housing, that some authors estimate as higher than 40% in developing countries. Among these materials, Portland cement takes a major part that in absolute amounts up to 15% of total cost of housing in these countries\textsuperscript{[3]}. Imported raw materials have a significant share in the local cost of traditional building materials. Had the production of building materials been done locally with raw materials available in the vicinity of the workshops, the resulting product could likely be affordable for a wider range of population that normally does not have access to traditional building materials. The resulting products should be able to compete in quality and price with the traditional ones and would likely have a better environmental profile since local raw materials normally come in the form of recycled industrial or agricultural wastes.

This kind of small-scale production would also stimulate local economy mainly by creating new job opportunities. Besides, the environment is preserved since the potential threats in the form of wastes are profitably used. The amount of embodied energy\textsuperscript{[4, 5]} incorporated in the new product is lower as compared to traditional products since transport costs are cut to the minimum and technological processes are quite simple.

This has brought about the concept underlying this paper: ecomaterials. The “ecomaterials” (eco stands for ecology and economy) have become an alternative to traditional building materials manufacture. They are similar to traditional building materials although their manufacturing conditions are significantly different. The ecomaterials are manufactured at a very small scale, with appropriate technologies, using local resources. They become a source of decentralized development since local unskilled labor is used, while the products are traded in the surrounds of the workshop in order to save transport costs.

The technologies for the manufacture of ecomaterials do include flexible systems for quality assurance based on field and lab trials adapted to local possibilities in underdeveloped countries. This allows attaining a reasonable high standard for the manufactured products, which then become competitive at local scale. The concept “ecomaterials” comprises a wide variety of building materials with different origin and end use. However the best experiences are reported in the manufacture of Microconcrete Roofing Tiles (MCR), lime pozzolana binder CP-40, hollow concrete blocks and non-stabilized adobe bricks.

In conclusion, the resulting product does not significantly vary when compared to the traditional one, moreover, it becomes a competitive alternative in the local market once it has attained local acceptance. The target product is good (good performance, high strength and durability, and soft ecological profile), beautiful (high quality, good looks) and cheap (low cost), which is the golden dream of every entrepreneur/manufacturer.
Implementing the model: technology for the production of low cost binder

In this section ideas on the production of alternatives binders developed by CIDEM in interaction with several academic partners in developed countries will be presented. Although the paper will focus on the research and scientific part of this work, most of the technologies developed were implemented at the grassroots level.

(a) Recycling agriculture wastes for the production of pozzolans for lime-pozzolan binders

Sugar cane has the ability of fixing silica in its organic structure. When burnt, the organic volatiles disappear and the remaining ash is rich in micro-crystalline silica. Depending on the burning and cooling régimes, the ash can occur in an amorphous, reactive, state or in less-reactive crystalline forms. To produce a reactive pozzolan out of sugar cane, it must be fired and the temperature must be kept within 400-800 degrees Celsius, in order to prevent the transition to crystalline phases during heating. [6,7,8,11].

Burning is the most frequent way to recycle these wastes. Different procedures have been developed to burn the organic wastes under controlled conditions. Some of them, like the Fluidized Bed Boiler (FBB) require complicated operational systems, and others, like rudimentary incinerators simply burn under very simple conditions. It appears that burning temperature, residence time and cooling regime are the most influencing factors.

The author has studied different approaches to produce pozzolans through recycling processes that involve burning bio-wastes of the sugar industry:

1. Collecting the ashes produced during firing agricultural wastes in boilers.
2. Producing ashes through firing sugar cane straw under controlled conditions in an specially designed incinerator
3. Producing a reactive ash, which consists of thermally activated clay resulting from firing a solid fuel block (SFB), a briquette made of clay and finely shredded sugar cane straw.

Ashes collected from the boilers of the sugar industry

The easiest procedure is to collect the ashes just as they are produce in the industry, without any further treatment. Two types of ash were examined. The SCBA ash was extracted directly from boilers of the sugar factory “10 de Octubre” in the province of Villa Clara, Cuba. The SCSA ash was sampled from the heaps of open air-burnt straw in the fields surrounding the sugar factory. The ash was collected as a representative sample from the entire heap – e.g. by taking several grab samples at different heap depths and then blending them together.

The main results of this study may be summarized as [9].
1. SCBA-ash that is produced in boilers of the sugar industry shows a poor pozzolanic activity. The high firing temperatures, incomplete non-uniform combustion and slow cooling that take place in the boilers are likely reasons for the low reactivity. The main factors that affect the reactivity are the resultant degree of crystallinity of the silica present in the ash and the presence of impurities like carbon and unburnt material.

2. SCSA that is produced from burning sugar cane straw in the open air has proved to be a reactive pozzolan that fulfills the principal requirements for pozzolanic materials. Probably, this is due to the lower temperatures occurring in the combustion, mainly providing an amorphous structure for the silica present in the ash.

**Ash treated in rudimentary incinerators**

If one expects a higher reactivity from the pozzolan, the thermal treatment of the biomass during firing must be strictly controlled. With this purpose, a rudimentary incinerator was conceived and built with the aim of firing the bio-wastes at temperature under 700 oC, and the residence time under 2 hours, in order to create optimal conditions to produce a reactive ash. The incinerator was designed to process raw sugar cane straw. The target output of the incinerator is 25 kg of ash per hour. \(^{[10]}\)

The incinerator was built so as to guarantee that the airflow in the combustion chamber travels through meshes in the external walls. After the start of combustion, the incoming air drags heat from the burning mass to the chimney outlet, and cools down the burning chamber. The input of cool air can be regulated in order to attain the target burning temperature and residence time. A faster airflow lowers the temperature inside the burning chamber and lowers the residence time, as the biomass burns faster with an ample supply of oxygen.

Based upon the strength results, there appears to be no significant benefit in firing sugar-cane wastes in semi-controlled conditions, when compared to firing in open-air heaps. Although the mineralogical study shows that the ashes resulting from incinerator firing have less crystalline phases and more glass phase, this difference is not reflected in strength gain.

The reason for this could be the relatively long residence time of the ash in the burning chamber of the incinerator, and the slow cooling process afterward, which would not promote the retention of the more-reactive glass phase. This, combined with the low output shown by the incinerators during their use, confirms that from a practical/economic viewpoint transition from open-field firing to rudimentary incinerator firing is not warranted. A more sophisticated, higher output, version of incinerator with better and more uniform temperature control coupled with controlled cooling might prove to be a worthwhile future endeavour.

**Ash from Solid Fuel Blocks made out of clay and waste biomass**

Previous testing has indicated that if firing-temperature is kept below 750 oC, a reactive ash can be obtained by burning bio-wastes, but the practical applications of this solution are limited because at this low temperature heat recovery devices are difficult to implement.
When firing above 750 oC, the ashes resulting from burning bio-wastes become highly crystalline and thus non-reactive\textsuperscript{[11]}. At this range of temperature the only chance to produce reactive pozzolans through thermal treatment is by calcining clay. This is a well-known procedure, which involves a relatively large energy consumption, but yields a highly reactive pozzolan. If the energy needed to calcine clay could come from firing bio-wastes, the whole process would be more economically viable, and less dependent on external energy.

To contribute to this, the author has developed the Solid Fuel Block (SFB)\textsuperscript{[12]}. In this block, the bio-waste is mixed with clay before burning and pressed into briquettes; its high calorific value can be used at its maximum potential and the resulting ash – a mixture of the non-reactive ashes from the biomass (approx. 20-30\%) and the likely reactive activated clay (approx 70-80\%) - can likely be used as a pozzolan. The SFB can be burnt at temperatures around 800-950°C. The higher firing temperature increases the options for use of the resulting energy -- for instance, to fire clay or fly ash-clay bricks. Various techniques for energy utilization from this process are currently under investigation.

The Solid Fuel Block (SFB) is an attractive alternative to recycle waste biomass for the production of reactive pozzolan. Waste biomass, such as agri-wastes, sawdust or waste paper is shredded to fine particles, wet mixed with a suitable clay and pressed into solid fuel blocks. The clay that is used should be high in silica content because the activated clay becomes the main source of pozzolanic material, as the ashes resulting from firing the bio-wastes at temperature above 750 oC are likely non-reactive. The optimum proportion of clay has been found by experiment to be in the range 20-30\% by mass. The SFB typically has a dry density of 800 to 1100 kg/m\(^3\). The average calorific value is 15 kJ/kg, which makes the SFB acceptable for use as a sole source of fuel in an ordinary furnace.

The ash that results from SFB firing needs to be cooled fairly rapidly in order to form a primarily amorphous reactive silica. Slower cooling results in a higher proportion of non-reactive crystalline compounds. Sophisticated techniques for rapid cooling produce optimum pozzolanic activity of the ash but are not practicable for implementation within an agricultural community. It has been found in experimental trials that a simple process of periodically removing the ash from the furnace and spreading it on a metal surface cools the ash rapidly enough to produce a highly reactive pozzolan, which can be used in the manufacture of lime-pozzolan cements or as a supplementary cementing material.

(b) Using calcined clays as supplementary cementitious materials

Metakaolin (Al\(_2\)Si\(_2\)O\(_7\)) (MK) is a highly reactive pozzolan made through the calcination of a clay rich in kaolin. It is produced from high quality crude clays using state of the art technologies to remove impurities and control particle size. The reactivity of MK depends on various factors, such as temperature, heating rate and cooling regime. The optimal temperature window is 700-800 oC, although the dehydroxylation of clay is known to begin above 500 oC\textsuperscript{[13]}.

MK is rich in alumina, thus introducing extra alumina in the system when used as SCM in cement. The pozzolanic reaction of MK in blended cements can be then described as:
The volume of new hydrated alumina phases is increased as a result of adding MK to the system. If calcium carbonate is supplied through an external source to the system, the alumina phases will further react with it and form the following phases:

Hemicarboaluminate \[3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 0.5\text{Ca(OH)}_2 \cdot 0.5\text{CaCO}_3 \cdot 11.5\text{H}_2\text{O}\]

Monocarboaluminate \[3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{CaCO}_3 \cdot 11\text{H}_2\text{O}\]

Based on this cementitious system, a mass of clinker can be replaced by the same mass of a mix of MK/calcium carbonate having a 2:1 molar ratio, and yet form new hydration products capable of filling out the pore system in the matrix, thus contributing to improve strength. A prognosis based on thermodynamic modeling (Antoni M. et al 2012) shows that up to 60% of clinker can be substituted without decreasing the total volume of reaction products produced during cement hydration, thus the strength should not be compromised. The alumina phases are faster in reacting, thus the strength gain at early ages is not compromised. This cementitious system can move the boundaries of clinker substitution further without compromising performance compared to a normal OPC.

Calcining the clay

Characterization of the Cuban clayey soil from Manicaragua revealed that it was composed of a variety of minerals including quartz, feldspar and 3 types of clays (kaolinite, illite and montmorillonite). The kaolinite content of the soil was 17%. In order to increase its pozzolanic potential, the clayey fraction of the soil was extracted by a sedimentation process and the kaolinite content of the clay obtained was 40%. Those two materials (soil and clay) were thermally activated for their use as cement replacement materials \[^{14}\].

Characterization of the materials after calcination allowed us to identify an optimum temperature window, which was a compromise between loss of crystallinity and agglomeration of the clayey particles due to sintering phenomena. 800°C was found to be the optimum activation temperature for both the soil and the clayey material.

The study of the interactions with cement was done by substituting 30% of cement by calcined clays in the production of pastes and mortars. It was shown that clay calcined at its optimum activation temperature had a high pozzolanic activity that was indicated by a consumption of the calcium hydroxide produced by the cement during its hydration. This contributed to the final compressive strength of the materials (see figure 1).
Ternary blends clinquer-calcined clay-limestone

The aim was to optimize the replacement of cement by calcined clays, including the use of calcium carbonate and gypsum supplementary addition. It has been decided to concentrate on the investigation of the synergies possible in the ternary blends cement – calcined clays – limestone with pure industrial materials, optimize their use in the ternary blends together with limestone and finally study their use in concrete application as well as the durability issues\cite{15}.

The new type of cement demands needs optimisation of the sulphate addition at all replacement levels. The replacement of cement by the blend of kaolinitic clay and limestone is associated with increasing reactivity of the aluminates phases, due to the aluminates content of the metakaolin. A correct sulphate level allows a good mechanical strength development by retarding sufficiently the aluminates peak to allow the main peak of the C3S hydration to occur. Gypsum correction for cements made with 15\% clinker substitution (B15) and 45\% substitution (B45).

Compressive strength of the ternary cement were tested in prisms were cast with a lab made cement using clinker and gypsum from the cement factory Siguaney: (a) SIG-B15, 78\% clinker, 10\% MK, 5\% limestone and 7\% gypsum, and (b) SIG-B45, 48\% clinker, 30\% MK, 15\% limestone and 7.5 \% gypsum. The mortar prisms were subjected to compressive and bending stress tests. The results (see table 1) prove that the new cements outperform the Ordinary Portland Cement produced in the industry.

Figure 1: Compressive strength development of Portland-calcined Cuban clays blends compared to standard Portland cement and Portland cement with highly active metakaolin
Table 1: Compressive strength of mortar prisms made with SIG-B15 and SIG-B45

<table>
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<tr>
<th>Index</th>
<th>Parameters</th>
<th>MU</th>
<th>Average CPO in Siguaney</th>
<th>SIG B-15*</th>
<th>SIG B-45*</th>
</tr>
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<tr>
<td>Mechanical</td>
<td>Bend. Strength</td>
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<td>7d</td>
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<td>MPa</td>
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<td>13.1</td>
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<td>7d</td>
<td>MPa</td>
<td>35</td>
<td>51.2</td>
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<tr>
<td></td>
<td>28d</td>
<td>MPa</td>
<td>45</td>
<td>61.2</td>
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</table>

The whole innovation loop started back in 1992, and the first tonnes of the ternary cement will be produced in Cuba and India in 2013. In the meantime several workshops in Cuba and overseas have produced the lime-pozzolan binder for the local markets. After 20 years, the product has entered a real industrial phase of dissemination, whose impact on economy and environment will be significant.

**Appropriate technology? The choice of the scale**

Appropriate technology is characterized by: (a) use of locally available raw materials, including the possibility of recycling waste materials, (b) use of machinery adapted to the context, i.e. in rural areas with unskilled labor it should be simple to operate, (c) pursuit of a decrease on the energy consumed in the production process, including transport of raw materials and finished product. In developing countries it could be interpreted as small scale production, mostly done in rural areas [16].

This whole process does not apply for every single technology without exceptions. The author tried in the past to develop a technology for the production of a low cost binder, basically a lime-pozzolan binder, made through intimate mixing and grinding of both raw materials until the desired finesse is reached. The R&D work was done, machinery was developed for the purpose of introducing it at several communities [17], and more than 25 new workshops were created, where pozzolanic cement, together with other materials were produced.

Although still in production, this technology has not been widespread like other similar technologies for several reasons: (a) the production output (1 tpd) did not allow an interesting economic scheme, (b) raw materials processing, above all drying, was extremely complex to implement at a very small scale, and thus the quality of the production was affected, (c) the quality of the resulting product was not consistent through the time, mainly because it proved impossible to scale testing procedures down to the level of field tests, (d)
the product had a poor acceptance among the target population, caused by most of the problems described above.

During the 1970’s interesting reports were launched about the “mini-cement plants” in India[18]. The output was between 100-150 tpd and the plant was conceived for a local and regional market. This idea was abandoned due to the low energy efficiency attained, basically because of the firing technology chosen (vertical shaft kilns).

The new chemistry of cement described above in this paper, where clinker substitution has reached 60% without affecting the properties of cement. The technology has been tailored to the conditions of developing countries, that is, simplified to the maximum and the automation is limited only to specific areas. It would be especially interesting –also for developed countries- in a context where oil prices would skyrocket and long distance transportation could be hindered.

If this project takes off, a new alternative for cheap cement shall be made available on the recently opened building materials market in Cuba—non subsidized-. Further, the possibility of replacing Portland cement in many applications such as the production of hollow concrete blocks and roofing tiles could make these products more affordable for the population, and thus could boost local construction. The relatively large scale of the production could enable a relatively large production, and thus a great impact on the target population in a short period of time.

Replication and/or dissemination of this technology elsewhere are not straightforward. It should be coupled with the build-up of local capacity to test local materials for reactivity, either in local research centres, or by creating scientific core groups at universities in target countries at the universities, which again, would imply a change of paradigms in the connection of science with the grassroots. Further, the developers of the technology should devise a comprehensive methodology as to how to implement the project in the target country; financing schemes to foster the creation of partnerships between the academy, civil society and the private or industrial sector; and the engagement of the governments to establish trade policies to benefit the poor, etc.

Social impact. The Cuba case

From 1959-1988, the system for housing provision in Cuba was based on the centralized production of building materials in large, automated facilities operated by the Ministry of Construction. Prefabricated building materials were produced and supplied by road or rail to areas far from the industrial centers; it was an energy-intensive system based upon the supply of cheap oil from the former USSR.

The collapse of the Soviet Union and East European socialist states had a dramatic effect on the system: energy became scarce, roads deteriorated because of the lack of maintenance, the fleet of trucks became obsolete and the supply of spare parts was threatened. This had a great impact on the construction materials industry, which was no longer able to maintain a steady supply of building materials, particularly to areas distant from the production centers.
The lack of availability of building materials led to a decrease in new housing construction and a rapid deterioration of existing housing stock due to lack of maintenance, as the population did not have the means to renovate or maintain their homes in good repair.

The new situation prompted a fundamental shift from centralized production based on long-distance transportation, to the local production of building materials in order to lower energy and transportation costs. Suitable for both rural and suburban areas, the technologies developed by CIDEM are geared towards small-scale production, with a focus on stimulating the local economy through the creation of new job opportunities. The project’s main features include:

- An innovative process of technology development and transfer, which has resulted in a set of appropriate technologies for the manufacture of building materials at municipal level. The whole process has been organized as a south-south endeavor, as machinery and know-how come from Cuba and other countries in Latin America. Ecomaterials workshops are carried out that include personnel training and a post-sale advisory service.

- A large-scale decentralized program for production of building materials at municipal level, which contributes to providing affordable and accessible building materials in a sustainable manner, particularly in areas where hurricanes have caused serious damage and a quick post-disaster response is required. This model has been embraced by the Cuban government as the model for housing development, and since June 2009 it has become the official approach of the Cuban government for housing at municipal scale.

- Creation and further improvement of a new decentralized management model for housing renovation, which gives local authorities new opportunities to act independently as well as increase their capacity for resolving urban renewal issues. The model includes the new legal framework for small and medium enterprises working on private (non-state) or collective (cooperative) property, and the launch of pilot projects that stimulate this new production sector in the Cuban society.

CIDEM’s work has resulted into a contribution to the gradual migration from a centralized production model based on state-owned, subsidized enterprises to a decentralized production model based on non-state, market oriented production figures operating at municipal scale: 48 municipalities equipped with facilities to locally produce approximately 65% of the materials needed for their own housing programs; a national program for the Local Production of Materials launched by the Ministry of Construction, with funds allocated to progressively expand the model to the rest of the municipalities in Cuba.

Cuba is moving slowly towards an economy where market shall play an important role. The party congress in 2011 has approved a series of measures that will introduce real changes in the municipal economy. However, this is not being implemented as an economic shock, the measures will be solidly planned and implemented within the framework of the constitution and defined in laws (not in decrees). CIDEM has been called to provide advisory service at a very high level at the Cuban government and at Parliament level, to implement a
new housing program based on the use of local resources, and a clear emphasis on the non-state productive sector[19].

Concluding remarks

• The collaboration between cutting edge science institutions in industrialized countries and partner in developing countries is feasible and desirable, and can bring about interesting results for both the industrialized and the developing countries.

• The incorporation of fundamental research, coupled to applied research, lowers the possibilities of improvisation, and thus the potential errors or flaws in the technology implementation, which are so common in our environment.

• The collaboration itself becomes a mechanism to build capacity at the partner institution in the developing country, which then –due to the prestige acquired- is called by local clients in the industry to introduce their results.

• Innovation oriented to sustainable production practices could attract industrial stakeholders and thus create potential financing schemes. For instance, a sound partnership with the cement industry in Cuba has helped favouring a sustainable introduction of results, with own funding allocated for the technological transfer.

• The “domino effect” of good scientific partnerships North-South for developing countries can be created: more capacity built, better options for R&D work, more credibility at governmental level, more funding comes.

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The Process Of Implementing Project Management and BIM In The Colombian AEC Industry.

Mario Flórez¹, José Guevara², Ana Ozuna³, Hernando Vargas.⁴

Abstract

Since 2006 the Engineering and Construction Management research group at Universidad de los Andes has documented 20 case studies of Colombian companies using or implementing Project Management and BIM tools. Results showed that knowledge and understanding of Project Management and BIM principles, top management support, and organizational culture are the most influential factors when formulating an implementation strategy. It was also observed that some of the requirements for implementing BIM, such as transparency, process efficiency and new decision making procedures, made the process particularly challenging for some actors in the supply chain. The purpose of this paper is to present the results of a comparative review of these research projects. After analysing common failures described on the industry, it was found that most of BIM principles involve managerial improvements, therefore implementing contractual mechanisms to demand BIM in private and public biddings would surely improve industry’s efficiency.

Keywords: Project Management, BIM, literature Review, Colombian AEC industry.

1. Introduction

Over the past decade, the Colombian Architecture, Engineering and Construction (AEC) industry has grown significantly. The AEC industry has been analysed in several MA dissertations in order to identify the failures and advantages of project execution. The most concurrent topics in such dissertations from Universidad de los Andes since 2006 will be analysed in order to identify the recurrent themes, main failures and propose future research subjects.

The approach proposed describes recurrent subjects found in the dissertations treating two main topics: Project Management and Building Integrated Modelling (BIM). These topics were selected based on the importance and advantages evident when leading construction

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industry; therefore, identification of the main barriers are relevant for improving Colombian productivity and success rates in Architecture Engineering and Construction (AEC) projects.

With respect to Project Management, two main categories arise as the most recurrent, Risk Management and Cost Management, each is described based on the main failures identified, and compared to international standards. Similarly, an identification of BIM’s advantages and requirements for implementing this technology is analysed and compared to internationally defined maturity levels.

Nevertheless, the themes that will be treated on this paper are among a variety of project management strategies such as Lean and sustainable construction, that Universidad de los Andes has studied and published on different academic works.

2. Research methodology

The selection of dissertations for the elaboration of this paper was based on filter criteria according to the project’s title and topic. The topic must be related to the main work areas established by the PMBOK which include Knowledge Management, Risk Management and Cost Management.

Several of the dissertations reviewed suggest the inclusion of an instrument for improving practices. Therefore, documents regarding Building Integrated Modelling (BIM) were included in the review and searched for, in the Uniandes database.

Examining the content of these papers, the common trends and propositions for future studies were analysed and compared with international trends. The most frequently cited academic papers were included in this research document. Table 1 lists all the documents and main topics reviewed. The methodology proposed is based, in the first place, on a local literature review that includes the most relevant documents presented since 2006 at Universidad de los Andes; and secondly, an international literature review based on the most frequently cited documents and new trends in such topics,. Finally, according to the literature reviews, a classification of the state of Risk Management and BIM development in Colombia was completed.

3. Project management

Project management has been defined as the standard to deal with and create changes within several management practices such as creation of new products, services or changes in organizational processes (Cleland & Gareis, 2006). Several changes have occurred over the past years whereby Project Management turned from being a rudimentary process—part of general management—to an independent, well-structured and defined process recognized by several associations such as PMI (Project Management Institute) and IPMA (International Project Management Association). These associations have documented and guided the best practices in order to undertake an accurate analysis based on cost, schedule and technical performance. According to the PMI, the main areas of focus for
successful project execution are: time, cost, quality, scope, risk, procurement, human resources and integration management.

**Table 1: Documents revised for the elaboration of this document**

<table>
<thead>
<tr>
<th>Author and year of publication</th>
<th>Main topics</th>
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<tbody>
<tr>
<td><strong>Project Management</strong></td>
<td>Tools for controlling cost, time and quality on projects; Project Management organizational schemes. Better practices; Methodology and software design; Management Model (APRAM) for managing schedule, cost, and quality risks in the construction industry; Project Management generalities and evolution; Evaluation of human resources on a project management group.</td>
</tr>
<tr>
<td><strong>Cost / financial management</strong></td>
<td>Cost optimization and dynamic project control; Scheduling, resource management and cash-flow-analysis; Financial modeling; Profitability on priority housing projects; Real projects best practices; Cost control structure; Budget control standards; Budget database actualization and completion; Earned Value Method (EVM) improvements; Free cash flow of a project based on risks and mitigation measures; Influence of inflation in the variation of prices of raw materials and services; Real Options on financial evaluation of projects.</td>
</tr>
<tr>
<td><strong>Risk Management</strong></td>
<td>Risk analysis; Methodology for implementing a &quot;learned lessons&quot; philosophy; Common risks presented during planning phase; Corrective actions that must be done to avoid risks; Risk identification, register and analysis during the operation and maintenance phase on construction projects; Case of study, identify, quantify, analyze and control risks present; Uncertainty management of activities' duration; Mode and Effect Analysis (FMEA) in the construction industry for mitigation of risks; Development and prove of a tool for evaluating state of risk management; Risk Analysis on public contracts; Comparison between the PMBOK and the NTC 5254 (Colombian regulation) on risk management procedures; Contingency model via Monte Carlo simulation for risk analysis and for providing contingency assessments.</td>
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<tr>
<td><strong>BIM</strong></td>
<td>BIM influence on design, cost and scheduling on projects; BIM implementation plan for Colombian companies; Revision of BIM implementation on a Colombian AEC company; International guidelines and BIM Framework; BIM generalities and most relevant aspects for implementing BIM in Colombian industry; BIM literature review. Feasibility of BIM implementation; BIM generalities regarding definition, requirements, stakeholders and advantages of this implementing this technology; Case of study a Colombian AEC company and the methodology for implementing BIM in the organization.</td>
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3.1 Risk Management

Project Management Body of Knowledge (PMBOK) defines Risk Management as “the process concerned with identifying, analyzing and responding to project risk” (PMI Standards Committee, 1996). An effective risk management leads to the minimization of negative impacts on the objectives, cost time and quality of a project, through improved practices to deal with uncertain events.

3.1.1 Local Literature review

According to Colombian studies undertaken by MA students in Project Management for Construction, the importance of risk management is related to the nature of the Architecture, Engineering and Construction (AEC) industry; catalogued as one of the most dangerous (Sura, 2012) and recurrently affected by risks. Therefore, it is essential to qualify and identify the risks that companies involved within this sector and projects are exposed to.

The current state of project success in Colombian public biddings is alarmingly low, according to Beltrán, only 44% of the total projects planned by a public entity during the years 2006 and 2007 (311) were delivered based on the initial plan (Beltrán Real, 2011). Such statistics suggest that the initial phase of projects (planning phase) is not being appropriately developed; which naturally reflects the importance of this process where uncertainty is prevalent, risks are more probable and the basic decisions that define a project’s scope, requirements and success are made (Muñoz Redondo, 2007).

In relation to analyses undertaken over the past 6 years, the main causes involved with project failure on scope, quality, cost or schedule is initially related to the lack of a well-structured definition of projects, caused mainly by the inexistence of a serious planning methodology and unreliable control entities. All Colombian AEC projects must be validated by a local public entity, responsible for checking that normativity on urban, structural and architectural designs is in accordance with the regulations. Although, these entities do not have a standardized process for construction license approval, the criteria used is based on particular concepts and different interpretations of legal regulations, which consequently lead to major problems during and after construction (Mendoza Paternina, 2007).

On the whole, the importance of classifying risk is to find possible mitigation methodologies. Some of the strategies identified lean towards the implementation of new technologies and simulation tools (Puentes Hernandez, 2008) in order to improve planning, control and efficiency so that differences between executed and planned projects can be reduced (Salas Callejas, 2008).

Particularly in the case of the Colombian AEC industry, it has been shown that the construction of the basic unit model not only improves sales efficiency, but helps to identify and correct design errors before the construction phase begins (Salgado, 2008). However, the most recurrent and important method identified was the implementation of knowledge management, discussed next.
3.1.2 Knowledge Management

In Colombian practice, knowledge management has been one of the least developed practices involved with project management (Galán, 2007). The importance of this area is based on the supply of tools to positively influence the decision-making process during project execution (risk mitigation). The main input is a representative database resuming the history, projects executed and influential decisions made with their impact.

As mentioned previously, the Colombian sector does not understand the relevance and does not provide the personnel required to manage, store and analyse information regarding projects in the private and public sectors. Not even the most important company in the Colombian AEC industry, in charge of representing the public contractors, manages its information appropriately (Galán, 2007).

In order to evade the negative effects that risks could entail, several studies suggest that a complete database, that involves internal and external rules such as requirements on legal normativity (Caycedo, 2007), must be put together. To achieve success on any construction project, all the members of the company must be involved with the risk management process and contribute to the risk database at all the phases of the project. (García Villamizar, 2007). This database shall be used as the main input for the construction of a Risk Breakdown Structure that clearly characterizes and identifies risk and the respective mitigation, based on a learned-lessons philosophy (Duque Tejeiro, 2011).

3.1.3 International literature Review

After reviewing some studies developed globally and cited by several academic papers, it is evident that efforts are continuously increasing and even the most important projects such as the Panama Canal expansion, develop and invest in leading risk management techniques. In particular, the conventional concept of analysing cost and time effects separately has been replaced by an integrated view of these dimensions to obtain common risk factors and perform and adequate analysis of vulnerability during the different phases of the project. According to Alarcón et al (2011), a successful view of risk management is a 10 steps iterative-process where risks should be identified, analysed, prioritized, managed, triggered, measured, tracked, so a critical risk analysis and additional mitigation actions can be defined. Using this methodology, risks can be more accurately identified and the project managers can develop specially designed strategies to mitigate vulnerability and contingency levels.

3.2 Cost Management

Cost management is defined by the PMBOK guide as the processes that involve estimating, budgeting and controlling costs so that the project can be completed within the approved budget (PMI Standards Committee, 1996). Compared to risk management, cost management in Colombia is in a higher stage of development, possibly because the importance of budget control, the evident impact on project success and the nature of financing projects lead to better practices in this area.
3.2.1 Local Literature review

As defined by Rodriguez (2010), most private Colombian AEC projects are based on a capital structure that involves equity and debt, the latter in a much higher proportion. Therefore, the project must be clearly defined on cost and schedule in order to formulate a cash flow based on expenditures and obtain a construction loan via building societies (Correa, 2007).

Local research has uncovered the need for the implementation of a general economic Net Present Value model for each project. It must be designed to modify the most important variables regarding participation of the whole cost, to identify the critical elements and design a proper business structure (Zapata, 2010). The main variables that influence budget on typical Colombian construction projects are Workforce, Concrete and Steel prices (Cuello, 2008); hereafter research into project development must be based on sensibility analyses of these main variables.

3.2.2 International literature Review

Among international trends, Real Options have turned into a recurrent topic related to project evaluation regarding cost management. These options are strictly related to “real” projects based on the production of services or wells such as AEC projects, which are usually analyzed via Net Present Value. In terms of Real Options, an analysis is made according to the different decisions and scenarios that the environment and project execution can present with their respective probability of occurrence. After such analysis, the project manager has the flexibility to study the whole project and decide whether to continue, resize, freeze or abandon the project.

As already mentioned, AEC project environments are very variable and directly affect the development of any project, so a proper Real Option analysis can be very helpful in providing the necessary tools for making the right decisions that will lead to positive results (Garvin & Ford, 2012).

Although, international evidence emphasizes the importance of Probabilistic and Net Present Value project analyses, the Colombian AEC industry presents some limitations brought about by traditional risk management techniques still implemented by most project managers. Project managers are prone to making decisions that reduce uncertainty, therefore professionals in this industry usually do not select new ideas, they prefer to use conventional processes instead of investing time and resources on well-structured decision making methodologies (Garvin & Ford, 2012).

However another three main elements were identified as common deficiencies. Managers in this industry are loyal to the first budget made; they don’t refresh values, so budgets that could initially lead to successful projects, prove not to be profitable once execution begins (Piedrahita, 2010). Another critical element that must be considered for determining the prices and consequently the success of any housing project is sales speed as this implies loan costs from the early phases if the project is not sold rapidly (Velasco, 2012). Finally, the
lack of a defined methodology for time control and analysis of work planned vs. work performed leads to cost control failures when deciding which strategy should be implemented to finish with the initial budget (Lucero, 2008).

3.3 Maturity level

In addition to process definition, several attempts have been made to analyse the state and the culture of an organization's risk management capabilities. RM3 (Risk Management Maturity Model) was a tool created to develop a maturity assessment model, in which 5 main attributes were identified: Management, Risk Culture, Ability to identify risk, Ability to analyse risk and Application of standardized risk management system (Zou, Chen, & Chan, 2010)

In order to be in the highest level or maturity of risk management according to Zou et al. (2010) the company must: Continuously improve to maintain mature in risk management capabilities, ensure continued commitment by upper management and perform regular reviews of processes and techniques to guarantee the quality of risk management applications and practices. Other practices include investing in improving risk processes, identification techniques, risk analysis tools, employee skills and provide regular training to employees to maintain high levels of knowledge and skills.

According to these parameters, the Colombian AEC companies analysed are in the lowest phase of development, the main characteristics described in the case studies highlight the involvement of the upper management and their attempts to create a generic risk management process. Nevertheless, very low levels of training within the employees are identified and, as mentioned above, there is a huge failure in terms of documentation and even conceptual definition of the projects. Figure 1 summarizes the level of risk management in Colombia based on Zou et Al. (2010) levels.
4. BIM

BIM (Building Integrated Modeling) has been defined as one of the worldwide predominant trends to manage projects in the AEC industry. It is a representation of projects that changes the conventional 2D CAD model into an nD model that, instead of representing elements as lines, describes a series of objects with attributes (materials, team leaders, cost, etc.) that allows a better visualization and, therefore, avoids clashes between various systems (Eastman, Teicholz, Sacks, & Liston, 2011).

The main advantages of implementing this model are the reduction of industry fragmentation, improvement of efficiency, lowering of the high costs of inadequate interoperability, design support throughout the phases, project control throughout its life cycle, and regulation of the project team providing a well-defined mechanism to identify changes in roles and relationships (Succar, 2009).

Consequently the whole project is of better quality, lower costs and shorter durations, which can be understood as improvements in terms of knowledge and cost management, treated previously in this document.

4.1.1 Local Literature review

On Colombian companies, BIM is not a common trend, although among the studies included in the research methodology, two companies had already begun the process of implementing BIM as their modeling strategy for projects. According to Sánchez & Valencia (2011), the main barriers found in this process are the initial cost of acquiring the software, training personnel, technical support and the cultural change of modifying the standard process that has been used for a long time.

One of the companies analyzed had already begun this process, but the whole concept of implementing this technology was understood as the acquisition of the basic software and basic training. Only a few designers from different areas of expertise were instructed and, mounting the whole project in BIM has turned into the responsibility of those few, meaning that the work kept being fragmented (Igarán, 2010). The second company that uses BIM technology began to do so because its main contractor demanded this technology as the standard for planning and developing their projects, therefore this process and the better practices were basically obligatory if they were going to stay in the business (Isaza, 2008). Although, the analysis proved that the technology was not being completely exploited and the main improvements that BIM assures were not being accomplished, a huge and recurrent mistake is that companies do not have the level of detail required to take advantage of the program and the model is only being used during the design phase. Therefore, the improvements in terms of the whole process and results are very limited (Castañeda, 2009).
4.2 Maturity level

Based on the maturity stages of BIM proposed by Succar (2009), it was found that the companies studied in the theses included in the literature review, are divided into two levels; Pre-BIM status and Object based modeling synopsis. The former is the basic stage in which project documentation is 2D, quantities and costs are not related to the model or documentation, work flow is linear and asynchronous and there is a low investment in technology and lack of interoperability. The object based modeling synopsis is characterized by single-disciplinary models, a lack of collaborative philosophy and disjointed communications. In order to get to the Integrated Project Delivery (IPD) level, which is the highest, coordination, communication, decision support, and other work processes enabled by integration of data in all directions must be implemented and standardized. Figure 2 locates the Colombian level of maturity regarding BIM based on Succar (2009) maturity stages.

5. Conclusions

Most of the documents reviewed in this paper, studied individual cases related to specific areas of project management regarding practices among small and mid-sized companies. Nevertheless, other studies have been made to define the process of implementing managerial techniques among most relevant companies in the industry; as detailed studies of practices implemented by leader companies on innovation, planning and management. It is worth to mention that an effort is being made to spread and implement better practices among agents involved in this industry, and big companies have proven to comprehend them.

As described above, it is evident that the mid and small sized Colombian AEC industry companies present very low grades of development according to the scales established...
internationally with respect to risk management, knowledge management and BIM implementation. Therefore, a well-defined strategy must be employed to reduce the main deficiencies present, and improve the poor rates of success that are present on the execution of Colombian projects. Among the malpractices that should be highlighted, are the inner and outer fragmentations present within companies that hinder integration, knowledge management and the constant learning process that leads to the implementation of better practices.

According to the studies analysed, the most common risks present in the Colombian AEC industry are related mainly to planning and financial failures. In order to mitigate planning risks, a better-established process for approving construction licenses must be developed with the intention of reducing the adversities present during construction and encourage better planning phases for projects. The definition and standardization of the approval parameters is suggested as future work for the local planning authorities, which surely will ensure better success rates on public and private projects.

Insofar as financial failures, international trends such as real option evaluation and Net Present Value sensibility analysis of the most important materials that determine the viability of projects must be made.

The advantages of BIM were continuously cited as present failures of the AEC industry, consequently the implementation of this technology can be identified as one of the most feasible options to improve industry results. Although it was also observed that some of the requirements for implementing BIM, such as transparency, process efficiency and new decision making procedures, made the process particularly challenging for some actors in the supply chain.

The impacts and requirements of implementing a contractual methodology to overcome these difficulties and boost positive results via demanding the use of BIM for participating on public and private biddings are suggested as a future work.

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