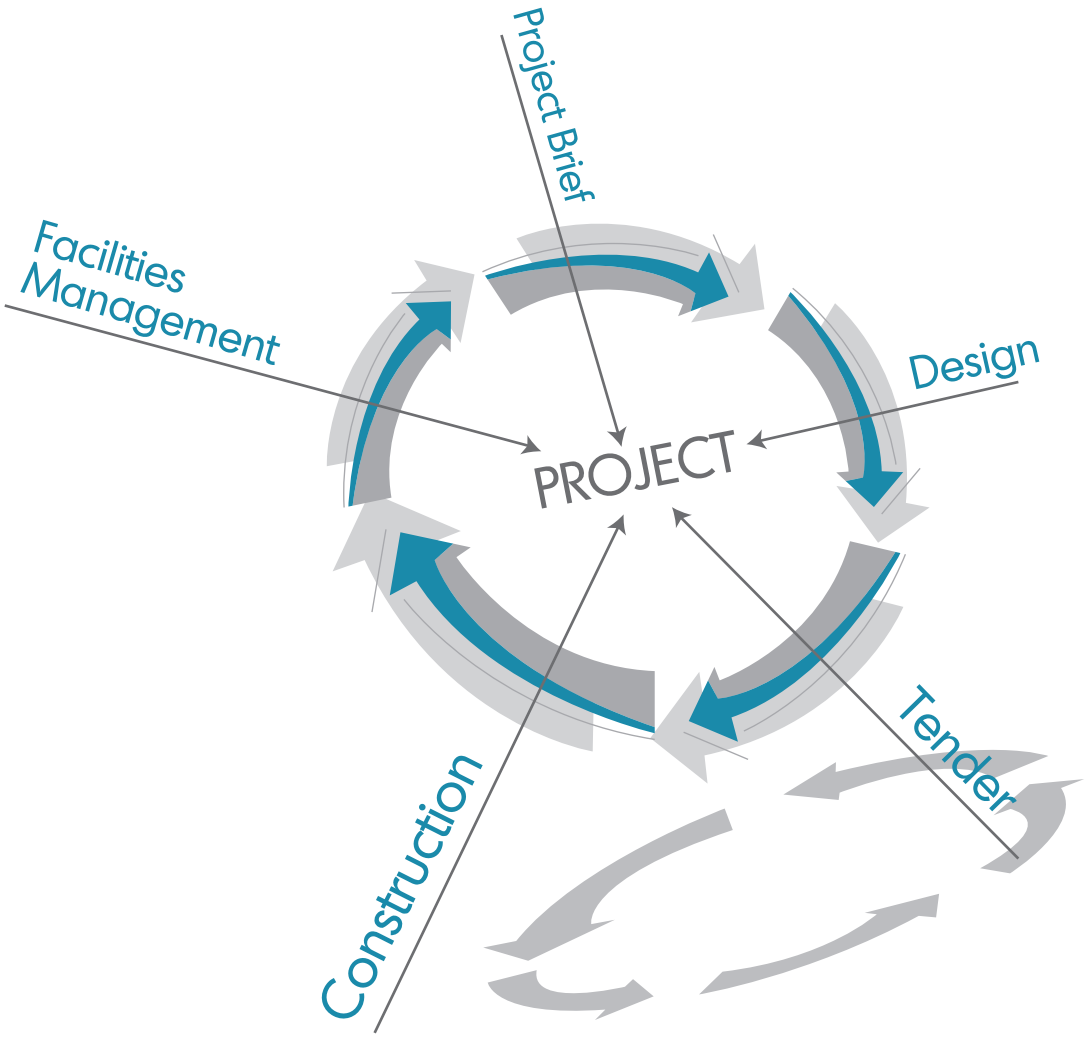
MCRJ Volume 18 | No.1 | 2016

ISSN 1985 - 3807

Malaysian Construction Research Journal



CREAM
Construction Research Institute of Malaysia

CIDB MALAYSIA

MALAYSIAN CONSTRUCTION RESEARCH JOURNAL (MCRJ)

Volume 18 | No. 1 | 2016

The Malaysian Construction Research Journal is indexed in

Scopus Elsevier

ISSN No.: 1985 - 3807

Construction Research Institute of Malaysia (CREAM)
MAKMAL KERJA RAYA MALAYSIA
1st Floor, Block E, Lot 8, Jalan Chan Sow Lin,
55200 Kuala Lumpur
MALAYSIA

Contents

Editorial Advisory Board

Editorial

Welcome from the Editors

Welcome to the eighteenth (18th) issue of Malaysian Construction Research Journal (MCRJ). We are pleased to announce that MCRJ will be published three volume per year, starting from 2016. We would like to express our sincere gratitude to our reviewers, contributing authors, and readers for their continuous support to MCRJ. We look forward to publish more high quality research papers in the coming volumes.

The 18th MCRJ features ten (10) interesting papers covering wide range of research area: five (5) quantitative analysis research papers; four (4) review papers, and one (1) technical paper. It is hoped that the readers will find informative articles from this edition of MCRJ.

In this issue:

Foo Chee Hung, *et. al.,* assess the readiness of Malaysian contractors towards trade liberalization through the respondents' level of awareness of FTAs, ability of local competition, and intention to export overseas. Besides, the relative advantage or disadvantage of the Malaysian construction industry in the global market is evaluated through the calculation of the Balassa's Revealed Comparative Advantage Index (RCA).

Nor Asma Hafizah Hadzaman, *et. al.,* investigate the processes of Building Information Modeling Execution Plan (BEP) and the strategies to implement BIM in mega construction projects. The results of the research provide an insight into the Malaysia construction projects and will provide a valuable guideline in managing BIM for Mega construction projects.

Through questionnaire survey, **Anuar Alias and Azlan Shah Ali** identify five dimensions of issues surrounding highland development, and two main control mechanisms. The associative test revealed that there were significant relationships between control mechanisms and the challenges of highland development, which indicates the effectiveness of these mechanisms in addressing current problems.

Hamimah Adnan, *et. al.,* conduct a partnering research that focused on small-sized contractors, in order to ascertain the partnering concept, as well as to identify the problems and effects as perceived by the small-sized contractors from the Malaysian's perspective.

Mastura Jaafar, *et. al.*, measure the satisfaction level of professional women in work-life balance in order to examine the obstacles faced by women professional quantity surveyors in the Malaysian construction industry.

Through literature review and modified Delphi questionnaire, **Mohd Fairullazi Ayob and Khairuddin Abdul Rashid** attempt to identify the most appropriate methodology for investigating the quality of cost data inputs in Life Cycle Cost (LCC) analysis for building works in the Malaysian construction industry.

Mohd Zamri Ramli and Azlan Adnan review back the problems and design of the bridge under seismic effect in Malaysia. They found that bridge inspection identifies the current conditions and the problems in the bridge but seismic vulnerability identifies the expected potential of seismic hazards of a bridge due to lateral seismic forces. Since the effects of the Sumatran earthquakes toward Malaysian bridges are still questionable, modifications to the current code of practice are necessary, as well as the inclusion of a proper site-inspection and post-earthquake inspection.

Khairuddin Abdul Rashid and Samer Shahedza Khairuddin review the evolution of the Malaysian systems of registration of contractors and the newly introduced One Registration System for Contractors (1RoC). The review mainly focuses on the registration system working process, the migration from previous dual system of registration to the 1RoC, and the benefits of the 1RoC to the contracting services and the construction industry of Malaysia.

Through conducting content analysis of past studies, **Samer Shahedza Khairuddin, *et. al.,*** attempt to provide a better understand on the competency levels of QSs in relation to Private Finance Initiative (PFI) services.

Mohamad Nazli Md Jamil and Norazura Muhamad Bunnori investigate the reuse of sewage sludge ashes (SSA) as a natural admixture to the cement mortar in varying incinerated temperature. Several tests were performed to measure the physical and chemical properties of the cement mortar. It is revealed that the optimum incinerated temperature for SSA is at 900^{o}C as it had preferable flow value, high in compressive strength, low in water absorption, and low in heavy metal concentration.

Editorial Committee

A STUDY ON THE READINESS OF MALAYSIAN CONTRACTORS TOWARDS TRADE LIBERALIZATION

Foo Chee Hung[1], Zuhairi Abd. Hamid[1], Cheng Ming Yu[2], Zainora Zainal[3], and Nurul Hayati Khalil[3]
[1] Construction Research Institute of Malaysia (CREAM), Makmal Kerja Raya Malaysia, CIDB Wilayah Persekutuan, 1st Floor, Block E, Lot 8, Jalan Chan Sow Lin, 55200 Kuala Lumpur, Malaysia.
[2] Universiti Tunku Abdul Rahman, Sungai Long Campus, Lot PT 21144, Jalan Sungai Long, Bandar Sg. Long, Cheras, 43000 Kajang, Selangor, Malaysia.
[3] International Unit, Construction Industry Development Board, (CIDB), Menara Dato' Onn, Level 33B, PWTC, Kuala Lumpur 50480 Malaysia

Abstract
Malaysia is committed under various trade and economic agreements. In line with the ASEAN Framework Agreement of Services (AFAS), the country's construction sector is earmarked for full liberalization in 2015. While the introduction of liberalization policies may increase the productivity and create a healthy competition between the leading domestic and international construction industry, unpleasant speculation is rising among local contractors as they felt that domestic players may not be able to stand a chance for their business survival. As such, the present study was conducted: (i) to evaluate the level of readiness of local contractors towards liberalization, and (ii) to identify challenges and opportunities of liberalization on local contractors. The findings reveal that the respondents' readiness towards trade liberalization can be categorized with respect to the level of awareness of FTAs, ability of local competition, and intention to export overseas. Most of the respondents (62.3%) were found not aware of the FTAs, but with the opinion that local contractors are able to compete in local market when the market is opening up, and having no plan to export their services within the next three years. Such confidence was mainly built upon the advantage local contractors enjoy in domestic market due to their knowledge of the domestic market and superiority in relationship with government and firms. Low awareness of FTAs and inspiration among respondents to venture into international market are mainly due to the lack of connection and information about overseas markets, particularly the requirements and acceptance of local workmanship quality, as well as lack of international exposure are the main constraints contributed to the low motivation of venturing out of their comfort zone.

Keywords: *Construction; Contractors; Liberalization; Malaysia, Readiness.*

INTRODUCTION

Liberalization refers to the relaxation of laws or rules by a government. In the arena of international trade, liberalization means the removal or reduction of restrictions on the free exchange of goods between nations. Malaysia is considered as a great beneficiary of trade liberalization as it is offered the opportunities to access to a large international market ever since various trade and economic agreements were concluded, signed, and implemented by the country. International trade is an important contributor to Malaysia's economic growth with exports contribution amounting to 97% of its GDP (EPU, 2012). Many Malaysian companies from various sectors (i.e. oil and gas services sector, education, aviation, health, and other professional services) have successfully ventured into global markets. The financial sector, for example, has evolved into a new level of performance through liberalization, with many key achievements such as the consolidation and rationalization of the banking industry, diversification of the financial sector with a deep and liquid debt securities market, and the strengthening of corporate governance and risk management practices, as compared to its previous performance which used to be characterized as having a fragmented banking system

and poorly developed bond market (Bank Negara Malaysia, 2012). The success of the market-oriented growth strategies has led the country to direct its trade policy towards creating a more liberalized and fair global trading environment.

However, as like many other developing countries, liberalizing the construction sector is still a challenging issue for Malaysia to deal with. Considering its position and role in the development process, the construction industry's competitiveness has become a deep concern of most developing countries. For centuries, the construction industry has played a key role in the socio-economic development of all countries, ranging from providing infrastructure support to factors of production for other economy sectors (Maznah et al., 2006). It is especially so in the case of developing countries as construction industry is responsible for the provision of infrastructure, road, bridges, water, sewerage, electricity, telecommunications, and shelter (Gubago, 2000). A review of the world construction market shows that international contracting organizations, which mainly consist of contractors from the major industrialized countries, are occupying an increasingly dominant role in the international construction markets. Although some developing countries have been exporting construction services successfully and have attained a certain competitive advantage, they still have extremely limited success in penetrating the markets of developed countries. Factors that seriously affect the competitiveness of developing countries as well as their access to the world construction markets are such as the rapidly changing economic environment, privatization of public utilities, internationalization of production, diminishing financial assistance from the government, weak domestic banking systems etc. (UNCTAD, 2000). Besides, construction markets are particularly unpredictable, making planning to penetrate foreign market more difficult. Firms attempting to export services must conform to numerous regulations, including the use of land, building regulations, technical requirements, building permits and inspection, registration of proprietors, contractors and professionals, regulations of fees and remunerations, environmental regulations, and even fiscal policy measures (UNCTAD, 2000). Despite the increasing competition and the growing technical sophistication of the world construction process, there still exist several reasons for construction companies to expand their business into international market. Among these reasons are such as the stagnant domestic markets, spreading risk through diversification into new markets, competitive use of resources, and taking advantage of the opportunities offered by the global economy (Maznah et al., 2006). Similarly, Ahmad and Kitchen (2008) and Ragayah (1999) have also pointed out that the major reasons for a company to expand internationally are to find new markets for growth, overcome import restrictions, and barriers of the host country, diversify risks, and seek and obtain cheaper resources abroad.

Being position as a growth enabler in other sectors, the Malaysian construction industry is generally perceived as under achieving, with low profitability, does not invest enough capital in training, research and development, and lack of competitiveness against international top industry leaders. It has also been said not to spread good practices and lack of the adoption of information and communications technology (ICT). The introduction of liberalization policies is seen as a shift towards attracting more inward investment and foreign companies into the country, as to heighten the image, productivity, and efficiency of the construction industry. Under the ASEAN Framework Agreement of Services (AFAS), a targeted timeline for liberalizing the construction sector is set, where 51% and 75% of the equity liberalization

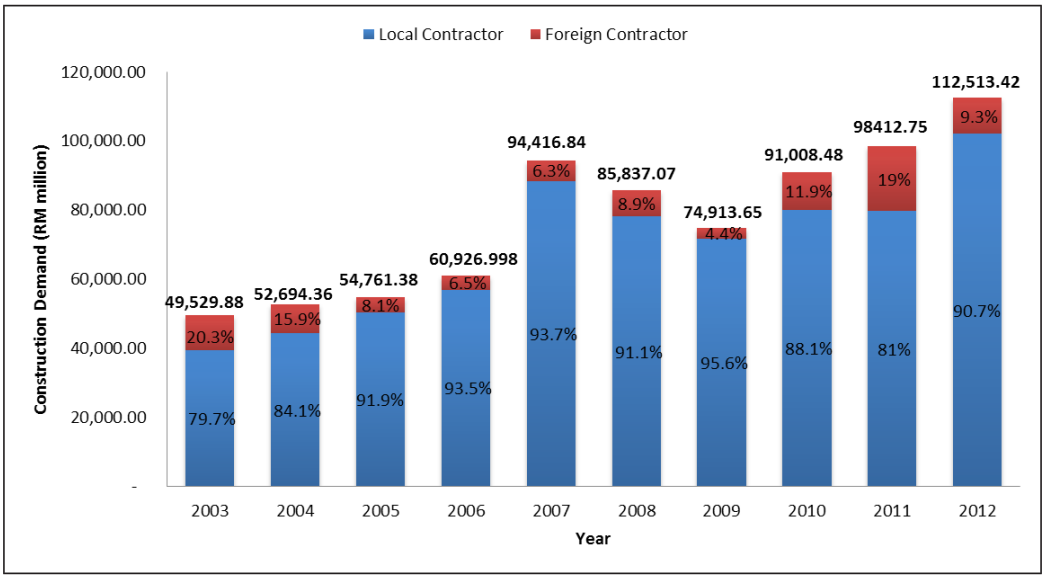
were expected to achieve in 2008 and 2015, respectively (MITI, 2011). Although such move deems to further stimulate the growth of the country's construction industry, arguements arise that opening up the market to international competition would place the country's construction industry in a lucrative target that might benefit the strong players but jeopardise the growth potential of the domestic market. To ensure liberalization meets its initial objectives while minimizing any undesirable outcomes, it is necessary to identify the domestic preparedness to the international competition. The present study, thus, strives (i) to evaluate the level of readiness of local contractors towards trade liberalization; and (ii) to identify challenges and opportunities brought by liberalization to the local contractors.

STUDY BACKGROUND

The Status of Malaysian Construction Market

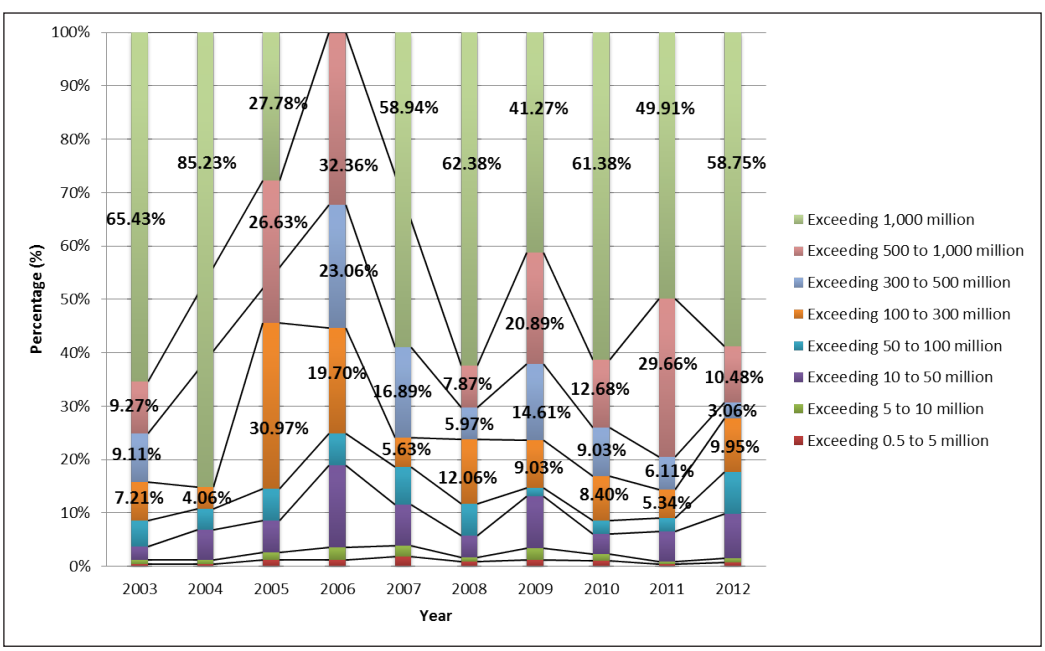
Historical statistics show that the Malaysian construction market is competitive with local companies taking the lead. Foreign contractors only account for a small portion of the market. For example, in 2012, the share of project value awarded to foreign contractors was 9.3%, as compared to 90.7% awarded to the local contractors, with projects totalling RM112.5 billion (Figure 1). This is because of the equity conditions applied to foreign players based on different trade agreements and other operational barriers to entry, such as access to business and project financing, lack of track record in the successful past completion of local projects, availability of manpower, etc. Besides, Malaysian contractors have gained high reputation in general construction works (i.e. building, road, highways, bridges etc.) due to their experiences and active involvement in the domestic mega projects (Mustaffa et al., 2012). International tenders will only be invited for projects that are of high value, more complexes, technology-driven, and require application of project management skills of international standard (i.e. projects for oil refineries, power plants etc.) which local expertise and capability are not available.

A closer look at the breakdown of projects (based on value range) may find that foreign contractors normally involve in projects valued RM500 million and above. In fact, projects with value range exceeding RM500 million to RM1, 000 million consists of about 15% of the total awarded project to foreign players, while projects with value range exceeding RM1, 000 million accounts for nearly 51% (Figure 2). This is in contrast to the local contractors, where they mostly involve in projects valued from RM0.5 million to RM300 million. Approximately 31% of the projects undertaken by local contractors came from those with value range exceeding RM10 million to RM50 million. Projects with value range exceeding RM50 million to RM100 million and RM100 million to RM300 million contribute about 14.4% and 17.6%, respectively (Figure 3). Among the foreign contractors that involved in local construction work, East Asia (i.e. Japan (24%), China (19%), and Korea (18%)) have been covering a significant portion of work awarded, followed by Germany (10%), Switzerland (7%), and India (5%) (Figure 4). Hong Kong and Taiwan are the other two East Asia countries that contribute about 2% each to the total foreign involvement in local construction work. Among the ASEAN countries, Singapore (4%) and Thailand (1%) are actively involving in the Malaysian construction work.



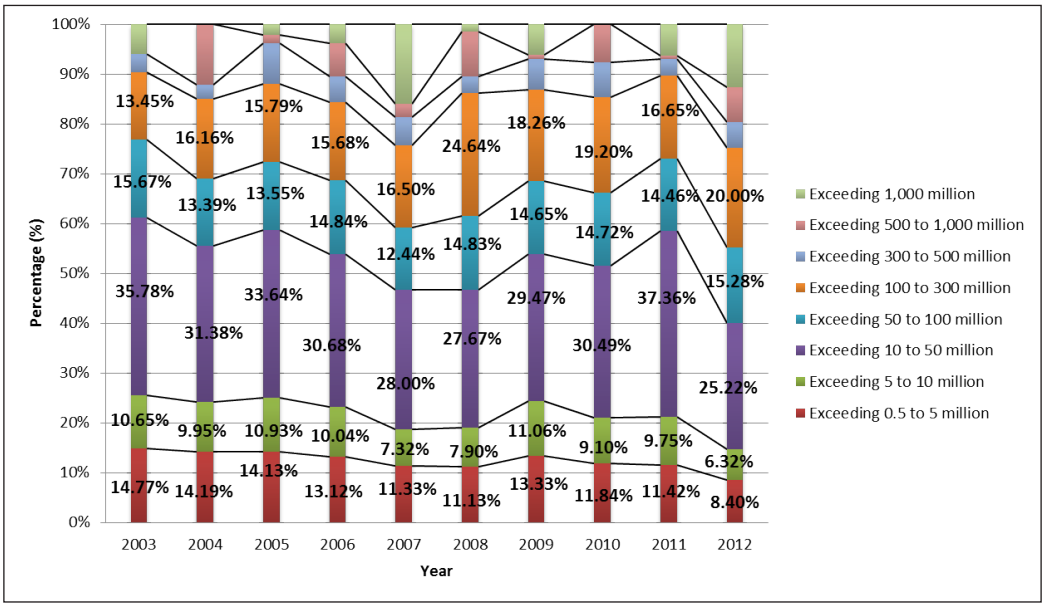
(*Data source: CIDB Construction Quarterly Statistical Bulletin; Own calculation*)

Figure 1. Percentage of project value awarded to local and foreign contractors



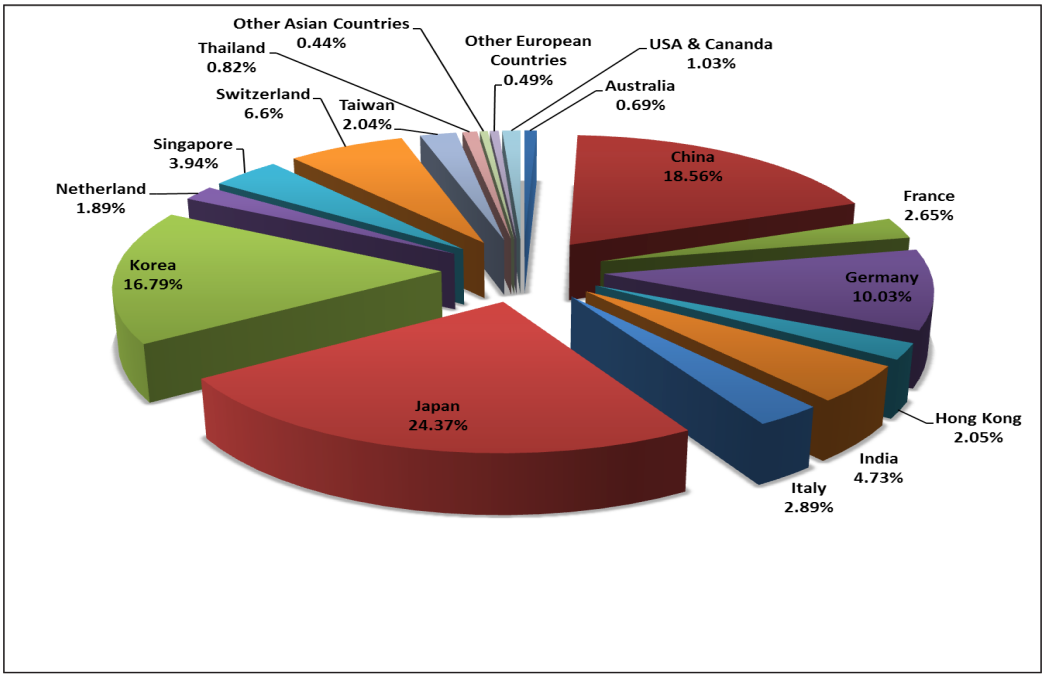
(*Data source: CIDB Construction Quarterly Statistical Bulletin; Own calculation*)

Figure 2. Share percentage of construction project with different value range undertaken by foreign contractor, 2003 – 2012



(*Data source: CIDB Construction Quarterly Statistical Bulletin; Own calculation*)

Figure 3. Share percentage of construction project with different value range undertaken by local contractor, 2003 – 2012

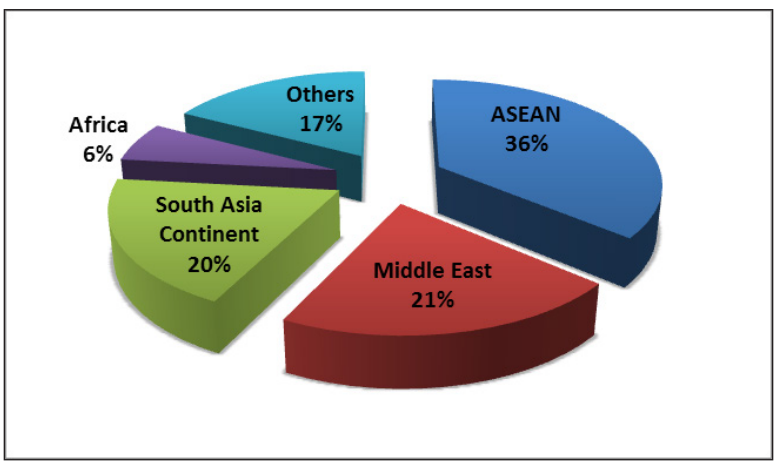


(*Data source: Unpublished data from CIDB IT Department*)

Figure 4. The involvement of foreign contractors in local construction work based on value of project awarded, 2007 – 2012

The Status of Malaysian Contractors in International Market

In terms of business expansion, the Malaysian contractors have a regional focus with ASEAN countries being the main market. The local contractors also make their presence in Middle East, South Asia, and Africa (Figure 5). Some of them even involved with projects in countries like Bosnia, China, Mongolia, Papua New Guinea and Hong Kong. The types of construction project awarded to Malaysian companies cover a wide range, with highway, building, power plant, residential, and mixed development being the top five overseas projects that contribute to more than RM65,000 million (Table 1).



(*Data source: CIDB International Project Database*)

Figure 5. Percentage of projects undertaken by Malaysian contractor in various regions as of March 2013

Table 1. Summary of overseas project by category as of March 2013

Category	Total Project	Project Value (RM million)
Highway	77	17,433.20
Building (Institution, recreation/sport, automation system, commercials)	139	13,400.88
Power plant	16	12,807.87
Residential	55	11,745.24
Mixed development	22	10,256.40
Water treatment system	45	4,969.58
Airport	27	3,726.42
Structural frame	81	3,321.45
Jetty/pot	11	3,051.21
Railway	9	2,873.30
Oil 7 gas	43	2,808.43
Mechanical & electrical	68	2,149.92
Road	33	595.35
Power transmission	23	454.24
Bridge	7	341.51
Telecommunication	2	134.78
Tunnel	6	123.21

Heavy engineering	10	119.35
Geotechnical	7	69.72
Landscape	1	69.72
Flood/disaster	2	9.80

(*Data source: CIDB International Project Database*)

Up to March 2013, there have been 115 companies venturing into overseas market (CIDB International Project Database), providing services to 50 countries, as compared to year 2010, where 109 Malaysian companies involved in overseas projects originated from 49 countries (Musttafa et al., 2012). However, a declining participation of local contractors in the global market is observed. A total of 59 projects were undertaken by Malaysian contractors in 2006 and the number has declined to only 5 projects in 2012 (Table 2). On a positive note, the declining trend does not indicate a lack of competencies on the part of domestic firms, but rather a softening that has been experienced by major markets around the world. While many trade liberalization efforts have been taken over the years, the construction services sector has not shown big improvement in terms of the participation in global market. Based on a simple analysis of the focus of Free Trade Agreements (FTAs), most trade liberalization initiatives have not involved the sector's major export markets – apart from countries in the ASEAN region. Major markets, such as the Middle East, have not been part of any trade liberalization efforts, while liberalization efforts with India only began in 2011. In addition, Malaysian construction companies have been performing well in these markets even without trade liberalization efforts, as demonstrated by the capture of RM13.736 billion in projects from the Middle East in 2007 (EPU, 2012).

Table 2. Number of projects undertaken by Malaysian Contractors in the global market, 2006 – 2012

Country/Region	2006	2007	2008	2009	2010	2011	2012
ASEAN	13	20	7	2	12	2	-
India	9	8	1	2	3	2	-
Middle East	25	29	24	29	4	1	5
Africa	2	-	3	-	-	-	-
Others	10	17	20	5	5	4	-
Total	**59**	**74**	**55**	**38**	**24**	**9**	**5**

(*Source: Adapted from CIDB Construction Quarterly Statistical Bulletin*)

METHODOLOGY

A combination of research techniques is used to achieve the study objectives. Macro Scale Analysis was performed by calculating the Revealed Comparative Advantage Index (RCA), while Micro Scale Analysis was accomplished through informal interviews with respective industry players, focus group discussion, and questionnaire survey. The collected data were then integrated and analysed to draw conclusions.

Macro Scale Analysis

The relative advantage/disadvantage of the Malaysian construction industry in the

global market is assessed through Balassa's Revealed Comparative Advantage Index (RCA). According to Balassa (1965), the comparative advantage of a nation can be revealed from the nation's trade performance, by comparing the relative shares of a country's exports of a particular commodity/service to the world exports. In general, trade benefits countries that specialized in the production of goods and services with the lowest opportunity costs. A country is said to have the comparative advantage in the production of a good/service if that country is able to produce the said product/service at a cost (opportunity cost) lower than others. Empirically, RCA is expressed as in Equation 1. The numerator represents the percentage share of a given service sector in national exports, while the denominator represents the percentage share of a given service sector in world exports. A country's comparative advantage is revealed if RCA > 1, which means the exports share of country *i* in commodity *j* is higher than the share of commodity *j* in the world total exports. A country is said to have a weak comparative advantage when the calculated RCA is between 1 and 2, while a country has a strong comparative advantage when the RCA is between 2 and 3. By having a RCA above 3, a country is said to have a very strong comparative advantage.

Equation 1. Revealed Comparative Advantage Index (RCA)

$$RCA = \frac{\frac{x_{ij}}{X_i}}{\frac{x_{wj}}{X_w}} = \frac{\text{percentage share of exports of commodity j from country i}}{\text{percentage share of exports of commodity j from the world}}$$

Interpreting a country's comparative advantage depends on which measures to be used. Although the standard measure of RCA totals sector *i* over all trade exports (merchandise and services), there are other RCA measures which the differences lay in the summation of the different sectors. One of the measures totals sector *i* over all service exports (excluding the merchandise), while the other one totals sector *i* over gross domestic product (GDP) of the given country. For example, China, a big export country, may report a comparative advantage in construction sector when RCA that totals construction sector over all service exports (excluding merchandise). However, due to the size of China's merchandise trade, the respective comparative advantage is diminished when service exports are weighted by total trade (merchandise and services). In the present study, two types of RCA measure were presented: (1) the one weighted by total trade (merchandise and services); and (2) the one weighted by overall service exports (excluding the merchandise). With reference to these two types of RCA, the present study allows for a more nuanced understanding of the role that construction services export play in the country's economy.

For the calculation of RCA index, data of world services exports for a period of 12 years (2000 – 2012) were collected from the United Nations Conference on Trade and Development (UNCTAD) database for all 11 categories. Table 3 lists the countries for which RCA are calculated. To note, only upper-middle income (with GNI per capita between $4,086 and $12,615) and high income countries (with GNI per capita $12,616 or more) are included in the calculation, while the low income (with GNI per capita $1,035 or less) and lower middle income countries (with GNI per capita between $1,036 and $4,085) are excluded, as to avoid any confusion happens to the RCA ranking due to the inclusion of countries with relatively

lower services export in general (i.e. Laos, Myanmar). Besides, low income countries do not often possess completed set of data across all eleven services sectors, which in turn may lead to a higher ranking in those sectors for which data are available.

Micro Scale Analysis

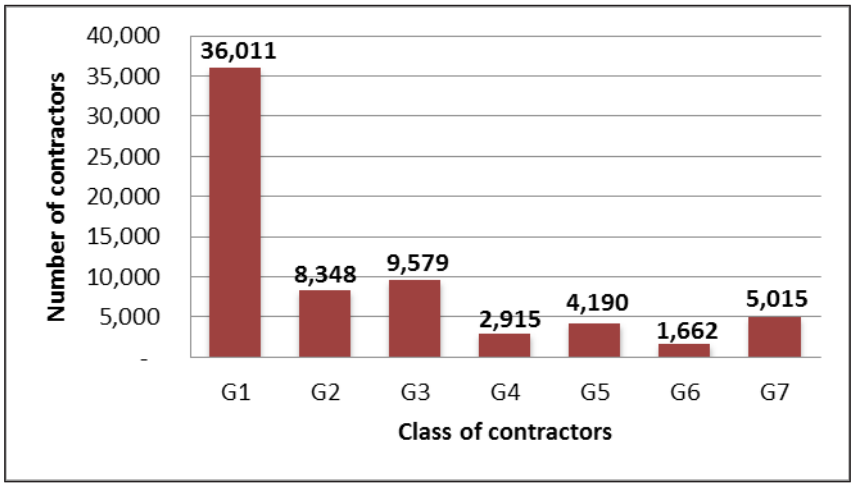
A structured questionnaire was designed to study the perception of local contractors towards trade liberalization. The level of readiness was assessed from the perspectives of (i) Awareness – understanding on the concept of liberalization (in terms of Free Trade Agreements (FTA)), (ii) Competition – ability to compete with foreign contractors in local market, and (iii) Intention – planning to export construction services. The first part of the questionnaire covers the contractors' profile, such as services provided by the company, year of establishment, number of employee etc. The second part asked about the contractors' awareness of FTAs and the utilization of FTAs in exporting services to overseas. The third part consists of questions on preparedness with regard to the competition from foreign players, benefits and challenges that the contractors perceived with respect to the trade and liberalization in construction industry. In the fourth part, the respondents were asked whether they are exporting their services to overseas, intention to provide services to other countries in the next three years, and their agreement/disagreement on statements regarding the benefits and challenges of going abroad. The response formats include both open and close-end. The close-end questions were either in multiple choices or in ranking scale (a 5-point Likert scale).

Among the seven classes of contractor (Table 3), only G5, G6, and G7 contractors were covered in the survey, with a total population of 10,867 (Figure 6). G1 to G4 contractors were omitted because they normally do not export their services to overseas. Besides, they mainly involve in projects with value ranges from RM0.5 million to RM5 million, which are seldom undertaken by the foreign contractors. G5 to G7 contractors, on the other hand, are the major player for projects with value ranges from RM5 million and above, and they are likely to be affected following the trade liberalization in the construction industry. In order to achieve 90% confidence levels and maintain 3% margins of sampling errors, which is the accepted confidence interval and sampling error in research surveys, 400 local contractors were surveyed. The survey data were analysed using the Statistical Packages for Social Sciences (SPSS). Among the statistical tests to be applied in this study are: frequency analysis, crosstab analysis, Kruskal Wallis test, Mann Whitney U, and Spearman correlation. The Relative Importance Index (RII) (Equation 2) was used to rank statements with 5-point Likert scale, while the average index analysis (Equation 3) was applied to obtain the average level of competitiveness among surveyed respondents (Table 4).

Table 3. Status of contractor under CIDB registration grade

Grade	Limit for tender
G1	Not exceeding RM200,000
G2	Not exceeding RM500,000
G3	Not exceeding RM1 million
G4	Not exceeding RM3 million
G5	Not exceeding RM5 million
G6	Not exceeding RM10 million
G7	No limit

(*Source: Construction Industry Development Board Malaysia (CIDB)*)



(*Data source: CIDB Construction Quarterly Statistical Bulletin*)

Figure 6. Total number of registered contractors as of 31st December 2012

Equation 2. Relative importance index (RII)

$$RII = \frac{\sum w}{An}$$

Where:

w = Weight given to each factors by the respondent

A = The highest weight in this study, which is 5

n = The total number of sample

RII = The relative important index, 0<RII<1

Equation 3. Average index analysis

$$\text{Average Index} = \frac{\sum (1x_1 + 2x_2 + 3x_3 + 4x_4 + 5x_5)}{N}$$

Where:

x_1 = Number of respondents for Not Important/Strongly Disagree

x_2 = Number of respondents for Less Important Disagree

x_3 = Number of respondents for Average/Fair

x_4 = Number of respondents for Important/Agree

x_5 = Number of respondents for Very Important/Strongly Agree

Table 4. Average Index interpretation table

Average Index	Level of competitiveness
0.00 ≤ Average Index < 1.50	Low
1.50 ≤ Average Index < 2.50	Medium-low
2.50 ≤ Average Index < 3.50	Medium
3.50 ≤ Average Index < 4.50	Medium-high
4.50 ≤ Average Index ≤ 5.00	High

RESULTS

Comparative Advantage of the Malaysian Construction Sector

A snapshot of the 2011 country rankings of construction service exporters is provided, instead of 2012, since most countries reported data for that year. Both Table 5 and Table 6 report the RCA ranking of upper-middle income to high income countries for construction industry in 2011, where the construction services were weighted against total exports (merchandise and services) and against all services exports (excluding merchandise), respectively. Some countries are excluded in the ranking because not all countries involve in construction services export. A completed set of RCA figures, from year 2000 to 2012, are available in appendix. When ranking was done based on total trade (merchandise and services), Malaysia was placed at 39th (Table 5), while a higher place was achieved (27th) when only services exports were considered (Table 6). Such ranking pattern is common for countries that actively involved in mass merchandise export because countries with relatively large resource or merchandise export may lose ground in the RCA ranking (weighted by total trade) as their services exports are relatively lesser than goods exports. A typical example can be observed through the RCA rankings of China and Russia, where both these countries have shown tremendous improvement when the calculation of RCA is excluding the goods exports.

In general, RCA ranking provides an indication of the relative importance of construction services export for the entire economy of a country. Based on the two RCA rankings, Malaysia's construction services export is ahead of other ASEAN countries (Table 7). Coincidently, these countries are also the major market for Malaysian contractors. On the other hand, the country's construction industry is still lagged behind as compared to those from the East Asia countries, particularly Japan, China, and Korea, as players from these countries have been penetrating local market successfully through involving in projects with a wide range of value.

Table 5. Countries' RCA (weighted by total trade) ranking for construction industry, 2011

Rank	Country	RCA		Rank	Country	RCA
1	Korea, Republic of	5.079		36	Belarus	1.068
2	Montenegro	4.953		37	French Polynesia	1.046
3	Lebanon	4.214		38	Luxembourg	0.929
4	Greece	4.076		**39**	**Malaysia**	**0.904**
5	Albania	3.919		40	Netherlands	0.851
6	Finland	3.866		41	Sweden	0.743
7	Serbia	3.602		42	Lithuania	0.742
8	Tunisia	3.425		43	United Kingdom	0.741
9	Estonia	3.225		44	Slovakia	0.719
10	Faeroe Islands	2.887		45	Austria	0.707
11	Curaçao	2.816		46	Hungary	0.705
12	Sint Maarten (Dutch part)	2.760		47	Azerbaijan	0.614
13	Japan	2.541		48	Bulgaria	0.481

Rank	Country	RCA		Rank	Country	RCA
14	France	2.530		49	Singapore	0.459
15	Bosnia and Herzegovina	2.476		50	Saint Kitts and Nevis	0.451
16	New Caledonia	2.464		51	Denmark	0.392
17	Israel	2.236		52	Thailand	0.358
18	Spain	2.036		53	Algeria	0.351
19	Portugal	1.984		54	United States	0.317
20	Iceland	1.859		55	Norway	0.285
21	Mauritius	1.803		56	Botswana	0.251
22	Bermuda	1.767		57	China, Taiwan Province of	0.213
23	China	1.526		58	Canada	0.172
24	Poland	1.507		59	South Africa	0.114
25	Turkey	1.475		60	Argentina	0.095
26	Germany	1.462		61	Kazakhstan	0.095
27	Croatia	1.445		62	China, Hong Kong SAR	0.058
28	Belgium	1.422		63	Trinidad and Tobago	0.058
29	Romania	1.365		64	Australia	0.051
30	Slovenia	1.307		65	Aruba	0.050
31	Russian Federation	1.173		66	Italy	0.037
32	Latvia	1.146		67	New Zealand	0.017
33	Czech Republic	1.144		68	Panama	0.016
34	Cyprus	1.100		69	Brazil	0.013
35	TFYR of Macedonia	1.075				

(*Data source: UNCTAD; Own calculations*)

Table 6. Countries' RCA (weighted by overall service exports) ranking for construction industry, 2011

Rank	Country	RCA		Rank	Country	RCA
1	Korea, Republic of	6.362		36	Netherland	0.767
2	China	3.268		37	Latvia	0.767
3	Faeroe Islands	3.237		38	Botswana	0.652
4	Russian Federation	3.125		39	Sint Maarten (Dutch part)	0.608
5	Japan	2.948		40	Mauritius	0.591
6	Tunisia	2.934		41	Singapore	0.556
7	Bosnia and Herzegovina	2.745		42	Croatia	0.544
8	Finland	2.531		43	Austria	0.490
9	Estonia	2.388		44	Sweden	0.476
10	Serbia	2.357		45	Norway	0.471

Rank	Country	RCA		Rank	Country	RCA
11	New Caledonia	1.910		46	Bulgaria	0.417
12	Germany	1.811		47	Thailand	0.416
13	Romania	1.781		48	Kazakhstan	0.378
14	Poland	1.680		49	United Kingdom	0.353
15	Belarus	1.675		50	Bermuda	0.344
16	France	1.660		51	China, Taiwan Province of	0.297
17	Slovakia	1.626		52	Cyprus	0.244
18	Azerbaijan	1.616		53	French Polynesia	0.236
19	Montenegro	1.495		54	Luxembourg	0.214
20	Israel	1.464		55	Canada	0.211
21	Czech Republic	1.449		56	Denmark	0.201
22	Algeria	1.389		57	United States	0.199
23	Albania	1.363		58	South Africa	0.172
24	Slovenia	1.276		59	Argentina	0.117
25	Greece	1.260		60	Saint Kitts and Nevis	0.114
26	Turkey	1.250		61	Iceland	0.097
27	**Malaysia**	**1.204**		62	Australia	0.058
28	Spain	1.171		63	China, Hong Kong SAR	0.047
29	Portugal	1.166		64	Italy	0.042
30	Belgium	1.153		65	Trinidad and Tobago	0.040
31	Lebanon	1.061		66	Aruba	0.039
32	TFYR of Macedonia	1.026		67	Brazil	0.019
33	Curaçao	0.955		68	New Zealand	0.015
34	Lithuania	0.916		69	Panama	0.010
35	Hungary	0.794				

(*Data source: UNCTAD; Own calculations*)

Table 7: RCA ranking for construction industry among ASEAN countries and several selected East Asia countries, 2011

Rank	Country	RCA (weighted by total trade)		Rank	Country	RCA (weighted by overall service exports)
1	Korea, Republic of	5.079		1	Korea, Republic of	6.362
2	Japan	2.541		2	China	3.268
3	China	1.526		3	Japan	2.948
4	**Malaysia**	**0.904**		**4**	**Malaysia**	**1.204**

Rank	Country	RCA (weighted by total trade)		Rank	Country	RCA (weighted by overall service exports)
5	Lao People's Dem. Rep.	0.881		5	Indonesia	1.043
6	Indonesia	0.504		6	Lao People's Dem. Rep.	0.856
7	Singapore	0.459		7	Singapore	0.556
8	Thailand	0.358		8	Thailand	0.416
9	Cambodia	0.220		9	China, Taiwan Province of	0.297
10	China, Taiwan Province of	0.213		10	Cambodia	0.148
11	Philippines	0.151		11	Philippines	0.102
12	China, Hong Kong SAR	0.058		12	China, Hong Kong SAR	0.047

(*Data source: UNCTAD; Own calculations*)

Contractors' Perception Towards Trade Liberalization

Among the survey respondents, 99.3% (or 397 companies) were Malaysian owned companies and 0.7% (or 3 companies) was joint venture with other Malaysian company. Most of the companies have less than 50 employees, with a revenue less than RM5 million. This implies that most of them are small and medium size enterprises (SME). Only 2% (or 9 companies) were currently exporting their construction services with market covering Singapore, China, India, Myanmar, Indonesia, Vietnam, Thailand, Pakistan, Australia, Korea and Japan.

The level of awareness of FTAs among respondents was rather low. Only 19.5% (or 78 respondents) were aware of FTAs that Malaysia has signed with other countries. Low awareness of FTAs was also observed among those who plan to export their services, in which 50 out of 83 respondents are not aware. The results show no significant differences among G5, G6, and G7 contractors but relatively more G7 contractors were aware of FTAs. Besides, there is no significant correlation between awareness of FTAs and having a membership of any industry/business associations/professional bodies. Such result indicates that Malaysian government agency still plays an important role in raising the awareness of FTAs as well as conveying message related to the impact of liberalization. Majority of the respondents reckoned the access to better technology or best practices from other countries as the most important benefit to be gained from liberalization (Table 8). Other benefits of liberalization that seem to be important to the respondents are such as the opportunity to expand business activities in other countries, and the improvement of local contractors' competitiveness in international market. The respondents viewed increasing competition for consumers in the local market from foreign companies as the most important consequence of liberalization (Table 9). They also concerned about increasing cost of operations for their companies as a result of liberalization.

Table 8. Ranking of main benefits to local contractors as a result of liberalization

Benefits	RII	Rank
Access to better technology	0.736	1
Business expansion	0.734	2
Improve the competitiveness of local contractors	0.731	3
Growth in revenues from services export overseas	0.724	4
Improvement of local construction industry	0.721	5
Address the issue of skills shortages	0.705	6

Table 9. Ranking of liberalization effects due to the opening of domestic construction industry

Challenges	RII	Rank
Increasing competition for local consumers	0.7455	1
Increasing cost of operations for local companies	0.7160	2
Increasing mobility of local skilled human capital	0.7155	3
Increasing competition for local skilled human capital	0.7055	4

By conducting the average index analysis, the respondents' perceived competitiveness level was found to be 3.65 (with maximum 5 point), which can be interpreted as medium-high level. Respondents were basically optimism in having the ability to compete with foreign players in the local market. In terms of the kinds of assistance needed by the local contractors to stay competitive against foreign players, majority of the respondents perceived that financial assistance in the form of public procurement was the most necessity (Table 10). Among the possible challenges that may be faced by local contractors in the process of liberalization are such as the limited financial resources, out-dated technologies, heavy reliance on government projects and foreign workers (Table 11).

Table 10. Assistance needed by the local contractors in order to be competitive against foreign players

Assistance	RII	Rank
Financial assistance (i.e. public procurements)	0.7660	1
Continued domestic protection through regulations	0.7535	2
Advice/guidance from professional bodies/industry associations	0.7365	3

Table 11. Existing limitations among local contractors which may affect their competitiveness in the process of liberalization

Limitations	RII	Rank
Limited financial resources	0.7710	1
Out-dated technology	0.7535	2
Heavy reliance on government projects	0.7535	2
Heavy reliance on foreign workers	0.7520	3
Lack of investment in R&D	0.7450	4
Low productivity	0.7410	5
Increasing cost of operation	0.7395	6
Lack of market information	0.7365	7
Lack of guidance and advice from experts	0.7285	8
Lack of skilled workers	0.7245	9

Throughout the survey, as high as 79% (or 313) of the respondents (mostly consisted of G5 contractors) are lack of intention to venture into overseas markets. For those who are planning to export their services, East and South East Asia, South Asia and Middle East are the three most preferred destinations. Among the barriers that holding back the local contractors for venturing into overseas market, lack of connection for market entry, lack of international experience and lack of information about overseas markets were perceived as the main obstacles for local contractors to explore and expand their businesses overseas (Table 12).

Table 12. Barriers to entry the international market

Limitations	RII	Rank
Lack of connection for market entry	0.7795	**1**
Lack of international experience	0.7720	**2**
Lack of information about overseas markets	0.7715	**3**
Lack of financial resources	0.7670	**4**
Lack of government support to explore new markets	0.7635	**5**
Lack of clear policy direction	0.7605	**6**
Lack of state-of art equipment	0.7575	**7**
Lack of investment in R&D	0.7475	**8**
Lack of quality products and services	0.7415	**9**
Lack of expertise	0.7390	**10**

In general, the respondents' readiness towards trade liberalization can be categorized based on the level of awareness of FTAs, ability of local competition, and intention to export overseas. Most of the respondents (62.3%) fell into the **No-Yes-No** group, which they are not aware of the FTAs, but with the opinion that local contractors are able to compete in local market when the market is opening up, and having no plan to export their services within the next three years (Table 13).

Table 13. Categorization of respondents based on the level of readiness

No Yes			Plan to export within the next 3 years		Total
Not Aware of FTA	Ability to compete in local market	**No**	23 (5.8%)	2 (0.5%)	25
		Yes	**246 (62.3%)**	48 (12.2%)	294
	Total		269	50	319
Aware of FTA	Ability to compete in local market	**No**	1 (0.3%)	2 (0.5%)	3
		Yes	42 (10.6%)	31 (7.8%)	73
	Total		43	33	76
	Grand Total		312	83	395

DISCUSSIONS

According to the Malaysia's most recent SME Annual Report, over 99% of all Malaysian companies were SMEs, while almost 87% of Malaysia's SMEs were service sector enterprises. SMEs are also at the core of the Malaysian construction industry, accounting for 90% of companies undertaking construction work (EPU, 2012). Following the increasing trend of globalization, these companies are inevitably facing the need to internationalize further, either to outgrow their domestic market or to face the growing foreign competition within their home market. In the domestic market, local construction companies are not 'under siege' structurally as it was thought. Instead, local contractors were more competitive given that a level of playing field was established in the domestic market, such as familiarity with the geography and supply chain. Besides, foreign contractors are normally perceived to involve in projects which local expertise is not available or required skills and technologies that are not affordable by the local players. Either as a norm in actual practice or subject to compulsory subcontracting to local subcontractors under the condition of FTAs, foreign players who are awarded project will outsource most portions of the work to local players, in order to cut cost and to maximize their profit of margin. Hence, local players are confident with their business survival as they perceived to compete with foreign players in different stages. More importantly, the public procurement and government expenditure in Malaysia is still high, covering the purchase of goods, payment for all kinds of services, and spending on a variety of projects, ranging from the building of schools and roads to billion-dollar mega-dams and industrial complexes. Although the government spending on construction projects has been declining in recent years, its role in maintaining the flow of national development projects (i.e. construction and maintenance of public infrastructure) and the sustainability of local construction companies is undeniable.

However, highly reliance on the domestic market has rendered local contractors' attempt to venture into foreign market. According to the EPU (2012), as high as 67.7% of the construction and related services companies were receiving less than 10% of their revenue by exporting services. In moving ahead with trade liberalization, it is crucial for the local players to get prepared their involvement in the global market. If "readiness" is to be assessed from the state of competitiveness performance of a construction company in penetrating global market, one may find that most of the local players are indicated to have low readiness level, especially those small and medium sized firms. These firms are not intending to enter the global market services because of the unsolved problems such as uncertainties of the market and the lack of resources. To be familiarized with the foreign culture is always a major risk for a company that venturing foreign market. It is also the main reason that many local players have been hold back as they are unable to deal with many issues such as the legal issues, land acquisition etc. In addition, it is rare for SMEs to possess formal risks management and mitigation (i.e. political risk, economic risk, technology risk, social risk) as compared to those large companies. Large firms may have the capacity to internationalize with an appetite for risk, but SMEs tend to struggle with internationalization as they do not have the balance sheet, the financial strength, or the time to seek overseas work.

Moreover, not all firms are ready for all the markets. The competition is always stiff in bidding for overseas projects as Malaysian construction comapnies needed to compete

with the well-established Japanese, Korean, United States, and European players. Only firms that offer services which are of high specification and demand to certain markets can make their business sustainable in those particular markets, because these firms will have: (i) better knowledge and information of foreign governments' policy of those countries that they enter; and (ii) better clientele in the market. For example, following the softening of the Middle East market, only those Malaysian construction companies that specialized in steel works can continue their good performance while most of the general works contractors are experiencing difficulty in that particular market. As such, one may conclude that most of the Malaysian construction companies possess low capacity of market penetration with regard to markets that demand for high specification and technology (i.e. Europe, East Asia). In contrast, they are quite ready for those markets that require large scale of general infrastructure development (i.e. ASEAN).

CONCLUSION

The present study evaluates the level of readiness of local contractors towards liberalization, and identifies challenges and opportunities of liberalization on local contractors. The findings reveal that the respondents' readiness towards trade liberalization can be categorized with respect to the level of awareness of FTAs, ability of local competition, and intention to export overseas. Most of the respondents (62.3%) were found not aware of the FTAs, but with the opinion that local contractors are able to compete in local market when the market is opening up, and having no plan to export their services within the next three years. Such confidence was mainly built upon the advantage local contractors enjoy in domestic market due to their knowledge of the domestic market and superiority in relationship with government and firms. Low awareness of FTAs and inspiration among respondents to venture into international market are mainly due to the lack of connection and information about overseas markets, particularly the requirements and acceptance of local workmanship quality, as well as lack of international exposure are the main constraints contributed to the low motivation of venturing out of their comfort zone.

Since not all firms are ready for all markets, a gradual liberalization measure may likely to inject some elements of competition and prepare suppliers to the domestic market. The commitments undertaken by Malaysia under the GATs and AFAS would eventually lead to a greater presence of foreign services providers in the country. This is envisaged as creating stiffer competition to local providers, but the extent of such competition would depend, in part, on the type, quality and price competitiveness of services offered by the foreign providers, as well as the preparedness of local contractors through capacity building and improving the method of construction. The construction industry needs to polish their skills to a higher level so that the opportunity to work with foreign companies can be improved. Similarly, the company's facilities and infrastructure including human resources platform must be prepared so that the transfer of technology through foreign investment and companies into the country will not be delayed or stalled.

At present, no detailed and specific condition is mentioned in the procurement with regard to the ways of foreign technology to be transferred, to what extent it should be conducted, how this technology is to be sustained in the future, and how it can be of useful in enhancing

the capabilities of local construction industry. Enhancement to the procurement process can be made by structuring the award that emphasizes the requirement of using Malaysian sub-contractors and products (i.e. building and construction materials, heavy equipment and machineries, etc.), the responsibility of foreign contractors in building up local contractors/ sub-contractors' specialization in niche areas. Besides, there is a need to put in place regular monitoring/audit to ensure that the planned knowledge sharing program is on-track and the expected technology transfer is met.

ACKNOWLEDGEMENT

The authors acknowledge the support given by the International Unit, Construction Industry Development Board (CIDB) for the provision of funding in undertaking the present study. Acknowledgements are also given to the IT Department, CIDB for providing data for analysis, as well as other parties that have been contributing their efforts to the success of this study.

REFERENCES

Ahmad S.Z., and Kitchen P.J. (2008). Transnational corporations from Asian developing countries: the internationalization characteristics and business strategies of Sime Darby Berhad, *International Journal of Business Science and Applied Management*, Vol. 3(2), pp. 22-36.

Balassa, B. (1965), Trade Liberalisation and "Revealed" Comparative Advantage. *The Manchester School*, 33: 99 – 123.

Bank Negara Malaysia (BNM). (2012). Financial Sector Blueprint 2011 – 2020. http://www.bnm.gov.my

Construction Industry Development Board (CIDB). International Project Database. https://www.cidb.gov.my/

Construction Industry Development Board (CIDB). Construction Quarterly Statistical Bulletin. https://www.cidb.gov.my/

Economic Planning Unit (EPU) Malaysia. (2012). Report of utilization of trade agreements amongst services firms – Study to assess impact of liberalization on the services sector.

Gubago, B. (2000). Developing Citizen Capacity in the face of globalization and foreign competition, *2nd International Conference on Construction in Developing Countries: challenges facing the construction industry in developing countries*, 15 – 17 November 2000, Gabarone, Botswana.

Maznah, C.M., Hamimah A., Rohani I.E., Noraliza B. (2006). Malaysian Contractors' Opinions Towards International Market Expansion, *International Conference in the Built Environment in the 21st Century* (ICiBE), 13th – 15th June 2006, Kuala Lumpur, Malaysia.

Ministry of International Trade and Industry (MITI). (2009). Liberalization of the services sector will not hamper Bumiputera participation in the services sector. http://www.miti.gov.my/

Ministry of International Trade and Industry (MITI). (2011). Liberalization of services under ASEAN Framework Agreement on Services (AFAS). Presentation Slides. 17th March 2011.

Mustaffa, N.K., Adnan, H. and Zakaria, M.Z. (2012). Entry strageties for Malaysian

construction related companies going abroad. *Australian Journal of Basic and Applied Sciences*, 6(6): 323 – 330.

Ragayah M.Z. (1999). Malaysian Reverse Investments: Trends and Strategies, *Asia Pacific Journal of Management*, Vol. 16(3), pp. 469-96.

United Nations Conference on Trade and Development (UNCTAD), http://unctadstat.unctad.org/

United Nations conference on Trade and Development (2000). Regulation and liberalization in the construction services sector and its contribution to the development of developing countries.

Appendix 1. Countries' RCA (weighted by total trade) for construction industry, 2000 – 2012

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Albania	-	-	-	0.665	0.518	0.343	0.218	0.512	1.127	1.575	1.581	3.919	1.530
Algeria	-	-	-	-	-	0.789	0.995	0.938	0.671	0.567	0.557	0.351	-
Argentina	-	-	0.127	0.279	0.381	0.224	0.079	0.115	6.430E-3	0.039	0.149	0.095	0.087
Armenia	-	0.310	2.115	2.178	2.795	1.742	1.491	1.308	1.514	0.904	0.838	0.732	0.696
Aruba	0.159	0.251	0.108	0.010	-	2.00E-3	0.053	0.279	0.077	0.249	0.730	0.050	-
Australia	0.091	0.162	0.191	0.168	0.169	0.160	0.140	0.076	0.052	0.071	0.062	0.051	0.033
Austria	1.811	1.908	1.535	2.140	1.978	1.424	1.224	1.315	1.313	1.175	1.132	0.707	0.761
Azerbaijan	0.629	0.703	0.623	0.294	0.572	0.261	0.706	0.406	0.599	0.113	1.002	0.614	1.329
Barbados	0.559	0.560	0.570	0.627	0.657	0.456	0.356	0.943	0.180	0.929	0.256	-	-
Belarus	1.479	1.362	1.405	1.297	1.275	0.772	0.486	0.618	0.482	0.443	0.987	1.066	1.225
Belgium	1.156	1.067	1.500	2.123	1.735	1.504	1.574	0.873	1.033	1.194	1.408	1.422	1.244
Bermuda	-	-	-	-	-	-	8.541	5.311	5.385	3.740	1.676	1.767	-
Bosnia and Herzegovina	12.367	11.966	8.799	12.710	11.061	9.858	10.280	7.948	6.249	6.220	5.447	2.476	-
Botswana	0.072	0.666	0.652	0.558	0.471	0.352	0.327	0.250	0.351	0.282	0.161	0.251	0.425
Brazil	0.928	0.063	0.039	0.028	6.189E-3	0.014	0.031	0.018	0.018	0.012	0.023	0.013	0.017
Bulgaria	1.929	2.377	1.907	1.938	2.205	1.489	1.866	2.171	1.577	2.904	1.307	0.481	1.680
Canada	0.178	0.143	0.078	0.072	0.084	0.099	0.122	0.131	0.081	0.134	0.159	0.172	0.090
China	0.580	0.691	0.810	0.662	0.558	0.724	0.587	0.833	1.211	1.1312	1.626	1.526	1.436
China, Hong Kong SAR	0.374	0.442	0.332	0.468	0.300	0.207	0.155	0.167	0.082	0.054	0.057	0.058	-
China, Taiwan Province of	0.186	0.169	0.151	0.169	0.183	0.126	0.136	0.148	0.149	0.199	0.221	0.213	0.263
Croatia	6.200	6.001	7.333	7.433	6.648	0.531	0.838	0.701	0.990	1.085	2.580	1.445	-
Cyprus	3.272	3.312	4.194	6.042	4.926	4.782	5.264	4.114	2.605	0.903	0.984	1.100	2.152
Czech Republic	1.251	0.972	0.633	0.495	0.380	0.665	0.502	0.545	0.619	0.656	1.413	1.144	1.252
Denmark	-	-	-	-	-	0.373	0.316	0.339	0.242	0.364	0.440	0.392	0.190

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Estonia	2.198	3.892	3.535	3.099	2.505	3.997	1.474	2.646	3.883	2.510	2.584	3.225	3.208
Faeroe Islands	2.119	1.623	2.295	1.631	2.439	1.096	1.569	1.735	0.332	1.519	1.308	2.887	-
Finland	2.191	1.907	1.115	1.584	2.455	1.621	0.835	0.780	1.905	2.285	2.216	3.866	-
France	2.035	1.861	1.861	1.511	1.482	1.511	1.526	1.575	1.604	2.526	2.492	2.530	2.213
French Polynesia	-	-	3.250	0.426	0.795	0.608	6.647E-3	2.864E-4	-	8.875E-3	0.291	1.046	-
Germany	1.816	1.632	1.670	2.032	1.682	2.124	2.113	1.786	1.709	1.531	1.500	1.462	1.267
Greece	2.120	1.740	1.461	1.321	1.110	1.296	1.221	1.130	0.900	1.052	2.290	4.076	3.043
Hungary	0.729	0.622	0.979	0.897	0.622	0.540	0.967	0.948	0.878	0.734	0.650	0.705	0.637
Iceland	0.169	0.032	0.095	0.891	0.113	6.582E-3	-	-	-	0.049	0.028	1.859	-
Iran (Islamic Republic of)	-	-	-	-	6.292	4.956	2.756	2.631	2.534	0.194	1.634	-	-
Israel	1.028	1.349	1.249	1.355	1.540	1.548	1.760	1.870	1.770	1.696	1.947	2.236	2.928
Italy	1.193	1.318	1.251	1.316	1.134	1.090	0.996	1.012	0.078	0.112	0.037	0.037	0.116
Japan	2.972	2.663	2.378	2.152	2.700	2.491	2.777	2.658	2.843	2.937	2.386	2.541	2.449
Kazakhstan	5.068E-3	0.044	0.022	0.306	0.036	0.015	0.018	0.021	0.042	0.020	0.066	0.095	0.039
Korea, Republic of	1.198	1.636	2.661	2.162	2.185	3.237	4.032	4.361	4.833	5.358	4.266	5.079	7.119
Latvia	1.091	0.929	0.406	1.677	1.934	0.439	0.646	0.919	1.125	0.535	1.211	1.146	1.602
Lebanon	-	-	-	-	-	5.891E-3	-	-	-	-	5.224	4.214	-
Lithuania	0.716	0.702	0.826	0.595	0.637	0.524	0.379	0.632	0.600	0.490	0.604	0.742	1.115
Luxembourg	-	-	0.951	1.131	1.226	1.215	1.136	1.196	1.267	1.009	1.085	0.929	0.802
Malaysia	**0.753**	**0.823**	**0.936**	**0.551**	**0.789**	**1.174**	**1.230**	**1.374**	**0.977**	**0.774**	**0.900**	**0.904**	**1.092**
Mauritius	0.956	0.302	0.497	0.259	0.331	1.491	1.003	0.351	0.366	0.272	1.377	1.803	-
Montenegro	-	-	-	-	-	-	-	-	7.437	4.188	4.552	4.953	5.292
Netherlands	2.703	3.117	2.326	1.372	1.329	1.465	1.050	0.911	0.918	0.878	0.912	0.851	0.865
Netherlands Antilles	4.384	5.889	5.497	2.082	1.695	2.087	2.995	3.823	3.237	2.420	2.381	-	-
New Caledonia	-	-	1.160	0.993	0.828	0.161	0.602	0.154	0.180	0.040	0.224	0.018	-

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
New Zealand	0.110	0.223	0.204	0.403	0.313	0.279	0.067	0.042	0.045	0.056	-	0.017	-
Norway	0.235	0.280	0.263	0.319	0.266	0.445	0.478	0.404	0.396	0.424	0.363	0.285	-
Panama	-	-	-	-	-	-	-	8.378E-3	0.027	0.013	0.017	0.016	0.030
Poland	1.725	2.093	2.296	2.524	1.725	1.794	2.009	1.926	1.664	1.389	1.303	1.507	1.587
Portugal	1.188	1.393	1.307	1.691	2.042	1.582	1.922	2.264	2.126	1.680	1.781	1.984	1.914
Romania	0.666	1.096	0.951	1.282	1.112	1.389	1.394	0.903	1.385	1.585	2.284	1.365	-
Russian Federation	0.399	1.621	1.373	1.717	1.938	1.920	2.064	1.823	1.655	1.518	1.151	1.173	1.537
Saint Kitts and Nevis	2.732	2.573	2.745	0.086	0.313	0.389	0.172	0.271	0.317	0.429	0.348	0.451	-
Serbia	-	-	-	-	-	-	-	-	4.198	2.879	3.100	3.602	2.993
Singapore	0.199	0.293	0.420	0.532	0.655	0.439	0.369	0.404	0.386	0.400	0.435	0.459	0.502
Sint Maarten (Dutch part)	-	-	-	-	-	-	-	-	-	-	-	2.76	-
Slovakia	1.284	1.103	0.690	0.838	0.900	0.760	0.412	0.389	0.417	0.328	0.456	0.719	-
Slovenia	1.669	1.560	1.667	1.271	1.151	1.415	1.141	1.315	2.206	1.511	1.238	1.307	1.808
South Africa	-	0.110	0.094	0.112	0.121	0.119	0.116	0.125	0.109	0.094	0.123	0.114	-
Spain	0.941	1.097	1.140	1.126	1.222	1.337	1.513	2.184	2.337	1.894	2.119	2.036	2.464
Sweden	1.657	1.483	1.068	1.324	1.170	0.891	0.750	0.858	0.743	0.573	0.734	0.743	0.665
Thailand	0.756	0.969	0.712	0.497	0.518	0.461	0.499	0.595	0.547	0.415	0.408	0.358	0.351
TFYR of Macedonia	2.481	2.388	1.311	5.602	6.583	5.350	3.439	3.570	2.255	1.842	0.806	1.075	2.425
Tonga	-	-	-	1.158	0.660	9.246	2.857	0.251	0.229	1.959	-	-	-
Trinidad and Tobago	-	-	-	-	-	-	-	-	-	-	-	0.058	-
Tunisia	1.573	1.853	2.222	2.766	2.723	2.407	2.264	1.997	2.190	3.050	4.207	3.423	-
Turkey	5.422	3.363	3.682	2.627	2.034	1.956	1.781	1.235	1.210	1.414	1.403	1.475	1.583
United Kingdom	0.131	0.159	0.168	0.214	0.233	0.430	0.481	0.567	0.568	0.631	0.648	0.741	0.774
United States	0.455	0.585	0.672	0.518	0.428	0.244	0.288	0.344	0.391	0.405	0.280	0.317	-

Appendix 2. Countries' RCA (weighted by overall services exports) for construction industry, 2000 – 2012

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Albania	-	-	-	0.218	0.168	0.106	0.065	0.160	0.343	0.498	0.540	1.363	0.576
Algeria	-	-	-	-	-	3.049	4.338	4.216	3.104	2.038	1.935	1.389	-
Argentina	0.071	-	0.216	0.433	0.580	0.315	0.105	0.148	0.086	0.053	0.182	0.117	0.108
Armenia	-	0.173	1.564	1.824	1.799	1.175	0.860	0.772	0.772	0.424	0.418	0.396	0.375
Aruba	0.106	0.171	0.054	0.006	-	0.002	0.048	0.254	0.067	0.126	0.175	0.039	0.068
Australia	0.072	0.142	0.161	0.128	0.137	0.139	0.124	0.066	0.051	0.070	0.067	0.058	0.039
Austria	1.292	1.401	1.150	1.526	1.543	1.066	0.890	1.012	0.934	0.843	0.824	0.490	0.4661
Azerbaijan	0.980	1.137	0.934	0.420	0.993	0.632	2.046	1.471	2.447	3.219	2.769	1.616	2.241
Barbados	0.136	0.140	0.145	0.156	0.165	0.113	0.092	0.248	0.045	0.259	0.066	-	-
Belarus	2.114	1.953	1.90	1.924	2.289	1.327	0.834	1.008	0.786	0.650	1.277	1.675	2.768
Belgium	0.932	0.874	1.604	2.097	1.795	1.554	1.568	0.839	0.881	0.970	1.122	1.153	0.890
Bermuda	-	-	-	-	-	-	1.693	1.083	1.076	0.850	0.346	0.344	-
Bosnia and Herzegovina	8.125	7.593	5.346	7.450	7.554	6.922	7.555	5.990	4.802	5.131	5.391	2.745	2.897
Botswana	0.126	1.028	0.768	0.644	0.565	0.442	0.434	0.374	0.450	0.971	0.573	0.652	1.956
Brazil	1.206	0.091	0.058	0.046	0.011	0.023	0.049	0.028	0.026	0.017	0.034	0.019	0.023
Bulgaria	1.162	1.545	1.275	1.264	1.520	1.066	1.337	1.606	1.133	2.029	1.052	0.417	1.175
Canada	0.273	0.220	0.115	0.103	0.127	0.149	0.173	0.192	0.118	0.165	0.198	0.211	0.110
China	0.996	1.200	1.451	1.320	1.132	1.594	1.255	1.764	2.438	2.401	3.426	3.268	2.505
China, Hong Kong SAR	0.421	0.481	0.356	0.524	0.343	0.225	0.155	0.164	0.076	0.054	0.053	0.047	-
China, Taiwan Province of	0.299	0.240	0.214	0.244	0.295	0.214	0.218	0.240	0.222	0.304	0.337	0.297	0.334
Croatia	2.464	2.292	2.711	2.481	2.489	0.198	0.312	0.270	0.364	0.428	1.031	0.544	0.278
Cyprus	0.756	0.784	0.973	1.363	1.170	1.160	1.166	0.927	0.576	0.219	0.229	0.244	0.279
Czech Republic	1.229	1.086	0.804	0.691	0.607	0.919	0.654	0.751	0.775	0.827	1.788	1.449	1.471
Denmark	-	-	-	-	-	0.215	0.169	0.180	0.122	0.212	0.227	0.201	0.097

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Estonia	1.314	2.285	2.109	1.832	1.540	2.686	1.013	1.770	2.440	1.566	1.798	2.388	2.279
Faeroe Islands	3.983	3.239	3.984	2.857	4.021	1.208	1.447	1.559	0.287	1.857	1.424	3.237	-
Finland	2.849	2.091	1.155	1.707	2.462	1.540	0.842	0.737	1.440	1.539	1.554	2.531	5.384
France	1.787	1.679	1.664	1.357	1.382	1.359	1.348	1.417	1.393	1.841	1.810	1.660	1.474
French Polynesia	-	-	0.804	0.100	0.188	0.144	0.002	6.67E-05	-	0.002	0.070	0.236	-
Germany	2.567	2.332	2.276	2.761	2.412	2.914	2.765	2.440	2.187	1.866	1.883	1.811	1.514
Greece	0.606	0.520	0.426	0.386	0.327	0.385	0.355	0.339	0.2665	0.341	0.719	1.260	-
Hungary	0.799	0.699	1.197	1.027	0.770	0.621	1.199	1.216	1.077	0.868	0.759	0.794	0.735
Iceland	0.091	0.018	0.058	0.493	0.064	0.003	-	-	-	0.029	0.016	0.097	-
Iran (Islamic Republic of)	-	-	-	-	13.671	13.504	7.372	7.653	6.472	0.558	4.402	-	-
Israel	0.583	0.864	0.855	0.910	1.055	0.944	1.166	1.318	1.188	1.193	1.319	1.464	1.758
Italy	1.200	1.369	1.326	1.373	1.180	1.117	1.016	1.112	0.087	0.132	0.042	0.042	0.132
Japan	4.248	3.577	3.254	2.809	3.522	2.999	3.215	3.205	3.203	3.189	2.886	2.948	3.109
Kazakhstan	0.010	0.070	0.034	0.540	0.082	0.042	0.052	0.0620	0.142	0.050	0.209	0.378	0.151
Korea, Republic of	1.489	1.898	3.305	2.789	2.988	4.331	5.170	5.325	5.243	6.499	5.260	6.362	7.739
Latvia	0.566	0.521	0.242	1.001	1.302	0.299	0.398	0.571	0.656	0.322	0.825	0.767	1.122
Lebanon	-	-	-	-	-	0.001	-	-	-	-	1.432	1.061	-
Lithuania	0.663	0.727	0.853	0.611	0.617	0.499	0.363	0.669	0.703	0.599	0.798	0.916	1.315
Luxembourg	-	-	0.271	0.311	0.343	0.325	0.279	0.296	0.311	0.264	0.268	0.214	0.165
Malaysia	**1.136**	**1.127**	**1.327**	**0.925**	**1.326**	**1.897**	**1.920**	**1.850**	**1.388**	**1.038**	**1.247**	**1.204**	**1.365**
Mauritius	0.438	0.136	0.249	0.124	0.157	0.678	0.445	0.136	0.133	0.105	0.497	0.591	0.412
Montenegro	-	-	-	-	-	-	-	-	2.342	1.337	1.374	1.495	1.479
Netherlands	2.487	2.992	2.153	1.250	1.254	1.371	0.987	0.908	0.893	0.845	0.904	0.767	0.820
Netherlands Antilles	1.092	1.490	1.381	0.502	0.437	0.542	0.749	0.974	0.927	0.699	0.657	-	-
New Caledonia	-	-	3.116	2.999	2.937	0.609	2.355	1.161	1.667	2.299	2.930	1.910	-

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
New Zealand	0.084	0.178	0.146	0.266	0.220	0.193	0.047	0.031	0.037	0.048	-	0.015	0.015
Norway	0.194	0.229	0.208	0.256	0.226	0.397	0.415	0.341	0.358	0.364	0.590	0.471	0.490
Panama	-	-	-	-	-	-	-	0.005	0.015	0.009	0.010	0.010245	0.018
Poland	1.434	2.130	2.535	3.133	2.456	2.434	2.498	2.245	1.870	1.699	1.548	1.680	1.528
Portugal	0.838	0.984	0.921	1.197	1.476	1.100	1.227	1.427	1.271	1.028	1.092	1.166	1.154
Romania	0.864	1.398	1.281	1.684	1.672	1.753	1.475	0.920	1.256	1.677	2.971	1.781	1.451
Russian Federation	0.879	3.103	2.377	3.095	3.833	4.049	4.115	3.523	3.163	3.194	2.964	3.125	3.144
Saint Kitts and Nevis	0.795	0.796	0.948	0.027	0.091	0.107	0.0447	0.073	0.089	0.123	0.088	0.114	-
Serbia	-	-	-	-	-	-	-	-	2.873	1.967415	2.164	2.357	2.001
Singapore	0.237	0.326	0.454	0.537	0.669	0.445	0.351	0.356	0.323	0.46316	0.419	0.556	0.586
Sint Maarten (Dutch part)	-	-	-	-	-	-	-	-	-	-	-	0.608	0.518
Slovakia	1.483	1.180	0.833	1.237	1.514	1.227	0.662	0.693	0.746	0.688	1.072	1.626	1.748
Slovenia	1.766	1.746	1.804	1.378	1.299	1.537	1.219	1.464	2.104	1.491	1.230	1.276	1.704
South Africa	-	0.158	0.134	0.121	0.142	0.140	0.137	0.158	0.157	0.127	0.172	0.172	0.157
Spain	0.564	0.659	0.695	0.678	0.769	0.805	0.862	1.290	1.302	1.115	1.273	1.171	1.375
Sweden	1.585	1.296	0.927	1.103	0.973	0.709	0.571	0.621	0.509	0.388	0.505	0.476	0.388
Thailand	0.834	1.094	0.735	0.568	0.620	0.587	0.574	0.691	0.645	0.515	0.527	0.416	0.348
TFYR of Macedonia	2.452	2.704	1.438	5.193	6.233	5.245	3.351	3.684	2.170	1.691	0.776	1.026	2.238
Tonga	-	-	-	0.412	0.231	2.663	0.772	0.075	0.0578	0.540	-	-	-
Trinidad and Tobago	-	-	-	-	-	-	-	-	-	-	-	0.040	-
Tunisia	0.916	1.173	1.541	1.985	2.038	1.718	1.561	1.570	1.717	2.284	3.160	2.934	-
Turkey	2.546	2.055	2.798	1.974	1.620	1.508	1.534	1.182	1.129	1.232	1.227	1.250	1.229
United Kingdom	0.082	0.101	0.102	0.121	0.129	0.240	0.258	0.276	0.279	0.310	0.322	0.353	0.334
United States	0.316	0.410	0.451	0.345	0.291	0.164	0.185	0.223	0.251	0.259	0.183	0.199	-

Appendix 3. ASEAN countries' RCA (weighted by total trade) for construction industry, 2000 – 2012

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cambodia	-	-	-	0.106	0.136	0.113	0.108	0.119	0.212	0.235	0.353	0.22	0.387
Indonesia	-	-	-	-	1.386	1.118	0.853	0.702	0.760	0.650	0.558	0.504	0.819
Lao People's Dem. Rep.	-	-	-	-	-	-	-	-	-	2.955	1.132	0.881	-
Malaysia	**0.753**	**0.823**	**0.936**	**0.551**	**0.789**	**1.174**	**1.230**	**1.374**	**0.977**	**0.774**	**0.900**	**0.904**	**1.092**
Philippines	0.641	0.464	0.188	0.309	0.415	0.344	0.295	0.397	0.288	0.255	0.365	0.151	0.363
Singapore	0.199	0.293	0.420	0.532	0.655	0.439	0.369	0.404	0.386	0.400	0.435	0.459	0.502
Thailand	0.756	0.969	0.712	0.497	0.518	0.461	0.499	0.595	0.547	0.415	0.408	0.358	0.351

Appendix 4. ASEAN countries' RCA (weighted by overall services exports) for construction industry, 2000 – 2012

Country	Year												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cambodia	-	-	-	0.103	0.115	0.081	0.081	0.087	0.161	0.155	0.240	0.148	0.255
Indonesia	-	-	-	-	1.924	1.714	1.662	1.473	1.518	1.462	1.189	1.043	1.460
Lao People's Dem. Rep.	-	-	-	-	-	-	-	-	-	2.229	0.981	0.856	-
Malaysia	**1.136**	**1.127**	**1.327**	**0.925**	**1.326**	**1.897**	**1.920**	**1.849**	**1.388**	**1.038**	**1.247**	**1.204**	**1.365**
Philippines	1.446	1.004	0.405	0.678	0.879	0.668	0.449	0.464	0.322	0.233	0.329	0.102	0.235
Singapore	0.237	0.326	0.454	0.537	0.669	0.445	0.351	0.356	0.323	0.463	0.419	0.556	0.586
Thailand	0.834	1.094	0.735	0.568	0.620	0.587	0.574	0.691	0.645	0.515	0.527	0.416	0.348

AN EXPLORATORY STUDY: BUILDING INFORMATION MODELLING EXECUTION PLAN (BEP) PROCEDURE IN MEGA CONSTRUCTION PROJECTS

Nor Asma Hafizah Hadzaman, Roshana Takim, Abdul-Hadi Nawawi and Mohammad Fadhil Mohammad
Centre for Postgraduate Studies, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA (UiTM) Shah Alam, Malaysia

Abstract
Building Information Modelling (BIM) is defined as a parametric modelling of a building containing a precise and relevant data needed to support the project phase activities. The Building Information Modelling Execution Plan (BEP) however emerges as an important business and managerial concern for BIM projects. BEP is an effective document to describe on how to implement BIM for a particular project across project phase involving the flow of work and data input that need to comply by users. Nevertheless, in Malaysia the lacks of details, ambiguity, fragmentations, and poor knowledge in executing BIM technology have obstructed the building performance. Although the potential benefits of BIM are well documented, the implementation process procedure is still unsystematic and requires a standardised plan complete with expert hands-on to execute BIM in Mega construction projects. Hence, the objectives of this paper are: to investigate the processes of BEP, to identify the information exchange among stakeholders, and to establish strategies to implement BIM in Mega construction projects. The research engaged semi-structured interviews with four respondents from the public and private organisations. Data from the interviews were analysed by using content analysis techniques. The BEP processes have revealed four (4) important elements. These are: BIM goals, BIM Use, responsible parties and decision making. The four (4) information exchanges gathered from BEP processes are: responsible parties, level of development, collaboration, and modelling requirements. Finally, six (6) strategies to implement BIM are: training program, software and hardware, government involvement, and understanding of the full potentials of BIM, participation in standard development and co-ordination workshop. The results of the research provide an insight into the Malaysia construction projects and will provide a valuable guideline in managing BIM for Mega construction projects.

Keywords: *Building Information Modelling (BIM; BIM Execution Plan (BEP); mega projects; stakeholders*

INTRODUCTION

In Malaysia, the deployment of computer-based technology in construction, particularly Building Information Modelling (BIM), is described by many researchers and practitioners as a new IT tool that could serve as a solution to a number of inefficiencies in the construction environment (Muafi et al., 2012; Ismail et al., 2013). The reasons are to capture and store information systematically, and to prevent loss of process continuity during project implementations, especially for Mega construction projects (JBIM, 2007). One of the Malaysian government agenda in the 12 National Key Economic Areas (NKEAs) is to enhance the business growth in the Architectural, Engineering and Construction (AEC) industry. Through the agenda, the AEC organisations have aggressively embraced new technology in order to remain competitive in the current market (Alshawi et al., 2010). Hence, BIM applications have grown tremendously, from a tool to design in three dimensions, used for model analysis, clash detection, product selection, and whole project conceptualization (Weygant, 2011). It is a system developed in a parametric modelling with a precise data needed to support the

project and business requirements.

Despite the industries awareness on the potential of BIM which has existed for over 20 years, Malaysia had started to focus on the benefits of adopting BIM in construction to increase the efficiency of construction projects since 2007. Nevertheless, Malaysia is still crawling on pre-BIM stage and BIM initiatives are currently uncoordinated (Public Works Department, 2013). Among others, beginning April 2013, the Public Works Department (PWD) of Malaysia has initiated the industry engagement of BIM Roadmap 2011-2016. The PWD BIM Roadmap focuses on the areas of governance, people, process and technology. The PWD and Construction Industry Development Board (CIDB) are also in progress in developing BIM requirements, execution plan and BIM standard. The PWD BIM policies (i.e., BIM Roadmap and BIM Rolled out) are set out to take place by mid-2014 which will begin to enforce the use of BIM for all Government projects that exceeds RM10 million of the total projects cost.

BIM AND BEP EXECUTION PLAN

Building Information Modelling (BIM) is a comprehensive concept of processes and tools (i.e., software) which integrate all projects required data and information occurs during project life cycle (Shourangiz et al., 2011). In line with Hooper and Ekholm (2010) BIM amongst other things, seeks to streamline processes, present construction information in an accessible and common way, minimise the possibility of missing or clashing information and ensure optimised project coordination. According to them, BIM could be defined *as parametric modelling to support the project life cycle through the relevant data and information shared among stakeholders to improve the final project outcomes* (cost, time and quality). The idea corroborates with Lutra (2010) which indicated that using BIM technology makes it possible to construct an accurate virtual 3D and parametric model of a building containing precise geometry and relevant data to support construction, fabrication, and procurement activities necessary for the building processes.

Building Information Modelling Execution Plan (BEP) however, emerges as an important business and managerial concern for BIM projects. BEP is perceived as solution procedures to implement BIM platform to enhance project delivery in construction. BEP is an *effective document to describe how to implement BIM for a particular project across project phases involving the flow of work and data input that need to comply by users* (McAdam, 2010). The development of BEP could facilitates industry players with BIM processes, interplay between the conceptual clarity of the processes and its relative messiness in practice, creates legal and organisational challenges. Thus, BIM is a tool to manage the BEP process, and BEP merely manage the process and roadmap, while the software (i.e., *Revit, Bentley, Graphisoft ArchiCAD, Tekla Structure, and Naviswork) are* simply a set of toolkits to deliver the information among project stakeholders. According to Christian (2012), the purpose of BEP is to ensure the upstream information fit for downstream use and that information is delivered in the most efficient and productive manner to reduce waste, rework, claims and litigation.

Basically two important steps in the BEP processes are: the design of *BIM project execution process* and developing *information exchange*. BIM project execution process includes the

tasks supported by BIM along with information exchange. It covers the elements of BIM goals, BIM use, responsible parties, BIM use information exchange (IE), BIM overview map, and detailed BIM use (Hooper and Ekholm, 2010; Rohena, 2011; PSU, 2011; Singapore BIM Guide, 2012). According to Hooper and Ekholm (2010) this allows team members to understand on how their work processes interact with the processes performed by other team members. The first level of BEP process is to develop BIM overview map to show the relationship of BIM Uses employed for the project. The overview map is divided into 2 parts, Level 1 and Level 2. Level 1 contains *high level information exchanges* that occur throughout project lifecycle. Level 2 is the *detailed BIM Use Process Map*, which is developed after the high Level 1 is performed for each responsible party. According to Hooper and Ekholm (2010) detailed BIM Use process maps are created to define the sequence of various processes to be performed. These maps will identify the responsible parties for each process, reference information content, and the information exchanges to be shared with other processes.

It is important for team members (author and receiver to understand clearly and precisely the information content (i.e., information exchange worksheet, responsible parties, output & input, level of development, model element breakdown and collaboration for each exchange). Information is the integral part in BIM (Hooper and Ekholm, 2010; PSU, 2011; Singapore BIM Guide, 2012; and Princeton University, 2012). There are many information exchanges that can be shared among project stakeholders once the project starts and information to be updated from time to time in the information exchange table (worksheet). Each line item in an information exchange worksheet should indicate authorized parties to be responsible for authoring the information. This worksheet is to aid the project team to state the information required for BIM Use. The purpose is to record information delivery expectations against a pre-determine model element breakdown through the schematic design, design development and construction documents stages for each BIM use (Hooper and Ekholm, 2010).

PROBLEM STATEMENT

In Malaysia, despite many latest technology that has been adopted in the development of construction projects, many Mega construction projects (i.e. projects which cost more than 10 million) are now becoming much more complex and difficult to manage (Williams, 2002; Alshawi and Ingirige, 2003; Chan et al., 2004; and Othman, 2011). Design mistakes, incompatible drawings, lack of details, inefficient construction methods, specification ambiguity and errors are repeatedly occurred which deterred the building performance on the long run. The implementation of BIM with insufficient and unsystematic formal data causes failure to the construction projects.

As such Building Information Modelling Execution Plan (BEP) is a procedure to implement BIM across project phases involving a systematic flow of work and data input by users. BIM is an information-rich, model-centric process that provides an integrated solution to transform project delivery and add value across the project life cycle. Despite the industry's awareness of the potential of BIM, construction organisations are yet to utilise it aggressively. According to Khosrowshahi and Arayici (2012) the UK construction sector is also facing slow progressive changes in the BIM implementation. The probable reasons could be the difficulty to implement BIM and understanding the *BEP processes* precisely, adoption could

incur higher additional project cost, require a comprehensive training, and majority of the designers are still familiar in using AutoCAD in their design services instead of BIM and BEP.

Furthermore, fragmentation among project teams in the AEC industry could affect the performance of construction projects (Ibrahim, 2006; Motsa et al., 2008; Othman, 2011). The involvements of multitude of participants in the design environments contribute to inaccurate information transfer, poor design information, and wrong delivery solutions which make the industry a highly fragmented business. These issues are attributed to the fact that the industry is made up of separate parties from diverse professions that operate by their own rules, lack of collaboration, and complications in the *information exchange*. In order to address these issues, several strategies are needed by the industry. Since, the expert in BIM is lacking, the BEP processes is perceived to be harder to execute. The lack of comprehensive hands-on training program to users to execute BIM by using respective software in the market, lack of government support, and fail to understand the full potentials of BIM are respective issues to be addressed thoroughly by both industry and academia. Hence, the objectives of this paper are: to investigate the processes of BEP, to identify the information exchange among stakeholders, and to establish strategies to implement BIM in construction

METHODOLOGY

The study starts with the literature search which reviews the processes of BEP, information exchange and strategies to implement BIM in construction. Further research has been carried out through a primary data collection. The methodology used for this research is based on purely qualitative research techniques. According to Merriam (2002) the qualitative research paradigm demands an in depth understanding of a phenomenon, an individual or a situation. In this paradigm, the qualitative researcher is not interested in people's surface opinion such as in survey research, on in cause and effect as in experimental research; rather the researcher wants to know how people do things and what meaning they give to their lives (Omar, 2012). Samples were randomly selected from the listing provided by BIM committee (the public and private organisations) that had experienced of using BIM and BEP for their Mega projects. Semi-structured interviews were conducted among four respondents from the public (3 respondents) and private sectors (1 respondents) for the primary data collection. The face-to-face interviews were designed to gather preliminary data on BEP in BIM construction projects. The interviews were recorded and transcribed verbatim for content analysis.

Limitations

Firstly, the numbers of selected interviews session were restricted to four companies due to the short period of study (3 months of MSc program) and in Malaysia at present; implementing BIM in construction projects is still at infant stage by many public and private organisations. Initially six organisations were identified. Nevertheless, two of the private organisations failed to participate for some technical reasons (not ready to reveal information) and anonymity problems. Secondly, very little information of literature search was captured from Malaysian researchers on BIM. Instead, most of the secondary data for the study of BIM and BEP processes were gathered from developed countries such as United States of America and Singapore. These limitations are not considered to be severe, since the rapid communication

processes of modern and new technology ensure that most trends are international. Thirdly, the respondents of the respective organisations are not willing to disclose detailed information on how the organisations executing BIM for their projects. Hence respective data on the BIM Execution Plan; detailed projects information; level of BIM (LOD 100-LOD 500) are difficult to measure and reported.

DATA COLLECTION AND FINDINGS

Table 1 shows the profile of respondents and years of experience in construction industry as well as in BIM. Twelve questioned were asked during the interviews within a-one month period. Majority of them has more than 10 years' working experience in the industry and an average of 6 years in BIM (since 2007) indicating that it is reasonable to infer that respondents have a wide-ranging knowledge in BIM and the data is relevant and reliable.

Table 1. Profile of respondents and their experience

Respondent	Designations	Background	Experience (industry)	Experience (BIM)
Public Organisations				
Respondent 1	Senior Manager	Building	20 years	6 years
Respondent 2	Principal Assistant Director	Civil Engineering	27 years	7 years
Respondent 3	Assistant Vice President	Architect	8 years	6 years
Respondent 4		Fail to participate		
Private Organisations				
Respondent 5	Head of Development	Architect	18 years	5 years
Respondent 6		Fail to participate		

Process in BIM Project Execution Plan (BEP)

Table 2 shows the results on the processes of BEP conducted to four respondents. 100 percent (100%) of the respondents agreed that the three main elements in BEP are: BIM goals, BIM use and responsible parties that involved in the BIM projects as highlighted consecutively. The identification of *BIM Goals* and *Uses* covers as the first and second important elements of BEP procedures. These goals could be based on project performance and include items such as reducing the schedule duration, achieving higher field of productivity, increasing quality, reducing cost of change orders, or obtaining important operational data for the facility. Once the team has defined measurable BIM goals (from project and company perspectives), specific BIM uses of the project can be identified. According to PSU (2011) a *BIM Use* is a unique task or procedure for a project from the integration of BIM into the BEP processes. Several examples of *BIM Uses* include design authoring, 4D modelling, cost estimating, space management and record modelling. As mentioned by the Respondent 5 *"a BIM Use is a detail works that need to commit by the team members. In the BEP, it will detail out what are the programs under each stage. For instance, the detail uses of BIM are in the form of visualization and programming at the project design stage".*

Table 2. Process in BIM Execution Plan (BEP)

VARIABLES	RESULTS FROM INTERVIEWS			
Processes in the BIM Project Execution Plan (BEP)	Public Organisations			Private Organisations
	Res. 1	Res. 2	Res. 3	Res. 4
BIM Goals	√	√	√	√
BIM Use	√	√	x	√
Responsible Parties	√	√	√	√
BIM Use Information Exchange(IE)	x	√	x	x
Level 1: BIM Overview Map	x	√	x	x
Level 2: Detailed BIM Use	x	√	x	x
Decision making	√	√	*x*	√

The third important element is *responsible parties*. Despite each player sees its own opportunities, most of them recognize that value can be gained by improving the ability of team members to share data and integrated (McGraw Hill, 2009). The above statement is supported by the Respondent 1 who indicated that *"it is important to identify the responsible parties in the early stage of the projects. Each party will perform the task based on the requirements from the BEP guide line. Parties in the project could be architect, mechanical and electrical consultants, quantity surveying, planner and others. Therefore, each discipline is to be involved"*.

However, with the exception of PWD, the other three elements (BIM use information exchange, Level 1: BIM overview map and Level 2: detailed BIM use) were not regarded as important by the interviewees although these elements are listed as important elements of BEP process in the BEP literature review (PSU, 2011 and Singapore BIM Guide, 2012). The probable reasons could be the three elements are rarely used in the adoption of BIM and difficult to develop by some of the organisations in Malaysia. At the end of the interview session, *decision making* has been mentioned repeatedly by the respondents. Although *decision making* is not appeared in the literature search, the variable is taken as an important element to be included in the BIM Project Execution Plan **(**BEP).

Information Exchanges among Stakeholders in BIM

Table 3 shows the results on information exchanges among stakeholders. According to Howell and Batcheler (2005) it is imperative for team members (i.e., the author and receiver information exchanges transaction) to understand the information content as defined in the worksheet or table. All of the respondents unanimously admitted that the key factors in information exchange are: *responsible parties*, *level of development* and *collaboration procedures*. Surprisingly, once again the factor of 'responsible parties' emerged in this category which is repetitive in nature. The unexpected result could be due to the misunderstanding of the term 'stakeholders' by respondents. Another reason could be due to the criticality of responsible parties in the BIM projects that make respondents associated it with the information exchange and collaboration factors. Thus, to most respondents regarded the 'responsible parties' and 'collaboration' to have similar meaning.

Table 3. Information exchange among stakeholders

VARIABLES	RESULTS FROM INTERVIEW			
Information Exchanges among Stakeholders in BIM Projects	**Public Organisations**			**Private Organisations**
	Res. 1	**Res. 2**	**Res. 3**	**Res. 4**
Information Exchange Worksheet	x	√	x	x
Responsible Parties	√	√	√	√
Output & Input	x	√	x	x
Level of Development	√	√	√	√
Model Element Breakdown	x	√	x	x
Collaboration	√	√	x	√
Modelling requirements	√	√	*x*	√

As mentioned by McGraw Hill (2009) when using BIM across an entire project, each form has an opportunity to realize its own distinct benefits and organisations may see the correct and systematic data input could create a significant value. The above statement is supported by Respondent 5 stated that *"different stages of project will involve different parties, representing the respective disciplines in each project stage. The respective parties will perform the task for the data input systematically and deliver the information required in BIM that will be shared among the team's members"*.

The Level of development (LOD) comprises of five levels; from LOD 100 to LOD 500. Each level will presents each description for each project life cycle. According to Porwal & Hewage (2013) the levels of details range from the lowest level (LOD 100) of conceptual approximation to the highest level of representational precision (LOD 500). Nevertheless, the concept of LOD various among countries and could be up to LOD 700 to certain developed countries such as Hong Kong and USA. As what claimed by respondents, the LOD definitions is different for every organisations. The Respondent 5 claimed that *"the level of development indicated the maturity for BIM progress. Each level of development is divided into conceptual, schematic, building plan which is from LOD 100 up to LOD 500"*.

In addition, collaboration among team players is high when 'information' of the projects is certainly understood by each member, in particular design changes. Design changes are usually occurred from the modification within or outside the original scope of work and require re-design and revision to the contract documents (Shourangiz et al., 2011). Most of these changes happen during the construction phase and they are the roots of cost and time overruns disputes and relationship deterioration. The Respondent 2 claimed that *"the first thing that needs to achieve is the collaboration and understanding the concept of BIM itself. In Malaysia, BIM is considered as new and not all people can adopt the concept in the right manner. Hence, to make it realize, we must develop a dedicated team to support and help each other's, this how collaboration comes in. The information exchange among teams could happen when they realize how important to deliver a successful project outcomes (i.e., cost, time and quality)"by using BIM through the correct BEP processes"*.

The other three elements (information exchange worksheet, output & input and model element breakdown) were not regarded as important by the interviewees although these elements are listed as important information to information exchanges among stakeholders.

According to PSU (2011) there are many information exchanges that can be shared among the stakeholder once the project started. The additional data includes IE worksheet; output and input; and model element breakdown. Among others, the Respondent 2 organisation is the solely organisation in Malaysia that has comprehensively incorporating all the three listed variables compared to others. This implies that the government of Malaysia is serious in implementing BIM and BEP in the Mega government projects through Respondent 2 organisation. Once again, a new variable emerged known as *'modelling requirements'* during the interview session. The modelling requirements (i.e., 3D, 4D or even 5D also right to 'nD') should be established at the initial stage of BEP development to make sure all parties involved are able to follow it accordingly.

Strategies to Implement BIM in Construction

Table 4 indicates strategies to implement BIM in construction projects. Initially, six strategies have been identified in the literature. These are: education process, training programs, software and hardware, government involvement, understanding the potentials, and project management. Among others, training program is regarded as the utmost critical factor by most respondents to implement BIM Execution Plan. The results supported the opinions of Ibrahim and Okeil (2011) which stated that the BIM and BEP training programs (depending on selected software used) should be provided to all participants, the team members who would model and draft digitally, designers and project managers who oversee the process and review the drawings. The statement also in line with the opinion of the Respondent 1 indicated that *"there is ample BIM software in the market such as Revit, Bentley, Graphisoft ArchiCAD, Tekla Structure, Naviswork and etc. Hence, the vendors must struggle hard to train users to use BIM software comprehensively through hands-training classes until they are conversant with the tool in order to make it effectively"*.

Table 4. Strategies to implement BIM in Construction Projects

VARIABLES	RESULTS FROM INTERVIEW			
Strategies to implement BIM in Construction Projects	**Public Organisations**			**Private Organisations**
	Res. 1	**Res. 2**	**Res. 3**	**Res. 4**
Education Processes (Circular)	x	√	√	x
Training Program	√	√	√	√
Software & Hardware	x	√	√	√
Government Involvement	√	√	√	√
Understanding the potentials	√	√	√	√
Project Management	x	x	√	x
Participation in standard development	√	√	*x*	√
Coordination workshop	√	√	*x*	√

Furthermore, many organisations are reluctant to use BIM due to higher cost in purchasing respective software and conducting a comprehensive training program for employees. Instead, some organisations tend to appoint BIM consultant to do the design and BIM model for the particular project as to fulfil the client needs. These costs of paying consultants are driven by nature of project, market forces and contract arrangement (e.g. warranties, maintenance and structured technical support). The above statement is supported by Respondent 3 which stated that *"the software is too costly to our organisation. To a certain extent, since the price of the*

software is too high, there are no initiatives in using BIM for our projects unless enforced by project client or government". In this regard, the government involvement is seen as a pushing factor in the implementation of BIM for Mega construction projects in Malaysia. The Respondent 3 further emphasised that *"if Malaysia is truly serious to implement BIM in the Mega construction projects; the initiative should come from the top level of decision makers as the push factor to derive the initiatives"*.

In addition, it is important for the CAD manager to explain the full potential of BIM technology and how BIM based CAD connects to other applications and analysis tools, instead of relying on the automatic drawing generation (Graphisoft, 2003). Public and private organisations are called to guide in-house employees towards the benefit of BIM for the projects in the long run. As pointed out by the Respondent 5 *"our Organisation's/Company's objective regarding BIM is to deliver the project in an effective manner, within the cost, time and quality. Thus, adopting BIM now for our new Mega projects is inevitable so that technical project data are captured and stored throughout project phases systematically. Despite the difficulties in executing BIM at the beginning of project phase, the benefits of it could be seen in the long run for business potentials and agility"*.

Surprisingly 'education processes' and 'project management' were not regarded as significant by the interviewees in BIM Execution Plan. This is contradicted to the opinion of Ibrahim (2007) stating that it is important to differentiate between the benefits gained professionally in BIM and the education processes. Through BIM, knowledge is acquired in digestible doses that could be applied for future projects in which the monetary quantum could be substantial, in particular for a multi-million projects (Lee, 2013) and benefits of BIM would accrue over the lifetime of building. Once again, two additional variables emerged 'standard development' and 'coordination workshop' from the interviews. These variables are taken as additional strategies in the BIM Execution Plan Procedure.

CONCLUSION

This paper examines the current views on identifying the processes of BEP, information exchanges among stakeholders and strategies to implement BIM in the AEC industry. The BEP processes have revealed four (4) important elements. These are: BIM goals, BIM Use, responsible parties and additional variable of 'decision making'. The four (4) information exchanges, gathered from BEP processes are: responsible parties, level of development, collaboration, and 'modelling requirements'. In the end, the findings revealed six (6) strategies to implement BIM in construction projects. These are: training program, software and hardware, government involvement, and understanding of the full potentials of BIM in construction. Two additional variables added into the strategies are: participation in standard development and co-ordination workshop. These possible strategies are suggested to address the issues of uncoordinated on BIM Uses in construction projects.

Undoubtedly, the findings from the literature is inclined to the work experienced by the Respondent 2 organisation showing that all the three categories of variables gathered (i.e., BEP processes, Information Exchange, and strategies to implement BIM) are closely related to the work practised by them. Respondent 2 organisation acts as a fore-front government

organisation that had initiated the industry engagement of Malaysia BIM Roadmap 2011-2016 at national level, thus the initiatives are to be praised. In conclusion, all respondents unanimously asserted that in order to become competitive and to be in line with the international construction players, adopting BIM technology in construction is inevitable for the Malaysian construction industry. Continuous supports from Government of Malaysia in implementing BIM in construction through the push factors (i.e., organisational regulations and policies) are required to be materialised for the future development of Mega construction projects. As such, CIDB of Malaysia, through collaboration with academia from various institutions of higher learning has also trying hard to support the use of BIM for construction projects in the form of conducting seminars, BIM workshops frequently to various categories of contractors. CIDB has started to form a National BIM Steering Committee, producing BIM guidelines and in the process of developing a National BIM Roadmap 2014 – 2020 for Malaysian construction industry.

The research presented in this paper is part of a Master program dissertation at the Faculty of Architecture, Planning and Surveying (FSPU), UiTM. The results of the research provide an insight into the Malaysia construction projects and will provide a valuable guideline in implementing BIM and BEP processes for Mega construction projects.

REFERENCES

Alshawi, B., Ingirige, B. (2003). Web-Enabled Project Management and Emerging Paradigm in Construction. *Automation in Construction* 12 (4), 349–364.

Alshawi, M., Lou, E.C.W., Khosrowshahi, F., and Underwood, J. (2010). *Strategic Positioning of it in Construction: The Way Forward. Proceedings of the International Conference on Computing in Civil and Building Engineering,* Nottingham University Press

Chan, A.P.C., Scott, D., Chan, A.P.L. (2004). Factors Affecting the Success of a Construction Project. *Journal of Construction Engineering and Management* 130, 153–155.

Graphisoft, (2003). Graphisoft Strengthens Commitment to Interoperability &International IFC Industry Initiative." Graphisoft

Hooper M. and Ekholm A. (2010). A pilot study: Towards BIM integration – an analysis of design information exchange & coordination. Proceedings of the CIB W78 2010: 27th International Conference –Cairo, Egypt, 16-18 November, 2010, Retrieved April 18, 2013, from http://lup.lub.lu.se/record/1766917/file/1766923.pdf

Howell, I. and Batcheler, B. (2005) Building Information Modelling Two Years Later — Huge Potential, Some Success, and Several Limitations. Retrieved December 1, 2013, from www.laiserin.com/features/bim/newforma_bim.pdf

Ibrahim, M. (2007). - Teaching BIM, What is Missing? The Challenge of Integrating BIM based CAD in Today's Architectural Curricular, *Embodying Virtual Architecture: The Third International Conference of the Arab Society for Computer Aided Architectural Design (ASCAAD 2007),* 28-30November 2007, Alexandria, Egypt, pp. 651-660

Ibrahim, M. (2006). To BIM or not to BIM, This is NOT the Question: How to Implement BIM Solutions in Large Design Firm Environments, Retrieved May 24, 2013 from http://www.iit.edu/~ibramag

Ibrahim, M. and Okeil, A. (2011*). Building Information Modelling in Architectural Education: The Case of the Middle East.* Paper presented at the Sixth International Conference on

Construction in the 21st Century (CITC-VI) "Construction Challenges in the New Decade", Kuala Lumpur, Malaysia. RetrievedMay 24, 2013, from http://academia.edu/2033445/Building_Information_Modelling_in_Architectural_Education_The_Case_of_the_Middle_East

Ismail, M.H, Takim, R. and Nawawi, A. (2013). Building Information Modelling (BIM): Barrier, Solutions and Benefits for SMEs in Malaysia, *Social and Behavioral Sciences*

JBIM, (2007), Journal of Building Information Modelling, Official Publication of the National BIM Standard (NBIMS) and the National Institute of Building Science, Washington D.CLuthra. A. (2010). Implementation of Building Information Modelling in Architectural Firms in India, College of Technology Directed Projects. Paper 1. Retrieved May 24, 2013, from http://docs.lib.purdue.edu/techdirproj/1

McAdam, B. (2010). Building Information Modelling: The UK Legal Context. *International Journal of Law in the Built Environment* 2 (3), 246-259

McGraw Hill. (2009). The Business Value of BIM: Getting to the Bottom Line Retrieved September 20, 2013, from www.bim.construction.com/research/2009.

Merriam, S.B. (2002). Qualitative Research and Case Study Application in Education. Californis: Jossey-Bass Inc.

Motsa, N., Oladapo, A. and Othman, A.A.E. (2008). The Benefits of Using Constructability During the Design Process. Proceedings of the 5th post Graduate Conference on Construction Industry Development, Bloemfontein, South Africa, 16 - 18 March 2008, 158-167.

Muafi, Gusaptono R. H., Effendi, M. I., and Charibaldi, N. (2012) The Information Technology (IT) Adoption Process and E-Readiness to Use within Yogyakarta Indonesian Small Medium Enterprises (SME), *International Journal of Information and Communication Technology Research*

Omar, R., (2012). *Technology Transfer (TT): Level of Absorptive Capacity and Technological Capabilities in Mega Construction Projects*, (Unpublished Doctoral Dissertation). Universtiti Teknologi MARA

Othman, A. A. E., (2011). Improving Building Performance through Integrating Constructability in the Design Process. *Built and Natural Environment Research Papers*

Pennsylvania State University (2010), University Park, PA, USA. The Computer Integrated Construction Research Program. (2010). "BIM Project Execution Planning Guide – Version 2.0." July

Porwal, A. and Hewage, K. N. (2013). Building Information Modelling (BIM) Partnering Framework for Public Construction Projects. *Automation in Construction* 31 204–214

Public Work Department (2013). JKR Adoption in Construction Industry: JKR BIM Roadmap, Industry Engagement April 4th, 2013

Shourangiz, E., Mohamad, M.I., Hassanabadi, M.S., Banihashemi, S.S., Bakhtiari, M., and Torabi, M., (2011). Flexibility of BIM towards Design Change, Universiti Teknologi Malaysia. *In: 2nd International Conference on Construction and Project Management IPEDR vol.15 (2011) © (2011) IACSIT Press, Singapore*. Retrieved December 7, 2013, from www.ipedr.com/vol15/16-ICCPM2011A00022.pdf

Singapore BIM Guide, (2012). Building and Construction Authority, version 1.0. Retrieved April 18, 2013, from www.bca.gov.sg

Weygant, R. S. (2011). *BIM Content Development, Standards, Strategies, and Best Practices*, Construction Specification Institute

Williams, T., (2002).*Modelling Complex Projects*.Wiley,London,UK
Wong, A.K.D., Wong, F.K.W. and Nadeem, A. (2011). Government Roles in Implementing Building Information Modelling Systems-Comparison between Hong Kong and the United Stated, *Construction Innovation,* Vol. 11 No. 1, pp. 61-76.

CHALLENGES AND CONTROL MECHANISM FOR DEVELOPMENT ON HIGHLAND AND STEEP SLOPE: THE CASE OF KLANG VALLEY

Anuar Alias and Azlan Shah Ali
Center for Construction, Building and Urban Studies (CeBUS), Faculty of Built Environment, University of Malaya, 50603 Kuala Lumpur

Abstract
Development in highland areas carries a high risk of erosion and an increased risk of landslides both during and after construction. Since 1990, more than 13 cases of highland development incidents in the Klang Valley have been reported in newspapers, of which a few involved deaths of people. Hence, this paper discusses the issues and challenges of land development in highland and steep slope areas. The study also shows the effect of control mechanisms on the challenges identified in highland development. The quantitative survey adopted in this study was based on a framework developed from literature reviews. 200 questionnaires were distributed to relevant government agencies and developers. Of those, 157 found to be useful for data analysis. SPSS version 18.0 was used as the main tool for the data analyses. From the study, five dimensions of issues surrounding highland development were identified: planning, environmental, economic, social, and land development. Two main control mechanisms were also identified, namely the One Stop Centre (OSC) and the sustainable development approach. The associative test revealed that there were two significant relationships between control mechanisms and the challenges of highland development, which indicates the effectiveness of these mechanisms in addressing current problems.

Keywords: *Development, Highland, Steep Slope*

INTRODUCTION

Development in highlands or hillsides carries a risk of soil erosion and landslides during and after the construction process. This may result in natural water quality and wildlife being affected as a result of sedimentation and pollution. While there are guidelines for controlling pollution and preventing the collapse of construction in highlands, improvements of these parameters are necessary for the safety of the public and the environment.

Landslides can occur on slopes and soft hillsides. In addition, landslides are said to be the second most dangerous natural disaster after flooding, which can affect infrastructure facilities as well as the surrounding population (Ibrahim and Fakhru'l-Razi, 2006).

In Malaysia, some areas have been identified as vulnerable to the occurrence of landslides, such as Hulu Kelang, Cameron Highlands and Genting Highlands. Among the landslide tragedies that have occurred is the collapse of the Highland Towers in Hulu Kelang, in December 1993. Local newspapers also reported that there were some tragedies surrounding another collapse occurring in the Klang Valley. More than 13 cases have occurred since 1990, mostly taking place in Hulu Kelang and some involving the loss of human lives. The rest occurred in the vicinity of Cheras, Puchong and Bukit Tunku.

Although some preventive efforts have been taken by responsible government agencies, problems and tragedies still happen. More attention should be given to ongoing developments

in the highlands to avoid these tragedies from recurring. There is a significant gap in the scientific literature on challenges in highland development regarding measures to overcome these challenges (Othman, et al., 2014). Most prior studies have only investigated property development from the perspective of challenges, without discussing solutions (Abu-Samah, 2007). Therefore, this paper discusses challenges in highland development as well as possible mechanisms to help overcome them. The study also explores the significant relationships between the challenges and control mechanisms.

LITERATURE REVIEW: DEVELOPMENT IN HIGHLANDS

Highland Development Scenario in the Klang Valley

High demand for residential developments and infrastructure facilities has resulted in many new areas being explored. These include highland areas that have a challenging terrain, particularly in the areas around and near Kuala Lumpur. The demand for highland locations that provide interesting panoramic views has increased sharply (Huat and Ali, 2012). Geographical setting is also a factor that affects highland and hill slope development in Malaysia. It is reported that geo disasters in Malaysia started in 1919 and have since then caused loss of life and properties, as well as negative effects on the economy.

Concern over the adverse effects of highland and hill slope development increased significantly during the Highland Towers, Bukit Antarabangsa collapse on 11 December 1993. The geo disasters continued and increased in frequency between 2004 and 2009. The New Straits Times reported on 12 June 2006 that some areas in Hulu Klang, specifically, about 80%of the area – are comprised of 'schist rock', which is considered to be the weakest ground and not suitable for any development. The study carried out two years ago by experts also showed that the Hulu Klang area was at risk for landslides (Othman, et al. 2014). The geological aspect seems to be currently neglected in development planning. The fact of the matter is that the geological setting is one of the most important aspects that need to be taken into account when examining any development. However, awareness of geological and geographical settings that change in reaction to climate changes and natural disasters is still lacking in the decision making process.

Nevertheless, the state of Selangor has responded to geo disasters by implementing some stringent measures. On 2nd April 2008, the government of Selangor banned developments of highland and hill slope areas categorised under Class 3 (more than 25-to-35 degrees) and Class 4 (35 degrees and above). The action was taken to prevent more disasters from happening. Banning development is a good solution to overcome disasters (Hutchison, 2009) because it minimizes the clearing of natural vegetation on high hill areas. However, this indirectly affects property development and economic growth as a whole. Nonetheless, this type of measure has been proven to be successful in some developed countries such as Hong Kong and Taiwan (Gue and Tan, 2003).

Issues in Development of Highlands

According to a census carried out by the Selangor Branch of the Real Estate and Housing Developers' Association Malaysia (REHDA), there are an estimated 1,800 hectares of

hillside land in Selangor valued at about RM1.4 billion. According to the Chief Minister of Selangor, many developers have urged the government to reconsider the ban of Class 3 and 4 developments and have appealed to review earlier guidelines (The Star, 2009).

There are fifteen hillside housing estates in Selangor that have been identified as being at risk of landslides. These areas will now come under continuous monitoring by local authorities. 47% of Selangor's topography consists of highlands. Development of highland and hill slope areas started in the middle of the 1980's and grew rapidly from the early 1990's up till the present. The State of Selangor Planning and Development Direction has indicated that land use distribution of Selangor should comprise of 39.7% for developing areas, 30% for forests, 30% for agriculture, and 21% for water bodies. This has limited areas for development and created pressure and demand for land space, which has resulted in violations on highlands and hill slopes as the best option to cater for the demand.

As a result of this, disasters frequently happen in highland and steep slope areas, especially landslides. Ng (2009) added that hill slope development today is not any safer than it was a long time ago. Zakaria (2003) further expressed concerns about the development proposals of very steep and high cut slopes that do not include comprehensive studies on site assessment. The importance of looking at upstream and downstream development as well to obtain a comprehensive understanding of the situation has also been emphasized (Chan, 2009). Gue and Tan (2003a) additionally found that many of the landslides were caused by design and construction errors. This includes lack of obtaining soil parameters, misunderstanding of fundamental soil mechanics, and dumping of loose fill down slopes to form a filled platform or filled slope. More often than not, there were errors in the construction method such as forming cut slopes by excavating slopes from the bottom up instead of the correct practice of cutting from the top downwards. This poor practice contributes to the risk of landslides.

Rapid development coupled with economic growth can result in uneven developments, which ignore the importance of the environment. Chan (2009) indicates that forest clearance due to human activities such as logging, farming, clearing or other environment related activities has significantly changed hydrological constraints, particularly the meteorological conditions, which are highly erosive. In response to the safeguarding of natural environments including hill slopes, The National Physical Plan states that environmentally sensitive areas should be conserved and integrated into the planning and management of land use and natural resources. The Town & Country Planning Act Section 52A additionally states that the National Physical Planning Council can provide advice on applications submitted for developments that upset hilltops, hill gradients, and other areas marked as ecologically fragile. There is also a clear directive by the National Physical Planning Council regarding hilltops, hill slopes, and highlands in general.

Kwan (2009) pointed out that there must be proper policy, legislation and regulations governing hill slope development to make it sustainable. The concern is that the holistic approach needs a strong political will and competent professionals in the property development industry. Previously, there were other factors that needed to be considered in implementing the holistic approach, such as the importance of looking at upstream and downstream comprehensively during development. Ng (2009) further suggested that government agencies should consider

implementing some actions in order to sustain property development in highland and steep slope areas. For instance, relevant authorities need to carry out research on categorising existing hillsides across the country as well as on identifying permitted development to avoid incidents of erosion and landslides. Authorities also need to inform the public of findings related to highlands, and to set up a special division monitoring legislation, regulations and policies on hill slope development, maintenance, implementation, and enforcement of rules. In addition, all relevant parties should be subject to heavy penalties including imprisonment as this involves the safety of human life (Ng, 2009).

Challenges in Property Development of Hill Land

Planning Aspects

Planning is considered an important device used to manage land development, such as planning control. This refers to Part IV of the Town and Country Planning Act (TCPA), 1976 planning guidelines, which state, *"no person, other than the local authorities, shall commence, undertake, or carry out any development unless planning permission in respect of the development has been granted"*. The laws, procedures and guidelines pertaining to the planning and development process in Malaysia are quite extensive. There are fifty over guidelines, policies and regulations that may be initiated and that pose constraints on decisions when undertaking a property development project. Of those, the most relevant and crucial laws to comply with include the National Land Code (NLC), 1965 (NLC, 2008), the Town and Country Planning Act, 1976 (Act 172), the Government Act, 1976 (Act 171), the Uniform Building By Law, 1984 (UBBL), the Street, Drainage and Building Act, 1974 (Act 133), and the Environmental Quality Act, 1984.

Alias et al. (2014) remarked that some of the issues pertaining to planning laws are:

a) Difficulties in complying with planning standards
b) Not complying with planning guidelines
c) Not complying with guidelines for layout and building designs
d) Lack of monitoring debris in drains on slope
e) Lack of monitoring damaged drains

It is notable that these problems are always reported by the public to respective local authorities in the context of developments on hilly slopes.

Environmental Aspects

Previous studies in this field reported that building and development activities contribute up to 50% of CO_2 emissions, 50% of all material requirements, 40% of energy consumption, 16% use of water, 40%of solid waste disposal and 71% of electricity consumption (Atkinson, 2007; Newell and Manaf, 2008). In addition, the development of these activities could potentially affect environmental pollution, for example, landslides that cause loss of life (Nik-Ahmad and Ahmed-Asraf, 2013). Hence, it is vital to have tools to control the effect of development related activities on the environment.

Sections 69 and 70 of the Local Government Act 1976 provide provisions for fines and

penalties for the pollution of water resources such as rivers, drainage channels, and public waterways. They also impose preventive and controlled measures to prevent pollution. Furthermore, the licensing authority that may be obtained under this Act can also be used to control pollution. Additionally, the Town and Country Planning Act 1976 was enacted for the control and surveillance of town and country planning activities in the local authority area. The Act requires development activities carried out in a local authority area to comply with the local plan and to be checked and reviewed by the State Planning Committee. This Act provides for the submission of reports on the development, which is equivalent to conducting an Environmental Impact Assessment (EIA) report. The reports are useful because they allow authorities to incorporate environmental concerns into the planning process. This is especially important when an activity is not included as a prescribed activity under the Environmental Quality Order 1995. The Act also empowers local planning authorities to cancel or modify the planning permission granted under this Act or any other laws of local government.

Moreover, the Street, Drainage and Building Act 1974, Act 133 (1974) empowers the local authorities to construct, maintain and repair drains and water resources. Section 25 of this Act also specifies for the control of any trade wastes that flow into the river or sea.

The Land Conservation Act 1960, Act 385 (Revised 1989) specifies for the conservation of hill land, the protection of soil from erosion, and for the protection of land with rivers flowing to the foreshore and eventually to the sea. The measures stated in the Act should be implemented to prevent passage of soil or sediment to rivers, canals, or drains. This includes preserving the biodiversity of the development area by retaining environmental conservation, retaining cultural heritage characteristics, preserving soil structure, and the issuance of an EIA to be used in the land development process.

Social Aspects

Social changes can occur as a result of development intruding into social life. Aggression takes place in the form of implementation of specific development projects, exposure to other cultures, and changes in technology, etc. Social change resulting from intrusions into public life can also be beneficial, but usually the invasion has a negative effect. Although in the long run there may be a possible positive impact on the social well-being of the community, it typically has an unwanted short-term effect (Abd-Rahman, 2009).

Abd-Rahman (2009) explained that a Social Impact Assessment (SIA) is the process of analysing, anticipating, evaluating and managing unwanted effects of human intervention on the environment. This usually involves policies, plans, programs, projects, social activities and a process of social change in order to create a more sustainable environment. SIA also functions as an umbrella or comprehensive framework that analyses human impact from various perspectives, such as aesthetics, archeology, economic, and fiscal. The report also conveys important information to the stakeholders before starting a development, including feedback from the public, especially those who stay nearby development areas.

Economic Aspects

Increased property development would contribute to better growth for the local and

national economy. Leong (2013) reported that property development contributes almost 44% of 58 billion of new investment in first the half of 2012. This indicates that investment in a real estate rather attractive and offers great opportunity especially for developers' organisation to growth. Property developer always looking for potential lands to be developed especially those located in strategic places such as Klang Valley.

However, development of highlands could affect natural resources in the area. New developments should preserve natural elements as much as possible and consider sustainable green concepts in construction and building design. Design and development of buildings with "green" characteristics are becoming more obvious; appraisers will increasingly be called to consider the elements of green or sustainability in their evaluations. The assessment must be based on evidence of the enhanced market value related to these elements (Pitts and Jackson, 2008). Unfortunately, the development of highlands is currently conducted to maximize developer profit rather than to sustain natural resources, which could contribute to a better environment.

Sustainability Aspects (Environmental, Social and Economic)

In general, the environmental degradations caused by development activities can be categorized into water pollution, toxics, climate change, species extinction, deforestation, land degradation, the lack of fish, the reduction of resources that cannot be renewed, the thinning of the ozone and acid rain (Alias et al., 2014). Malaysia is a good example of a country that faces serious problems related to pollution of the water industry. The water produced for industrial and domestic use is often returned polluted to surface water systems after use, which can damage a source of water for other uses. This trend has continued in sustainable forest exploitation, except that the rationale has shifted to meet the modernization and development of the country concerned. This rapid economic growth has been influenced by industrial exports and by the extraction of natural resources (Ambali, 2011).

The changing of eco-systems due to land development activities can influence the balance in nature, which will result in an adverse impact to natural systems and human society (Chan, 1998). Production of cement, for instance, involves the explosion of limestone in a quarry, resulting in the release of dust into the air and water around it. This has a negative impact on wildlife health, deforestation, land degradation, soil contamination, and landslides, and may cause loss of human life as well as damage properties and infrastructures (Ambali, 2011). The extent of negative impact caused by the development of highlands on the eco system and environment is still inconclusive and needs further investigation.

Mechanisms to Control Development in Highlands

Using a One Stop Centre (OSC) for Planning Applications

Before the implementation of the OSC, all applications for new or existing developments were made separately to the respective responsible agencies. Thus, the period required was longer because the applications were usually reviewed at different times. Only after the approval of the layout plan, building plans were submitted for approval with the rest of the drawings for tracing purposes. In order to overcome this problem, the government established

the OSC to ensure that the approval process of development proposals would be carried out more efficiently and effectively. At present, the OSC is in place in most local authorities. It is an independent body that acts as a coordinator for the application process of plan production at the level of local authorities. Prior to the acquisition of development areas, developers must get the plan approved in order for physical work to be carried out on site and for advertising permission to be obtained from relevant authorities. The government has also taken initiatives to increase the effectiveness of development system implementation and monitoring by introducing the use of the certificate of completion and compliance (CCC).

All planning approvals are subject to the planning permission process referred to under Part IV, the Planning Act 1976 (Act 172) and the city. In general, local authorities will initially only offer conditional approval. The party submitting it has to make amendments to comply with the letter of conditional approval issued by the various technical departments. Therefore, it is suggested that more coordination in the development approval process be achieved especially when involving approval for highland development projects.

Sustainable Property Development Indicators

Indicators in sustainable property development are used to identify, measure and assess sustainable development progress in a particular area. In 2007, indicators were identified as being able to determine and evaluate goals. A sustainable development indicator reflects the interconnection between three main aspects, which are the environment, economy, and society. Indicators are also necessary to measure sustainable development in order to foresee and handle future sustainability (Siwar etal., 2008). There are three models related to property development, which are Local Agenda 21, the Malaysian Quality of Life Index (MQLI), and the Urban Sustainable Indicators.

Local Agenda 21

Agenda 21 is an action plan prepared by the United Nations with regards to sustainable development. At the moment it is a non-binding document and can be implemented voluntarily. Ngah et al. (2011) highlighted that Agenda 21 was the first comprehensive action plan that addressed sustainable development indicators. This plan is also useful for measuring the social, environmental and economic condition of a nation. Moreover, this indicator is capable of monitoring and forecasting any proposed development to achieve the objective of sustainability for a particular area.

The Malaysian Quality of life Index (MQLI)

MQLI can be used to assess the degree of well-being and equality of life in specific circumstances. Milbrath (1978) mentioned that quality of life is defined as happiness, well-being, or satisfaction. The Malaysian government has strived to provide guidelines and policies for rapid economic growth to bring about a better quality of life for its people(Omar, 2009). The Malaysian Economic Planning Unit (EPU) explains that MQLI 2002 defines quality of life as involving personal advancement, freedom to pursue knowledge, and a healthy lifestyle, while at the same time not ignoring the aspirations of the nation. The Economic Planning Unit (EPU) is located within the Prime Minister's Department and is a central government

agency whose primary responsibility is national development planning and coordination in Malaysia. Preparation of the MQLI coincided with the call in Chapter 35 of Agenda 21, which mentioned that *"countries with the assistance of international organizations develop, apply and institute the necessary tools for sustainable development including developing quality-of-life indicators covering, for example, health, education, social welfare, state of the environment, and the economy"* (Siwar etal., 2008).

METHODOLOGY

The study adopted a quantitative technique in which questionnaire surveys were used to collect data. A total of 200 questionnaires were distributed to 12 local authorities, the Public Works Department, the Department of Town and Regional Planning, the Department of Mineral and Geoscience, and developers. 157 replied questionnaires were found to be useful in forming a database for analysis. The detailed research framework is shown in Figure 1.

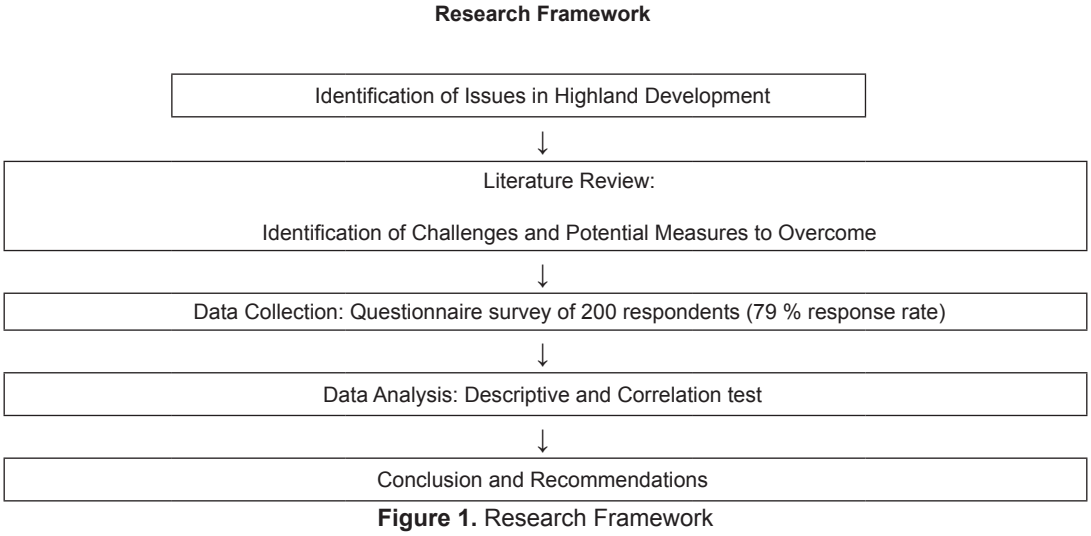


Figure 1. Research Framework

This study applied non-random judgment/purposive sampling. This was because the primary consideration in purposive sampling is the judgment of the researcher regarding who can provide the best information to fulfil the objectives of the research. The questionnaire was divided into five main parts, which were: (1) the respondent's background, (2) development issues of highlands, (3) control mechanisms for highland development, (4) approaches for sustainable development of highlands, and (5) suggestions regarding development of highlands. Generally, the measurements used in the questionnaire (except mentioned otherwise) were based on five-point Likert scales that use either interval or ordinal categories (Sekaran, 2000). The scale used in this study falls under the ordinal category, where a scale for neutral exists in the scale lines.

Data was mainly analysed and elaborated on using descriptive analysis. The data analyses were carried out using SPSS version 18.0 software. Statistical tests such as measures of central tendency and correlation tests were utilized. Moreover, a correlation analysis explained the strength and direction of the relationship between two variables indicated via the correlation

coefficient (Ali and Rahmat, 2009). In this paper, a correlation test was employed between the variables of hill slope development challenges and control mechanisms. This was to explore the possible significant relationships between 2 groups of construct variables, i.e., challenges and control mechanisms, as shown in Figure 2.

Figure 2. Potential Relationship between Challenges and Control Mechanism Variables

RESULTS AND DISCUSSION

Before further analyses were carried out, a reliability test was employed to check data validity. The reliability test showed an overall Cronbach's Alpha coefficient score of 0.860. Since the score was more than 0.7, all variables indicated internal consistency and high reliability (Nunally, 1998).

Descriptive Results

Table 1 shows the response rates for the questionnaire survey. The results showed that 72% of the respondents were from the government sector, while the remaining 28% were private sector employees. As expected, government professionals dominated the sample, as they are the ones primarily involved in monitoring highland developments. Furthermore, the questionnaires were researcher-administered, which contributed to a good response rate and quality feedback from the participants.

Table 1. The Respondents' Rates

Characteristic	Category	Frequency (N)	Percentage (%)
Organization	Private	44	28
	Government	113	72
	Total	157	100

Table 2. Demographic Profile of the Respondents

Item		Frequency (N)	Percentage (%)
Job Title	Town Planner	48	30.6
	Project Manager	2	1.3
	Engineer	33	21
	Architect	5	3.2
	Others	69	43.9
	Total	157	100
Working Experience	Less than 5 years	85	54.1
	5-10 years	45	28.7

Item		Frequency (N)	Percentage (%)
	10-15 years	12	7.6
	More than 15 years	15	9.6
	Total	157	100
Related Experience in land development process	Involved in planning permission	41	26.1
	Involved in development evaluation	27	17.2
	Involved in development application decision making	12	7.6
	Involved in development control	54	34.4
	Involved in development design and mitigation	23	14.6
	Total	157	100

Table 2 shows the demographic profiles of the respondents in this study. The results show that 56.1% of the respondents were construction related professionals, i.e., town planners, project managers, engineers, and architects. The other 43.9% came from other disciplines and included administrators, assistant architects, assistant engineers, geologists, property consultants and technical officers. The majority of respondents (54.1%) had less than 5 years of working experience in the field of highland development, while only 28.7% had 5-10 years of relevant experience. Most of the respondents (34.4%) were involved in development control, while 26.1% were involved in planning permission. 17.2% were involved in development evaluation and 14.6% were responsible for development design and mitigation.

Development Challenges of Highland Areas

Planning Aspects

Five planning issues with regards to highland development were listed for respondents to evaluate. Table 3 shows most respondents agreed that overcoming planning issues involved compliance of planning guidelines as well as compliance with guidelines for layout and building design, as the means for these variables were 4.20 and 4.14 respectively. This supports the findings of Alias et al. (2014), who reported a similar situation in their study. The respondents also classified complying with planning standards and monitoring debris in drains on slopes as potentially reducing the problem of development in highlands. Where it becomes necessary to develop on high lands, adhering strictly to planning guidelines is crucial both for safety of the development and its inhabitants and preserving the environment. According to Othman, Alias, Ali & Muhamad (2014) development activities in hill land areas must stringently adhere to planning frameworks and requires constant managing mechanisms, noting further that safety, environmental preservation and sustainability are the important aspects that must be considered.

Table 3. Planning Related Issues

Variable - Planning Issues	N	Mean	Std. Deviation
a) Comply with planning standards	157	3.90	.883
b) Comply with planning guidelines	157	4.20	.796
c) Comply with guidelines for layout and building design	157	4.14	.804
d) Monitoring debris in drains on slopes	157	3.84	.693
e) Monitoring damaged drains	157	3.79	.801

Environmental Aspects

Table 4 shows the descriptive statistics of the respondents' opinion regarding environmental aspects of highland development. As shown in Table 4, the mean values of all variables ranged from 3.66 to 4.08. Soil structure achieved the highest score, which indicates the respondents agreed that the best way to control environmental problems in highlands is by retaining the soil structure. This supports the argument by Maintain (2007) that development activities affect the environment. Meanwhile, usage of the Environmental Impact Assessment (EIA) report in addressing environmental problems ranked second (mean=3.98), indicating the need to reduce negative environmental impact caused by land development. Meanwhile, the variable given the least importance in preserving the environment was retaining cultural heritage characteristics, with a mean score of 3.66. According to Hutchinson (2009), exercising a ban on development activities in hill land areas is a good solution to curbing environmental concerns. Although arguments that this indirectly affects economic growth by the lack of property development activities is countered by successful implementation of bans on development activities in hill land areas in countries such as Taiwan and Hong Kong (Gue and Tan, 2003). Taken together, these result simply that professionals consider environmental aspects to be of primary concern in the development of highlands.

Table 4. Environmental Related Issues

Variable – Environmental issues	N	Mean	Std. Deviation
a) Preserve the biodiversity of that area	157	3.76	.796
b) By retaining environmental conservation	157	3.68	.768
c) Retaining cultural heritage characteristics	157	3.66	.860
d) By retaining soil structure	157	4.08	.694
e) Environmental impact assessment (EIA) usage in land development process	157	3.98	.738

Social Aspects

The results shown in Table 5 reveal the opinion of the respondents regarding social aspects of highland development. The mean values for social issues ranged from 3.69 to 3.97, which indicate that social issues also need to be considered in the development of highland areas. The highest mean value indicated was 3.97, for the variable of cooperation with the public, especially with those who stay nearby development areas. Meanwhile, information to the stakeholders and the use of SIA reports in determining the social impact of the development were considered the least important solutions to the problem. These results contrast sharply with the views of Abd-Rahman (2009), who emphasized the importance of SIA in any proposed

new development, noting that taking into consideration the social impacts of developments on people living especially within the vicinity of development areas by conducting a detailed SIA is crucial. Human impacts from perspectives such as economic, fiscal, aesthetics, and archeology are aspects necessary to be resolved by an SIA.

Table 5. Social Related Issues

Variable – Social issues	N	Mean	Std. Deviation
a) SIA usage in land development process	157	3.69	.940
b) Information to the stakeholders is the main thing before starting a development	157	3.73	.788
c) Cooperation with the public is important especially people that stay nearby the development areas	157	3.97	.751

Economic Aspects

Table 6 shows the results of the respondents' opinion regarding economic aspects of highland development. The mean values of the variables ranged from 3.13 to 3.29.The scores were considerably less than the scores for the planning, environmental, and social aspects. The highest mean score was 3.59, which indicates the respondents agreed that development of highlands (especially residential buildings) are aimed more at profit rather than at preserving natural resources (which only achieved a mean of 2.80). This result implies that developments in highlands could have minimal impact on natural resources, provided all parties adhere to regulations and policies endorsed by the government. The respondents also supported the development of highlands, which they perceived could contribute to the growth of national economy. It becomes a problem, however, where developments are purely economically driven. While property development contributed almost half of new investment revenues in the earlier part of 2012 (Leong, 2013), it should be noted that purely economically driven property developments result in severe adverse effects on the environment. With the rise in buildings with "green" characteristics, Pitts and Jackson (2008) noted that such elements must provide evidence of enhanced market value. The implication is that where green-building features does not result directly or indirectly in economic value, retaining them through new developments becomes difficult.

Table 6. Economic Related Issues

Variable – Economic issues	N	Mean	Std. Deviation
a) Home ownership of highland areas just focuses on high income earners	157	3.59	.956
b) Development of highlands are more profitable than usual development	157	3.50	.897
c) Development of highlands could contribute to a good impact on the national economy	157	3.52	.901
d) Development of highlands preserves the natural resources	157	2.80	.790

Land Development Issues

The respondents were asked to provide their opinions on nine specific issues regarding land development in highlands. The results are shown in Table 7. The mean values ranged from 3.55 to 4.07. The highest mean was the landslide issue, which recorded a 4.07 mean score, while silt (sediment) in runoff from construction sites, logging and land clearing sites was the lowest with a

3.53 mean score. This implies that the respondents agreed landslides are the primary issue in relation to land development in highlands. The results also indicate the government needs to be more stringent regarding landslide protection when dealing with development in highlands. This is important because landslides do not only affect the development itself, but also the safety of people and other infrastructures near the development.

Table7. Land Development Related Issues

Variable – Land development issues	N	Mean	Std. Deviation
a) Urban sprawl encroached towards environmentally sensitive areas	157	3.55	.763
b) Silt (sediment) in runoff from construction sites, logging and land clearing sites	157	3.53	.820
c) Deforestation	157	3.73	.931
d) Land degradation	157	3.74	.786
e) Soil contamination	157	3.68	.871
f) Tree and bush debris from development activities	157	3.95	.668
g) Broken water lines and other underground utilities in the building areas	157	3.75	.713
h) Landslides	157	4.07	.777
i) Loss of human life and damaging properties and infrastructures	157	3.78	.745

Perceptions of Control Mechanisms in Highland Development

The Implementation of the One Stop Centre (OSC)

Table 8 shows the response towards using an OSC for land development in highlands. The OSC is a concept where clients of a potential development need to submit all related documents to one coordinated office. Previously, the documents were submitted to various office agencies, which ended up in coordination difficulties. The highest mean score for the function of OSC was 4.16, (ensuring the compliance of legislations in the land development process). The lowest mean score recorded was 3.62 for the variable of controlling the land development trend in highland areas. OSC is a mechanism to ensure that respective departments carry out the process of development approval simultaneously, based in a central meeting place. The results implied that the respondents supported the OSC as a mechanism to control legislations in relation to the land development process.

Table 8. OSC Function

Variable – OSC	N	Mean	Std. Deviation
a) Can reduce risk of failing development	157	3.76	.841
b) In decision making for land development process	157	3.89	.646
c) As a medium for public awareness regarding the procedures of the proposed land development	157	3.90	.856
d) In controlling the trend of land development in highland areas	157	3.62	.624
e) In ensuring the compliance of legislations in the land development process	157	4.16	.647

Sustainable Development of Highlands Approach

Local Agenda 21

Table 9 shows the results for the respondents' opinion regarding Local Agenda 21, which was implemented by the government for sustainable development.

Table 9. Local Agenda 21 Control Mechanism

	Variable – Local Agenda 21	N	Mean	Std. Deviation
a)	Does emphasizing Local Agenda 21 improve sustainable development in Malaysia	157	3.91	.857
b)	Agenda 21does not help increase levels of awareness due to the fact that this agenda is still new in Malaysia	157	3.65	.750
c)	Local Agenda 21 is sufficient to be promoted at the local authorities level.	157	2.50	.910
d)	Local Agenda 21 highlights improving the quality of life and managing environment issues	157	3.83	.719

The majority of the respondents agreed that by emphasizing Local Agenda 21, sustainable development in Malaysia could be enhanced and improved (mean score of 3.91). However, the respondents did not agree that it is sufficient for local authorities to promote Local Agenda 21 (mean score 2.51). These results need to be shared with other relevant agencies and the public so that the main purpose of having this Agenda can be achieved in a short time. The respondents also agreed that Local Agenda 21 could be used as a mechanism to improve and manage sustainable development in highland areas, with a mean score of 3.83.

Malaysian Quality of Life Index (MQLI)

Table 10 shows the descriptive statistics of the respondents' perception of MQLI with regards to land development in highlands. The highest mean value of the items on the MQLI was 3.68 and the lowest mean value was 2.81. The highest mean score indicates that the respondents agreed MQLI has the ability to control index components, which include the environment, housing, lifestyles and urban services. The respondents also agreed that the scale could be used to improve the quality of life for the public, especially in the urban area (mean score 3.64). However, most respondents disagreed with the idea that the index could be effective in controlling deterioration and reducing development in highlands.

Table 10. Malaysian Quality of Life Index Control Mechanism

	Variable – Malaysian Urban Quality of Life Index	N	Mean	Std. Deviation
a)	The index could control the index component, which includes environment, housing, lifestyles and urban services	157	3.68	.760
b)	The index will reduce development in urban areas and highlands, and control the deterioration index	157	2.81	.751
c)	The index could be utilized to improve the quality of life	157	3.64	.855

Correlation Test

The purpose of the correlation test was to determine whether there was any significant relationship between the challenges of highland development and control mechanisms. Table 11 shows the results of the test. From the analysis, only two of the variables associated with the challenges had significant relationships with the control mechanisms, as follows:

- Problems in planning aspects could be controlled by implementing OSC (correlation coefficient of 0.408 at 1% significant level)
- Issues in land development could be minimized by implementing the sustainable approach (correlation coefficient of 0.568 at 5% significant level)

Table 11. Correlation Matrix between Challenges and Perceptions of Control Mechanisms in Highland Development

Challenges	Implementation of OSC	Sustainable Development Approach
Planning	.408**	.108
Environmental	.061	.039
Social	.054	.020
Economic	.057	.179
Land Development	.119	.568*

Note: * Correlation at 5% significance level
** Correlation at 1%significance level

The results indicate that the use of OSC significantly reduces problems with regards to planning aspects. This supports the statement by the Ministry of Urban Wellbeing, Housing and Local Government (KPKT 2008), which specified that the main reason of introducing OSC was to have more efficient and effective implementation and monitoring of developments. The second correlation was between land development issues and implementation of the sustainable approach. Two measures were found to be effective under the sustainable approach, which were Local Agenda 21 and MQLI. The results support the statement by Ng et al. (2011) and Omar (2009) who mentioned the function of Agenda 21 and MQLI was to monitor and forecast any proposed development in order to produce a better quality of life. Implementing these measures could therefore most likely reduce issues in land development.

Given these results, it can be concluded that both control mechanisms have great potential to be used in minimizing some of the problems surrounding highland development.

CONCLUSION

This study discussed five dimensions of challenges in highland development. They were: planning, environmental, economic, and social and land development. The study identified that compliance to planning guidelines as well as guidelines to layout and building design are necessary measures to overcoming planning issues. Also, retaining the soil structure could result in the control of environmental problems. Among curbing social issues, cooperation with the public, especially those within the vicinity of highland development areas is crucial. Also, land development issues could be more checked by establishing stringent guidelines from the government regarding landslide protection. In addition, two measures were identified

as control mechanisms that could overcome these problems. They were the implementation of OSC and the sustainable development approach. The associative test revealed that there were significant relationships between the use of OSC and problems in planning aspects and between the sustainable approach and issues in land development. This indicates the effectiveness of these two control mechanisms in addressing current problems in highland development.

As such, further research of the issues in highland development, which utilise a case study method, should be encouraged. Both control mechanisms could be tested the reliability to actual cases. In addition, future study could also examine more respondent's behaviour that involved in highland development especially for other parts in Malaysia. The data obtained possibly to be used for development of a prediction model of this issue.

REFERENCES

Abd-Rahman, N.S. (2009). *Social Impact Assessment in Urban Development in Malaysia*, Unpublished Undergraduate Dissertation, Universiti Malaysia Pahang

Ali, A.S., Rahmat, I. (2009). Methods of coordination in managing the design process of refurbishment projects, Journal of Building Appraisal Volume 5, Issue 1, June 2009, pp. 87-98

Ambali A.R. (2011). Policy of Sustainable Environment: Malaysian Experience, *European Journal of Scientific Research, 48* (3) (2011), pp. 466-492

Abu-Samah, F. (2007). Landslides on the Hillside Development, The Hulu Klang, Klang Valley. *Post-Graduate Seminar Semester 2 2006/2007, 6 March 2007*, Rumah Alumni, Universiti Teknologi Malaysia, pp. 148-162

Alias A., Mohd Isa, N.K. and Abdul-Samad, Z. (2014), Sustainable Building through Project Planning Process, *European Journal of Sustainable Development, 3*(4). pp.207-218.

Atkinson, A. (2007). 'Measuring those big property footprints', *Ethical Investor, 64*, pp. 32-33.

Chan, N.W. (1998). Environmental Hazards Associated with Hill Land Development in Penang Island, Malaysia: Some Recommendation on Effective Management, Journal of Disaster Prevention and Management: *An International Journal, Vol.7* (No.4), pp. 305-318.

Chan, R. (2009). *Report on 'Safe Hill-site Development' Seminar, 2009*, Geotechnical Technical Division, The Institution of Engineers, Malaysia

DTCP, (2009). Guidelines for Planning Development: Development in Hilly & Highland Area. Department of Town and Country Planning, Peninsular of Malaysia & Ministry of Housing and Local Government Malaysia

Gue, S.S. & Tan, Y. C. (2003), *Hillside Development – Issues and Challenges Kuala Lumpur, 19-20 August 2003,* The National Institute of Valuation (INSPEN), Valuation and Property Services Department, Ministry of Finance Malaysia.

Gue, S.S. & Tan, Y.C. (2003a). Current Status and Future Development of Geotechnical Engineering Practice in Malaysia, *Proceeding of 12th Asian Regional Conference on Soil Mechanics and Geotechnical Engineering, Vol. 2. Singapore, 4th- 8thAugust, 2003*.

Hezri, A.A. (2004). Sustainability indicator system and policy processes in Malaysia: a framework for utilisation and learning, *Journal of Environmental Management 73* (2004)

357–371

Huat L.T. and Ali F. (2012). Slope hazard assessment in urbanized area. *Electronic Journal of Geotechnical Engineering, 17*,341-352.

Hutchison, C.S. (2009). Metamorphism. In: Hutchison, C.S & Tan, D.N.K., (eds). Geology of Peninsular Malaysia, University of Malaya and Geological Society of Malaysia, Kuala Lumpur

Ibrahim, M.S. & Fakhru'l-Razi, A. (2006). Technological Disaster Prevention- The Case of Malaysia, *Disaster Prevention and Management 15*(5), pp. 286-298

Kwan, F.K. (2009). Construction Industry Outlooks, Master Builders Association Malaysia (MBAM)

Leong, T. (2013). Malaysia's economy fuelled by property development as FDI dries up, RHB Research, The Malaysia Insider

LPHS (2008), Garis Panduan Umum Perancangan, Lembaga Perumahan Hartanah Selangor, Malaysia

Malaysia, Building and Common Property Act (Maintenance and Management) 2007 (Act 663).

Malaysia, Town and Country Planning Act, 1976 (Act 172).

Malaysia, Street, Drainage and Building Act 1974, Act 133 (1974).

Malaysia, Land Conservation Act 1960, Act 385 (Revised 1989).

Malaysia, Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) (Amendment) Order 1995.

Milbrath, L.W. (1978). Indicators of environmental quality in UNESCO, Indicators of Environmental Quality and Quality of Life, *Reports and Papers in Social Sciences No.38*, pp. 3-56.

Newell, G. and Manaf, Z. (2008). The significance of sustainability practices by the Malaysian property sector, *Local Economy, Vol. 23* No. 3, pp. 152-167.

Ngah, K., Mustaffa, J., Zakaria, Z. and Noordin, N. and Mohamed-Sawal, M.Z.H. (2011). Formulation of Agenda 21 Process Indicators for Malaysia. *Journal of Management and Sustainability, 1* (1), pp. 82-89.

Ng, Y.S. (2009). National House Buyers Association (HBA), *Report on 'Safe Hill-site Development' Seminar, 2009*, Geotechnical Technical Division, The Institution of Engineers, Malaysia

Nik-Nazli, N.A. and Ahmed-Salat, A.H. (2013). Environmental disclosures of Malaysian property development companies: towards legitimacy or accountability? *Social Responsibility Journal, Vol. 9* Iss 2 pp. 241 - 258

Omar, D.B. (2009). Assessing Residents' Quality of Life in Malaysian New Towns. *Asian Social Science, 5*(6), 94-102.

Othman, K.N., Alias, A. & Ali, N.H. (2014). *Property Development Prospect on High Land and Steep Slope Areas- A case Study in Bukit Antarabangsa*, State of Selangor. World Journal of Engineering and Technology, 2, pp. 55-60

Othman, K. N., Alias, A., Ali, N., & Muhamad, I. (2014). Re-Examining the Control Mechanism for Sustainable Property Development on Highland Areas: A Case of Malaysia. *European Journal of Sustainable Development, 3*(4), 219-230.

Pitts, J. and Jackson, T. (2008). *Green Buildings: Valuation Issues and Perspectives*. *The Appraisal Journal, Spring 2008*. pp. 115-118.

Rosly, D. (2011). Advancing the Sustainable Development Agenda Through Aligning

Malaysia Plans & Policies, Federal Department of Town & Country Planning, Peninsular Malaysia.

Sekaran, U. (2000). *Research Methods for Business: A Skill Building Approach*, 4rd Ed., New York: John Wiley & Sons Inc.

Siwar, C., Ghazali, R., Hossain, M.E & Mumin, A.A (2008). *Linking Rural Poverty and Environment: Governance and Policies.* LESTARI, UKM Press, Malaysia.

The Star, (2009). Safeguarding Our Hill Slopes, Retrieved on December 7, 2012 from http://biz.thestar.com.my/news/story.asp?file=/2009/11/14/business/5103467&sec=business

Zakaria, Z. (2003). The Institutional Framework for Urban Transportation and Land Use Planning and Management in the Globalizing Kuala Lumpur Region. Fall 2002 Inception Report, MIT.

PARTNERING FOR SMALL-SIZED CONTRACTORS IN MALAYSIA

Hamimah Adnan[1], Ismail Rahmat[1], Mohd Hafizuddin Idris[1] and Heap-Yih Chong[2]
[1] Faculty of Architecture, Planning and Surveying Universiti Teknologi MARA, Shah Alam, 40450, Selangor, Malaysia
[2] School of Built Environment, Curtin University, WA 6845, Australia

Abstract
Partnering is one of effective procurement systems in the construction industry. Many large companies have been benefited from this procurement system. Yet, the related partnering research hardly focused on small-sized contractors. Hence, the objectives of this paper are (a) to ascertain the partnering concept, and (b) identify the problems and partnering effects as perceived by the small-sized contractors from the Malaysian's perspective. Quantitative analysis was conducted based on forty sets of valid and responded questionnaires. The results show the partnering concept was well received among the contractors in the local industry. The respondents also perceived some positive effects from the partnering approach, such as knowledge sharing, technical know-how sharing, profit and losses sharing, efficient management, higher decision making skills and exchange of ideas from different thinking processes. The findings render insightful references to any small-sized construction organisations from both local and international contexts in their quest for the effective use of this procurement system.

Keywords: *Partnering, small medium, contractor, construction industry, Malaysia*

INTRODUCTION

Since the publication of the Latham (1994) report, "Constructing the Team", partnering has been increasingly used as a procurement system in the construction industry. The procurement system enables the stakeholders to understand clearly its clients' needs and objectives including improved efficiency and cost-effectiveness, increased innovation opportunities and the continuous improvement of quality products and services.

To Malaysia, the construction industry has been facing with the increased growth of the number of contractors (CIDB, 2011). If the population of the country (26 million) is divided by the number of contractors (42,313), the ratio can be calculated as 1 contractor to 614 persons. This is an extremely high ratio. Most of the contractors (31,569, 70%) are classified as the smallest-scaled Class "F" category. The objective is to have a smaller number of contractors getting a bigger share of the limited amount of contracting works. The issue in this research concerns with the existence of too many small-sized contractors in bidding for limited projects. Thus, the implementation of the partnering among small-sized contractors in Malaysia is hoped to ease the problem. The contractors can partner together to secure larger businesses and also to increase their competitiveness (Onojaefe and Ukpere, 2009). As a result the partnering concept would provide positive impacts to the construction industry.

Besides, a rising number of small-sized contractors are facing delays in payments, shrinking contracts as well as difficulty in getting loans due to tougher operating environments in the construction industry (Wang and Abdul-Rahman, 2010). Additionally, some face insufficient financing, lack of experience in material price escalation, lack of sufficiently skilled work

force, lack of performance and time management and poor productivity. It is envisaged that by using the partnering concept, they can receive more benefits instead of operating or managing the project solely on their own. This would enable them to share the project's objectives and risks towards a common goal or mission.

Moreover, it is difficult to find and refer a related partnering research that is focused on the small-sized contractors. Therefore, this research differs from prior studies which mainly investigated on large companies in driving changes and utilizing the partnering concept (Bayliss et al., 2004; Anderson and Polkinghorn, 2008; Chan et al., 2008; Bygballe et al., 2010; Adnan et al., 2011) and its success factors (Black et al., 2000; Chan et al., 2004, 2008; Chen and Chen, 2007; Jacobson and Choi, 2008). The objectives of the research are to ascertain the practice of the partnering concept; and identify the problems and effects of partnering among the small-sized contractors in the construction industry. Results derived from this Malaysian study would address the gap in the area of small-sized contractor partnerships. The accomplishment of this research would also contribute directly to the literature in this area.

AN OVERVIEW OF PARTNERING

Crowley and Karim (1995) define the partnering concept as "an organization implementing a co-operative strategy b separating companies in a competitive climate". This is a set of strategic actions to improve the project performance (Bennett and Jayes, 1995). It is driven by a clear understanding of mutual objectives and co-operative decision-making by multiple firms.

In a partnering arrangement, the fundamental components are formalized mutual objectives, agreed problem resolution methods and an active search for continuous measurable improvements. These fundamental components are lacking in other procurement systems. The ultimate goal of the partnering system should be to achieve a "win-win" situation for all parties. The partnering relationship is based on trust, dedication to common goals and an understanding of each other's individual expectations and values (Matthews et al., 2000). Without these, the partnered team would lack of the basis for open, mutual learning, communication and real integration. In particular, the trust allows the team to focus on interests rather than on personalities or positions. It promotes openness and encourages people to put their cards on the table, which is related to the reliability and integrity of the partners (Botha and Waldt, 2010).

According to Tennyson (2003), partnering workshops should be initiated and organized to establish a platform for exchanging information in a construction network. The gathering of information in the partnering workshops includes skills, comments, ideas, data, facts and knowledge (Bennett and Jayes, 1998; Swan and Khalfan, 2007). The following outcomes could be achieved at the end of the workshops:

- Awareness raising, where appropriate;
- Mutual objectives;
- Performance measurement frameworks;
- Roles and responsibilities;

- Tools and processes.
- Greater certainty of the outcome in cost and time;
- Reduced wastage;
- Improving communications;
- Improving safety;
- Reduced costs associated with disputes; and
- Potential for continuous improvement.

In sum, the successful partnering system aims at empowering problem solving at the lowest possible level and earliest possible time and over the shortest possible period. If the team members can come to an agreement, they do not need help from upper management. But, if the problem is not resolved in a timely manner on one level of management, the issue then escalates according to a pre-arranged formula. Thus, leadership involvement in the partnering process is critical. The leaders must not only agree to the partnering concept; but they should drive it and implement it as early as possible (Stevens, 2004).

The Malaysian Construction Industry

The construction industry plays an important role in a country's economic development. It contributes to the infrastructure required for socioeconomic development and serves as a major contributor to overall economic growth (Abdullah, 2004). The Malaysian Construction Industry Master Plan emphasizes the role played by the construction industry and the private sector in generating wealth and improving the quality of life for Malaysians through the Government's socio economic policies into social and economic infrastructures and buildings. The industry also provides job opportunities to approximately 800,000 people. Further, it also creates various economic impacts to other industries, including manufacturing, financial and professional services. As Malaysia moves from developing country status towards a developed and industrialized nation as envisaged in Vision 2020, its construction industry will need to respond to the changes in construction demand. Any attempt to formulate strategies for fulfilling future demand would require a reliable understanding of the past and present scenario of the industry (Abdullah, 2004). Fundamentally, the performance and prospects of the economy have implications for the industry and construction industry development should be considered in the context of a country's economic development.

Small-sized contractors carry out several types of construction works with the cost limit of works up to RM 200, 0000.00. The value capital for small-sized contractors is RM 10,000.00. According to Shahimi (2006), there are fewer professionals involved in small construction firms, which the firms normally comprise persons with primary or secondary academic qualifications. Majority of small-sized contractors operates their company in their own premises due to their small capital. However, some who are established contractors, own their offices. Ownership of construction offices will ease the contractor's job in operating the organization and implementing work without interruptions. In 2006, the government allocated a budget of RM 2 billion for small-sized contractors to implement maintenance and basic infrastructure projects.

Many issues have been reported in the mass media involving small-sized contractors

in Malaysia. This can be expected when some contractors are more interested in making a quick profit by selling their contracts and licenses than in fulfilling the contracts (Kamil, 2007). It has motivated many to register and work as the contractor, including those without the expertise or required capital. Consequently, there are too many numbers of small-sized contractors who sometimes only advertise their names as holders for the company; where the license is not used by them to get any kind of projects (Shahimi, 2006). They would sublet their licenses to other companies and take a percentage of the profit. However, this practice hinders them to grow and expand their business.

DESIGN AND ADMINISTRATION OF THE QUESTIONNAIRE SURVEY

The questionnaire was developed based on the literature findings from the generic view of the partnering concept and practice in the construction industry. The literature was to investigate on different research subject, namely, small-sized contractors in Malaysia. This approach would ensure and ascertain the partnering concept in the local industry and also identify the problems and partnering effects as perceived by the contractors.

The survey questionnaires were distributed to two hundred and fifty small-sized contractors in the state of Selangor, Malaysia. The research selected Selangor as the scope of study, mainly due to the statistical reasons and strategic location of the state in Klang Valley. Selangor has the highest numbers of small-sized contractors in Malaysia and most of them are active contractors. This selection would provide greater accuracy to this study. Forty copies were duly answered and returned for statistical analyses. Though the sample size was relatively small and unable to represent the whole population. But, when a sample size is more than thirty, it is considered sufficiently large to apply central limit theorem ($\mu_{\bar{x}} = \mu$) to model the sample mean (Mann, 2005). The statistical results will approach to the normal distribution, where the mean of the sample size could represent the mean of the population (Chong and Zin, 2010). Therefore, means and percentage of frequency were suitable and applied to investigate the trends and scenario of the contractors.

The first analysis was conducted on the demographic data provided by the respondents. Twenty out of the forty small-sized contractors were involved in the construction industry for 6 to 10 years, representing 50%. This followed by those with11 to 15 years of experience. There were only 3 contractors who had experience of 1 to 5 years or more than 21 years in the construction industry. It is believed that more experienced small-sized contractors were involved in the construction industry.

Table 1. Scope of Works and the Jobs awarded to the small-sized contractors

NO	QUESTION: Which type/scope of works do you involved in project?		
	ANSWER	FREQUENCY	(%)
1	Repair/Maintenance Works	40/40	100
2	Building Works	38/40	95
3	Electrical Works	14/40	35
4	Infrastructure Works	31/40	78
5	Trade Works	29/40	73
6	Other Works	8/40	20

Table 1 shows that all small-sized contractors were involved in repair and maintenance works, followed by building works involving 95% of small-sized contractors and another 35% involved in electrical works. The lowest percentage was 20%, involving eight (8) small-sized contractors conducting other works such as mechanical, telecommunication and landscaping works, solid waste, etc.

It was found that 40% of small-sized contractors were awarded jobs 6 to 10 times within a span of 5 years followed by 33% contractors whom were awarded jobs 3 to 5 times within 5 years. Most of the jobs offered were from Government or public sectors.

Table 2. Problems faced during project stage

NO	QUESTION: What are the problems faced by the small-sized contractors during the early project stage?		
	ANSWER	**FREQUENCY**	**(%)**
1	Financial problems	30/40	75
2	Late payments	28/40	70
3	Not enough equipment	15/40	38
4	Not enough labours and traders	15/40	38
5	Not well experienced and unfamiliar with jobs given	15/40	38
6	Others	1/40	3

Table 2 shows that the finance or capital was the most common problem faced by the contractors. Thirty respondents claimed that finance is their main problem during the project stage, followed by the late payments caused by the client which accounted for 70% of the respondents. Fifteen respondents stated they did not have enough equipment, labours and trades during the project stage.

Table 3. Participation in partnering projects

NO	QUESTION: Have you participated in a partnering project?		
	ANSWER	**FREQUENCY**	**(%)**
1	Yes	14	35
2	No	26	65
	TOTAL	**40**	**100**

As is illustrated in Table 3, twenty-six (65%) small-sized contractors had never participated in any partnering projects while the remaining fourteen (14) have done so.

Table 4. Consideration of using the partnering concept to merge with other small contractors

NO	QUESTION: Have you considered doing so by using this concept to merge with other small-sized contractors?		
	ANSWER	**FREQUENCY**	**(%)**
1	Yes	14	54
2	No	12	46
	TOTAL	**26**	**100**

Table 4 shows that fifty four percent (54%) of the respondents stated that they had

considered partnering and were ready to merge with other small contractors but the remaining twelve respondents stated otherwise.

Table 5. The initiator of the partnering concept

NO	QUESTION: Who initiated the concept? ANSWER	FREQUENCY	(%)
1	Main Contractor	9/14	64
2	Design Team	5/14	36
3	Others	3/14	22
4	Client	3/14	21

Table 5 shows that most of the respondents said that the main contractor determined the partnering concept; whereas five out of fourteen respondents stated it was the design team's call. Only three respondents claimed that the concept was determined by the client and others such as friends in the same background small-sized contractors.

Table 6. The achievement of the objectives

NO	QUESTION: Were the objectives being achieved? ANSWER	FREQUENCY	(%)
1	Completely	2	14
2	Between 25% to 66%	5	36
3	More than 66%	7	50
4	None	0	0
	TOTAL	**14**	**100**

Table 6 shows that 50% of the respondents claimed that they had achieved more than 66% objectives; while only 14% of respondents claimed that they had completely achieved the objectives of partnering as shown in Table 7. None of the respondents claimed that they did not achieve any objectives.

Table 7. Successful implementation of the partnering concept among small-sized contractors

Rank	Issues	Percentage
1	Clear understanding of partnering concept	58
2	Joint agreement/ contract	54
3	Good communication/ information	54
4	Good manager and management skills	50
5	Experience of partner company	46
6	Effective collaboration and cooperation	42
7	No hidden agendas	42
8	Policy/political	42
9	Ability to share decision making process	42
10	Willing to share power	39
11	Mutual understanding/ trust	38
12	Organisation structure/ management	38
13	Willing to share profit	38
14	Trust need of partners	38
15	Others	0

The question shown in Table 7 was designed to identify the successful implementation of the partnering concept among small-sized contractors in Malaysia according to small-sized contractors' general knowledge and experiences. Only twenty-six respondents answered the question. This question applies the Likert-Scale of 1 to 5, with 5 representing strongly agree, 4 for agree, 3 for undecided, 2 for disagree and 1 for strongly disagree. Most respondents (58%) strongly agreed with clear understanding of the partnering concept. This followed by the successful joint agreement or contract and good communication/information. All the issues were considered important and well-received by the respondents.

Table 8. Potential management issues in implementing the partnering concept

Rank	Management Issues	Percentage
1	Inefficiency of working committee	55%
2	Inadequate project organization structure	54%
3	Poor project relationships and disputes with partner	48%
4	Partner's lack of management competence and resource fullness	47%
5	Disagreement exists on allocation of staff positions in Partnering	45%
6	Disagreement exists on allocation of works	44%
7	Lack of knowledge in Partnering concept	43%
8	Improper project planning and budgeting	40%
9	Employees from each partner distrust each other	38%
Rank	**Financial Issues**	
1	Bankruptcy of partners/ financial problems	60%
2	Disagreement on accounting of shares of profits and losses	60%
Rank	**Technical Issues**	
1	Incompetence of partner's workers	60%
2	Lack of technical communication between partners	55%
3	Poor quality /workmanship produced by partner	53%
4	Problems due to partner from different practice	42%
Rank	**Legal Issues**	
1	Breach of contract by partners	65%
2	Disagree with some conditions of contract	48%
3	Lack of enforcement by legal judgment	45%
4	Incomplete contract terms with partners (loophole in agreement)	45%

This question shown in Table 8 was designed to identify problems in the implementing the partnering concept among the contractors. Four problems were classified such as, management problems, financial problems, technical problems and legal problems. The problems were arranged in ranking based on the statistical results on the Likert scale. The scale was 1 to 5: with 1 representing the very lowest priority; 2 for low priority; 3 for average; 4 for high priority and 5 for the very highest priority. Based on the overall results, it was found that, the inefficiency of working committee was ranked the first for the management problems with 55% highest priority followed by the inadequate project organization structure. The element of poor project relationships and disputes with partner was ranked in the third place with 48%. It was then followed by the element of partner's lack of management competence and resourcefulness where 47% respondents voted for an average.

Most of the respondents (60%) had voted equally on both the financial issues, namely, bankruptcy of partners or financial problems, and disagreement on accounting of share of profits and losses. This means the issue of disagreement on accounting of share of profits has a highly probability of occurring.

To the technical problems, 60% of respondents agreed on the incompetence of partner's workers. This followed by 55% respondents voted on the issue of lack of technical communication between partners. Poor quality/workmanship produced by partner received 53% votes while problems due to partners from different practice received the lowest percentage.

To the legal issues, the highest percentage (65%) of respondents voted on breach of contract by partners while 48% of respondents voted on the issue of disagreement with some conditions of contract, followed by lack of enforcement by legal judgment and incomplete contract terms with partners which received 45% each.

DISCUSSION

General Problems in Small-Sized Contractors in Malaysia

Various problems have been facing by most small-sized contractors in the Malaysian construction industry. The Government of Malaysia has taken serious steps to mitigate these problems, and in particular, the Ministry of Works aims to restructure the industry by merging companies involved in the same sectors to increase the contractors' skills and competitiveness. Most of the contractors do not have sufficient capital to finance their undertakings. Banks do not accept the construction equipment owned by the contractor as collateral. Therefore, the contractors face the problem of seeking sufficient capital to undertake their business. Furthermore, too many small contractors compete for too few jobs in the industry. Most respondents agreed that there was too much competition in obtaining projects. They only managed to obtain projects 6 to 10 times for a period of five (5) years. Moreover, the contractors also face logistics problems such as insufficient plant and machineries, materials, etc. This is due to lack of skills to wheel and deal with suppliers.

Therefore, the small-sized contractors require different means in addressing the problems above. The partnering approach could be one of the most effective ways to help and train the contractor, where the contractors' shortcomings could be covered and helped the partner. This would complement one and another in improving their skills and competitiveness to complete the project successfully (Matthews et al., 2000; Botha and Waldt, 2010).

The Partnering Concept and Effects

By referring on the quantitative findings, it was found that most of small-sized contractors have basic knowledge and understanding of the practice of the partnering concept. Most of them felt that the concept of partnering is suitable to be applied due to the current problems

in the construction industry. On top of that, partnering can be used in various situations that demand productivity within a short given period, well equipped plants and materials, enough capital and experience. Work productivity can be raised if the small-sized contractors are fully committed to partnering.

In addition, most of the respondents felt that the implementation of the partnering concept among small-sized contractors can produce reputable and competitive small-sized contractors. Workers or skilled labour from the different partners could be worked together so that their skills may be utilized in different scope of works. The partnering concept will enhance knowledge and skills-sharing in the industry. Therefore, all of them can share experiences, develop their skills and bid for projects depending on their combined expertise.

To the management perspective, the experience brought by various contractors can be shared, leading to better communication, more efficient management and resourcefulness. Some creative ideas from the experienced contractors can be shared for developing the present business into a larger business in accordance with the demands of the construction industry nowadays. Eventually, different types of contractors from big to small-sized contractors can merge to form a consortium.

Overall, the quantitative results reflect almost the same findings on the collaborative practices in the partnering concept (Black et al., 2000). It will improve the project performance and increase the competitiveness of the involved organisations. The benefits and management issues are also rather similar to the general scenario in the construction industry, which relate to the trust and working commitment in the partnership for a mutual objective (Matthew et al., 2000; Chan et al., 2004; Chan et al., 2008). However, the partnering concept will change and evolve in the small-size contractors after certain levels of development and maturity. This is mainly due to the need for coping with the different institutional and national settings (Bygballe et al., 2010). Hence, the Malaysian scenario could be the first example and reference for other small-sized contractors in other countries, if the partnering concept has been developed and implemented successfully in the Malaysian construction industry.

CONCLUSIONS AND RECOMMENDATIONS

The research has analysed the partnering concept and achieved the objectives for small-sized contractors in Malaysia. The partnering concept was well received among the contractors in the local industry. The key benefits of the partnering concept include knowledge sharing, technical sharing, profit and losses sharing, efficient management, higher decision making skills, transfer of ideas from different thinking, etc. Thus, those small contractors who face obstacles in obtaining projects because their business is new, small and less established, will benefit from partnering as collaboration, knowledge and technical sharing which are inherent in the partnering concept, will help them to surmount these challenges.

While most small-sized contractors have basic knowledge and understanding of the partnering concept, their confidence and commitment may be further augmented by knowledge sharing and enhancing seminars and workshops. Consequently, the contractors who are knowledgeable about and truly committed will have the opportunity to reform and

revolutionize their companies.

It is suggested that the Malaysian government and its Contractor Centre Service provide more courses and seminars for small-sized contractors to clarify the partnering concept. Comprehensive knowledge on partnering is required so that small-sized contractors will be more confident to practice the concept. In addition, partnering courses are crucial for attracting small-sized contractors to participate and discuss related issues with the relevant bodies in the construction industry. Besides, the partnering concept should also be broadened to include medium and large contractors who could collaborate with the small-sized contractors. The partnership could come from the same areas of specialization according to the types of works undertaken. This is to increase efficiency within the partnering teams.

Further research could focus on the formation of a project distribution centre to facilitate partnering job distribution. The project distribution centre is to ensure the effective and efficient distribution of projects, in particularly public projects. Good governance and freedom from political interruptions should be the hallmarks of the distribution centre. Moreover, further investigation should be carried out on those had bad experiences in the partnering concept or practice. It would be able to draw a clear picture on the behaviours and strategies for future implementation.

In conclusion, the research provides insightful references based the quantitative analysis on the partnering concept for the Malaysian small-sized contractor. The findings can be referred by any construction organisations in Malaysia or other countries.

REFERENCES

Abdullah, F (2004). *Construction Industry - Economic Development: The Malaysian Scene* . Malaysia: Penerbit UTM.

Adnan, H., Chong, H. Y., & Morledge, R. (2011). Success criteria for international joint ventures: The experience of Malaysian contractors in the Middle East. *African Journal of Business Management*, 5(13), 5254-5260.

Anderson LL, Polkinghorn B (2008). Managing conflict in construction mega projects: leadership and third-party principles. *Conflict Resolution Quarterly*, 26 (2): 167–198.

Barlow JC, Cohen M, Jashapara A, Simpson Y (1997). T*owards Positive Partnering.* Bristol: The Policy Press.

Bayliss R,Cheung S-O,Suen HCH,Wong S-P (2004). Effective partnering tools in construction: a case study on MTRCTKE contract 604 in Hong Kong. *International Journal of Project Management*, 22: 253–263.

Bennett J, Jayes S, Stevens T (1995). *Trusting The Team: The Best Practice Guide to Partnering in Construction.* University of Reading, Centre for Strategic Studies in Construction.

Bennett J, Jayes S (1998). *The Seven Pillars of Partnering: Guide to Second Generation Partnering.* London: Thomas Telford

Botha E, Waldt DLR vd (2010). Relationship antecedents that impact on outcomes of strategic stakeholder alliances. *African Journal of Business Management*, 4(8): 1629-1638.

Black C, Akintoye A, Fitzgerald E (2000). Analysis of success factors and benefits of partnering in construction. *International Journal of Project Management*., 18: 423–434.

Bygballe LE, Jahre M, Sward A (2010). Partnering relationships in construction: A literature review. *Journal of Purchasing & Supply Management*, 16: 239-253.

Chan APC, Chan DWM, Chiang YH, Tang BS, Chan EHW, Ho KSK (2004). Exploring critical success factors for partnering in construction projects. *Journal of Construction Engineering. & Management*, 130(2): 188–198.

Chan APC, Chan DWM, Fan LCN, Lam PTI, Yeung JFY (2008). Achieving partnering success through an incentive agreement: lessons learned from an underground railway extension project in Hong Kong. *Journal of Management in Engineering*, 24(3):128–137.

Chen WT, Chen TT (2007). Critical success factors for construction partnering in Taiwan. *International Journal of Project Management*, 25: 475–484.

Chong, H. Y., & Zin, R. M. (2010). A case study into the language structure of construction standard form in Malaysia. *International Journal of Project Management*, *28*(6), 601-608.

CIDB (2011). Construction Industry Development Board, Malaysia, www.cidb.gov.my.

Crowley LG, Karim MA (1995). Conceptual Model of Partnering. *Journal of Management in Engineering* , 13 (3): 57-62.

Jacobson C, Choi SO (2008). Success factors: public works and public–private partnerships. *International Journal of Public Sector Management*, 21(6): 637–657.

Latham M (1994). *Constructing The Team: Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry.* London: HMSO.

Mann, P.S., 2005. I*ntroductory Statistics Using Technology, fifth ed*. John Wiley & Sons, New York.

Matthews J. (1996). *A Project Partnering Approach to the Main Contractor-Subcontractor Relationship.* Loughborough University.

Matthews JP, Pellew L, Phua F, Rowlinson S (2000). Quality Relationships: Partnering in the Construction Supply Chain. *International Journal of Quality & Reliability Management*, 17 (4/5): 493-510.

Onojaefe D, Ukpere WI (2009). Partnership and the e-commerce initiative of small businesses. *African Journal of Business Mangaement*, 3(12): 855-861.

Shahimi, N. (2006). *A Study on The Achievement of Class F Contractors. Shah Alam: Department of Quantity Surveying*, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA Malaysia.

Swan W, Khalfan MMA (2007). Mutual Objective Setting For Partnering Projects in the Public Sector. *Engineering, Construction and Architectural Management*, 14(2): 119-130.

Stevens, R. (2004). "Partnering, Environmental & Risk Management",. International Construction Conference 2004. CIOB Malaysia.

Tennyson R (2003). *Institutionalising Partnerships: Lesson From the Front Line*. International Business Leaders Forum.

Wang C, Abdul-Rahman H (2010). Decoding organizational culture: A study of Malaysian construction firms. *African Journal of Business Management*, 4(10): 1985-1989.

WORK-LIFE BALANCE: A PRELIMINARY STUDY ON PROFESSIONAL WOMEN QUANTITY SURVEYOR IN MALAYSIA

Mastura Jaafar, Loh Chin Bok, Azlan Raofuddin Nuruddin, Alireza Jalali and Faraziera Mohd Raslim
Quantity Surveying Department, School of Housing Building and Planning, Universiti Sains Malaysia, 11800, Minden, Pulau Pinang.

Abstract
Studies on women in construction industry have attracted minimal attention in Malaysia. The objectives of this study are to measure the satisfaction level of professional women in work-life balance; to examine the obstacles faced by women professional quantity surveyors in the Malaysian construction industry with respect to work-life balance and to identify the relationships between the two. Probability sampling was used to collect data in which 251 questionnaires were sent to registered women quantity surveyors obtained from the Board of Quantity Surveyors Malaysia (BQSM) list, with 35 respondents returning the questionnaires. The findings revealed that women professional quantity surveyors were satisfied and achieved work-life balance with their current career and family life. Long working hours, uneven adoption of policies, lack of formalisation and temporal adjustment to working time were among the obstacles identified from this study. Women quantity surveyors secure work-life balance through avoiding spending long hours at work. It was also interesting to note that majority of their employers do not have any written policy to support their work-life balance. This study provides new insights on the dynamics of work-life balance implementation on professional women quantity surveyors in the Malaysia construction industry.

Keywords: *Work-life balance, satisfaction, obstacles, professional women quantity surveyor and construction industry.*

INTRODUCTION

Since the 1940s, a growing number of women have entered the labour force at a rate of over 20% progressively (Riley and McCloskey, 1996). Work-life balance involves the effective management and support of both paid work and other vital activities, including time with family, sports and recreation, volunteer work, and further studies (Kaewsri and Thongthong, 2013). Nonetheless, the rigidity of working hours and the working environment prevent women from working effectively because they must also devote their time for childcare and other family responsibilities (Ellison, 2001; Wilson, 1998). Many researchers have examined how the conflicting demands of career and family can be balanced (Hattery, 2001; Parasuramanet al., 1996; Walter, 1999; Williams, 2001). Spencer and Podmore (1987) related this issue to the concept of professional commitment, which they recognize as a key factor in the marginalization of women in the professional sector.

Professional women must achieve the ideal work-life balance as they are empowered and motivated by a well-balanced lifestyle that fulfils both career and family responsibilities (Kaewsri and Thongthong, 2013). By contrast, personal overload, conflicts between family and work and overstress result in burnout or bored syndrome which negatively affects both family and work life and can possibly induce sickness, lack of productivity and additional individual problems (Varatharaj and Vasantha, 2012). By attaining work-life balance, professional women will not feel overworked while being satisfied with their jobs and careers

(Malik, 2011). This satisfaction may translate into higher efficiency and productivity, which in turn benefits their employers. Lim and Ling, (2012) emphasized on the need for work-life balance for female staff members in construction companies.

This study further incorporates the barriers to work-life balance into the conceptual domain of work environments that support families. In particular, this research focuses on the causal factors that limit the effective management of career and family by women, given that, in addition to workplace commitments and responsibilities, the patterns of career development for women are typically influenced by family, unlike those for men. This paper aims to fill the research gap by catering to two objectives: (1) To examine the satisfaction level of registered women Quantity Surveyors with work-life balance; (2) To determine the obstacles to work-life balance as faced by registered women Quantity Surveyors and (3) To identify the relationships between the satisfaction of work-life balance and their obstacles.
This paper is structured as follows. Section 1 discusses on the construction industry and women participation before characterizing the basic concepts of work-life balance; section 2 describes the research methodology, and section 3 presents the basic findings. Finally, Section 4 summarizes the results along with their implications.

LITERATURE REVIEW

Construction industry and Malaysian construction industry

The construction industry is unique, large in nature, and houses a wide diversity of professions, specialists, and suppliers (Arslan and Kivrak, 2004). In the 21st century, this increasingly complex industry necessitates the involvement of various professionals, such as architects, interior designers, quantity surveyors, civil, mechanical, electrical, and structural engineers (Hussin and Omran, 2009). In Malaysia, the construction industry is one of the most important sectors that contribute to the economic growth of the country (Rozanah and Kamal, 2008). This sector recorded growth of 18.5% in 2012 (Judin, 2013) and according to Statistics Department Malaysia, in 2013 the number of employed workers in the industry is 1,244,000 with only 8.8% or 109,000 being women. Furthermore, this sector is the source of numerous and highly complex projects, which are significantly challenging and provide vast opportunities to various companies in the construction industry.

Construction industry and construction organisations

There is a difference in the nature of careers between the construction industry and construction organisations. Basically, the industry refers to all businesses in the same line of work such as computer industry, manufacturing industry and construction industry. In the construction industry, there are groups of companies or organisations making and/or selling the same products or services for instance: engineers, architects, quantity surveyors and contractors in construction industry (Dainty, Grugulis, and Langford, 2007). Construction organisations involved a group of persons either professional or non-professional working in the same direction or common goals that is to achieve the objectives of the organisations (Jaafar and Othman, 2013). Amaratunga et al. (2006) in their research revealed that the true position of professional women in the construction industry and organisations was less compared to

non-professional women. Accordingly, 84% of women in construction held secretarial posts, whereas only 10% were employed in a professional capacity and the remaining 6% were craft and trade level employees. In addition, a previous study found that most women in the United Kingdom construction industry and organisations were employed in administrative positions (Fielden et al., 2001) while according to Watts (2007), there was a disproportionate absence of women in the professional positions of construction industry such as those related to technical and managerial disciplines.

Nature of career and women participation in construction industry

The careers within the construction industry are extremely different from each other and composed of unskilled, craft, managerial and administrative workers (Dainty et al., 2007). Moor (2006) argued that the inclusion of more women in the workforce provides individual and social benefits. Since Malaysian women make up almost half of the population (Malaysia Statistics Department, 2010), it would thus be significant to incorporate women in the construction industry (Radhlinah and Jingmond, 2011). The under-representation of women in this industry has been well-documented. Court and Moralee (1995) reported that in the mid-1990s, women constituted only 10% of the approximately 1.77 million people employed by the UK construction industry. In Australia, Lingard and Lin (2004) reported that women accounted for only 14% of the employees in the Australian building industry. Although sectoral changes in the Malaysian economy have enhanced the proportion of women engaged in technical and professional activities, according to Goh, Seow, and Goh (2013) however, the participation rate of women in the Malaysian workforce remains lower than other Asian countries.

Wangle (2009), Chandra and Loosemore (2004), Agapiou (2002), Whittock (2002), and Fielden et al., (2000) investigated why women avoided the construction industry and determined that most of the common barriers were physical incapability, sexual harassment, sexual discrimination, social acceptance of career choice, sexual-inappropriateness of the occupation, the lack of qualification for blue-collar jobs, and labour conditions such as extreme weather, unsociable working hours, and occupational hazards. Besides that, the working conditions and inflexible working hours were among the factors that lead to less participation of professional women in construction industry (Barbara, David and Gulsh, 2008 ; Lim and Ling, 2012). This underrepresentation of women in construction industry is also due to their marital status and commitment to demands stemming from their roles as wives and mothers which sometimes lead to career breaks and limit their ability to explore other career opportunities which suit their requirement better (Kehinde and Okoli, 2004).

The current study concentrates on registered women quantity surveyors. The quantity surveyors' (QS) role is to minimise the costs of the construction project and improve value for money, and at that same time getting the required standards and quality (Abdullah, Arshad, and Ariffin, 2013). QSs relate to people at all levels whether they are consultants, developers, contractors and sub-contractors, and act on behalf of the client to ensure value for money and check the accuracy of the contractor's application for payment (QS Professionals, 2013).

Work-life or work-family balance

Work-life balance generally refers to the organizational support for dependent care, flexible work arrangements and family-related or personal leaves (Estes and Michael, 2009). By achieving work-life balance, professionals do not feel overworked and are therefore satisfied with their jobs (Kehinde and Okoli, 2004). As a result, they become highly efficient and productive, which in turn benefits their employers. Work-life balance is the current focus of discussions related to the improvement of working conditions and paid work flexibility. In this respect, the appropriate design and implementation of policies for work-life balance can facilitate the autonomy of workers in integrating the spheres of work and non-work life (Felstead et al., 2002). Work-life balance generates various "win-win" outcomes for both employers and employees. Employers benefit from increased productivity, reduced accommodation costs (e.g., hot-desking), low absenteeism rates, improved recruitment, retention and customer services, and employee motivation (Woodland et al., 2003). Employees can mould their increasingly flexible work-times around household and care responsibilities (Tietze and Musson, 2005). As a result, they are less stressed (McDowell et al., 2005).

Satisfaction of women in work-life balance

Previous studies on either family or work satisfaction cannot ascertain whether women have experienced a cultural reversal (Kiecolt, 2003). However, the distribution of satisfaction between work and family life (Pleck, 1985) in assessing "the relative emotional magnetism of home and work" (Hochschild, 1997) cannot be ignored. Based on these ideas, relative work-home satisfaction is defined by a two-by-two typology. First, Hochschild (1996) examined women who considered work as a haven from home and who were more satisfied with work than with family. This work-as-haven pattern is a cultural reversal of the second pattern of "family as haven from work" (Hochschild, 1996). This pattern is more traditional and typical than the first. Third, some women work around a "double-positive" pattern of "work-home balance" and find both work and home to be pleasurable (Hochschild, 1996).

Aryee and Debrah (1992) reported that career satisfaction is related to organizational commitment and conclude that employees "exchange" organizational commitment for the rewards associated with the satisfaction of career aspirations. When their career expectations are not met, women become disillusioned and uncommitted. Lingard and Francis (2002) and Lingard and Sublet (2002) stated that the demands of construction work affect the personal relationships of construction professionals. Although both men and women must balance the demands of work and home life, women continue to bear the primary responsibility for domestic duties in most households (Demo and Acock, 1993; Higgins et al., 2000). Dainty et al. (1999) reported that the satisfaction levels of women in the construction industry decline under significant issues because male-oriented work practices prevent the balance of work and family life.

OBSTACLES TO WORK-LIFE BALANCE

Uneven adoption of policies

The first obstacle in work-life balance is the uneven adoption of formal and written family-supportive policies according to enterprise size and sector. Family-supportive policies refer to services that simplify the day-to-day responsibilities of employees, including childcare, flexitime and telecommuting. Research has demonstrated that the implementation of family-friendly policies is linked to lessened work-life conflict (Frye and Breaugh, 2004; Gajendran and Harrison, 2007; Thompson et al., 1999). Moreover, policies that support work-life balance benefit not only the individual but also the organization.Many previous data sets indicate that work-life balance policies are not evenly distributed across sectors or organizations. Over a quarter of manufacturing establishments have not implemented policies related to any aspect of work-life balance (Hyman and Summers, 2004). Furthermore, organizations with fewer than 500 employees are less likely to develop such policies (Hyman and Summers, 2004). According to Cully et al. (1999), such policies have been implemented in the public sector and in large establishments. Dex and Colin (2002) also emphasized that organizations with high numbers of female employees are likely to implement such policies.

Lack of formalization

Professional women are typically managed directly by line managers who are usually untrained and lack awareness and understanding on issues requiring family-friendliness and work-life balance. Moreover, these managers can and do influence the effectiveness of work-life policies by acting as "gatekeepers to employees' access" in large companies (Dex and Colin, 2002; Dex and Scheibl, 2002; Bond et al., 2002). Lauzun et al. (2010) also argued that line managers cannot accommodate the needs of subordinates for work-life balance because of insufficient authority, insufficient resources, job requirements and the involvement of multiple parties with respect to such accommodations. Based on the studies on policy and cultural constraints (e.g., Eby et al., 2005; Ford, Heinen, and Langkamer, 2007), insufficient authority is the most common barrier. In the study by Lauzun et al. (2010) however, supervisors did not admit to being barriers despite indications in previous literature that immediate line managers can both facilitate and hinder the work-life balance of subordinates (Ford et al., 2007; Major et al., 2008; Thompson, Beauvais, and Lyness, 1999). Hyman and Summers (2004) mentioned that very few line managers, including those with delegated authority, had received specific training with respect to family-friendly working environments or work-life balance. Thus, the interpretation and implementation of formal policies remain subject to the informal discretion of often-uninformed line managers.

Long working hours

Attaining work-life balance is difficult for women with substantial household responsibilities because they must conform to the counterproductive "working long hours culture" (Lewis, 2000; Rapoport et al., 2002; White et al., 2003). Current work-life balance policies fail to address many of the core issues attributed to surrounding work conditions (Shorthose, 2004). Thus, allocating time and presence between work and home (Tietze and

Musson, 2005) remains challenging because employees feel that they must always remain on call and be available. Furthermore, they feel invisible and isolated by working at home (Harris, 2003).

Temporal adjustment

Temporal adjustment benefits both employers and staff by increasing motivation and corporate loyalty. Furthermore, employees approach their work with energy and enthusiasm (Macdonald, 2005). However, the considerable rhetoric on the desirability of work-life balance is not supported by recognized standards of "work-life balance" or "family-friendliness" (Hyman et al., 2003). In organizations, the appropriateness of recent arrangements for temporal flexibility is questioned in relation to how they serve employee needs rather than those of employers for productivity (see Lewis and Lewis, 1996, p.160). Between 1988 and 1998, the proportion of women working more than 50 hours a week increased from 4% to 10% (Hyman et al., 2003).

Many employees, including those with young families, work weekend shifts (Hyman and Summers, 2004). As previously mentioned, some employees work extra hours without compensation, and professional staff members commonly take work home even after putting in a full day in their offices (see also Harvey, 1999; Scase, 2002). Hogarth et al. (2000) also argued that professionals are the most likely to work regular and long additional hours without financial reward. According to Hyman et al. (2003), call centre employees are often exhausted after work, and approximately 40% of them claimed that they felt exhaustion as well throughout the working period. The same was true for over half of the respondents from the software industry. A large proportion of them claimed to experience sleep problems and were concerned that their work was adversely affecting their health. In addition, these professionals are highly stressed, especially those with childcare responsibilities.

Persistence of second shift

Hochschild (1989) reported that women worked roughly 15 hours longer than men each week and that most women work two shifts, namely one at the office and the other at home. Furthermore, significant proportions of female employees are exhausted when they return home, as well as suffer from the lack of sleep, anxiety about work while at home, and are generally stressed (Hyman and Summers, 2004). Despite the increased participation of women in paid work and its attendant concerns, efforts to balance household responsibilities in terms of domestic labour and childcare with work have developed slightly over time (Hyman and Summers, 2004). Regardless of employment status, women undertake domestic responsibilities (Newell, 1993; Charles and Kerr, 1999). Hence, the so-called second shift remains stubbornly intact. Labour research (2001, p.28) also revealed that women are still paid lesser than men. This discrimination may restrict their opportunities with regard to engaging in part-time work. This issue is further exacerbated by the general absence of affordable childcare.

METHODOLOGY

Table 1 shows the research objectives and research methodology for this study.

Table 1. Relationship between research objectives and study components

Research Objectives	Research Questions	Research Methodology
1. To measure the satisfaction level of women registered Quantity Surveyors.	What is the level of satisfaction among women registered Quantity Surveyors?	1. Literature review – to gain the understanding on women, career and life balance. 2. Questionnaire – to compare the literature review and the satisfaction level of selected respondents.
2. To examine obstacles that faced by women registered Quantity Surveyors in achieving work-life balance.	What are the obstacles that faced by women registered Quantity Surveyors in achieving work-life balance?	1. Literature review – to gain the information on the obstacles that faced by women registered Quantity Surveyors 2. Questionnaire – to compare the literature review and the obstacles faced by the selected respondents.

Sampling and data collection

A simple method of random sampling was applied to equalize the chances of selection for each sampling element and to reduce possible bias in the process. As a rule of thumb, Hoinville and Jowell (1978) suggested that the sample size should be 10% of the total population. A total number of 251 questionnaires were distributed to registered women quantity surveyors throughout Malaysia. According to the Board of Quantity Surveyors Malaysia (BQSM), the percentage of registered women quantity surveyors is 26.1% of which 251 are women and 712 men. A total of 35 positive feedbacks (14% participation rate) were obtained. For descriptive data analysis, the researcher utilised statistical tools and methods, such as frequency, means (*m*) and standard deviation (*STD*) generated by SPSS version 18.0.

Table 2. Sampling for current research

Population	Women registered QSs who work in registered QS firms under BQSM.
Sample	Women registered QSs who work in registered QS firms under the BQSM in Malaysia.
Sample size	251 Women registered QSs.

In the analysis, variables were ranked according to the mean value of the responses. The value ranges for each response were as follows: 4.50 to 5.00 for high level of satisfaction and a large number of obstacles for professional women (strongly agree), 3.50 to 4.49 (agree), 2.50 to 3.49 denotes the middle ground (neither agree nor disagree), 1.50 to 2.49 corresponds to a low level of satisfaction and a small number of obstacles for professional women (disagree), and>1.49 (strongly disagree).

Measures

To capture the demographic background of the respondents, seven question items were included, namely age, status, qualification, job tenure, position, salary and working status. These questions were based on a tool used by Mbah and Ikemefuna (2012), which was first introduced by Smith, Kendall, and Hulin (1969). The level of satisfaction was assessed using the 13-item scale of overall job satisfaction adopted from the studies conducted by White (1999), Saltzstein, Ting and Saltzstein (2001), Wheatley (2012) and Marks and Mac Dermid (1996). This scale assesses the overall affective responses of each organizational member to

his/her job by using a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). As shown in Table 3, Cronbach's alpha is 0.823. Thus, all 13 questions are acceptable and can determine the level of satisfaction of the respondents.

Table 3. Reliability statistics (Satisfaction of work-life balance)

Cronbach's Alpha	Cronbach'ss Alpha based on Standardized Items	*N* of Items
0.823	0.839	13

Level of obstacles was assessed using the seven-item scale based on the tool used by Hyman et al. (2003) and by the European Agency for Safety & Health at Works (2012). This scale is self-employed. The overall affective responses of professional women to their jobs were assessed by using a five-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). As depicted in Table 4, Cronbach's alpha is 0.885. Therefore, all seven questions are acceptable and can examine the level of obstacles of the respondents.

Table 4. Reliability statistics (Obstacles in work-life balance)

Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	*N* of Items
0.885	0.884	7

ANALYSIS AND RESULTS

Background profile of the respondents

Majority of respondents (32 or 91.4%) had more than 10 years of prior experience, followed by those with one year to three years and four years to six years of experience. Nine of the respondents (25.7%) run their own business while others worked in consulting firms, public sector and contracting and developer firms. With respect to company size, most of the respondents (22 or 62.9%) worked in large enterprises (with more than 30 employees) followed those in by medium-size enterprises (11 to 30 employees; seven respondents or 20.0%), and small enterprises (with less than 10 employees; six respondents or 17.1%).

Rating of respondents regarding satisfaction level in current work and life

As presented in Table 5, the descriptive analysis revealed that the top factor influencing the level of satisfaction of work-life balance was "I prefer to work compare to stay at home" ($m = 4.17$, $SD = 0.822$), followed by "trying to put a lot of themselves into everything they do" ($m = 4.03$, $SD = 0.747$), "thinking that mentoring programs, coaching, networking and partner or of other people's support can help in achieving work-life balance" ($m = 3.97$, $SD = 0.857$), "I am satisfied with the time they spend for their job, family and home-life" ($m = 3.89$, $SD = 0.993$), and "ability to allocate and interact with different resources" ($m = 3.83$, $SD = 0.923$). The three least-influential factors were "sometimes I feel workplace is like a home", "I think my employer understand my family condition", and "my company always support dependent care, flexible work arrangement and family or personal leave". These factors were related to company support.

Table 5. Level of satisfaction of work-life balance

	Mean	Std. Deviation	*N*	Rank
I am satisfied with the time I spent for my job, family and home life.	3.89	0.993	35	4
It is easy for me to balance my work, personal and family life demand.	3.77	1.087	35	6
I feel that I am very successful in balancing my work and family life.	3.77	0.973	35	6
I find satisfaction in everything I do.	3.66	0.725	35	7
Everything I do feels special to me; nothing stands out as more important or valuable than anything else.	3.46	0.817	35	8
I try to put a lot of myself into everything I do.	4.03	0.747	35	2
I can allocate and interact with different resources (time, money, scope of decision making, and physical, emotional, and social resources) in maintaining work-life balance.	3.83	0.923	35	5
I think that mentoring programs, coaching, networking, and partner or of other people's support can help in achieving work-life balance.	3.97	0.857	35	3
My company always support for dependent care, flexible work arrangement, and family or personal leave.	3.66	0.998	35	7
I prefer to work compare to stay at home.	4.17	0.822	35	1
Sometimes I feel living at home is like a workplace. (Deleted)	2.66	1.327	35	10
Sometimes I feel workplace is like a home.	2.80	1.346	35	9
I think my employer understand my family condition.	3.46	1.172	35	8

Rating of the respondents regarding the level of obstacles in current work and life

As exhibited in Table 6, the results of the descriptive analysis indicated that the main obstacles to work-life balance were "my company should have a written policy such as family-friendly policies to support work-life balance"(m = 4.17, SD = 0.822), followed by "I spend too much time at work" (m = 3.11, SD = 0.993) and "I do not to have too sufficient time for their own hobbies and interest" (m = 2.83, SD = 1.248). The three least-influential obstacles were associated with the lack of time for important personal or family activities because of work, limited opportunities to raise families as a result of long working hours, and the lack of time for family.

Table 6. Level of obstacles in work-life balance

	Mean	Std. Deviation	*N*	Rank
I spend too much time at work.	3.11	0.993	35	2
I spend too little time with my family.	2.60	1.117	35	5
Because of my job, I didn't have time to do things with my family or other important things in my life.	2.26	1.146	35	7
I do not have enough time for my own hobbies and interest.	2.83	1.248	35	3
Long working hours restricted my attention to look for family.	2.51	1.121	35	6

My company should have a written policy such as family-friendly policies to support work-life balance.	3.40	1.090	35	1
Inconsistent working hour affect me in achieving work-life balance.	2.80	1.132	35	4

Relationship between satisfaction factors of work-life balance and its obstacle

In relation to the above objective, this study showed that main factors such as "I am satisfied with the time I spent for my job, family and home life"; "It is easy for me to balance my work"; "personal and family life demand"; "I feel that I am very successful in balancing my work and family life" and "I can allocate and interact with different resources (time, money, scope of decision making, and physical, emotional and social resources) in maintaining work-life" were mostly negatively highly correlated with the all the obstacles except for obstacle "My company should have a written policy such as family-friendly policies to support work-life balance".

Table 7. Correlation results between satisfaction factors of work-life balance and its obstacles.

Obstacle Work life balance	Too much time at work	Too little time with my family	Because of my job, I didn't have time to do things with my family or other important things in my life	I do not have enough time for my own hobbies and interest	Long working hours restricted my attention to look for family	My company should have a written policy such as family-friendly policies to support work-life balance	Inconsistent working hour affect me in achieving work-life balance
I am satisfied with the time I spent for my job, family and home life.	-.612** .000 35	-.732** .000 35	-.516** .002 35	-.586** .000 35	-.764** .000 35	-.391* .020 35	-.570** .000 35
It is easy for me to balance my work, personal and family life demand	-.520** .001 35	-.635** .000 35	-.423* .011 35	-.615** .000 35	-.576** .000 35	-.218 .207 35	-.373* .027 35
I feel that I am very successful in balancing my work and family life	-.672** .000 35	-.655** .000 35	-.473* .004 35	-.615** .000 35	-.725** .000 35	-.244 .158 35	-.497** .002 35
I can allocate and interact with different resources (time, money, scope of decision making, and physical, emotional, and social resources) in maintaining work-life balance	-.427* .010 35	-.525** .001 35	-.346* .042 35	-.486** .003 35	-.594** .000 35	-.310 .070 35	-.484** .003 35
I try to put a lot of myself into everything I do	-.123 .480 35	-.480** .004 35	-.352* .038 35	-.247 .153 35	-.404* .016 35	-.303 .076 35	-.202 .245 35
Everything I do feels special to me; nothing stands out as more important or valuable than anything else	-.248 .152 35	-.406* .015 35	-.349* .040 35	-.584** .000 35	-.457** .006 35	-.145 .405 35	-.280 .104 35

Obstacle Work life balance	Too much time at work	Too little time with my family	Because of my job, I didn't have time to do things with my family or other important things in my life	I do not have enough time for my own hobbies and interest	Long working hours restricted my attention to look for family	My company should have a written policy such as family-friendly policies to support work-life balance	Inconsistent working hour affect me in achieving work-life balance
I find satisfaction in everything I do	-.230 .184 35	-.320 .061 35	-.209 .228 35	-.489** .003 35	-.428* .010 35	-.082 .640 35	-.193 .266 35
I think that mentoring programs, coaching, networking, and partner or of other people's support can help in achieving work-life balance	.108 .538 35	-.104 .550 35	-.052 .766 35	-.005 .979 35	-.168 .335 35	-.397* .018 35	-.339* .046 35
My company always support for dependent care, flexible work arrangement, and family or personal leave	-.078 .656 35	-.285 .097 35	-.152 .383 35	-.237 .170 35	-.337* .048 35	-.222 .201 35	-.323 .059 35
I prefer to work compare to stay at home	.047 .787 35	.013 .942 35	.077 .661 35	-.171 .325 35	-.130 .455 35	.085 .626 35	-.057 .746 35
Sometimes I feel living at home is like a workplace. (Deleted)	.254 .141 35	.044 .803 35	-.018 .920 35	.088 .616 35	-.016 .926 35	-.085 .626 35	-.125 .473 35

** Pearson correlation coefficient levels (p <0.01); *Pearson correlation coefficient levels (p <0.05)

DISCUSSION

Satisfaction level in work-life balance is a fulfilment of one's wishes, expectations, or needs in terms of the capability of individuals to combine work and household responsibilities successfully (Dan, 2012). From previous studies, some researchers used questionnaires approach to measure the level of satisfaction in work-life balance. For example Milkie and Peltola (1999), White (1999) and Saltzstein et al. (2001) asked "How successful do you feel in balancing your paid work and family life?". The findings from their study revealed that majority of the respondents were not able to achieve work-life balance. Additionally, according to Mergis Group Women in Finance Survey (2012), only 48% of women in accounting and finance were satisfied with the progression of their work-life balance. By comparison with previous studies, results of the current study suggest that most professional women in this industry were satisfied with their work-life balance and preferred to focus on their work. Majority of the professional women quantity surveyors were able to manage and were satisfied with their current work and life with the mean value of $3.706 \approx 4$ (Satisfy).

They also felt that they had effectively divided their time among job, family and home life; this finding supports the work of Dabke et al. (2008). Maloney and McFillen (1985) previously reported that construction employees were unsatisfied with their work, while professional women in the construction industry would easily adapt to the working culture. Moreover, most of the respondents possessed more than 10 years of experience and held

high positions in their respective companies. Hence, their employers support their employees' family commitments and permit flexible work arrangements. The respondents also utilized numerous personal leaves approved by their employers to achieve work-life balance. Consequently, they no longer felt pressured with workloads which they were already familiar with, compared to junior quantity surveyors who have to work longer durations in order to finish their tasks since all is relatively new to them.

The study results also showed that most professional women preferred to work rather than stay at home. These "workaholic" women were typically more satisfied with work than home life and managed their work with reasonable pressure or stress (Duncombe and Marsden, 1993). Hochschild (1996) argued that this pattern is increasingly prevalent. In addition, most professional women agreed that mentoring programs, coaching, networking, partnering with and obtaining support from other people can facilitate work-life balance. This result supported the notion by Noe (1988) that mentoring supported career and personal goals of women in construction. Mentoring was therefore recommended to help women break the so-called "glass ceiling" (Burke and McKeen, 1990). Mentoring could also help women progress in their careers in organizations where they were under-represented, such as the Tasmanian Department of Justice (MacGregor, 2000). Within organizations, good female role models or mentors were often difficult to find, especially in predominantly male industries. Therefore, a formal mentoring scheme should be effectively implemented on an industry wide basis to support the construction careers of women until they are equally represented in this industry.

With respect to work-life balance, the common obstacles faced by professional women in the construction industry were the uneven adoption of policies, lack of formalization, long working hours and temporal adjustment to working time. Generally, women with substantial household responsibilities achieved little work-life balance because they must follow and adhere to the counterproductive "working long hours culture" (Lewis, 2000; Rapoport et al., 2002; White et al., 2003). However, correlation results showed that professional quantity surveyors achieved their work life balance through adjusting or balancing their work and family time. They tried to avoid spending too much time at work and long working hours in order to strike a balance between their times with their families.

The study result revealed that most of the respondents believed that companies should implement written family-friendly policies to support work-life balance. Correlation results showed that organisation policy was weak in supporting their work-life balance. In developing countries, many organisations did not have such written policies unlike the public sector, in large establishments or in companies with recognized unions, and in enterprises with specialized human resource functions (Cully et al., 1999). Small firms generally do not develop formal policies. Instead, these companies provide informally for such needs, especially enterprises with work-life balance arrangements (Bond et al., 2002; Dex and Scheibl, 2002). Even in the context of professional surveyors in Australia and New Zealand, a survey showed that half of the respondents had no understanding or accessibility on work-life balance policies (Sara, 2008).The majority of the respondents stated that they require much time to complete their work, which restricted their time for personal hobbies and interests. However, these respondents did not sacrifice time with their family. In conjunction with this issue, a policy that regulates working hours must be implemented because long working hours

most strongly influence negative work-to-home spill over. This finding is consistent with that of White et al. (2003) who concluded that flexible-hour systems and personal discretion with respect to working time balances employee lifestyles. Nonetheless, these practices are currently implemented to only a small proportion of the labour force.

CONCLUSION

The involvement of women in the construction industry increases annually. However, research on women in the Malaysian construction industry remains limited, especially in relation to professional women. This study revealed that professional women were interested in work and could adapt to their workloads. The respondents believed in completing their work during office time while avoiding working long hours in order to balance time with their family. However, these women felt that their employers should be more considerate, understanding and supportive of their situations. This support could come in the form of flexible working hours, the provision of childcare centres, or the development of appropriate programs and guidelines to manage a diverse workforce. Although the respondents needed to spend much time at work at the expense of personal interests and hobbies, they were still able to manage their family time. It would thus appear that professional women in the Malaysian construction industry were satisfied with the work-life balance they currently maintain.

The results of this study should be of keen interest to the industry, researchers, public institutions and policymakers because these appointed bodies must acknowledge the importance of work-life balance in traditional male-dominated industries. As the number of women entering the construction industry increases annually, the contribution of professional women cannot be discounted nor ignored. These women work in a corporate environment with demanding project requirements, while simultaneously fulfilling the important role of parenting. Therefore, employers need to acknowledge the influence as well as ramifications of work-life balance on the decision of professional women entering the construction industry. The claim made by this study calls policy makers to rethink their attitude towards the elusive organizational support and recognize that the strategic measurement and management of work-life balance may be the most important managerial activity of the third millennium, given the expected proliferation of women in the workforce. Moving forward, future studies should also consider analysing the work-life balance of professional women in other industries, as well as how information and communications technology can be used to maintain work-life balance.

REFERENCES

Abdullah, N. Z., Arshad, R. A., & Ariffin, M. H. (2013) Technical Female Graduates in The Malaysian Construction Industry: Attrition Issues. *Research Journal*, 3(1): 33-43.

Agapiou, A. (2002) Perceptions of gender roles and attitudes toward work among male and female operatives in the Scottish construction industry. *Construction Management & Economics,* 20(8): 697-705.

Amaratunga, R.D.G., Haigh, R.P., Shanmugam, M., Lee, A.J. & Elvitigalage Dona, NG (2006) *Construction industry and women: a review of the barriers* , in: 3rd International

SCRI Research Symposium, Delft University, Netherlands.
Arslan, G. & Kivrak, S. (2004) The lower employment of women in the Turkish construction sector. *Building and Environment,* 39: 1379-1387.
Aryee, S., & Debrah, Y. A. (1992) Career planning an examination of individual non-work and work determinants. *International Journal of Human Resource Management, 3*(1): 85-104.
Barbara L. Chun, David Arditi, & Gulsah Balci. (2008) Women in construction management. *CM eJournal.*
Bond, S., Hyman, J., Summers, J., & Wise, S. (2002) Family-Friendly Working?Putting Policy into Practice. York: York Publishing Services, 48 pp.
Burke, R. J., & McKeen, C. A. (1990) Mentoring in organizations: Implications for women. *Journal of Business Ethics,* 9(4-5): 317-332.
Chan, T. K. (2009). Measuring performance of the Malaysian construction industry. *Construction Management and Economics*, 27(12): 1231- 1244.
Chandra, V., & Loosemore, M. (2004). Women's self-perception: an inter-sector comparison of construction, legal and nursing professionals. *Construction Management and Economics,* 22(9): 947-956.
Charles, N. a., & Kerr, M. (1999).Women's work. In G. Allan (Ed.), *The Sociology of the Family*. Oxford: Blackwell, 93-108.
Court, G., & Moralee, J. (1995). Balancing the Building Team. Brighton, GB: Institute for Employment Studies/CIOB, University of Sussex.
Cully, M., Woodland, S., O'Reilly, A., & Dix, G. (1999). *Britain at Work, Routledge*. London, 135 pp.
Dabke, S., Salem, O., Genaidy, A., & Daraiseh, N. (2008) Job satisfaction of women in construction trades. *Journal of Construction Engineering and Management,* 134(3): 205-216.
Dan Wheatley. (2012) Work-life balance, travel-to-work, and the dual career household. *Emerald*, 41(6): 813-831.
Dainty, A.R.J., Neale, R.H. and Bagilhole, B.M. (1999) Women's careers in large construction companies: expectations unfulfilled?' *Career Development International*, 4(7): 351-356.
Dainty, A., Grugulis, I., & Langford, D. (2007). Understanding construction employment: the need for a fresh research agenda. *Personnel Review* 36 (4): 501-508.
Demo, D. H., & Acock, A. C. (1993) Family diversity and the division of domestic labor: How much have things really changed? *Family Relations,* 42(3): 323-331.
Department of Statistics, Malaysia (2010) Population and Vital Statistics. Accessed 5 August 2012, http://www.statistics.gov.my/portal/index.php?option=com_content&view=article&id=363&Itemid=169&lang=en
Dex, S., & Colin, S. (2002) The Nature and Pattern of Family-friendly Employment Policies in Britain. Bristol, UK: The Policy Press, 3 pp.
Dex, S., & Scheibl, F. (2002) SMEs and Flexible Working Arrangements. Bristol: The Policy Press, 15 pp.
Duncombe, J., & Marsden, D. (1993) Love and Intimacy: The Gender Division of Emotion and Emotion Work' A Neglected Aspect of Sociological Discussion of Heterosexual Relationships. *Sociology,* 27(2): 221-241.
Eby, L. T., Casper, W. J., Lockwood, A., Bordeaux, C., & Brinley, A. (2005) Work and family research in IO/OB: Content analysis and review of the literature (1980-2002). *Journal of*

Vocational Behavior, 66(1): 124-197.
Ellison, L. (2001). Senior management in chartered surveying: where are the women? *Women in Management Review,* 16(6): 264-278.
Estes, S. B., & Michael, J. (2009). Work-family policies and gender inequality at work: a Sloan Work and Family Encyclopedia entry. Accessed 10 December 2013, http://wfnetwork.bc.edu/ encyclopedia_entry.php? id¼1230&area¼All
European Agency for Safety and Health at Work. (2012). Family Issues and Work- Life Balance. Accessed 15 October 2013,
https://osha.europa.eu/en/publications/e-facts/e-fact-57-family-issues-work-life-balance
Felstead, A., Jewson, N., Phizacklea, A., & Walters, S. (2002) Opportunities to work at home in the context of work-life balance. *Human Resource Management Journal,* 12(1): 54-76.
Fielden, S. L., Davidson, M. J., Gale, A. W., & Davey, C. L. (2000) Women in construction: the untapped resource. *Construction Management & Economics,* 18(1): 113-121.
Fielden, S., Davidson, M., Gale, A., & Davey, C. (2001) Women, equality and construction. *Journal of Management Development*, 20(4): 293-304.
Ford, M. T., Heinen, B. A., & Langkamer, K. L. (2007) Work and family satisfaction and conflict: a meta-analysis of cross-domain relations. *Journal of Applied Psychology,* 92(1): 57-80.
Frye, N. K., &Breaugh, J. A. (2004) Family-friendly policies, supervisor support, work–family conflict, family–work conflict, and satisfaction: A test of a conceptual model. *Journal of Business and Psychology,* 19(2): 197-220.
Gajendran, R. S., & Harrison, D. A. (2007) The good, the bad, and the unknown about telecommuting: meta-analysis of psychological mediators and individual consequences. *Journal of Applied Psychology,* 92(6), 15-24.
Goh, K. C., Seow , T. W., & Goh, H. H. (2013) Challenges of implementing sustainability in Malaysian housing industry. *Proceeding of the International Conference on Sustainable Built Environment for Now and the Future* (SBE2013). Hanoi, 26-27.
Guillaume, C., & Pochic, S. (2009) What would you sacrifice? Access to top management and the work–life balance. *Gender, Work & Organization,* 16(1): 14-36.
Harris, A. (2003) Teacher leadership as distributed leadership: heresy, fantasy or possibility? *School leadership & management,* 23(3): 313-324.
Harvey, M. (1999). Economies of time: a framework for analysing the restructuring of employment relations. In A. Felstead& N. Jewson (Eds.), Global Trends in Flexible Labour (pp. 21-42). Basingstoke: Macmillan, 5-31.
Hattery, A. J. (2001) Tag-team parenting: Costs and benefits of utilizing nonoverlapping shift work in families with young children. *Families in Society: The Journal of Contemporary Social Services,* 82(4): 419-427.
Higgins, C., Duxbury, L., & Johnson, K. L. (2000). Part-time work for women: does it really help balance work and family? *Human Resource Management,* 39(1): 17-32.
Hochschild, A. R. (2012). *The Second Shift*. New York, NY: Avon, 72 pp.
Hochschild, A. R. (1996). The emotional geography of work and family life. In L. Morris & E. S. Lyon (Eds.), Gender relations in public and private: New research perspectives. New York: St: Martin's Press, 13 pp.
Hochschild, A. R. (1997). The time bind: When work becomes home and home becomes work. New York: Metropolitan Books, 142 pp.
Hogarth, T., Hasluck, C. and Pierre, G. (2000) Work–Life Balance 2000: Baseline

Study of Work–Life Balance Practices in Great Britain. London, Dfee, 227 pp.
Hoinville, G., & Jowell, R. (1978). Survey Research Practice. London: Heinemann, 98 pp.
Human Resource Department, Statistic of Employment and Labour, Malaysia 2/2014
Hussin, A. A., & Omran, A. (2009) Roles of professionals in construction industry. *Proceeding of the International Conference on Economics and Administration.* Bucharest, Romania,
Hyman, J., Baldry, C., Scholarios, D., & Bunzel, D. (2003) Work–life imbalance in call centres and software development. *British Journal of Industrial Relations,* 41(2): 215-239.
Hyman, J., & Summers, J. (2004) Lacking balance?: Work-life employment practices in the modern economy. *Personnel Review, 33*(4): 418-429.
Jaafar, M., & Othman, N. L. (2013) Personal Competency of Selected Women Construction Project Managers in Malaysia. *Journal of Engineering, Design and Technology,* 11(3): 3-3.
Jaafar, M., Othman, R., & Jalali, A. (2014) Main Determinations of Female Entrepreneurs in the Construction Industry in Malaysia. *Project Management Journal,* 45(1): 76-86.
Judin Bin Abdul Karim, Chief Executive, Keynote Address : CIDB Malaysia for International Construction Conference 2013. Accessed 12 September 2013,
http://www.cidb.gov.my/cidbv4/index.php?option=com_content&view=article&id=553:keynote-address-y-bhg-dato-sri-ir-dr-judin-bin-abdul-karim-chief-executive-cidb-malaysia-for-international-construction-conference-2013&catid=50&Itemid=388&lang=en
Kaewsri, N. & Tongthong, T. (2013) Professional development of female engineers in the Thai construction industry. *Procedia - Social and Behavioral Sciences*, 88: 291–298.
Kehinde, J. & Okoli, O. (2004) Professional women and career impediments in the construction industry in Nigeria. *Journal of Professional Issues in engineering Education ansd Practice,* 130 (2): 115-119.
Kiecolt, K. J. (2003) Satisfaction with work and family life: No evidence of a cultural reversal. *Journal of Marriage and Family,* 65(1): 23- 35.
Lauzun, H. M., Morganson, V. J., Major, D. A., & Green, A. P. (2010) Seeking Work-Life Balance: Employees' Requests, Supervisors' Responses, and Organizational Barriers. *The Psychologist-Manager Journal,* 13(3): 184-205.
Labour Research (2001), "What working parents really need", Labour Research Department, London, 10 pp.
Lewis, S. (2000). Work-family arrangements in UK.In L. d. Dulk, A. V. D. Huiskes& J. Schippers (Eds.), *Work-family arrangements in Europe*. Amsterdam: Thela thesis, 75 pp.
Lewis, S., & Lewis, J. (1996).The Work-Family Challenge: Rethinking Employment. London: SAGE Publication Ltd, 44 pp.
Lim, L. J., & Ling, F. Y. (2012) Human resource practices of contractors that lead to job satisfaction of professional staff. *Engineering, Construction and Architectural Management,* 19(1): 101-118.
Lingard, H., & Francis, V. E. (2002) Construction Industry Institute, Work-life Issues in the Australian Construction Industry: Findings of a Pilot Study . Brisbane, Australia, 94 pp.
Lingard, H., & Lin, J. (2004) Career, family and work environment determinants of organizational commitment among women in the Australian construction industry. *Construction Management and Economics, 22*(4): 409-420.
Lingard, H., & Sublet, A. (2002) The impact of job and organizational demands on marital or relationship satisfaction and conflict among Australian civil engineers.*Construction Management & Economics, 20*(6): 507-521.

Macdonald, L. A. C. (2005). Wellness at Work: Protecting and Promoting Employee Health and Wellbeing. London: Chartered Institute of Personnel and Development, 58 pp.

Major, D. A., Fletcher, T. D., Davis, D. D., &Germano, L. M. (2008) The influence of work-family culture and workplace relationships on work interference with family: a multilevel model. *Journal of Organizational Behavior,* 29(7): 881-897.

Malik, M..(2011) Role Overload, job satisfaction and their effect on layoff survivor's Job Retention and Productivity. *Interdisciplinary Journal of contemporary Research in Business*, 2(11): 427-440.

Maloney, W. F., &McFillen, J. M. (1985) Valence of and satisfaction with job outcomes. *Journal of Construction Engineering and Management,* 111(1): 53-73.

Marks, S. R., &MacDermid, S. M. (1996) Multiple roles and the self: A theory of role balance. *Journal of Marriage and the Family,* 58(2): 417–432.

Mbah, S. E., &Ikemefuna, C. (2012) Job Satisfaction and Employees' Turnover Intentions in total Nigeria plc.in Lagos State. *International Journal of Humanities and Social Science,* 2(14): 275-287.

McDowell, L., Ray, K., Perrons, D., Fagan, C., & Ward, K. (2005) Women's paid work and moral economies of care. *Social & Cultural Geography,* 6(2): 219-235.

McGregor-Lowndes, M. (2000) Regulation infrastructure for nonprofit organization. Brisbane: Queens Land University of Technology, 38 pp.

Mergis Group. Women and Men in Accounting and Finance Careers. http://www.mergisgroup.com/About_Mergis/Press/Mergis_Women_in_Finance_2012.jsp

Milkie, M.A., & Peltola, P. (1999). Playing all the roles gender and the work-family balancing act. *Marriage & Family* 61: 476-490.

Moore, J. D. (2006). Women In Construction Management: Creating A Theory of Career Choice and Development. Colorado: ProQuest Information and Learning, 78 pp.

Newell, S. (1993) The superwoman syndrome: gender differences in attitudes towards equal opportunities at work and towards domestic responsibilities at home. *Work, Employment & Society, 7*(2): 275-289.

Noe, R. A. (1988) An investigation of the determinants of successful assigned mentoring relationships. *Personnel psychology,* 41(3): 457-479.

Orthner, D. K., & Pittman, J. F. (1986) Family contributions to work commitment. *Journal of Marriage and the Family,* 48(3): 573-581.

Parasuraman, S., Purohit, Y. S., Godshalk, V. M., &Beutell, N. J. (1996) Work and family variables, entrepreneurial career success, and psychological well-being. *Journal of Vocational Behavior,* 48(3): 275-300.

Pleck, J. 1985. Working Wives/Working Husbands. Beverly Hills, CA: Sage, 98 pp.

QS Professionals. (2013). The functions of a consultant qunatity surveyor. Accessed 7 September 2013, http://www.qsprofessionals.com/index.php?option=com_content&view+article&id=52:the-functions-of-a-consultant-quantity-surveyor

Radhlinah, A., & Jingmond, M. (2011). Issues confronting women participation in the construction industry. *Proceeding of the Advances in Engineering and Technology - Contribution of Scientific Research in Development.* Entebbe, Uganda, 312-318.

Rapoport, R., Bailyn, L., Fletcher, J., & Pruitt, B. (2002).Beyond Work–Family Balance: Advancing Gender Equity and Work Performance. Chichester: Wiley, 194 pp.

Riley, F. & McCloskey, D. W (1996). GTE's Experience with Telecommuting:Helping people balance work & family. SIGCPR/SIGMIS '96 Denver Colorado USA, ACM 1996, 85 pp.

Rozanah Ab rahman, K.H.H. (2008). Regulating high-risk activities in construction industry in Malaysia: The need for legal protection. *MyAis,* 246-258.

Saltzstein, A. L., Ting, Y., & Saltzstein, G. H. (2001) Work-family balance and job satisfaction: The impact of family-friendly policies on attitudes of federal government employees. *Public administration review,* 61(4): 452-467.

Sambasivan, M., & Soon, Y. W. (2007) Causes and effects of delays in Malaysian construction industry.*International Journal of project management,* 25(5): 517-526.

Sara J. Wilkinson, (2008) Work-life balance in the Australian and New Zealand surveying profession. *Structural Survey*, 26(2): 120 – 130.

Scase, R. (2002). Living in the Corporate Zoo: Life and Work in 2010. Capstone: Oxford, 112 pp.

Shorthose, J. (2004) Like summer and good sex? The limitations of the work-life balance campaign. *Capital & Class,* 28(1): 1-8.

Smith, P. C., Kendall, L. M., & Hulin, C. L. (1969). The Measurement of Satisfaction in Work and Retirement: A Strategy for the Study of Attitudes. Chicago, IL: Rand McNally, 31 pp.

Spencer, A., &Podmore, D. (1987). *Man's World* . London: Tavistock, 56 pp.

Thompson, C. A., Beauvais, L. L., &Lyness, K. S. (1999). When work–family benefits are not enough: The influence of work–family culture on benefit utilization, organizational attachment, and work–family conflict. *Journal of Vocational Behavior,* 54(3): 392-415.

Tietze, S., &Musson, G. (2005) Recasting the home-work relationship: a case of mutual adjustment? *Organization Studies,* 26(9): 1331-1352.

Varatharaj, V. and Vasantha, S. (2012) Work Life Balances a Source of Job Satisfaction - an Exploratory Study on the View of Women Employees in the Service Sector, *International Journal of Multidisciplinary Research,* 2(3): 450-458.

Walter, N. (1999). *The New Feminism*. London: Virago Press, 201 pp.

Wan Mahmood, W. Y., Mohammed, A. H., Misnan, M. S., Mohd.Yusof, Z., &Bakri, A. (2006). *Development of Quality Culture in the Construction Industry*. UniversitiTeknologi Malaysia. Malaysia. Accessed 7 November 2013,
http://eprints.utm.my/657/

Wangle, A. M. (2009). *Perceptions of traits of women in constructio.*Msc thesis, University of Florida, Folrida, US, 19 pp.

Watts, J.H. (2007) Porn, pride and pessimism: experiences of women working in professional construction roles. *Work Employment & Society,* 2(2): 299-316.

Wheatley, D. (2012) Work-life balance, travel-to-work, and the dual career household. *Personnel Review,* 41(6): 813-831.

White, J. M. (1999) Work-family stage and satisfaction with work-family balance. *Journal of Comparative Family Studies,* 30(2): 163-175.

White, M., Hill, S., McGovern, P., Mills, C., &Smeaton, D. (2003).'High-performance'Management Practices, Working Hours and Work–Life Balance. *British Journal of Industrial Relations,* 41(2): 175-195.

Whittock, M. (2002) Women's experiences of non-traditional employment: is gender equality in this area a possibility? *Construction Management & Economics,* 20(5): 449-456.

Williams, J. C. (2001) Unbending gender: Why work and family conflict and what to do about it. Oxford, UK: Oxford University Press, 61 pp.

Wilson, E. M. (1998) Gendered career paths. *Personnel Review,* 27(5): 398-411.

Woodland, S., Simmonds, N., Thornby, M., Fitzgerald, R., & McGee, A. (2003). *The Second Work-Life Balance Study: Results from the employers' Survey*. Employment Relations Research.Department for Trade and Industry.National Centre for Social Research. London, 201 pp.

REUSE OF SEWAGE SLUDGE ASHES IN CEMENT MORTAR MIXTURES ON VARIES INCINERATED TEMPERATURES

Mohamad Nazli Md Jamil and Norazura Muhamad Bunnori
School of Civil Engineering, Engineering Campus, Universiti Sains Malaysia (USM), 14300 NibongTebal, Pulau Pinang.

Abstract
Sewage sludge can be referred to residual semi-solid material that is produced as a by-product from wastewater treatment plant and it is unavoidable. Based on the perspective sludge production factor (SPF), about 5.3 million cubic meters of sewage sludge was produced per year by a national sewage company i.e Indah Water Konsortium (IWK) and the total sludge generated without centralized facilities was about 7.4 million cubic meters per year. The investigation towards the uses of sludge can be carried out more on a variety of purposes for sustainable environment. This study investigates the use of sewage sludge ash (SSA) as a natural admixture to the cement mortar in varying incinerated temperature. The thermal gravimetric analysis (TGA) and differential thermal analysis (DTA) was carried out to obtain the starting optimum incinerated temperature for SSA. As a result, the incinerated temperature for SSA started at 500$^{oC.}$ The investigation was continued by adding 5% replacement of SSA with incinerated temperature at the range from 500oC to 1000oC with 100 intervals respectively to the cement mortar mixture. Plain cement mortar and raw SSA mortar mixture were casted as control. The compressive strength and water absorption test was carried out to determine the physical properties of the cement mortar while flow table test was performed to measure the mortar workability. The value of these tests varied for different temperature of incineration. The heavy metal concentration in the cement mortar concentration was determined by using the ICP machine as conducted the acid digestion procedures from Method 3050b in USEPA. For all types of cement mortar, the results showed lower that the EQA requirement. From the result values of the conducted experiments, it can be concluded that the optimum incinerated temperature for SSA is at 900oC since it had preferable flow value, high in compressive strength, low in water absorption and low in heavy metal concentration.

Keywords: *Sewage sludge ash, cement mortar*

INTRODUCTION

Sewage sludge can be referred to residual semi-solid material that is produced as a by-product from wastewater treatment plant and it is unavoidable. Based on the Report of Census 2010 by The Department of Statistics, Malaysia has a population of 28.3 million and the estimation volume of wastewater generated by the municipal and industrial sector is 2.97 billion cubic meter per year (Tuan Mat et al., 2011). Based on the perspective sludge production factor (SPF), about 5.3 million cubic meters of sewage sludge was produced per year by a national sewage company i.e Indah Water Konsortium (IWK) and the total sludge generated without centralized facilities was about 7.4 million cubic meters per year. Sewage sludge will generate in an ever-increasing amount due to the urbanization and higher effluent criteria implemented in recent years. Without proper disposal, it will cause a secondary pollution problem to the environment. Space limitation on existing landfills and increasing environmental concerns such as groundwater pollution from landfill leachate, odour emission and soil contamination have prompted the investigation of alternative disposal routes.

The sludge can be reused as land reclamation, composting, rehabilitation of ex-mining sites,

power generation, reforestation and as building materials. In Malaysia, research development on sewage sludge reuse has been investigated recently by the local universities. Roslan et al. (2013) and Rosenani et al. (2008) had explored the possibility of sewage sludge as a fertilizer and potential mineralisable. Lema et al. (2015) and Yusuf et al. (2012) had studied the potential of sewage sludge as mineral admixture in cements and concretes. According to Yague et al. (2004), the sewage sludge has the potential to be applied to low mass concretes that could be used for bases and subbases of roads. Although concrete containing sewage sludge has low strength, but it has low water absorption which is highly beneficial for structures that are exposed to the wet environment and has longer service life (Barbosa et al., 2004). The sewage sludge can also be produced as lightweight cement composite as reported by Sales et al. (2010) and produced as paving block as reported by Tomaru et al. (2009). Thus, the investigation towards the uses of sludge can be carried out more on varying purposes for sustainable environment.

In this study, the reuse of sewage sludge ashes (SSA) in cement mortar mixtures on varying incinerated temperatures were carried out. Several tests were performed to measure the physical and chemical properties of the cement mortar. At the end, the optimum incinerated temperature for SSA will be determined.

Chemical Composition

According to ASTM C618-99, the natural admixture in Class N must follow these three requirements:

a) Total amount of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and iron oxide (Fe_2O_3) are of 70% minimum.
b) Maximum amount of sulphur trioxide (SO_3) is 4.0 %.
c) Maximum amount of loss on ignition (LOI) is 10%.

Table 1 shows the typical chemical composition of sewage sludge examined by Wang et al. (2005), Morais et al. (2009) and Tantawy et al. (2012) respectively. The total amount of SiO_2, Al_2O_3 and Fe_2O_3 found by those three researchers were 70.6%, 74.08% and 71.21% respectively which fulfilled the ASTM C618-99 requirement that needed a minimum value of 70%. The amount of SO3 also complied with the maximum requirement for Wang et al. (2005) and Morais et al. (2009) but slightly exceeded 0.04% for Tantawy et al. (2012). The amount of LOI for all researchers are accepted since the LOI value displayed on Tantawy et al. (2012) was 2.11% where the allowable amount was 10%. As a conclusion from Table 1, the sewage sludge has the potential to be a natural admixture as concrete replacement since it complies with the chemical requirements of ASTM C618-99.

Table 1. Typical chemical composition in sewage sludge

	Wang et a.l (2005)	*Morais et al. (2009)*	*Tantawy et al. (2012)*
Component	***wt%***	***wt%***	***wt%***
SiO_2	43.6	38.33	39.03
Al_2O_3	16.6	21.14	15.13
Fe_2O_3	10.4	14.61	17.05
P_2O_5	12.1	9.99	13.12
CaO	5.61	6.68	5.80

K_2O	2.34	1.36	0.62
MgO	1.40	1.8	1.93
SO_3	0.24	-	4.04
Na_2O	0.82	0.52	0.43
TiO_2	-	1.75	-
MnO	-	0.097	-
LOI	-	-	2.11

(Sources : Wang et al. 2005; Morais et al. 2009; Tantawy et al. 2012)

EXPERIMENTAL WORK

Sample Preparation

In this study, the raw sewage sludge was collected at the Jelutong Sewage Treatment Plant (JSTP) in Penang. The sludge was dehydrated by dewatering facilities before disposal. Physically, it has blackish brown in colour, spongy in texture and had a chemical odour.

In the beginning, the sludge must undergo drying process for 48 hours at 105°C to remove the humidity that causes odour from the reproduction of micro bacteria and fungi. After being oven dried, the mass of sludge was reduced up to 60% where the raw sludge contained about 60% of water or moisture content. Then, the dried sludge was grounded for 24 hours using the ball-mill equipment in the laboratory. To produce SSA, the sludge was finely sieved passing 300μm mesh in size and stored in a cool and dry place. The SSA was incinerated in temperature which ranged from 500^{oC} to 1000^{oC} in interval of 100 respectively for 2 hours at the rate of 10oC/min. This temperature range was determined by the thermal analysis, as mention below. Figure 1 shows the difference of SSA condition and incinerated temperature.

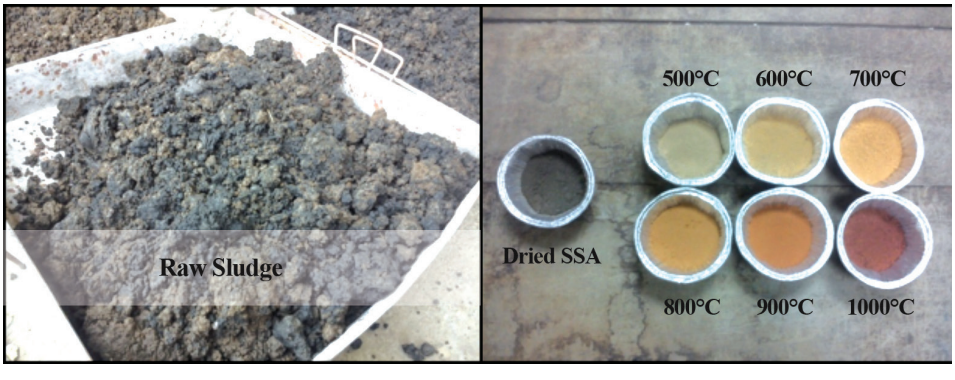


Figure 1. Sludge at different condition and varies of temperature

Differential Thermal Analysis (DTA) & Thermal Gravimetric Analysis (TGA)

TGA is a thermoanalytic technique that monitors the change of mass of the substance as a function of temperature or time, subjected to the controlled temperature program in a controlled atmosphere. While DTA is a thermal analysis technique where the sample of the material will undergo identical thermal cycles collectively with inert reference and the differences in the temperature were recorded for phase identification either exothermic or endothermic.

Figure 2 shows the DTA and TGA thermograms obtained from the conducted test on dried SSA. The purpose of these tests was to determine the ideal starting burning temperature of SSA for further experiments. The first weight loss which occurred in the range of temperature between 50°C to 100°C was due to the elimination of moisture content in the sample. The second weight loss which occurred in the range of temperature between 150°C to 300°C was possibly due to emission of volatile organic matters and combustion of complex non-volatile organic matters respectively. The last weight loss which occurred in the range of temperature between 400°C to 500°C was due to the decomposition of the carbonaceous matter. The temperature for the incineration process of the SSA started from 500°C to 1000°C with an interval of 100 respectively in 2 hours since the calcinations of SSA occurs at 550°C (Barbosa et al., 2004) and Calcite, $CaCO_3$ appeared after the incineration of SSA at 500°C from carbonation of some calcium compound by CO_2 (Tantawy et al., 2012). CaCO3 is an element in the concrete that produces durability when it is harden. This element is very useful to form a great concrete material.

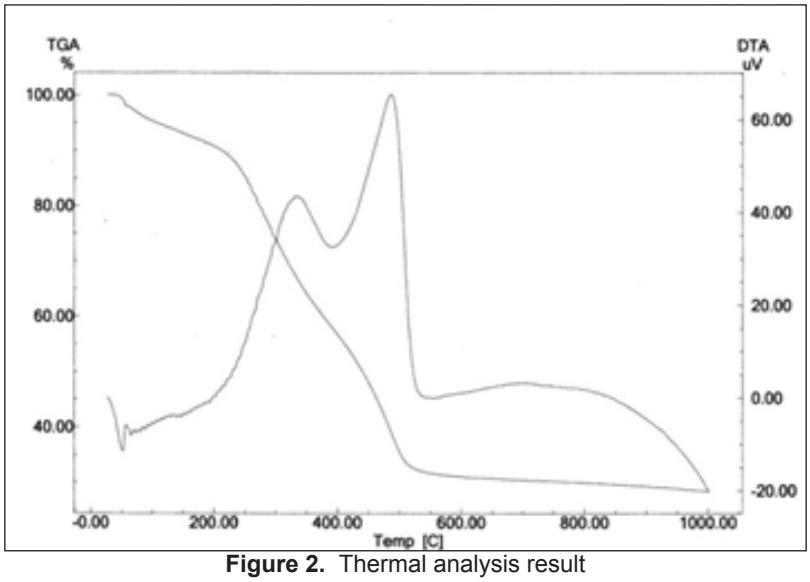


Figure 2. Thermal analysis result

Cement Mortar Preparation

The cement mortar was prepared in 50mm x 50mm x 50mm in size for every SSA incinerated temperature from 500°C to 1000°C including raw SSA and normal cement mortar as a control. The amount of SSA for every batch was constant with 5% of replacement except the normal cement mortar where no SSA was added. The mix proportion used Ordinary Portland cement which complies with BS EN 197-1:2000 and the fine aggregate that have been used was sieved passing 600μm in size. The water-cement ratio was 0.485 as followed in ASTM C109/C109M. The fresh cement mortar went through the flow table test using an equipment as in ASTM C230/C230M to measure the workability and flow consistency. The procedure was attempted and followed as in BS EN 1015-3:1999. Figure 3 shows an example of the mortar mixture that went through the flow table test in the laboratory.

Figure 3. Flow table test

In hardened stage, all the cement mortar cubes were tested on compressive strength and water absorption for 3, 7 and 28 days. There were three cement mortar cubes for each test and each curing day. In total, 18 cubes were prepared for each batch and 144 pieces in the overall study. The compressive strength test was conducted by using a compression machine with a maximum capacity of 3000kN with loading rate of 0.90 kN/min as in Figure 4.

Figure 4. Compression machine

The water absorption test was done using Cabrera and Lynsdale (1988) method. The hardened and cured mortar cubes were dried in the oven at 105^{oC} for 24 hours. The specimens were allowed to cool at room temperature and weight as w_1. Next, the specimens were placed in desiccators under vacuum pressure of 1 bar for 3 hours. Then, de-aerated water was poured into the desiccators until the cubes were fully submerged and vacuum pressure was applied for another 3 hours. After this period, the specimens were left soaking in the water at atmospheric pressure for 1 hour and weight as *w2*. Figure 5 shows the cement mortar specimens inside the desiccators during water absorption test. The value of water absorption of the specimens was

calculated using the Equation 1 below:

$$WA = \frac{w_2 - w_1}{w_1} \times 100 \qquad (1)$$

Where
W_A = water absorption (%)
w_1 = the oven dried weight (g)
w_2 = the final weight (g)

Figure 5. Cement mortar specimens during water absorption test

Acid Digestion Method

The acid digestion method was conducted as a preparation to extract solid mortar cube becoming a liquid solution for analysis by using inductive coupled plasma (ICP) as in Figure 6. The ICP machine was used to examine the chemical composition in the cement mortar and can detect up to 70 elements depending on the ICP standard solution used. In this study, ICP standard solution with 21 elements was used. The solution must be diluted into 20mg/L before operating the machine. The dilution process used the Equation 2 below:

$$M_1 V_1 = M_2 V_2 \qquad (2)$$

Where
M_1 = original concentration of standard solution (100mg/L)
V_1 = volume for standard solution
M_2 = diluted concentration (20mg/L)
V_2 = volume of diluted solution

The acid digestion method was carried out following Method 3050B Acid Digestion of Sediments, Sludges and Soil which was proposed by The United State Environmental Protection Agency (USEPA, 1996). This procedure was conducted on mortar specimens with age of 28 days. The specimens were oven dried at 105^{oC} for 24 hours to ensure they dried enough to avoid the residual specimens from sticking at the crusher machine. After the crushing process, the specimens were grounded by the ball milling machine for two hours and sieved passing 150μm in size.

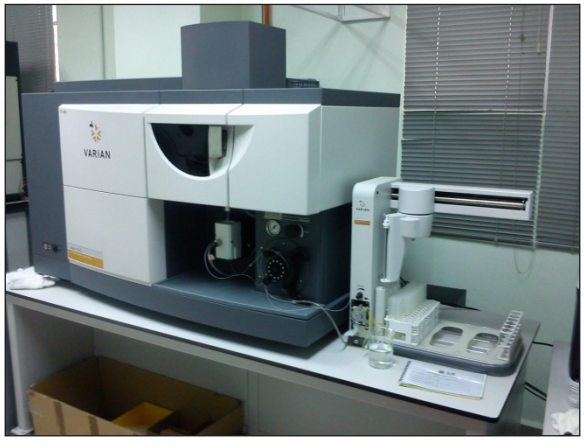


Figure 6. Inductive Couple Plasma (ICP) machine

To make acid digestion sample solutions, 1 gram of sieved specimens was added to 10ml of concentrated nitric acid (HNO_3) and refluxed without boiling on a hot plate for ten to fifteen minutes. The sample was allowed to cool and 5ml of HNO_3 was added and refluxed for thirty minutes. If there were brown fume generated, more 5ml of HNO_3 need to be added and the step was repeated until the brown fume disappears. After that, 2ml of distilled water and 3ml of 30% Hydrogen Peroxide (H_2O_2) were poured into the sample and refluxed for fifteen minutes. Lastly, 10ml of concentrated Hydrochloric acid (HCl) was added and refluxed for another fifteen minutes. The sample was allowed to cool and filtered by using GFC paper. The sample was diluted to 100ml with distilled water before examined with the ICP machine.

RESULTS AND DISCUSSION

Flow Table Test

The flow table test was carried out to determine the workability of the cement mortar. The increasing flow value indicates the increase in the degree of workability which is good for placement. Figure 7 shows the flow value for all types of cement mortar specimens. The normal cement mortar was labelled as OPC while SSA0 for raw SSA and the different notation number for different degree of incinerated temperature. The flow value for OPC was 45.3% while the flow values for SSA0 to SSA1000 were 43.3%, 38.3%, 33.7%, 32.3%, 39.0%, 40.0% and 37.3% respectively. The flow value decreased until SSA700 and had 29% of reduction compared to the OPC. According to Monzo et al (2003), partial substitution of Portland cement by SSA will reduce the mortar workability due to irregular morphology of the SSA particle. The flow value started to increase at SSA800. According to Tantawy et al. (2012), the amount of gypsum appeared to increase during incineration of SSA at 800^{oC}. The additional of gypsum will prevent the rapid flash setting when tricalcium alaminate (C_3A) react with water. This situation can be explained by the increasing flow value which resulted to SSA700 and SSA800. Thus, the lack of C3A compound will lead to increasing of workability which is good for placement.

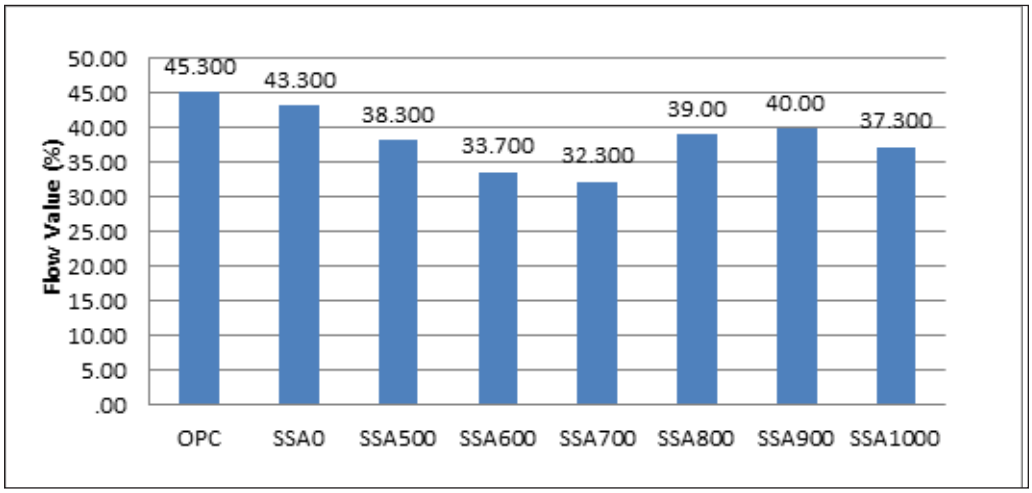


Figure 7. Flow value (%) for cement mortar specimens

Compressive Strength Test

Figure 8 shows the compressive strength results for all types of SSA incinerated temperature which was added to the cement mortar specimens of 3, 7 and 28 days of age. Generally, all types of specimen gained their strength by increasing the curing ages. The OPC had compressive strength of 14.90 MPa at 3 days, 19.96 MPa at 7days and 24.94 MPa at 28 days. It gained approximately 40% of strength at 28 days as compared to 7 days. It is noted that, the SSA0 recorded the lowest compressive strength for all ages. However, as compared to the early age specimen, SSA0 increased its strength drastically about 67.41% after 14 days and gained 76.97% of strength within 28 days. The compressive strength for SSA600 did not increase much from 7 days to 28 days, but it was comparable to the OPC when it achieved 28 days with 25.28 MPa. The highest compressive strength was obtained by SSA900 as 26.39MPa at 28 days with higher strength compared to OPC. According to Tantawy et al. (2012), the amount of calcium silicate increased after incineration of SSA which started at 800^{oC} and decreased when incinerated at 950^{oC}. This can lead to the increase of pozzalanic activities which could affect the strength development. These statements can be proven by the results of SSA800, SSA900 and SSA1000. The strength development of SSA increased by 9% from 24.25MPa on SSA800 to 26.39MPa on SSA900 at 28 days of age while reduced about 12% on SSA1000. Thus, the increasing amount of calcium silicate will increase the strength development of the specimens.

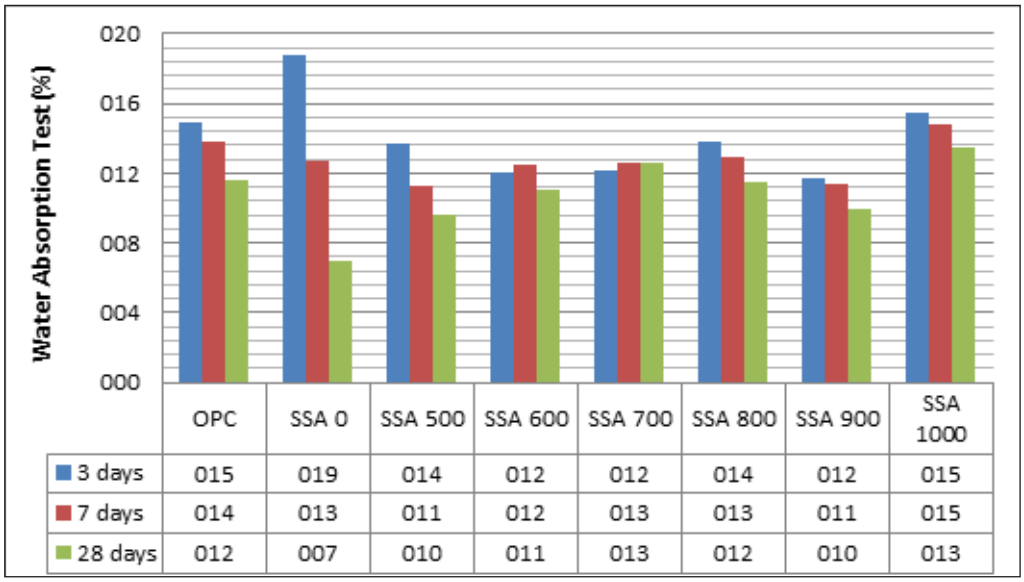
	OPC	SSA 0	SSA 500	SSA 600	SSA 700	SSA 800	SSA 900	SSA 1000
3 days	14.9	4.26	17.9	22.04	20.32	19.63	19.8	17.4
7 days	19.96	13.07	21.7	23.71	22.81	22.47	24.06	20.8
28 days	24.94	18.5	23.6	25.28	24.48	24.25	26.39	23

Figure 8. Compressive strength for cement mortar specimens

Besides that, the SSA mortars gained strength at an early age except for M0. The higher amount of aluminium oxide (12 – 19%) in incinerated SSA than cement (3-8%) possibly contribute much in serving C_3A and fasten the setting time. As reported by Tay and Show (1994), the hydration rate of aluminium oxide in SSA is faster than calcium silicate in OPC which high amount of aluminium oxide will shorten the setting time. Plus, the incinerated SSA promoted the formation of amorphous silica which increases reactivity of the mixture (Tay and Show, 1994; Fontes et al., 2004; Tantawy et al., 2012).

Water Absorption Test

In general, the water absorption test was investigated to indicate the weathering resistance by water penetration and ensure the durability of the cement mortar. Figure 9 shows the water absorption results for all types of cement mortar specimens. For overall types of the specimens, the water absorption decreased by an increase in the mortar ages. The OPC had water absorption of 14.87% at 3 days of age and 13.78% and 11.65% at the age of 7 and 28 days respectively. The SSA0 had the highest reduction of water absorption within 28 days of age which was as much as 63%. This situation can be explained by the effect of setting time. One of the causative factors of setting time is the existence of gypsum in the mixture. Gypsum was added to the cement for avoiding flash set on reaction of C_3A with water. The gypsum ($CaSO_4.2H_2O$) might occur when the CaO content from the cement reacted with the SO3 content from the SSA after water was poured in. The excessive gypsum content from the reaction and from the cement itself gave effect to the setting time. In this experiment, the SSA0 specimen took 48 hours to set before it was hard enough to be removed from the mould. When the SSA0 is not completely set, the strength development and water absorption cannot be achieved. These behaviours are shown in Figure 8 and Figure 9 respectively as SSA0 for 3 days. Lin et al. (2012) also recorded the delay in setting time on the cement with the addition of SSA.



	OPC	SSA 0	SSA 500	SSA 600	SSA 700	SSA 800	SSA 900	SSA 1000
3 days	015	019	014	012	012	014	012	015
7 days	014	013	011	012	013	013	011	015
28 days	012	007	010	011	013	012	010	013

Figure 9. Water absorption for cement mortar specimens

According to Tantaway et al. (2012), incinerated SSA at 800^{oC} preserves the amorphous nature of the resultant ash due to elimination of fixed carbon captured by silica. In this case, the pozzolanic activity was enhanced starting from incinerated SSA at 800^{oC} and decreased at 950^{oC}. Figure 9 shows a reduction value of water absorption on SSA800 and SSA900 from 11.51% to 9.96% at 28 days of age. Within this temperature, the calcite was decomposed into CaO and reacted with water to produce portlandite, $Ca(OH)_2$. The portlandite plays an important role in durability development. The existence of porlandite in SSA800 and SSA900 promoted the durability in the cement mortar specimens which can be proved by the value of their water absorption.

Environmental Classification

The environmental classification was carried out by measuring the heavy metal concentration by using the ICP machine to produce the amount of element for every type of cement mortar. All of the specimens were tested as a requirement in the Environmental Quality Act (EQA) 1974. The limitations for every element were referred to the Third Schedule of the Environmental Quality (Sewage and Industrial Effluents) Regulation, 1979. The schedule was clarified about the acceptable condition for discharge of industrial effluent to the stream. Since the cement mortar will be implemented as a building material with the addition of sewage sludge, it is a compulsory way to check whether the materials are hazardous and toxic to the nature.

Table 2. Heavy metal concentration in cement mortar specimens

Heavy Metal	Limit (mg/L)	OPC	SSA0	SSA500	SSA600	SSA700	SSA800	SSA900	SSA1000
Arsenic, As	**0.10**	< 0.01	< 0.01	< 0.01	0.0925	0.0826	< 0.01	0.0786	< 0.01
Cadmium, Cd	**0.02**	0.015	0.0086	0.0087	0.0139	0.0166	0.0089	0.0166	0.0079
Chromium, Cr	**1.0**	0.2265	0.1794	0.1158	0.2276	0.3013	0.0682	0.3229	0.1139

Copper, Cu	**1.0**	0.0601	0.0592	0.0434	0.1185	0.1639	0.0249	0.1262	0.0696
Nickel, Ni	**1.0**	0.0838	0.0652	0.0525	0.0107	0.1267	0.0385	0.1283	0.0529
Lead, Pb	**0.5**	0.0482	0.1170	0.0293	0.0835	0.0852	< 0.05	0.1616	0.0485
Selenium, Se	**0.5**	0.2908	0.2462	< 0.05	< 0.05	0.1956	0.1372	< 0.05	0.1142
Zinc, Zn	**2.0**	0.7970	0.6407	0.6453	0.9636	1.2500	0.6248	0.7435	0.8233

In this study, twenty one elements were obtained from the ICP results, but only eight elements were comparable to the limitation, including Arsenic, Cadmium, Chromium, Copper, Nickel, Lead, Selenium and Zinc. Table 2 shows the results of heavy metal concentration in mg/L for all types of cement mortar specimens along with their limitations from the EQA regulation. According to the results presented in Table 2, all of the specimens did not exceed the limitation and the heavy metals concentrations were detected to be very low for some of the elements in some specimens. However, there is no pattern for the overall results, which might be caused by inaccurate measurement while pouring the chemical during the acid digestion procedures or during the preparation of ICP standard solution. In other words, it was caused by parallax errors. The amount of chemical compound must be precise and every drop will give an effect. Instead of the acid digestion method, some researchers (Alqam et al., 2011; K. Lin, 2006; Wang et al., 2005) suggested other methods that can be used to measure heavy metal concentration such as Toxicity Characteristic Leaching Procedure (TLCP) which is simpler and more stable.

From the results shown in Table 2, the addition of SSA is suitable to be used as construction material as it complies with EQA regulation which is safe to the environmental.

CONCLUSION

This study investigated the use of sewage sludge ash as a natural admixture to the cement mortar in varying incinerated temperature. The study covered the flow table test for fresh mortar and compressive strength and water absorption test for hardened mortar. In the flow table test, the flow values reduced from SSA0 to SSA700 due to the increasing amount of C3A which led to flash setting. The flow value increased at SSA800 and might be caused by the appearance of additional amount of gypsum. In the compressive strength results, it was noted that the strength of the specimens increased by the increase in the incinerated temperature of SSA but decreased at 1000^{oC} caused by reduction in the amount of calcium silicate hydrate. The water absorption values were performed as representing the durability of the cement mortar. For 28 days of age, the water absorption values increased until SSA700 and decreased until SS900. This situation might be caused by the existence of portlandite from decomposing of CaO compound at incinerated temperature of 800^{oC}. Lastly, the specimens were tested in the ICP machine to determine the heavy metal concentration. As a result, all the specimens had low concentration values from the regulation and safe for the environment. From the result values on the conducted experiments, it can be concluded that the optimum incinerated temperature for SSA is at 900^{oC} since it has preferable flow value, high in compressive strength, low in water absorption and low in heavy metal concentration.

REFERENCES

Alqam, M., Jamrah, A., & Daghlas, H. (2011). Utilization of Cement Incorporated with Water Treatment Sludge. *Jordan Journal of Civil Engineering*, *5*(2), 268–277.

ASTM (1999) ASTM C109/C 109M – 99: Standard Test Method For Compressive Strength

of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens). American Society for Testing and Materials, West Conshohocken, PA 19428-2050, United States.

ASTM (1998) ASTM C230/C 230M – 98: Standard Specification for Flow Table for Use in Tests of Hydraulic Cement. American Society for Testing and Materials, West Conshohocken, PA 19428-2050, United States.

ASTM (1999) ASTM C618 – 99: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete. American Society for Testing and Materials, West Conshohocken, PA 19428-2050, United States.

Azman, E. T. M., Shaari, J., & How, V. K. (2013). *Wastewater Production , Treatment , and Use in Malaysia*.

Barbosa, M. C., & Filho, R. D. T. (2004). Potentiality Of Sewage Sludge Ash As Mineral Additive In Cement Mortar And High Performance. In *International RILEM Conference on the Use of Recycle Materials in Buildings and Structures* (pp. 797–806).

BS EN (2000) BS EN 197-1:2000: Cement. Composition, Specifications And Conformity Criteria For Low Eat Common Cements. British European Standard, London, United Kingdom.

BS EN (1999) BS EN 1015-3:1999: Method of Test For Mortar For Masonry. Determination of Consistency Of Fresh Mortar (By Flow Table). British European Standard, London, United Kingdom.

Department of Statistics, Malaysia, 2011. Population Distribution and Basic Demographical Characteristics. p. 1.

Environmental Quality Act (1974). Environmental Quality (Sewage and Industrial Effuents) Regulations, 1979.

Fontes, C. M. ., Barbosa, M. ., Filho, R. . T., & Goncalves, J. (2004). Potentiality Of Sewage Sludge Ash As Mineral Additive In Cement Mortar And High Performance.*International RILEM Conference on the Use of Recycle Materials in Buildings and Structures* (pp. 797–806).

Indah Water Konsortium Sdn. Bhd. (IWK). 2011. Sustainability Report 2011. p. 101. IWK.

Lin, K. L. (2006). Mineralogy and microstructures of sintered sewage sludge ash as lightweight aggregates. *Journal of Industrial and Engineering Chemistry*, *12*, 425–429.

Lema, D., Quraisyah, D. S., & Rahimah, S. (2015). Incinerated Domestic Waste Sludge Powder as Sustainable Replacement Material for Concrete, *23*(2), 193–205.

Lin, Y., Zhou, S., Li, F., & Lin, Y. (2012). Utilization of municipal sewage sludge as additives for the production of eco-cement. *Journal of Hazardous Materials*, *213-214*

Lynsdale, C. J., & Cabrera, J. G. (1988). A new gas permeameter for measuring the permeability of mortar and concrete. *Magazine of Concrete Research*, *40*(144), 177–182

Monzó, J., Payá, J., Borrachero, M. V., & Girbés, I. (2003). Reuse of sewage sludge ashes (SSA) in cement mixtures: The effect of SSA on the workability of cement mortars. *Waste Management*, *23*(4), 373–381

Morais, L. C., Dweck, J., Campos, V., & Büchler, P. M. (2009). Characterization of sewage sludge ashes to be used as a ceramic raw material. *Chemical Engineering Transactions*, *17*, 1813–1818.

Rosenani, A. B., Kala, D. R., & Fauziah, C. (2008). Characterization of Malaysian sewage sludge and nitrogen miniralization in three soil treated with sewage sludge. *Malaysian Journal of Soil Science*, *12*, 103 – 112.

Sales, A., De Souza, F. R., Dos Santos, W. N., Zimer, A. M., & Almeida, F. D. C. R. (2010). Lightweight composite concrete produced with water treatment sludge and sawdust: Thermal properties and potential application. *Construction and Building Materials*, *24*(12), 2446–2453.

Siti Noorain Roslan, S. S. G. (2013). Study on the Characteristics and Utilization of Sewage Sludge at Indah Water Konsortium (IWK). *International Journal of Environment, Earth Science and Engineering*, *7*(8), 536–540.

Tantawy, M. A., El-Roudi, A. M., Abdalla, E. M., & Abdelzaher, M. A. (2012). Evaluation of the Pozzolanic Activity of Sewage Sludge Ash. *ISRN Chemical Engineering*.

Tay, J.-H., & Show, K.-Y. (1994). Municipal wastewater sludge as cementitious and blended cement materials. *Cement and Concrete Composites*.

Tomaru, K., & Nakamura, M. (2009). Recycling Municipal Solid Waste Into Concrete Paving Blocks. In *9th International Conference on Concrete Block Paving* (pp. 1–10). Argentina.

USEPA (1996), Method 3050b: Acid Digestion of Sediments, Sludges and Soils. United States Environment Protection Agency. United State of America.

Wang, K. S., Chiou, I. J., Chen, C. H., & Wang, D. (2005). Lightweight properties and pore structure of foamed material made from sewage sludge ash. *Construction and Building Materials*, *19*(8), 627–633.

Yagüe, A., Valls, S., Vázquez, E., & Albareda, F. (2005). Durability of concrete with addition of dry sludge from waste water treatment plants. *Cement and Concrete Research*, *35*(6), 1064–1073.

Yusuf, R. O., Noor, Z. Z., Moh', N. a., Moh', D. F., Din, D., & Abba, A. H. (2012). Use of sewage sludge ash (SSA) in the production of cement and concrete - a review. *International Journal of Global Environmental Issues*, *12*(2/3/4), 214.

REVIEW OF METHODOLOGY DESIGNED TO INVESTIGATE QUALITY OF COST DATA INPUT IN LIFE CYCLE COST

Mohd Fairullazi Ayob and Khairuddin Abdul Rashid
Department of Quantity Surveying, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, P.O. Box 10, 50728, Kuala Lumpur, Malaysia.

Abstract
Life Cycle Cost (LCC) estimation process can be divided into three main phases: data inputs, conversion and outputs. The objective of this paper is to identify the most appropriate methodology to investigate the quality of data used as inputs in LCC estimation for building works in the Malaysian construction industry. The focus of quality data here is cost data inputs of building LCC. This paper reports part of a three-year research programme to enhance the quality of LCC outputs through the enhancement of quality data input requirements. A comprehensive literature review was carried out to critically review all the methodologies used to study LCC data inputs in other countries. The goal is to identify the most appropriate methodology to investigate the quality of cost data inputs in LCC analysis of building with regard to the context of Malaysian construction industry. The outcomes of the study proposed that a qualitative research strategy comprises of two approaches, i.e. a literature review and modified Delphi as the most appropriate methodology to critically review and examine behaviours of cost data inputs in LCC analysis of the building based on the opinions from a collective intelligence panellists. The considerable limitation of modified Delphi is to find the appropriate level of panellists that possess skills, knowledge and expertise in the field of LCC. In addition, the Delphi process is normally long and time-consuming because it involves multi-round of questionnaires.

Keywords: *Life cycle cost, building, cost data input, methodology, Malaysian construction industry*

INTRODUCTION

Life Cycle Cost (LCC) is an economic assessment technique that uses mathematical method to produce outputs, which will give useful cost information to the clients, cost estimators and researchers in facilitating them to make better decision in the process of determining the most optimum total ownership cost of an asset over an anticipated life or in comparing the most cost-effective of mutually exclusive alternatives. The LCC analysis calculates the total ownership costs of the building which include the initial capital cost, operation costs, replacement costs, financial costs, and salvage costs over an anticipated life (BSI, 2008; Langdon, 2010).

The LCC analysis process can be categorized into three main phases, i.e. data inputs, conversion and outputs (BS ISO 15686-5, 2008; Rist, 2011). Past studies have confirmed that the reliability of cost data used as inputs as well as the method used for the LCC analysis are of paramount importance in effort to produce reliable LCC outputs (Langdon, 2010; Rist, 2011; Ayob and Abdul Rashid, 2011a, 2011b, 2011c, 2012; Ayob, 2014). The underlying idea is that the inputs in terms of data that are quality for LCC analysis would produce reliable LCC outputs, on the assumption that the conversion process is also reliable and appropriate.

There are different kinds of data inputs required for LCC analysis; however the study

focuses only on cost data inputs of LCC. Cost data is the important inputs of LCC that should be identified and quantified by the estimators in the early stage of the project (Fuller, 2009; Davis Langdon, 2010). The literature study has identified the following as the key quality of data input requirements required for producing reliable LCC outputs:

i. Availability of cost data is defined as data certainty for LCC analysis (Gross and AEA, 2008; NATO Research and Technology Organisation, 2009; BS ISO 15686-5, 2008),
ii. Accessibility of cost data is defined as the ease of access to obtain cost data for generating LCC analysis (Ren and Zhang, 2007; Schade, 2007; BSI, 2008; Ashworth, 2010),
iii. Currency of cost data is defined as recent cost data used as inputs for producing reliable LCC analysis. Current data is frequently updated on a certain period of basis (i.e. monthly, quarterly or yearly) (www.statistic.gov.my; Khairani, 2009; DSM, 2010); and
iv. Reliability of cost data is defined as data consistency or data accuracy for LCC analysis (Annex 31, 2001; Creswell and Clark, 2007; King, 2007; CRES and Kikira, 2009; Giannarakis et al., 2011)

LITERATURE REVIEW

LCC is concerned with the time value of money which indicates the value of money today is worth more than the value in future as the money could be earned in the interim. The time value of money is a concept of discounting the future values to present values, using a specified discounting rate over a particular period of time (BS ISO 15686-5, 2008; BSI, 2008; Fuller, 2009; Kelly and Hunter, 2009). There are many kinds of data required as inputs for producing a comprehensive LCC analysis. Table 1 provides in summary the types of cost data for each category of cost components of LCC of a building.

Table 1. Cost components and types of cost data of LCC of a building

Cost component (Cost unit)	**Cost data**
Initial capital costs	Land acquisition cost, construction work costs (i.e. substructure, superstructure, finishes, fittings, services installation, external works, preliminaries, contingency including risk allowances, and contractor's design fees,), other construction related costs (i.e. professional services fees, marketing costs, decanting, infrastructure charges, infrastructure adoption and maintenance cost, highway cost, utility charges, licenses and permits, planning application and building regulation fees, party wall cost, rights to light cost, client's design development, financing cost, insurance, contingency including risk allowances), and client definable costs (e.g. cost incur to make value added on the building), landscaping cost
Operation costs	Utility costs, insurance, service costs, administration costs, security costs, cleaning costs, local and statutory charges in connection with the building operation
Maintenance and replacement costs	The costs of regular custodial care and repair, annual maintenance contracts, maintenance management, adaptation or refurbishment, redecoration, and salaries of facility staff performing maintenance tasks, repairs and replacement of minor components
Financial costs	Discount rates, inflation rates, interest rates and taxes

Cost component (Cost unit)	Cost data
Salvage costs	The cost, or gain, of getting the rid of assets after use at the end of study life (residual value, demolition cost, transferring cost, disposal inspection cost).

(Source: Kirk and Dell'Isola, 1995; BS ISO 15686-5, 2008; BSI, 2008; Fuller, 2009; Kelly and Hunter, 2009; Langdon, 2010)

The literature review on the history of LCC in the Malaysian construction industry has not identified any information when the LCC technique was actually started but the technique was first academically applied in 2007 using the LCC software (i.e. LCCsoft) by Mohd Mazlan (2007) through his research to compare the most cost-effective of amongst mutually exclusive components of roof finishes (i.e. concrete roof tile, clay roof tile, metal roof decking) for Educational, Cultural and Scientific Building (B11) at Faculty of Built Environment in Universiti Teknologi Malaysia, Johor Bahru, Johor . LCC has been taught as one of the topics in the economic subject of Bachelor degree in the tertiary institutions of Malaysian education system. The LCC analysis has become one of the research topics in the higher research programmes, i.e. Master and Doctorate in several major local universities.

The Malaysia Government through the Economic Planning Unit (EPU) and Public Works Department (PWD) have confirmed in the national standard guidelines that LCC is mandatory to be used as an economic assessment technique to provide crucial cost information which can facilitate the Government in making better investment decisions to achieve the best value for money and potential cost saving especially in the newer approaches and techniques of project delivery systems. These include the Public Private Partnership (3PU, 2009a:6; 3PU, 2009b:5; 3PU 2010a, 2010b), Value Management (EPU, 2011; PROKOM, 2011a, 2011b), Total Asset Management (Malaysia Government, 2009), Green Building Rating system (CIDB, 2007), and the Red Book procurement system of the Government-Linked Companies (PGC, 2006a, 2006b). In addition, the Construction Industry Development Board (CIDB) and the Building Industry President Council (BIPC) have strongly recommended in the Construction Industry Master Plan 2006-2015 (CIMP) that the clients' organization and building owners in the Malaysian construction industry should adopt LCC in the investment decision-making process in effort to achieve the best value for money (CIDB, 2007; Mohd Mazlan, 2010; CIDB, 2011c).

Nevertheless, there is no information found from the literature review to indicate that LCC technique has been officially practiced in the past as an economic assessment technique to provide total cost information to the Government and clients in facilitating them to make a better investment decision to achieve the best value for money. Indeed, many commentators pointed out that the LCC technique has been unsatisfactorily applied in the Malaysian construction industry due to the complexity faced by the LCC practitioners in getting all types of data as input into the process of producing a comprehensive and reliable LCC analysis. Ayob (2014) has identified the following as the key factors, which have imposed constraints to the implementation of LCC practice in the Malaysian construction industry:

i. The lack of reliable, quality and current cost data inputs, including insufficient theory has caused difficulties to estimators to practice a comprehensive LCC analysis in the construction industry (Levander et al., 2009; He and Yin, 2010a, 2010b; Rist, 2011;

Ayob and Abdul Rashid, 2011a, 2011b, 2011c, 2012, 2014b). Commentators pointed out that most published cost data in the Malaysian construction industry are historical, less current and fragmented, which are considered inappropriate and non-quality to be used as input for producing a reliable LCC output (Gheisari, 2009; Gheisari et al., 2010; Ayob and Abdul Rashid, 2011a, 2011b, 2011c, 2012).

ii. No model, system or guideline has been established in the Malaysian construction industry which can help the LCC practitioners to trace, define, collect, collate and manage different types of cost data inputs of building works for the purpose of generating LCC analysis (Ismail, 2005; Zulkifly Yaacob and Elizuan Rafys, personal communication, November 18, 2011; Ayob and Abdul Rashid, 2011a, 2011b, 2012).

iii. The local authorities in Malaysia have insufficient cost data due to unproductive data record which caused difficulties for the authorities to estimate accurately the total cost of the asset (Halide, 2005; Ladom, 2005; Cheong, n.d.).

iv. No policy with regard to LCC analysis has been produced and mandated by the Government that requires the Public Works Department (PWD) to carry out LCC analysis in the public projects for other government agencies in Malaysia (Ismail, 2005; Zulkifly Yaacob and Elizuan Rafys, personal communication, November 18, 2011).

v. The public financial constraint has caused the Government to put more emphasis on the initial capital costs but overlooked the total cost of public assets (Ismail, 2005; Cheong, n.d.). Due to limited fund available in the public projects, the cost estimation of new construction work is carried out within the context of the construction budget, whilst the maintenance budget is calculated separately during the in-use stage (Ismail, 2005; Mohd Mazlan Che Mat, personal communication, June 2, 2011).

vi. There is a very limited number of cost practitioners who have practiced LCC technique for building projects in the Malaysian construction industry (Ismail, 2005; Mohamed et al., 2007; Mohd Mazlan, 2010). A study by Cheong (n.d.) reports that the majority of professional groups in Malaysian construction industry who have a good understanding on the concepts of LCC analysis had never been practiced the technique in the past projects. Indeed, another important finding by Ismail (2005) was that the majority of the officers in the Tender, Contract and Cost Section, Department of Contract and Quantity Surveying of Public Work Department (PWD) have realized the significant use of LCC analysis in public projects. However, they advocated that the LCC technique cannot be practiced yet in the public project as the focus of Government agencies is still emphasized solely on the aesthetic value and construction cost but not on the total costs of the building (Ismail, 2005; Ladom, 2005; Cheong, n.d.).

To ensure the full potential of benefits can be achieved from the application of LCC analysis in the Malaysian construction industry, a comprehensive research needs to be carried out to identify types of cost data, which are satisfactory to be used as quality input for producing reliable LCC outputs in the Malaysian construction industry. The literature study has established that the availability, accessibility, currency and reliability of data is the key quality data input requirements of LCC, which should be emphasized to ensure a comprehensive LCC analysis is able to be carried out to produce reliable outputs.

OBJECTIVE OF THE PAPER

The objective of this paper is to present the identification of the most appropriate methodology to investigate the quality of data used as inputs in LCC estimation for building works in the Malaysian construction industry. The focus of quality data here is cost data input of LCC analysis for building works in the Malaysian construction industry. The study being reported in this paper is drawn from a three-year programme of research carried out by the first author to develop LCC strategy and protocol on cost data input in Malaysia (Ayob, 2014[8]). The aim of the research programme is to enhance the quality of LCC outputs through the enhancement of quality data input requirements.

This paper follows the other eight papers that have been presented elsewhere (Ayob and Abdul Rashid, 2011a[1], 2011b[2], 2011c[3], 2012[4], 2013a[5], 2013b[6], 2014[7]).

REVIEW OF RESEARCH STRATEGY

Research is an activity that requires a comprehensive investigation of a certain topic using an appropriate methodology to attain specified aims and objectives (Fellows and Liu, 2008; Royse, 2008). Experts suggested an appraisal on research strategies should be carried out to identify the differences and to ascertain the most appropriate strategy for the research (Naoum, 2007; Fellows and Liu, 2008). The factors that may influence the determination of the research strategy are the aims and objectives of the research, the ability to obtain the current and reliable data, the way the data should be collected and recorded, impact on the data, the style of data reporting, and the constraints of the strategy (Naoum, 2007).

The literature review has identified three types of research strategies, namely qualitative, quantitative and mixed methods research (Creswell and Clark, 2007; Fellows and Liu, 2008). The key differences of these three research strategies are shown in Table 2.

Table 2. Qualitative, quantitative and mixed method research

Research strategy	Functions	Nature of research
Qualitative strategy	It explores and evaluates attitudes, behaviour, experiences and definitions based on opinions, views or perceptions from the respondents on a particular subject (Creswell and Clark, 2007; Royse 2008).	The nature of research is subjective and data is rich (Creswell and Clark, 2007; Royse 2008).
Quantitative strategy	It evaluates numerical data using statistical analyses (Naoum, 2007; Fellows and Liu, 2008).	The nature of research is objective and data is hard, tangible and reliable (Naoum, 2007; Fellows and Liu, 2008).
Mixed methods research strategy	It combines the quantitative and qualitative researches that can counterbalance the differences of the other, eradicate weaknesses of the strategies and provide more opportunities for the researcher to explore in deep the problems and subject of the research from the perspective of qualitative and quantitative researches (Creswell and Clark, 2007; Fellows and Liu, 2008).	The nature of research and data is combined characteristics of qualitative and quantitative researches (Creswell and Clark, 2007; Fellows and Liu, 2008).

The literature study has identified the following as the key reasons of why the qualitative

research is the most appropriate strategy rather than the quantitative and mixed methods research to investigate the quality of data inputs of LCC for the study:

i. The nature of research in LCC data inputs is subjective, which requires the researchers to investigate LCC practice with specific reference to data input based on the opinions, ideas, views and perceptions from the panellists that have the knowledge, skills and expertise in LCC (Ayob and Abdul Rashid, 2011a, 2011b, 2011c, 2012).
ii. LCC deals with long-term financial costs and there are key parameters of LCC about which uncertainties exists (Levander et al., 2009). The recent study carried out by Langdon (2010) on the current practice of managing data uncertainty and risks of LCC analysis in 15 construction projects across 11 countries in Europe has identified that many LCC estimators preferred to use non-risk management techniques, i.e. conducting interviews with different property owners, experts, suppliers and specialists in the construction industry to overcome the problem of data uncertainty in LCC analysis rather than risk management techniques (i.e. sensitivity analysis, Monte Carlo simulation, and fuzzy approach) (NATO Research and Technology Organisation, 2007; Langdon, 2010; Goh et al., 2010).
iii. The qualitative research is more appropriate to establish the background, evolution and the present practice of LCC with specific reference to its practice in the construction industry. The qualitative research also is more suitable to critically review the previous published and unpublished information with regard to the scope of costs of the LCC analysis, data input requirements, methodology, its setbacks and the present practice of LCC analysis in the Malaysian construction industry.
iv. The qualitative research is more appropriate to generate a consensus of expert opinions regarding the state and degree of data availability, accessibility, and reliability in the Malaysian construction industry as inputs for producing LCC analysis as the data for LCC analysis is affluent and profound. The qualitative research strategy can generate data from the analysis of opinions, views and judgments from a group of panellists that have the knowledge, skills and expertise in LCC.
v. The current state of LCC application in the Malaysian construction industry is still at its infancy stage. Indeed, there is no information found from the literature review to support a satisfactorily large number of respondents who have knowledge about LCC analysis had practice the technique to estimate the total ownership cost of an asset over an anticipated life or in comparing the most cost-effective of mutually exclusive alternatives in the past in the Malaysian construction industry. The complexity of the domain research has made the quantitative and mixed methods research relatively difficult to be adopted in providing explicit and precise data which required for the research (Ayob and Abdul Rashid, 2011, 2012).

The literature study has identified several past researches that had chosen qualitative research as the strategy to study the concepts, practice, data inputs and methodology of LCC analysis based on the valuable opinions, experiences and perceptions from a group of respondents, i.e. Joyce et al. (1992), and Iyer (1999), Ismail (2005), King (2007), Gheisari (2009), Mohd Mazlan (2010). The study has validated that three of the list of the researchers, namely Mohd Mazlan (2010), Gheisari (2009) and Ismail (2005) selected qualitative research as the most appropriate strategy to investigate the concepts and practice of LCC analysis and its data inputs in the context of the Malaysian construction industry.

METHODOLOGY ADOPTED FOR THE RESEARCH

A research model was designed to represent inter-connectivity and relationship between the problem statements, research question and the consequent decision to adopt the selected methodology (see Figure 1). The qualitative research is the strategy designed for the research that comprises of two key data sources, i.e. literature review (secondary data collection), and modified Delphi (primary/fieldwork approach). In reference to the research model in Figure 1, a comprehensive literature review was carried out to establish the current state of LCC practice in the Malaysian construction industry with specific reference to data inputs. A series of modified Delphi questionnaires was carried out to identify and generate consensus regarding the state of data availability, accessibility, currency and reliability in the Malaysian construction industry, and the appropriate strategies to improve the quality of data in LCC analysis by observing and evaluating opinions and judgements from a group of panellists that have experience, skills and knowledge in LCC (Ayob, 2014).

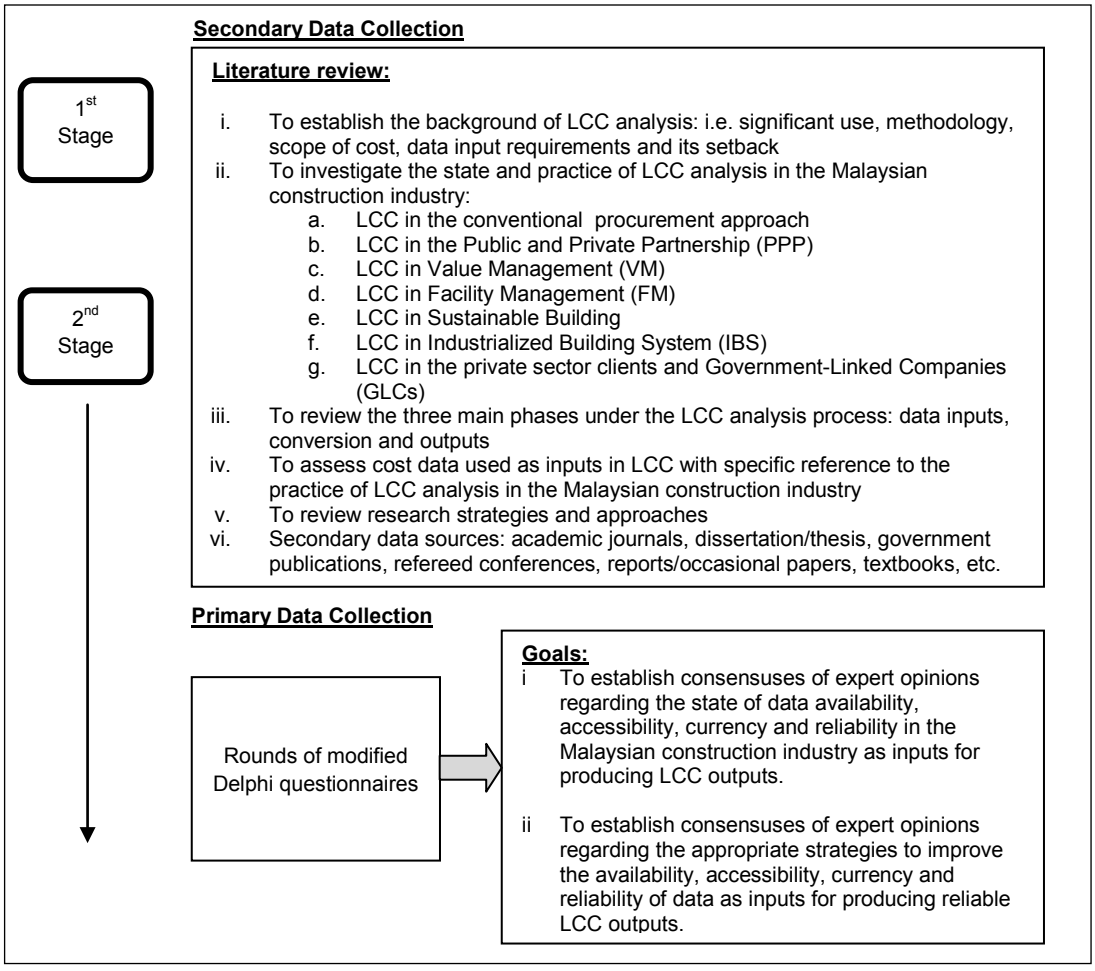


Figure 1. The schematic flow of research methodology

LITERATURE REVIEW

The literature review was carried out at the initial stage of the study to critically review what other people have studied, thought and discussed on the subject of the research (Naoum, 2007; Fellows and Liu, 2008; Wiersma and Jurs, 2009). The literature review is essential for the researchers as it provides a platform for seeking answers to the objectives of the research (Hesse-Biber and Leavy, 2006; Royse, 2008). The literature study has identified the following kinds of secondary data sources related to the subject of the research, i.e. academic journals (refereed), refereed conferences, dissertation/thesis, reports/occasional papers, government documents/publications, market research reports, technical reports, working papers, etc.

FIELDWORK APPROACH

The fieldwork approach is categorized as a primary data source (Creswell and Clark, 2007; Fellows and Liu, 2008; Knight and Ruddock, 2008). The literature review was carried out to identify the differences of the fieldwork approaches and to choose the most suitable approach for the qualitative research. The literature study has identified the following as the key reasons of why a modified Delphi is the most appropriate fieldwork approach rather than other typical approaches (e.g. surveys, case studies, action research) to acquire primary data in the qualitative research of the present study:

i. The modified Delphi is more appropriate than other typical research approaches in a situation where the nature of the research lacks current and reliable data, insufficient theory, and limited number of respondents to provide a sufficient response rate (Wiersma and Jurs, 2009; Hauck et al., 2007 as cited in Giannarakis et al., 2011; Goh et al., 2010). For example, a survey approach was rejected because of a limited number of respondents that have the knowledge, skills and experience in LCC to produce an appropriate response rates for the study.
ii. The complexity of the research domain has made the other typical research approaches (e.g. surveys, case studies, action research) relatively difficult and expensive to be conducted to provide explicit, precise and reliable data for LCC studies (NATO Research and Technology Organisation, 2007; Wiersma and Jurs, 2009; Hauck et al., 2007 as cited in Giannarakis et al., 2011). In addition, this approach was also acclaimed as "the best known qualitative, structured and indirect interaction futures method" to acquire primary data for particular studies that complex in nature (Woudenberg, 1991 as cited in King, 2007: 68).
iii. Several scholars claimed the modified Delphi technique is the most appropriate approach to procure data that is affluent and profound as the data is generated from the analyses of opinions, views, and judgments of the collective intelligence of the panellists, i.e. the experts, practitioners, knowledgeable persons and learned spectators in the LCC environment (NATO Research and Technology Organisation, 2007; Korpi and Al-Risku, 2008; Wiersma and Jurs, 2009).
iv. Several scholars asserted that the modified Delphi approach can be initiated through non-face-to-face interactions (i.e. mail, e-mail, phone calls) if the respondents resided far from the research location and were unable to meet the researcher (King, 2007; Wiersma and Jurs, 2009). This approach is considered very time efficient and cost effective as all the panellists do not have to agree to meet at a specified time and place

for the face-to-face discussion (Romano, 2010).

v. In comparison with the traditional way of collecting opinions from the panellists as practiced in the focus group discussion, the panellists in the modified Delphi approach are working individually, anonymously, free of influences from others to provide independent judgments, and have no constraints if wishing to provide extreme opinions in answering the Delphi questions (Parsons et al., 2008; Wiersma and Jurs, 2009). The anonymity of the Delphi panellists is maintained throughout the process to avoid open debate and dishonest opinions because the value of the output is specified based on the quality of the opinions rather than who proposed the idea. In addition, the non-face-to-face interaction between the researcher and panellists can maximise the amount of unbiased responses because there is no manipulation that can be forced in the communication process (Wiersma and Jurs, 2009.).

vi. There are many high impact publications that have indicated the Delphi technique as a reliable and valid research approach to collect primary data for the research. It was reported by Gordon (n.d.) based on the Scopus database assessment which was carried out in September 2008, that there are more than 15,000 peer-reviewed professional journals from 4,000 various publishers used Delphi technique as a fieldwork approach to develop, identify, forecast and evaluate primary data. Besides, Skulmoski et al., (2007) reported that there are more than 280 dissertations and theses used Delphi technique as one of the primary approaches to collect primary data for the research

The modified Delphi approach is classified as a structured group communication process that involves the process of acquiring responses and exchanging ideas from a group of experts through a number of sequential questionnaires, followed by a synthesis and analysis of opinions and ideas to generate reliable data for the research (King, 2007; Sandrey and Bulger, 2008; Giannarakis et al., 2011). This technique was developed by Norman Dalkey of the RAND Corporation in the 1950's to generate data from a consensus of expert opinion for a U.S. Air Force sponsored military project. The Delphi technique has been used widely in many areas of decision-making process particularly to solve complicated problems (e.g. lack of current and reliable data, insufficient theory, data is affluent and profound), and generate forecasts about the future (King, 2007). The Delphi approach has also been characterized as a family of methods with many variations and modifications as the process involves four essential elements, i.e. (i) sequential questionnaires, (ii) reiteration and controlled feedback, (iii) anonymous responses and (iv) statistical group response (King, 2007; Sandrey and Bulger, 2008; Landeta and Barrutia, 2011; Giannarakis et al., 2011).

The process of the Delphi approach was initially conducted using traditional mail in the 1960s, but now the process has been improved using electronic devices in order to accelerate data flow and reduce time delay between the rounds of questionnaires (DeReus, 2004). The modified Delphi approach is more robust than the basic Delphi approach because the initial round of the questionnaire can be conducted through a face-to-face interview that can improve the response rate and provide a solid grounding in previously developed work (King, 2007). Although the modified Delphi approach is comparable to the basic Delphi approach in terms of the process to attain consensus of expert opinion, however the significant difference is that the modified Delphi approach initiates the process with a set of carefully selected items derived from various sources including related competency profiles of panellists, synthesized

reviews of literature, and interviews with the selected panellists (Franklin and Hart, 2006; King, 2007).

The advantages of modified Delphi approach

The literature review has identified the following as the key advantages of the modified Delphi approach:

i. The panellists enjoy the flexibility of time to express valuable opinions and creative ideas before an agreed deadline (Sandrey and Bulger, 2008; Wiersma and Jurs, 2009; Romano, 2010; Giannarakis et al., 2011). Several scholars preferred to use this approach in their research works because it can avoid the problems of communication delay (Ciptono, 2007; Wiersma and Jurs, 2009). This approach is also practical if the panellists could not make to agree to meet either because they are located or reside far away from the research location, or no available time can be set for the discussion (Wiersma and Jurs, 2009; Romano, 2010)
ii. In-depth interviews can be carried out to explore detailed information regarding the future trends, events and occurrence of future developments (Wiersma and Jurs, 2009). This approach can be used to provide a complete documentation of responses on a large scale of respondents (Skulmoski et al., 2007; Giannarakis et al., 2011). Indeed, this approach can facilitate the researcher to procure a maximum amount of unbiased responses and information from the panellists that work on the same issue because no manipulation can be forced in the Delphi communication process (Wiersma and Jurs, 2009). In most cases, this approach was used to recommend oriented solutions to the problems that arose in the research (Wiersma and Jurs, 2009). In addition, Gordon (n.d.) asserted there is no method that was found to have had a more competitive advantage than the modified Delphi approach to procuring and synthesize the most reliable opinions and creative ideas in line with the forecasting analysis of future market trends and events.
iii. Several scholars asserted this approach is flexible as it can be used in many varieties of structure processes ranging from the qualitative to quantitative and to mixed-methods research (Skulmoski et al., 2007; Gordon, n.d.). It can be used in the quantitative simulation models, where a detailed scientific analysis can be carried out to determine significant differences about the value of independent variables based on the factoring outputs produced from the factor analysis (Skulmoski et al., 2007; Hon et al., 2011). Besides, other researchers like Hon et al. (2011) used Delphi in quantitative research by using mathematical formulas (i.e. Kendall's coefficient of concordance, Spearman's rho correlation, Kruskal-Walls test, Mann-Whitney U test) to evaluate responses and test hypotheses to determine whether every individual panellist provided a similar response using the same method and style on 5-point Likert-type scale (Hon et al., 2011).

Reliability and validity of modified Delphi approach

Reliability in the research can be defined as the dependability or consistency of data, which implies how comparable the data to the actual value arrived from similar and repetitive methods under the same research condition (Ashworth, 2004; Creswell and

Clark, 2007). Whilst, validity can be defined as the truthfulness of the data. The results can only be considered valid if the analysis is accurate, dependence, significant and justifiable (Creswell and Clark, 2007).

Several experts asserted that the modified Delphi approach can produce more reliable and valid outputs associated within the particular issues of research topic rather than procuring judgment based on the capability of a single individual expert (Linstone and Turoff, 1975, as cited in King, 2007; Gordon, n.d.). Besides, several experts claimed that the modified Delphi approach is "the best known qualitative, structured and indirect interaction futures method" to obtain explicit, precise and reliable data for the particular studies that complex in nature (Woudenberg, 1991 as cited in King, 2007: 68).

A recent study carried out by Langdon (2010) on the practice of LCC in 15 construction projects across 11 countries in Europe has identified that many LCC estimators preferred to use alternative methods that are not part of risk management techniques to overcome the problems with regard to the absence of current and reliable data in LCC, i.e. conducting interview with different property owners, suppliers and observing opinions and judgements from the LCC experts, suppliers and specialists in the construction industry (Langdon, 2010: 68). The main reason why the risk management techniques (e.g. sensitivity analysis, Monte Carlo simulation) were rarely applied by the LCC estimators in the construction projects in Europe is the absence of data required as inputs for risk management analysis (Langdon, 2010; Goh et al., 2010; NATO Research and Technology Organisation, 2007). Hence, it is not incorrect to state that the interviews with different panellists that have the knowledge, skills and experience in LCC using the modified Delphi is the most appropriate and applicable fieldwork approach to investigate the quality of data inputs in LCC estimation for building works in the Malaysian construction industry.

Some limitations of modified Delphi approach

The literature study has identified some considerable limitations that can hinder the implementation of modified Delphi practice. One of the limitations is to identify the appropriate level of panellists that possess the required skills, knowledge and expertise in the field of LCC. The competency and experience of the panellists and quality responses are some of the crucial factors in the implementation of Delphi practice. However, these two aforementioned factors are beyond the control of the researcher (Sandrey and Bulger, 2008).

The Delphi process is normally long and time-consuming as it involves multiple rounds of questionnaire to move the panellists toward of the consensus of opinion (Ratnasabapathy and Rameezdeen, 2006). Hence, the long Delphi process may affect the commitment of the panellists to complete all the rounds of Delphi process. The time constraint to complete the long Delphi process may persuade the panellists to response quickly and agree with the majority, which can become the cause of poor quality answers to the questions (Sandrey and Bulger, 2008).

CONCLUSION AND RECOMMENDATION

This paper presents the outcomes of the study on the identification of the most appropriate methodology to investigate the quality of cost data used as inputs in LCC estimation for building works in the Malaysian construction industry. The findings have suggested that the qualitative research, including two approaches, i.e. literature review and modified Delphi as the most appropriate methodology for the said study. The modified Delphi approach was identified as the most reliable and valid fieldwork approach to identify and generate a consensus of expert opinions on the state of quality of data of LCC based on the evaluation of opinions and judgments from collective intelligent panellists that possess skills, experience and knowledge in the field of LCC. However, the modified Delphi approach is limited by constraints in finding the appropriate level of panellists that have accessibility skills, experience and knowledge in the field of LCC. The Delphi process is also long and time-consuming. Further research is encouraged to find appropriate strategies to mitigate the aforementioned limitations of modified Delphi, which can be proposed as second part of the study

NOTES

i. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (2011a[1], June). A literature review on the state and practice of Life Cycle Cost (LCC) in Malaysia. Paper in the Proceedings of the International Building and Infrastructure Technology Conference 2011 (BITECH 2011), Universiti Sains Malaysia, Malaysia.
ii. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (2011b2, July). Proposing a methodology to investigate the reliability and validity of data inputs for building Life Cycle Cost (LCC). Paper in the Proceedings of the 10th Management in Construction Researchers Association (MiCRA) Conference 2011, International Islamic University Malaysia, Malaysia.
iii. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (2011c3, September). Investigating the reliability and validity of data inputs for building Life Cycle Cost (LCC). Paper in the Proceedings of the Seventh International Conference on Multi-National Joint Venture for Construction Works: Joint Venture for Infrastructure Development in the context of Decentralization and Globalization, Institute Technology of Bandung, Indonesia, Kyoto University, Japan, International Islamic University Malaysia, Malaysia.
iv. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (20124, December). Issues on Data Availability, Accessibility, Currency and Its Reliability as Inputs in the Life Cycle Cost (LCC) Studies in Malaysia. Paper in the Proceedings of the Management in Construction Research Association (MiCRA) Postgraduate Conference, Universiti Teknologi Malaysia, Malaysia.
v. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (20135, November). Strategies to Enhance Quality Data Input Requirements of Life Cycle Cost (LCC). Paper in the Proceedings of the International Conference of Architecture and Built Environment 2013 (ICABE2013) Redefining the concept of 'Islamic Architecture' and 'Islamic Built Environment organized by Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia.
vi. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (20136, December). The constraint of the Results of Modified Delphi Study on Enhancing the Quality Data Input Requirements of Life Cycle Cost (LCC). Paper in the Proceedings of the 12th

Management in Construction Researchers' Association (MiCRA) Conference and Annual General Meeting 2013 organized by International Islamic University Malaysia, Malaysia.

vii. Ayob, Mohd Fairullazi and Abdul Rashid, Khairuddin (20147) Identification of cost data input problems in life cycle cost analysis and the mitigation strategies. Paper in the Proceedings of the 13th Management in Construction Research's Association (MiCRA 2014) Annual Conference and Annual General Meeting (2014), International Islamic University Malaysia, Malaysia.

viii. Ayob, Mohd Fairullazi (20148). Development of Life Cycle Cost Strategy and Protocol on Cost Data Input in Malaysia. Unpublished doctoral dissertation, International Islamic University Malaysia.

ACKNOWLEDGEMENT

The first author is an Academic Trainee that received research funding from the Ministry of Higher Education Malaysia and the International Islamic University Malaysia (IIUM) to carry out a three-year programme of research on the "Development of Life Cycle Cost Strategy and Protocol on Cost Data Input in Malaysia" under the supervision of the second author (Ref: KPT (BS) 790816016443; IIUM/202/C/1/1/AT113). Since January 2014, the first author has been appointed as an Assistant Professor at IIUM (Ref: IIUM/202/C/1/1/0006985).

REFERENCES

Abdul Rashid, K. (2009) Understanding Private Finance Initiative (PFI), Scholarmind Publishing, Selangor, Malaysia.

Abdul Rashid, K. (2010a, August) PPP within the context of the procurement paradigm. Paper presented at the *Malaysia's Public-Private Partnership Seminar (2010)* organised by the Procurement & Project Delivery, System Research Unit, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia in collaboration with Public-Private Partnership Unit, Prime Minister Department, Petaling Jaya, Selangor.

Ashworth, A. (2004) Cost studies of buildings (4th ed.), Pearson Education Limited Harlow, England.

Ali, A. S., Kamaruzzaman, S. N., Sulaiman, R., & Peng, Y. C. (2010) Factors affecting housing maintenance cost in Malaysia. *Journal of Facilities Management*, 8(4), 285-298. Retrieved December 18, 2010, from Emerald database.

BS ISO 15686-5. (2008) International Standard: Buildings and constructed assets-Service Life Planning. Part 5: Life Cycle Costing (pp 1-40). Standards Policy and Strategy Committee. Retrieved Jun 9, 2010, from University of Bradford database.

BSI. (2008), Standardized method of life cycle costing for construction procurement: A supplement to BS ISO 15686-5 Buildings and constructed assets-Service Life Planning. Part 5: Life Cycle Costing (pp 1-87). London: British Standards Institutions. Retrieved August 4, 2011, from Universiti Tun Hussein Onn Malaysia database.

Che Mat, M. M. (2006, June) Value management as an effective tool for organizations in making strategic decisions. Paper presented at the *International Conference on Construction Industry 2006: Toward Innovative Approach in Construction and Property Development*. Retrieved January 5, 2011. http://www.fab.utm.my/download/ConferenceSemiar/ICCI2006S1PP19.pdf.

Che Mat, M. M. (2010, April) Application of Value Management: Value Management-the way

forward. Paper presented at the *Seminar Achieving Better Value in Construction Industry through Value Management & Life Cycle Costing* organized by CIDB, Putrajaya.

Cheong, L. K. (n.d) A study on Whole Life Costing in Malaysian construction industry and its barriers. Unpublished advanced diploma dissertation, School of Technology, Tunku Abdul Rahman College, Kuala Lumpur.

CIDB (2007) *Construction Industry Master Plan (CIMP) Malaysia 2006-2015*. Kuala Lumpur: Author.

CIDB (2011) *Asset and facility management: implementation manual*. Kuala Lumpur: Author.

Ciptono, W.S. (2007, August) Application of analytic hierarchy process in prioritization of critical success factors of TQM. Paper presented at the *9th International Symposium on the Analytic Hierarchy Process for Multi-Criteria Decision Making,* Chile. Retrieved April 24, 2011. http://www.isahp.org/2007Proceedings/Papers/Working%20Sessions/Project %20Evaluation/Critical%20Success%20Factors%20of%20TQM.pdf.

Creswell, J. W. & Clark, V. L. P. (2007) Designing and conducting mixed methods research. Sage Publications, Inc., London, UK.

DeReus, D. L. (2004) *Comparative analysis on the cost of oversight for the new national security space acquisition policy—a Delphi method approach*. Unpublished master dissertation, Graduate School of Engineering and Management, Air Force Institute of Technology, Air University, Air Education and Training Command, United States of America. Retrieved October 8, 2011. http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA422619

Economic Planning Unit (EPU) (2011) *Panduan perlaksanaan pengurusan nilai dalam program/projek kerajaan* [Value management implementation guideline for Government project/programme]. Unit Perancang Ekonomi, Jabatan Perdana Menteri, Putrajaya. Retrieved July 11, 2011. http://www.epu.gov.my/c/document_library/get_file?uuid=2c2f1aa9-55be-4376-9e9d-283aef6d9028&groupId=34492.

Fellows, R. & Liu, A. (2008) Research Methods for Construction. Wiley-Blackwell, Oxford, UK.

Franklin, K. K. & Hart, J. K. (2006) Influence of web-based distance education on the academic department on the academic department chair role. *Journal of Educational Technology & Society*, 9(1), 213-228. Retrieved Jun 13, 2011. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.103.7378.

Fuller, S. (2009) Life Cycle Cost Analysis (LCCA). National Institute of Standards and Technology (NIST). Retrieved May 15, 2010. http://www.wbdg.org/resources/lcca.php?r=hospital.

Gheisari, M. (2009) *A web-based environment for buildings' Life Cycle Cost Analysis*. Unpublished master dissertation, Universiti Teknologi Malaysia, Johor, Malaysia. Retrieved July 27, 2010. http://www.efka.utm.my/thesis /IMAGES/4MASTER/2009/JSB-P/MasoudGheisarifullthesis.pdf.

Gheisari, M., Abdullah, A., Irizarry, J., Pillai, C. (2010) A web-based environment for buildings' Life Cycle Cost Analysis. Paper in the Proceedings of the 6th International Conference on Innovation in Architecture, Engineering and Construction (AEC), Pennsylvania State University, USA. In Anumba, C.J., Bouchlaghem, N.M., Messner, J.I. & Parfitt, M.K., (eds.), pp. 262-270.

Giannarakis, G., Litinas, N. & Theotokas, I. (2011) A Delphi study to identify Corporate Social Responsibility indicators: the case of Greek telecommunication sector. *Journal*

of Sustainable Development, 4(2), 16-32. Retrieved April 24, 2011. http://ccsenet.org/journal/index.php/jsd/article/view/10171/7269.

Goh, Y.M., Newnes, L.B., Mileham, A.R., McMahon, C.A. & Saravi, M.E. (2010) Uncertainty in through Life Costing-review and perspectives. *IEEE Transactions on Engineering Management*, 57, 4. Retrieved November 1, 2011 from IEEE database, International Islamic University Malaysia

Gordon, T. J. (n.d.) The Delphi method. The Millennium Project. Retrieved March 3, 2011. http://www.gerenciamento.ufba.br/Downloads/delphi%20%281%29.pdf.

Halide, A. (2005) The implementation of cost control approaches for building projects in the public sector at pre-contract stages. Unpublished bachelor dissertation, Kulliyyah of Architecture and Environmental Design, International Islamic University, Kuala Lumpur.

He, W. & Yin, Y. (2010a) A design-oriented LCC database framework according to partnership theory. *IEEE*. Retrieved December 5, 2011. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5535846.

He, W. & Yin, Y. (2010b) OLII: An owner-oriented LCC Information Integrated Approach paper title. *IEEE*. Retrieved December 5, 2011. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5563748.

Hon, C.K.H., Chan, A. P. C. & Chan, D. W. M. (2011) Strategies for improving the safety performance of repair, maintenance, minor alteration and addition (RMAA) works. *Facilities*, 29(13/14), 591-610. Retrieved April 6, 2012, Emerald database.

Ismail, A. N. (2005) *The extent of implementation of Life-Cycle Costing in Government project with specific reference to Jabatan Kerja Raya Malaysia*. Unpublished bachelor dissertation, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia, Kuala Lumpur, Malaysia.

Ismail, M. (2010, April) Implementation of value management in the public sector. Paper presented at the *Seminar Achieving Better Value in Construction Industry through Value Management & Life Cycle Costing* organized by CIDB, Putrajaya.

Iyer, P. (1999) *The effect of maintenance policy system maintenance and system life cycle cost*. Unpublished master dissertation, Virginia Polytechnic Institute and State University, U.S. Retrieved October 1, 2011. http://scholar.lib.vt.edu/theses/available/etd-042199-212844/unrestricted/etd.pdf.

Joyce, B.D., Poppert, D.E. (1992) *Life cycle cost of alternative ICBM second stage designs*. Unpublished master dissertation, Faculty of the School of Systems and Logistics of the Air Force Institute of Technology Air University, U.S. Retrieved October 1, 2011. http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA258264.

Kelly, J. R. & Hunter, K. (2009) Life Cycle Costing of sustainable design. London: RICS. Retrieved Jun 14, 2010. http://www.rics.org/site/scripts/download _info.aspx?downloadID=4529 - 24k.

Khairuddin, A. Z. (2010, August) PPP guidelines: a conceptual framework. Paper presented at the *Malaysia's Public-Private Partnership Seminar* organised by Procurement & Project Delivery, System Research Unit, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia in collaboration with Public-Private Partnership Unit, Prime Minister Department, Selangor.

King, R. J. (2007) *A decision-making framework for total ownership cost management of complex systems: A Delphi study.* Unpublished doctoral dissertation, University of Phoenix, US. Retrieved May 25, 2011. http://gradworks.umi.com/3302636.pdf.

Kirk, S. & Dell'Isola, A. (1995) Life cycle costing for the design professional. McGraw-Hill, New York, USA.

Knight, A. & Ruddock, L. (2008) Advanced Research Methods in the Built Environment. Wiley-Blackwell, United Kingdom.

Korpi, E. & Al-Risku, T. (2008) Life cycle costing: a review of published case studies. *Journal of Managerial Auditing* 23(3), 240-261. Retrieved January 10, 2011, from Emerald database.

Ladom, Rohayah @ Norayati (2005). Roofing specification in Sabah-Assessment of supply chain and life cycle cost. Unpublished master thesis, School of Engineering and Information Technology, Universiti Malaysia Sabah.

Langdon, D. (2010) Development of a promotional campaign for Life Cycle Costing in construction. United Kingdom: Langdon. Retrieved November 20, 2011. ec.europa.eu/index_en.htm

Levander, E., Schade, J. & Stehn, L. (2009), Life cycle costing for buildings: Theory and suitability for addressing uncertainties about Timber Housing. Retrieved November 30, 2010. http://www.inpro-project-eu/media/LCC_for_buildings_Levander_Schade_Stehn-pdf.

Majid, N. N. (2010, August) An Overview of PPP and the Malaysian Experience. Paper presented at the *Malaysia's Public-Private Partnership Seminar (2010)* organised by Procurement & Project Delivery, System Research Unit, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia in collaboration with Public-Private Partnership Unit, Prime Minister Department, Petaling Jaya, Selangor.

MCM Value Sdn. Bhd. (2010) User manual: LCCsoft (version 4.0). Author, Malaysia.

Mohamed, O., Abdul Karim, S.B., Kho, M.Y. & Mohd Nor, F. (2007, August) The practice of life cycle costing (LCC) in the Malaysian construction industry-Application during design stages. *Proceedings of the Management in Construction Researchers Association 5th Annual Conference and Meeting (MiCRA 2007)*, Universiti Teknologi Mara, Shah Alam, Selangor.

Mohd Kamar, K. A., Abd Hamid, Z., Azman, M. N. A., Ahamad, M. S. S. (2011) Industrialized Building System (IBS): reverting issues of definition and classification. *Int. J. Emerg, Sci.*, 1(2), 120-132, June 2011. Retrieved July 15, 2011. http://ijes.info

Mohd Mazlan, M. Z. (2007) *Kos kitaran hayat bagi kemasan bumbung [Life cycle cost for roof finishing]*. Unpublished degree dissertation, Faculty of Built Environment, Universiti Teknologi Malaysia, Malaysia.

Mohd Mazlan, M. Z. (2010) *Application of Life Cycle Costing for construction projects in Malaysian Government-Linked Companies.* Unpublished master dissertation, Faculty of Architecture, Planning and Surveying, Universiti Teknologi Mara, Malaysia.

Naoum, S. G. (2007) Dissertation Research and Writing for Construction Students (2nd ed.). Elsevier Butterworth-Heinemann, Oxford, UK.

NATO Research and Technology Organisation. (2007) Methods and models for Life Cycle Costing. *RTO-TR-SAS-054 Technical Report*. Retrieved February 22, 2011. http://www.dtic.mil/cgibin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA515584.

Parsons, A. M., Almasude, A., Dunn, S. & Green, K. (2008) *A Delphi study of best practices of online instructional*. Unpublished doctoral dissertation, Capella University, United States. Retrieved December 31, 2011, from ProQuest LLC database, International Islamic University Malaysia.

Project Management Excellent (Prokom) (2011a) *Value Management in the government projects (part 1)*. Kuala Lumpur: Cawangan Kontrak dan Ukur Bahan JKR.

Project Management Excellent (Prokom) (2011b) *Value Engineering process & applications (part 2)*. Kuala Lumpur: Cawangan Kontrak dan Ukur Bahan JKR.

Ratnasabapathy, S. & Rameezdeen, R. (2006, September) A multiple decisive model for construction procurement system selection. *Proceedings of the Annual Research Conference of the Royal Institution of Chartered Surveyors, COBRA 2006*, University College London. Retrieved April 25, 2011. http://www.rics.org/site/download_feed.aspx?fileID=3267&fileExtension=PDF.

Rist, T. (2011) *A path to BIM-based LCA for whole buildings*. Unpublished master dissertation, Faculty of Engineering Science and Technology, Department of Civil and Transport Engineering, Norwegian University of Science and Technology. Retrieved January 10, 2012. http://www.ntnu.edu/c/document_ library/get_file?uuid=de2c6e9e-853c-4870-897d-1c8d48e42286&groupId=163835.

Romano, A. R. (2010) Malleable Delphi: Delphi research technique, its evolution, and business applications. *International Review of Business Research Papers*, 6(5), 235-243. Retrieved October 21, 2011. http://www.bizresearchpapers. com/18.Anthony-FINAL.pdf.

Royse, D. (2008) *Research methods in social work* (5th ed.). Thomson Learning Academic Resource Centre, United States of America.

Sandrey, M. A. & Bulger, S. M. (2008) The Delphi method: an approach for facilitating evidence-based practice in athletic training. *Athletic Training Education Journal*: 2008, 3(4), 135-142. Retrieved October 1, 2011. www.nataej.irg.

Skulmoski, G.J, Hartman, F.T. & Krahn, J. (2007) The Delphi method for graduate research. *Journal of Information Technology Education*, 6. Retrieved April 18, 2011. http:// informingscience.org/ jite/documents/Vol6/JITEv6poo1-0215kulmoski212.pdf.

Tapsir, S. S. (2007, April) Life cycle cost approach in the design of affordable housing in Malaysia. In the *Workshop on Building Maintenance, Commissioner of Building (COB)*. In MBAM (ed.), Master Builders 2nd Quarter 2007 Bulletin, pg.22. Kuala Lumpur: MBAM.

Wiersma, W. & Jurs, S.G. (2009) Research methods in education: An introduction (9th ed.). Pearson, Boston, USA.

3PU. (2009a) Public Private Partnership (PPP) guideline. Putrajaya, Malaysia: Public-Private Partnership Unit, Prime Minister Department. Retrieved August 15, 2010. http://www.3pu.gov.my/html/themes/miu/ content/ppp_bi_131109.pdf.

3PU. (2009b) Garis Panduan Kerjasama Awam-Swasta [Public Private Partnership-PPP], Putrajaya, Malaysia: Unit Kerjasama Awam-Swasta, Jabatan Perdana Menteri. Retrieved August 15, 2010. http://www.3pu.gov.my/html/themes/miu/content/GP_PPP_agensi_web.pdf.

3PU. (2010a, August) Public Private Partnership Unit Prime Minister's Department: Background. Paper presented at the *Malaysia's Public-Private Partnership Seminar (2010)*, Procurement & Project Delivery, System Research Unit, Kulliyyah of Architecture and Environmental Design, International Islamic University Malaysia in collaboration with Public-Private Partnership Unit, Prime Minister Department, Selangor.

3PU. (2010b, June) Public Private Partnership (PPP) in Malaysia. Paper presented at the *56th MBAM Annual General Meeting, Master Builders Association of Malaysia (MBAM)* organized by MBAM, Kuala Lumpur.

MALAYSIAN BRIDGES AND THE INFLUENCE OF SUMATRAN EARTHQUAKE IN BRIDGE DESIGN

Mohd Zamri Ramli and Azlan Adnan
Engineering Seismology and Earthquake Engineering Research (e-SEER), Faculty of Civil Engineering, Universiti Teknologi Malaysia 81310 UTM, Johor, Malaysia

Abstract
The development of bridge design in Malaysia has experienced several changes in its approaches. Bridge inspection identifies the current conditions and the problems in the bridge but seismic vulnerability identifies the expected potential of seismic hazards of a bridge due to lateral seismic forces. The influences and effects of the Sumatran earthquakes toward Malaysian bridges need revised in term of earthquake loading and some modifications and amendments are required for the current code of practice. This paper revealed that the effect from Sumatran earthquakes towards Malaysian bridges is still questionable and a proper site-inspection together with post-earthquake inspections is required to carry immediately. The National Guidelines for Bridge Inspection needs to implement proper schedule with trained and experienced staff for these exercise. Fortunately, the two Penang bridges were designed and considered the seismic loading and taken as examples to highlight the effect of long-distant earthquakes from Sumatra. Both bridges are used almost similar site-specific earthquake response spectra for return periods of 475 years in their designing.

Keywords: *Bridge, Bridge Inspection, Seismic Loading, Penang Bridge, Long-distant Earthquakes*

INTRODUCTION

Bridge is an important infrastructure to support the growth of economic activities by connecting two places using expressway or highway. The construction of bridges in Malaysia has begun since early 1920s and up to date, Malaysia has more than 10,000 bridges nationwide including culverts span over 0.50 m length (Ismail et al., 2012). In the early stage of development of bridges in Malaysia, it had been just for serviceability as compared to its function today as an emblematic significance with architectural cum engineering levels of understanding. The Public Work Department (PWD) manages more than 90 percent of the nation's bridge stock. Since 1970s, the PWD has looked into the inventory and has facilitated data management for most of the bridges. Later on, a computerised Bridge Management System (BMS) was developed in 1990 (Ng See King, 1999) and more than 2,000 bridges have been recorded in the system excluding the bridge stocks that are culverts. The concrete bridges in Malaysia are significant with more than 90 percent of bridges are concrete and 84 percent of them simply supported girder bridges. In the early stage of research and development (R&D) of the bridges in Malaysia, it had been more on identify, clarification, and justification of the problems faced on the structures of the bridges. However, the new era of the R&D in bridge is more on introducing the new method, technologies, and wide point of view on planning, designing, constructing, monitoring, and maintaining the bridges. In this paper, a description of these past research conducted is first presented, followed by a review of the bridge design with the influence of Sumatran earthquake. In order to facilitate an objective, the discussion is made on two Penang bridges where considered seismic effect in their designing. Thus, the design earthquake response spectra of both bridges were compared.

LITERATURE REVIEW

A bridge's condition can be identified by proper and scheduled bridge inspections. In the early stage of bridge inspection, it is more on collecting visual data, which could be undertaken by a knowledgeable person on the structures of the bridge. Detailed inspection is required on bridges with critical and serious damages to provide more scientific data. The inspection is important in ensuring safety, for inventory purposes, and retrieving statistics figure for planning at the national level. Mansfield and King (1984) indicated the importance of bridge inspection and strength assessment of existing bridges in Malaysia. The scheduled inspection by trained staff and supported by design data, including the drawing, is important to get proper results for future road planning and upgrading. The inspection outcome provides valuable data for bridge planners and designers to overcome the repeated cause of problem.

Besides, PWD has conducted a number of studies regarding bridge inspections. It includes a study of Annual Mandatory Bridge Inspection (AMBI), which involves a series of bridge inspection from 1995 until 1998. The working Committee of Bridge Inspection is formed under the Road Engineers Association of Malaysian (REAM) to develop National Guidelines for Bridge Inspection. In year 2001, a Guide to Bridge Inspection was published, and was revised in 2003. The inspection guide is based on Public Works Department (PWD) work of practice and has been adopted by all the bridge agencies in the country, as it is by default, a national guide for bridge inspection (Ng et al., 2010).

The bridge inspection for post-earthquake is important to increase the speed and efficiency of post-earthquake response and recovery efforts. In Malaysia the guidelines of bridge inspection for post-earthquake does not exist. Normally, after an earthquake, the bridge inspector uses the common bridge inspection procedure to rate the bridges' conditions. Although Akademi Sains Malaysia (ASM) has already allocated bridge study (the bridge inspection is one of the scopes of the study) as one of the sub-topics in their study, entitled 'Seismic and Tsunami Hazard and Risks Study in Malaysia' (Akademi Sains Malaysia, 2008), the inspection procedure is still taken from various sources, such as the International Building code (IBC) and American Association of State Highway and Transportation Officials (AASHTO) which are mainly based in United States. As a result from general inspections, supported by linear and non-linear finite element analyses, it was summarised that a Peak Ground Acceleration value, calculated for the various bridges in Malaysia had been within the capacity limit. The conclusions of their study are:

i) Bridges in the west coast of Peninsular Malaysia are less vulnerable to earthquake (low seismicity);
ii) Bridges in the east coast of Peninsular Malaysia are even less vulnerable (very low seismicity) ;
iii) Bridges in Sarawak are also generally less vulnerable to earthquake (low seismicity); and
iv) Bridges in Sabah are vulnerable, as Sabah is located in an earthquake zone (medium seismicity).

On the other hand, Azlan et al., (2008) developed the Artificial Neural Network (ANN) models used in the bridge rating prediction based on seismic condition, which were capable

in predicting the condition ratings with high accuracy. The actual rating with subjective observations is converted to a numerical rating using linear correlation coefficients. The purpose of this system is to predict rating automatically by the network. Their study proved that the potential by using ANN to recognized the pattern of data and present precise prediction even when the correlation between input and output data is very weak.

Sumatran Earthquake and Effect to Peninsular Malaysia

The Sumatran subduction zone is one of the most active seismic zones in the world. This subduction zone is formed by subduction of the Indian-Australian plate beneath the Eurasian plate. The nearest location of this subduction zone is about 500 to 600km to Peninsular Malaysia and it generates earthquakes from smaller to bigger intensity and also affects west coast of Peninsular Malaysia. There were a number of earthquakes that had been recorded around Malaysia. Figure 1 shows the seismicity map of the region with intensity bigger than 6.5 Magnitude in Richter Scale from year 1900 to May 2013 (usgs.gov).

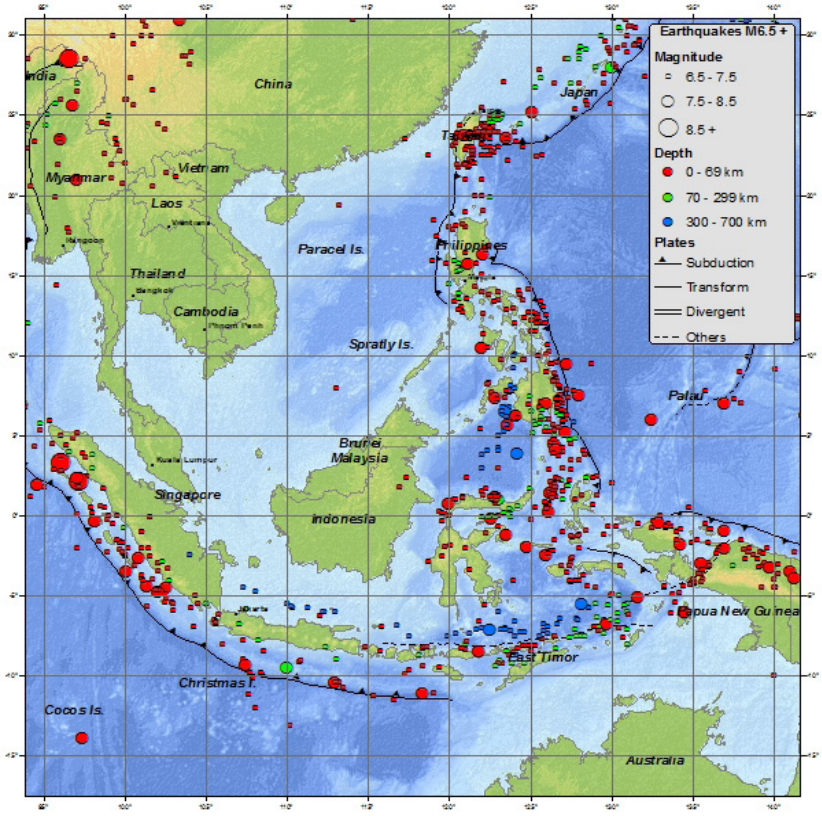


Figure 1. Seismicity Map from 1900 to May 2013 (usgs.gov)

The island of Sumatra itself also faces high seismic events, associated with the Sunda Arc off the west coast of the island. The 1900km long strike-slip fault is also called the Great Sumatran Fault, running from the entire length of the island and just 300-400km away from Peninsular Malaysia. The Sumatran fault has ruptured in at least 14 earthquakes with larger than 6.8 Magnitude in Richter scale since late 19th century (see Figure 2) and the later the earthquake was in October 1, 2009 with 6.6 Magnitude in Richter scale.

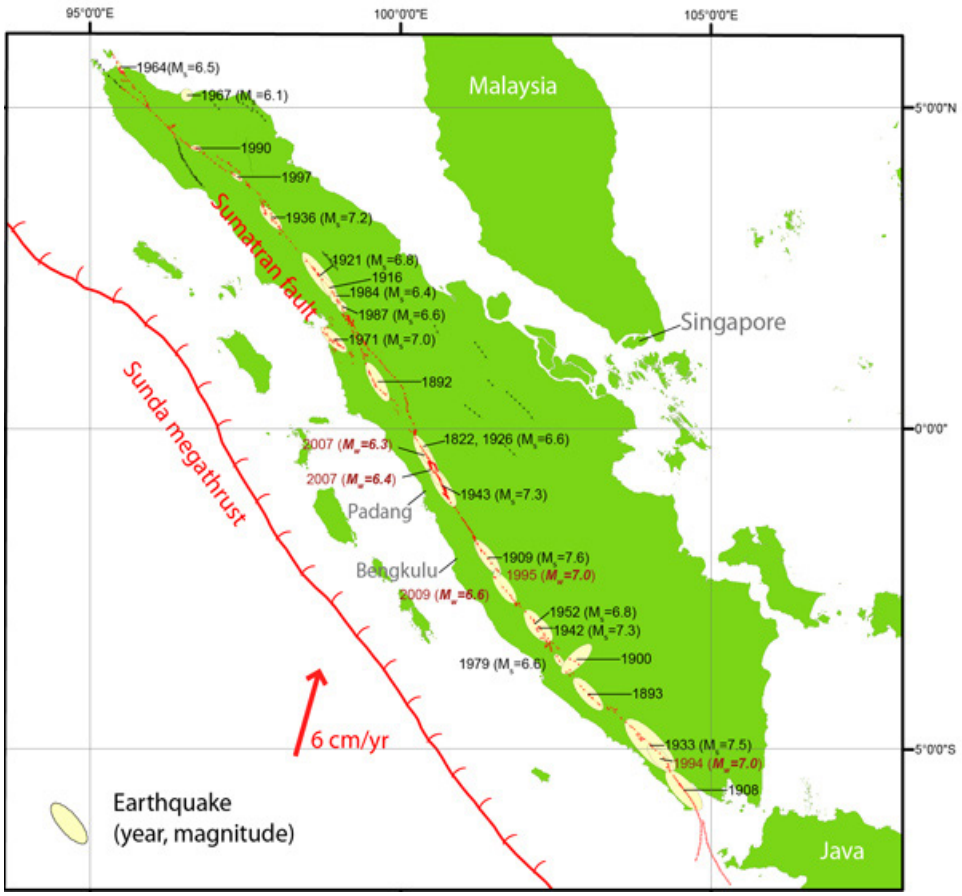


Figure 2. A History of earthquake at the Sumatran Fault (more than 6.0 Magnitude in Richter scale)

However, in general the structures of bridges in Malaysia are not designed to resist seismic loading but they are designed just to carry gravity load. High magnitudes of seismic waves from the Sumatran earthquake shake extensively the high-rise buildings in Penang, Kuala Lumpur, Putrajaya, and Johor Bahru. The earthquakes from both subduction zone and the Sumatran fault need to consider when designing high-rise buildings and bridges. The structural engineers need the Peak Ground Acceleration (PGA), hazard map and the response spectra to predict the seismic performance of the structures. The study on the seismic microzonation in Malaysia is quite new, but some researchers have already started excellent works to provide the necessary data which will be discussed later. Figure 3 shows the Seismic Hazard Map for the South East Asia Countries and it is extracted from the global seismic hazard map produced by USGS. Table 1 shows the range of PGA comparison between Petersen et al.,(2004), Petersen et al., (2008), Azlan Adnan et al., (2005), and Putra et al., (2012) for West Coast Peninsular Malaysia, East Coast Sumatra, Singapore and South Thailand.

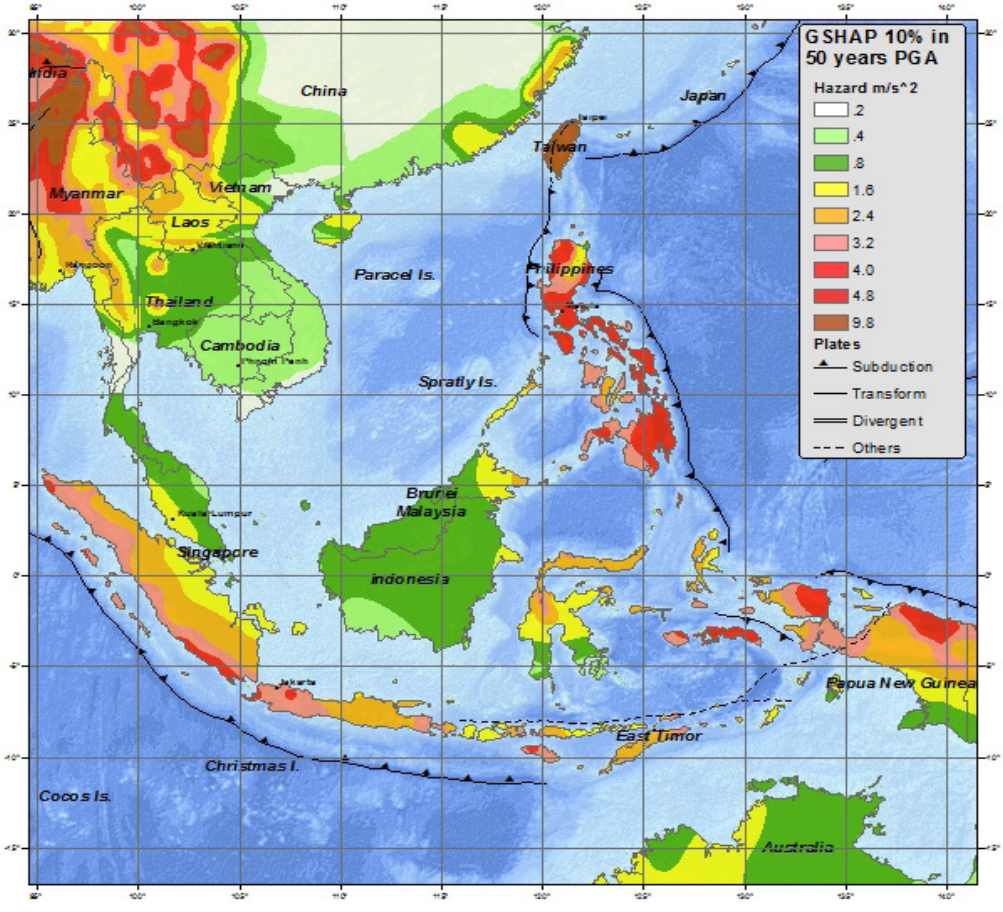


Figure 3. Seismic Hazard Map of South East Asia

Table 1. Range of Peak Ground Acceleration (PGA) for 475 years return period

Sources	West Coast Peninsular Malaysia	East Coast Sumatra	Singapore	South Thailand
Peterson (2004)	0.06g - 0.12g	0.07g - 0.30g	0.04g - 0.06g	-
Peterson (2008)	0.04g - 0.08g	0.04g - 0.25g	0.04g - 0.05g	0.02g - 0.04g
Adnan et al., (2005)	0.04g - 0.10g	-	0.04g - 0.06g	0.02g - 0.04g
Putra et al., (2012)	-	0.05g - 0.20g	-	-

METHODOLOGY

The study starts with literature search to review the bridge problems in Malaysia and design of the bridge under seismic effect. The code of practices used in bridge design is also highlighted. The two Penang bridges (Penang Bridge and Second Penang Bridge) are selected and the seismic design is extract to emphasize in the discussion. The design earthquake response spectra as an important parameter in seismic design of both bridges are also highlighted.

FINDINGS

Bridge design approaches in Malaysia are adopted from the British Standard (BS) due to the historical background of Malaysia as a British Colony. Public Work Department (PWD) has carried out some studies to make sure the standards and approaches taken from the standards to ensure it is suitability for Malaysia condition. The National Axle Load Study, completed in October 1987 had proposed to raise the present axle load limit in Malaysia. Ng et al. (1990) also proposed a new set of loading curves to be used for future bridge design and assessment.

Furthermore, two studies were carried out under Japan International Cooperation Agency (JICA) to look into bridge designs and bridge maintenance in Malaysia. The first study was looked into Bridge Maintenance and Rehabilitation (1990-92) and followed by the study of the Standardization of Bridge Design in Malaysia (1994-96). Results from the early studies suggested the need to eliminate design and construction deficiencies in new bridges. From the study on the Standardization of Bridge Design in Malaysia, PWD has introduced a standard bridge, which is constructed in reinforced and prestressed concrete, which includes the design of the superstructures, substructures, and foundation (Zainudin, 1996). The standardization plays an important role to minimise the cost of planning, designing, constructing, and maintaining the bridges.

Moreover, a number of studies have provided a lot of informative data and they are suitable for the Malaysian condition which had been translated into Malaysian standard by complying with British Standard (BS). The BS 5400 is used widely as a bridge design in Malaysia. This standard states the guidelines starting from the selection of bridge material such as steel, concrete or composite bridge, and selection for loading and bearing to the specification for materials and workmanship.

The lack of information in BS 5400 about seismic is due to very low seismic hazard in the British region and hence, the designs of bridge structure resistant to earthquake are ignored in this standard. Nevertheless, Malaysia faces a different situation regarding the seismic point of view. The location of Peninsular Malaysia is just 300 kilometres away from the Sumatra faults, where the probability of 8 Magnitude in Richter Scale has shown that the long-distant earthquake effect cannot to be neglected. This is called far feel effect or long-distant earthquake such as Mexico City had experienced serious destruction resulted by magnitude of 8.1 Richter Scale earthquake with epicentre was approximately 400 km away from the Mexico city in year 1985. The similarity between the Mexico City and Kuala Lumpur in term of distance from the earthquake epicentre implies that the seismic effects should not be totally ignored.

In the absence of specific data and guidelines for bridges, designers have attempted to adopt methods that have been developed for buildings. Thus, as far as the Malaysian structures are concerned, the designers have been adopted the United States standards, such as International Building Code (IBC) and American Association of State Highway and Transportation Officials (AASHTO) as the guidelines for seismic site specific study and structure design procedure under seismic effect.

However, two bridges in Malaysia have been already considered the long-distant earthquake effect in their design and construction phases. The first is the Penang Bridge and it was officially opened to traffic on 14 September 1985. The total length of the bridge is 13.5 km, making it the longest bridge in Malaysia. The bridge structural concrete was designed using CP110: 1972 by a Penang resident cum well-known civil engineer, Professor Chin Fung Kee. The second bridge is the Second Penang Bridge. Although the design and construction of this Second Penang Bridge project had begun after the era of Eurocodes (EC) introduced in Malaysia, only the durability requirements follow the codes, but the others like structural concrete design still using BS 5400: 2006. In Eurocodes, the EC8 explains how to design the buildings and others civil engineering structures that are to resist earthquakes and EC8 Part 2 is especially for bridges.

The Penang Bridge

The Penang Bridge connects George Town in the Island of Penang and Seberang Prai on the mainland of Peninsular Malaysia (see Figure 4). The 13.5 km bridge has secured many historical records for Malaysia and Southeast Asia, and it is important from the engineering point of view. This bridge is a combination of cable-stayed concrete girder for the main navigation span and, beam and slab deck for the approach span with 40 meter length for each span. Besides, this structure has become the first structure to look critically on seismic effect in design process. The site project is located at just about 300 km away from the strike-slip faulting of the northern Sumatra, Indonesia. According to Chin Fung Kee (1988), the shallow earthquakes occur mainly at a distance of about 300km from the site, whereas the intermediate focus of earthquake (depth approximately 200 km) has epicentres as close as 180 km to the site with the possibility of a magnitude 8 scale Richter earthquake occurring in this vicinity in the next century. The statement was a strong argument for Chin Fung Kee to consider earthquake in designing the Penang Bridge.

Figure 4. Penang Bridge

The earthquake design philosophy of the Penang Bridge is clear; to construct the bridge and to provide security against failure or loss of life during any earthquake with economical approaches. The final decision made by Chin Fung Kee was to provide a lower level of strength at lesser cost and to pay for the necessary repairs in the unlikely event of a maximum credible earthquake (MCE).

With the lack of quantitative attenuation of motion data from the Sumatran earthquake at that time, the major magnitude of 7 Richter Scale (i.e. half as great as the maximum credible earthquake used) was taken into account as the Design Basic Earthquake (DBE) was induced with significant motion at the bridge site. By using the soil condition and PGA, a response spectrum for the earthquake was developed and the MCE was assumed to have twice this intensity (see Figure 5). The designer conservative estimate of peak base rock acceleration at the site was 0.075g.

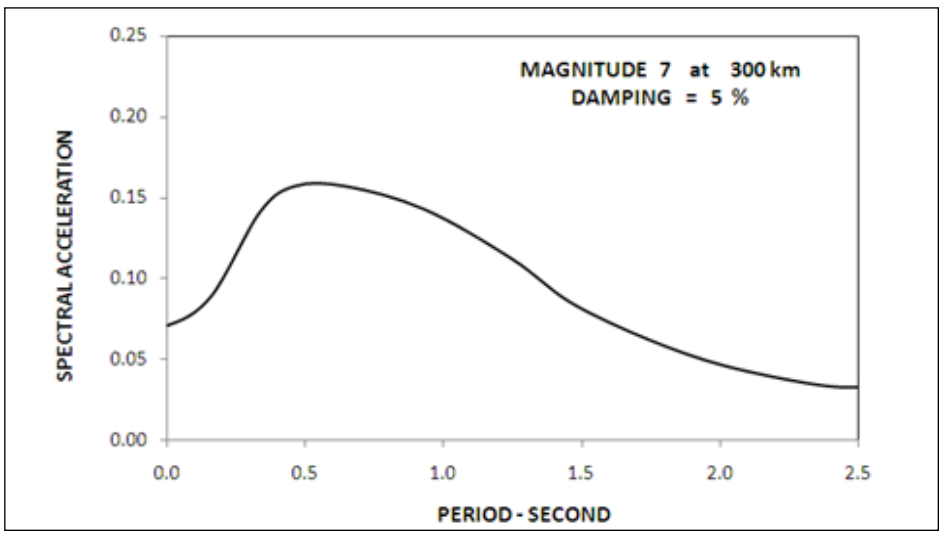


Figure 5. Design Earthquake Response Spectrum by Chin Fung Kee (1988)

As for design purposes, the spectra acceleration is obtained from Figure 5 and the value of the fundamental period of the structure was computed. Later, it was modified according to the seismic effect by considering the ductility of the structure. During the construction phase, the designer introduced the reinforced concrete shear blocks in order to restrain the orthotropic bridge deck against horizontal movements to exceed desirable limits.

The bridge has faced some repair works due to life expectancy and some from unknown causes. The maintenance check is regularly done by the Penang bridge maintenance team. Several repair works have already been performed, especially on the faulty bridge joint, cracking on structural part, replacement of the stay cable, and other part on non-structural components.

The Second Penang Bridge

The Second Penang Bridge connects Batu Maung on the island of Penang and Batu

Kawan on the mainland of Peninsula Malaysia. The total length of the bridge is 24 km with 16.9 km twin prestressed concrete box girder structure (55 km length for each span) is run over the sea (marine bridge), and the other 7 km T-beam bridge deck structure is in the land section where it is connected to the existing expressway. The main navigation bridge is cable-stayed bridge with beam and slab deck section. This bridge, with a design life of 120 years is the longest bridge in the Southeast Asia and plays the important role to accelerate the economic development of Penang. Nevertheless, it is also built in one of the most important parts of the seismic and hazardous reduction system in the region (see Figure 6).

Figure 6. The Second Penang Bridge or Sultan Abdul Halim Muadzam Shah Bridge, which was officially opened on 1 March 2014

Han et al., (2010) looked into the seismic performance of the bridge under Highway Planning and Design Institute Consultants Co (HP&DI), whereby it was assigned by Chinese Harbour Engineering Company (CHEC). The objective of the seismic design is to minimise the damage of the bridge during earthquake with no loss of life. The designer used the site specific response spectrum provided by Universiti Teknologi Malaysia (UTM) with return period of the design earthquake is 475 years (TR475), including the minor and repairable damages in the structure of the bridge. They also performed the finite element modelling and the data were analysed under seismic response analysis and capacity verification. The study concluded that the hollow section of the spun pile had the potential of brittle bending damage due to the strain and overstressing issue. The suggestion of using an isolation device was to provide sufficient stiffness to form superstructures to substructures, making it more durable and other properties required in the service state. The uses of shear blocks are also desired to avoid collapse in the economical way.

The base isolators are very suitable for Malaysia as it is the place where the research and development of base isolator originated. By introducing this technology and after several event of strong earthquakes in the United State and Japan, the used of base isolation for bridges has becoming popular. Due to the limited number of bridges that are instrumented, their

actual performance has been thoroughly investigated. Kelly et al., (1991) have qualitatively investigated the response of Sierra Point overpass in the United States based on the observed strong motion records.

The High Damping Natural Rubber (HDNR) isolator was successfully designed, fabricated, and tested based on the BS5400 and EN15129 Standards by the Malaysia Rubber Board (Malek et al., 2011) for the Second Penang Bridge. The total number of 1400 isolators for seismic protection was required for 17 km marine bridge, as well as 7 km land Expressway Bridge. The two laboratories used in this study were the Tun Abdul Razak Research Centre (TARRC) in United Kingdom, and Rubber Technology Centre in Sg. Buluh, Malaysia.

In addition, regarding the ambitious requirement from the client to provide a design with no collapse, the maximum credible earthquake with 2475 years return period of the design earthquake (TR2475) was used and the site specific response spectra were provided by UTM (Table 2 and Figure 7).

Table 2. Design Criteria of Seismic

Return Period (Years)	Peak Bedrock Acceleration (PBA)	Peak Response Acceleration (RPA)	Damage Performance Level		
			Marine Bridge	Land Expressway	
				Critical Bridge	Other Bridges
475	0.0555 g	0.1773 g	Minimal Damage	Minimal Damage	Repairable Damage
2475	0.11 g	0.3261 g	No Collapse		

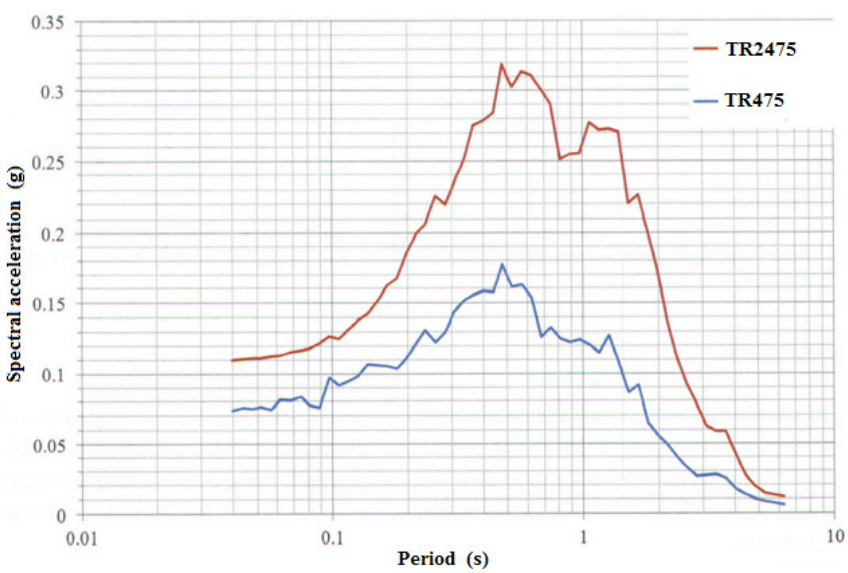


Figure 7. Site specific ground response spectra for TR475 and TR2475

The finite element analysis showed that the success results with all elements were still under the limit state and the objective to have “no collapse” level was achieved for bridge

with the analysis that included HDNR isolators.

CONCLUSION

Malaysia has thousands of bridges including some mega suspension bridges that need clear procedures in bridge inspection, especially during post-earthquake event. These procedures are important for engineers to made quick decision and response on past-earthquake for recovery and emergency purposes. Although in general, bridges in Malaysia are less vulnerable due to the low seismicity condition, the design of the new bridges need to consider the seismic effect and the decision to have the isolation device and other technique have to be looked into detail.

The designers of the Penang Bridge and the Second Penang Bridge have made advanced decision to consider seismic effects in their designs and constructions. The design process of the Penang Bridge had taken into account higher earthquake magnitude 7, with the designer's expectation to have earthquake with magnitude of 8 or more in future. This earthquake had already happened on 24 December 2004 and 28 March 2005 at the Northern Sumatra, Indonesia with Magnitude 9.0 and 8.6 respectively, and 12 September 2007 at Southern Sumatra, Indonesia with Magnitude 8.5. In November 2007, the state of Penang public works committee chairman informed to the public that the Penang Bridge was structurally safe although cracks were noted in several locations. The repaired cracks have been reported to come from unknown cause and this question can be answered if proper and efficient schedule inspections are done.

The design spectra of 475 years return period for the second Penang Bridge was almost similar and had only 12% to 35% differences due to the Peak Response Acceleration and Peak Bedrock Acceleration compared to Chin Fung Kee's design spectra. The objective of the design for 475 years return period was to have minimal and repairable damages and it had a similar objective with the Penang Bridge, which concentrated on economical purposes with no death during earthquake. The spectra were also within the range of PGA provided by previous researchers, as shown in Table 1.

Hence, the use of seismic isolation device for the second Penang Bridge has led to a valuable history event as far as the civil engineering field is concerned in the region, making it the longest seismic-resistant bridge in the world. The expertise and specialisation on natural rubber led by the Malaysian Rubber Board (MRB) has been successfully translated into high technology engineering and valuable products.

REFERENCES

Adnan, A., Hendriyawan., Marto, A., and Irsyam, M. (2004). Selection and development of appropriate attenuation relationship for Peninsular Malaysia. Submitted to Malaysian Science and Technology Congress (MSTC), 18/20 April 2005, Cititel Hotel, Midvalley, Kuala Lumpur.

Akademi Sains Malaysia (2008). Seismic and Tsunami Hazard and Risks Study in Malaysia. Project Report of MOSTI.

Azlan Adnan, Sophia C. Alih and Rozaina Ismail (2008). The Application of Artificial Neural

Network In Predicting Bridge Condition Based On Seismic Zonation. The 14th World Conference on Earthquake Engineering. 12-17 October 2008, Beijing, China.

Chin Fung Kee (1988). The Penang Bridge: Planning, Design and Construction. Malaysia Highway Authority .ISBN 0-983-99565-0-7.

Han Peng, Eang Junjie and Meng Jie (2010). Seismic Safety to the Approach Marine Bridge of the Second Penang Bridge. International Conference on Computer Design And Application (ICCDA 2010), 25-27 June 2010, Hebei, China.

James M. Kelly, Ian G. Buckle and Chan Ghee Koh (1987). Mechanical Characteristics of Base Isolation Bearings for A Bridge Deck Model Test. University of California: Berkeley.

Kamarudin Ab-Malek, Ahmadi Hamid, Muhr Alan, Stephens Ian, Gough Julia, Picken Judith, Lee Jian Jun and Muhammad Umar (2011). High Damping Rubber Bearing Design for Approach Bridge. 1st International Seminar on the Design & Construction of Second Penang Bridge, 15-16 November 2011, Kuala Lumpur, Malaysia.

Mansfield Robert & Ng See King, (1984). The Need for Bridge Inspection and Strength Assessment. Paper presented in Indian Road Congress, 1984, India.

Mark D. Petersen, James Dewey, Stephan Hartzell, Charles Mueller, Stephan Harmsen, Arthur D. Frankel, Ken Rukstales (2004). Probabilistic seismic hazard analysis for Sumatra, Indonesia and across the Southern Malaysian Peninsula. Tectonophysics 390 (2004) 141–158.

M.D. Petersen, S. Harmsen, C. Mueller, K. Haller, J. Dewey, N. Luco, A. Crone, K. Rukstales, and D. Lidke (2008). NEW USGS SOUTHEAST ASIA SEISMIC HAZARD MAPS. The 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing, China.

Ng See King, Malaysian Bridges – Status and Condition (1999). Lecture notes for Special Course on Bridge Assessment and Rehabilitation, Nov. 2-4, 1999, Civil Engineering Department, Universiti Putra Malaysia.

Ng See King, Mohd. Hisham Mohd. Yasin and Lim Char Ching (1990) Standard JKR Specification for Bridge Loading. Paper presented in the 6th Road Engineering of Asia & Australasia (REAAA), March 4-10, 1990, Kuala Lumpur, Malaysia.

Ng See King, and Ku Mohammad Sani Ku Mahamud (2010). Managing Structural Failure: Bridge under Surveillance. UTM/JKR Seminar on Managing Structural Failure, 18-19 January 2010, Kuala Lumpur.

Rusnaidi Rahmat Putra, Junji Kiyono, Yusuke Ono, Hari Ram Parajuli (2012). Seismic Hazard Analysis For Indonesia. Journal Of Natural Disaster Science, Vol. 33, Number 2, Pg 59 -70.

Z. Ismail, A. Z. C. Ong and A. G. A. Rahman (2012). Serviceability of concrete bridges in Malaysia focusing on susceptibility to atmospheric chloride corrosion. International Journal of the Physical Sciences Vol. 7(4), pp. 655 - 659.

A REVIEW OF THE ONE REGISTRATION SYSTEM FOR CONTRACTORS (1RoC)

Khairuddin Abdul Rashid[1] and Samer Shahedza Khairuddin[2]

[1] *Lecturer, Department of Quantity Surveying, Head of Procurement and Project Delivery System Research Unit, Kulliyyah of Architecture & Environmental Design (KAED), International Islamic University Malaysia (IIUM)*

[2] *Independent consultant and graduate student*

Abstract

This paper reports the outcome of a desk study on the Malaysian system for the registration of contractors in general and specifically on the newly introduced One Registration System for Contractors or 1RoC. Essentially, contractors are registered so as to ensure that only those with the acceptable level of resources, experience and expertise are permitted to carry out construction works. The evolution of the system can be said to comprise three phases. Initially it involved only contractors partaking in public sector works to be registered with a public agency known as *Pusat Khidmat Kontraktor* (PKK; Contractors Service Centre, CSC). The second phase was initiated with the passing of the CIDB Act 1994 which legally mandated registration of all contractors by the CIDB irrespective of whether they are participating in public or private sector works. Interestingly, a dual registration system was born. Then on 15th October 2012 the 1RoC *(Sistem Satu Pendaftaran Kontraktor or* SSPK*)* was introduced thereby completing the third phase. Key findings from the study include that the 1RoC in actual fact is not a new system rather a streamlined version of the CIDB's former registration system. Thus, with the 1RoC the previous PKK system is abolished, In addition, the 1RoC seems able to address critiques of the dual registration system whereby its implementation could lead to greater efficiencies. The implementation of the 1RoC is seen as a significant development in terms of the future development of the contracting services and the construction industry of Malaysia.

Keywords: *Construction; Contractor; Economy; Governance; Public, Registration System;*

INTRODUCTION

In the past and prior to the setting up of the Construction Industry Development Board Malaysia (CIDB) in 1994 the public authority that registered contractors undertaking and completing construction works for the public sector was the *Pusat Khidmat Kontraktor* (PKK or Contractors' Service Centre)[1]. However, effective 20th July 1995 and in accordance with the CIDB Act 1994, all contractors are required to register with the CIDB, notwithstanding whether they are undertaking and completing construction work for the public or private sectors. The key objective of the respective registration systems is to ensure only contractors in possession of the acceptable level of resources, experience and expertise are permitted to build.

Thus, since July 1996 when the CIDB Act 1994 on the registration of contractors was enforced there exist a dual registration system for contractors, namely the PKK and the CIDB registration systems. The former was done administratively by the Government for contractors undertaking and completing construction works for the public sector. The latter is mandated by the CIDB Act 1994 and applicable to all contractors undertaking and completing construction works for the public and private sectors.

Authors and commentators including Khairuddin (1998; 2002) had commented on the demerits and inefficiencies in maintaining the dual registration system for contractors especially when both systems are broadly similar as they concern the credibility and quality of contractors. The key difference between the two registration systems is that of authority: the PKK system is an accreditation system applicable to contractors for public works whereas the CIDB system is a licensing system empowered by statute.

Now almost two decades later, the Authorities have come to its senses and realized that the dual registration system is no longer appropriate and more importantly unsustainable, especially in the contexts of effective utilization of resources and excellence in the delivery of services to the public. Consequently, on 15th October 2012 the One Registration System for Contractors 1RoC *(Sistem Satu Pendaftaran Kontraktor* or SSPK*)* was implemented. The 1RoC, as the system is being referred to, requires all contractors undertaking or completing any construction work to register only with the CIDB.

Past studies concerning Malaysia's system for the registration of contractors is scarce. More importantly past study on the 1RoC is non-existence perhaps, due to the timing of its implementation, i.e. the 1RoC was only introduced in 2012. Currently available literature is more concerned with the procedures and guidelines for registration such as those published by the CIDB and PKK respectively[2]. Consequently, a desk study reviewing Malaysia's system for the registration of contractors in general and specifically on the 1RoC was carried out. The objectives of the study are two folds: to trace the evolution of the Malaysian systems of registration of contractors and to review the 1RoC. The review on the 1RoC focusses on its workings, the migration from previous dual system of registration to the 1RoC and to assess benefits of the 1RoC to the contracting services and the construction industry of Malaysia.

This paper is structured into 5 parts. Part 1, this part, introduced the paper and presents the study's problem statement and its objectives. Part 2 reviews the PKK, the former CIDB systems of registration of contractors and the 1RoC and its workings. Part 3 describes the mechanism on the migration from the PKK systems of registration to the 1RoC. Part 4 presents the assessment of the 1RoC in terms of its benefits to the contracting services and the construction industry of Malaysia and finally Part 5 of the paper provides a conclusion to the paper.

LITERATURE REVIEW

The PKK System of Registration of Contractors

Pusat Khidmat Kontraktor or PKK, formerly known as PUSAKABUMI, was established by the Government on 30th June 1981. The functions of PKK include registering contractors, assigning *Bumiputera* status to eligible contracting companies[3], a resource center for all matters related to construction contracting, and to provide advisory services to *Bumiputera* status contracting companies undertaking and completing construction works for the public sector[4].

In essence, contracting companies meeting requirements in terms of capital and financial

capabilities, basic qualification of staff and management personnel, companies' track record, in possession of the appropriate number of plant and equipment and appropriate equity structure may be registered as contractors. The registration system is such that eligible contractors may be registered into a Class, into one or more Categories of works (Heads) and into one or more areas of Specialization of works (Sub-Heads) as indicated in Table 1 to Table 3. With valid registration a PKK registered contractor may participate in public sector tenders and subsequently undertake and complete construction works corresponding to the class, category and area of specialization in which the company is registered.

Table 1. PKK registration of contractors for civil works

Class of registration	Minimum Capital (RM)	Financial Limit of Project (RM)
A	600,001.00	>10,000.000.00
B	400,001.00	5,000,001.00 – 10,000,000.00
C	100,001.00	2,000,001,00 – 5,000,000.00
D	35,001.00	500,001.00 – 2,000,000.00
E	17.501.00	200,001.00 – 500,000.00
F	10,000.00	Up to 200,000.00

Table 2. PKK registration of contractors for electrical works

Class of registration	Minimum Capital (RM)	Financial Limit of Project (RM)
I	75,001.00	50,001 and above
II	50,001.00	< 1,000,001.00
III	25,001.00	<500,001.00
IV	7,501.00	<150,001.00
V	2,501.00	<50,001.00
VI	1,001.00	<20,001.00

Table 3. Categories (Heads) and specialization (Sub-Heads) in the PKK system of registration of contractors

Category of works	Specialization[5]
Head I Civil engineering	Sub-Head 1 – 9
Head II Building	Sub-Head 1 – 9
Head III Mechanical, sanitary and water engineering	Sub-Head 1 – 17
Head IV Other specialist civil engineering	Sub-Head 1 – 10
Head V Quarrying, metal and earth supply cartage and transport	Sub-Head 1 – 4
Head VI Forest and land development	Sub-Head 1 – 9
Head VII Electrical	Sub-Head 1 – 16
Head VIII Telecommunications	Sub-Head 1 – 3

Under the PKK system of registration of contractors a company can only be registered into one Class of registration at any one time but the company may be registered into one or more Categories of works and into one or more areas of Specialization of works. In addition, a registered contracting company may apply for upgrading of Class or for additional Categories or for additional areas of Specialization. Furthermore, the PKK may de-register or downgrade a contractor's Class, Category or area of Specialization if he violates the conditions of registration.

Table 4 and Table 5 show the number of contractors registered with PKK, in 2010, according to various classes of registration for civil works and electrical works respectively. From a total of 44,428 registered contractors, civil works contractors form the overwhelming majority (92.45% or 41,078) and within that, Class F i.e. the lowest class of registration, forms the overwhelming majority (70.21% or 28,839).

Table 4. Civil works contractors registered with PKK, 2010

Class	No	%
A	2,194	5.34
B	1,210	2.95
C	2,139	5.21
E	4,226	10.29
E	2,470	6.01
F	28,839	70.21
Total	**41,078**	**100.00**

(Source: PKK at pkk.kkr.gov.my/laporan-tahunan, 22nd June 2013)

Table 5. Electrical works contractors registered with PKK, 2010

Class	No	%
I	455	13.58
II	603	18.00
III	1,451	43.31
IV	841	25.10
Total	**3,350**	**100.00**

(Source: PKK at pkk.kkr.gov.my/laporan-tahunan, 22nd June 2013)

The CIDB System of Registration of Contractors

CIDB was established by the Government in 1994 via the CIDB Act 1994 (Act 520) to undertake eleven (11) key functions related to the construction industry. Function no 10 i.e. "To accredit and register contractors including to cancel, suspend or reinstate the registration of any registered contractors" concerns the establishment and maintenance of the CIDB System of Registration of Contractors. Detailed contents of the Act can be found in Part VI Registration of Contractors, Section 25 to Section 31 thus;

S. 25. (1) No person shall undertake to carry out and complete any construction works unless he is registered with the Lembaga and holds a valid certificate of registration issued by the Lembaga. (2) Every certificate of registration shall be in the prescribed manner and form.

S. 26. The Lembaga shall keep and maintain a Register which shall contain the names, business addresses and other particulars of contractors who are registered as registered contractors.

S. 27. (1) For the purpose of carrying out its functions under section 4, the Lembaga may by notice in the prescribed form require any person to furnish any particulars which are within the person`s knowledge, or which he is able to obtain, relating to any contractor or construction works in such manner and form as the Lembaga may specify.

(2) The notice under subsection (1) may be served by delivering it to the person at the construction site, his working place or at his residence.

(3) A notice may require the information to be furnished at specific times or within specific intervals.

(4) The Lembaga shall not require any person to supply information which will disclose any trade secret.

S. 28. A person who

a) fails to comply with the requirements of a notice issued under section 27: or

b) knowingly or recklessly furnishes or causes to be furnished any false particulars on any matter specified in the notice issued under section 27, shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding five hundred ringgit and, in the case of a continuing offence, to a fine not exceeding five hundred ringgit for every day or part of a day during which the offence continues after conviction.

S. 29. A person who undertakes to carry out or carries out and completes any construction works without being registered as a registered contractor with the Lembaga shall be guilty of an offence under this Act and shall, on conviction, be liable to a fine not exceeding fifty thousand ringgit.

S. 30. (1) Where the Lembaga finds that construction works are being undertaken or carried out by a contractor who is not registered with the Lembaga, the Lembaga may by notice in the prescribed form served on the contractor require him to abstain from commencing or proceeding with the construction works.

(2) A person who fails to comply with the requirements of the notice under subsection (1) shall be guilty of an offence and shall, on conviction, be liable to a fine not exceeding five hundred ringgit, and in the case of a continuing offence, to a fine not exceeding five hundred ringgit for every day or part of a day during which the offence continues after conviction.

S. 31. Every registered contractor shall be subject to this Act.

The procedure to register as a contractor with CIDB is detailed out in a CIDB publication entitled "Contractor Registrations Requirements and Procedures." Briefly, to register as a contractor, a company must fulfil criteria that include financial capability, in the form of the amount of paid-up capital or net worth, and technical capability that includes in possession of the appropriate number of personnel with the necessary qualification and experience. The registration of contractors was fully implemented on 22nd July 1996.

The system registers eligible contractor into a Grade, into one or more Categories and areas of Specialization of works as indicated in Table 6 and 7. Consequently, a CIDB registered contractor may participate in tenders and subsequently undertake and complete construction works corresponding to the grade, category and area of specialization in which he is registered. However, a CIDB registered contractor cannot tender and undertake and complete construction works in the public sector unless he is registered with the PKK.

Table 6. CIDB registration of contractors

Grade	Tendering capacity (RM)	Paid-up capital/net worth (RM)
7	No limit	750,000.00
6	Not exceeding 10 million	500,000.00
5	Not exceeding 5 million	250,000.00
4	Not exceeding 3 million	150,000.00
3	Not exceeding 1 million	50,000.00
2	Not exceeding 500,000.00	25,000.00
1	Not exceeding 200,000.00	5,000.00

Table 7. CIDB registration of contractors, category and specialization

Category	Specialization[6]
1. CE – Civil engineering construction	CE 01 – CE21
2. B – Building construction	B01 – B11
3. ME – Mechanical and electrical	M01 – M15 E01 – E09

Under the CIDB system of registration of contractors a company can only be registered into one Grade of registration at any one time but the company may be registered into one or more Categories and areas of Specialization of works. In addition, a registered contracting company may apply for upgrading of Grade or for additional Categories or for additional areas of Specialization. Furthermore, the CIDB may de-register or downgrade a contractor's Grade, Category or area of Specialization if he violates the conditions of registration.

Table 8 shows the number of contracting firms registered with CIDB, as of March 2012, according to grades of registration. From a total of 66,210 registered contractors 50.93% (33,720) are the G1 contractors, i.e. the lowest grade of registration.

Table 8. Contractors registered with CIDB, March 2012

Grade	No	%
1	33,720	50.93
2	8,669	13.09
3	11,042	16.68
4	2,766	4.18
5	3,922	5.92
6	1,423	2.15
7	4,668	7.05
Total	66,210	100.00

(Source: CIDB at https://www.cidb.gov.my accessed 22nd June 2013)

The One Registration System for Contractors (1 RoC)

The 1RoC is the result of a decision made by the Malaysian Cabinet during its meeting held on 14th September 2012. The meeting decided that the registration system of contractors by the PKK is rescinded and replaced by the 1RoC and the system will be enforced and

administered by the CIDB. The key objective of the Government in implementing the 1RoC is to increase efficiency in service delivery to the public. The 1RoC becomes effective on 15th October 2012.

However, one must not confuse in thinking that the 1RoC is entirely a new system of registration of contractors. On the surface this might appear to be the case but in actual fact the 1RoC is a makeover of the CIDB system of registration of contractors given a new label. The key elements of the 1RoC in terms of the Grade, Categories and areas of Specialization are as shown in Tables 9 to 11. Thus, the areas of makeover are (i) a revised set of financial limits under the tendering capacity of the various Grades of registration (Table 9), (ii) a new set of financial limits for electrical contractors (Table 10), and the revised areas of Specialization i.e. adding more areas, for all Categories (Table 11)[7]. For the CIDB system of registration of contractors see Tables 6 to 7 hereinbefore.

The re-labeling of the previous CIDB system of registration of contractors, principally with the addition of the word '*Satu*' or 'One' (1) is deemed necessary to reflect the makeover but more importantly it is believed that it's the Authorities' effort to reiterate that from the 15th October 2012 there is only one system of registration of contractors in the country.

Table 9. Tendering capacity of contractors for building, civil and mechanical works under the 1RoC

Grade	Tendering capacity (RM)
G1	200,000.00 or less
G2	200,001 to 500,000.00
G3	500,001 to 1,000,000.00
G4	1,000,001.00 to 3,000,000.00
G5	3,000,001.00 to 5,000,000.00
G6	5,000,001.00 to 10,000,000.00
G7	10,000,001 and above

Table 10. Tendering capacity of contractors for electrical under the 1RoC

Grade	Tendering capacity (RM)
G1	Up to 200,000.00
G2	Up to 500,000.00
G3	Up to 1,000,000.00
G4	200,001.00 to 3,000,000.00
G5	200,001.00 to 5,000,000.00
G6	200,001.00 to 10,000,000.00
G7	200,001.00 and above

Table 11. 1RoC's category and specialization

Category	Specialization[8]
1. CE – Civil engineering construction	CE 01 – CE43
2. B – Building construction	B01 – B28
3. ME – Mechanical and electrical	M01 – M21 E01 – E14

MOVING FROM THE PREVIOUS REGISTRATION SYSTEMS TO THE 1ROC

The challenge for the contractors and other industry players then was not so much to understand what the 1RoC is all about (as mentioned hereinbefore the 1RoC is the makeover and re-labelling of the CIDB system of registration of contractors). The challenge therefore is for contractors, especially the PKK registered contractors, to abide with the 1RoC.

What was considered urgent then i.e. at the time the 1RoC became mandatory is to determine how those contractors with valid PKK registration could get their companies registered under the 1RoC and into what Grades, Category and areas of Specializations. To this end the CIDB provided a useful set of guidelines *"Kaedah Penyerapan dan Pelarasan Pendaftaran Kontraktor melalui Pelaksanaan Sistem Satu Pendaftaran Kontraktor (1RoC) (Kontraktor Sedia-Daftar dengan PKK)"* or Procedure to Absorb and Rationalize Contractors' Registration through the Implementation of the Single Registration System for Contractors. In accordance to the guidelines all PKK registered contractors that are in possession of valid registration will be absorbed into the 1RoC automatically when the CIDB issued to each contractor a Certificate of Registration of Contractor *(Perakuan Pendaftaran Kontraktor)*. This certificate would enable them to carry out works as defined by S. 25 of the CIDB Act 1994. In addition, the PKK contractors will be issued certification for procurement of Government works *(Sijil Perolehan Kerja Kerajaan,* SPKK*)* that certify them as contractors meeting the requirements set by the Ministry of Finance. With the SPKK, the contractors are eligible to participate in public tenders corresponding to the category of construction and qualification. Furthermore, the PKK contractors in possession of valid *Bumiputera* status will be issued a certificate of *Bumiputera* status *(Sijil Taraf Bumiputera,* STB*)* so as to enable them to participate in public tenders reserved for *Bumiputera* only.

To facilitate absorbing the PKK registered contractors into the 1RoC, the CIDB has come up with a systematic approach in rationalizing the respective Classes to Grades, Categories and areas of Specialization, as illustrated in Figure 1. During the transition period, the PKK registered contractors are not required to submit fresh application for registration as the process of absorbing them into the 1RoC will be done by the CIDB.

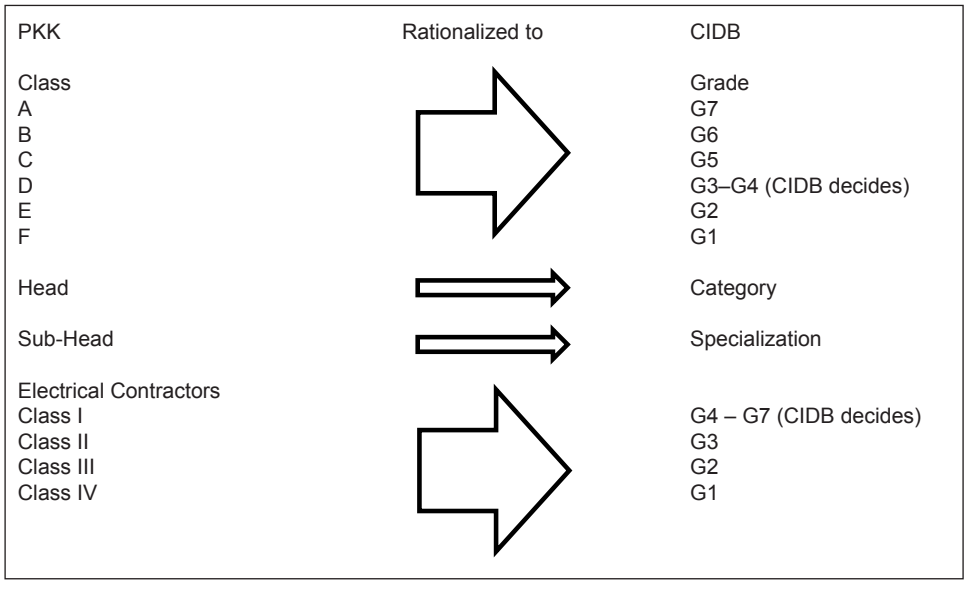


Figure 1. Rationalization of PKK system of registration into CIDB system of registration

ASSESSMENT OF THE 1RoC

It is not difficult to realize that under the dual system of registration of contractors, namely by the PKK and CIDB respectively, maintaining two separate but broadly similar systems of registration of contractors, operated by two different Government agencies, have led to issues and problems including unnecessary bureaucracies, ineffective use of resources and additional costs to all parties especially to the Government in its capacity as the authority and as initiator and client of construction projects.

Specifically, to the Government, the dual system of registration brought problems including in terms of efficiency in the processes of registration of contractors and in enforcing the conditions of the registration. As for the contractors they face problems including having to register, maintain and pay fees for two registrations at any one time (if they aspire to tender and undertake construction works for the public sector). In addition, there were overlapping of activities between the PKK and CIDB. Furthermore, information on contractors and their performances were not shared between these two government agencies (Khairuddin, 1998; 2002).

Consequently, Khairuddin (1998) had proposed for the CIDB and the PKK systems of registration of contractors to be merged into one central registration and performed by a single authority namely the CIDB. He listed the following as the key benefits of having one central registration system;

1. One stop registration services for all contractors. They would only need to apply for registration once in order to be allowed to participate in all public and private sectors' tenders and to build and construct;

2. The merging of the PKK and CIDB systems of registration would enable monitoring of contractors' performance to be done centrally and that performance could be assessed based upon a standard set of criteria and that information could be centrally collected, stored and disseminated to all relevant bodies; and
3. Saving in resources by both the Government and the construction industry as a whole.

It appears that the proposal made by Khairuddin (1998; 2002) is consistent with the action taken by the Government through the implementation of the 1RoC. The Government also entrusted the CIDB to be the authority in charge. The PKK however, remained responsible to assign the *Bumiputera* status to eligible contracting companies and to provide advisory services to the *Bumiputera* status contractors.

In the course of carrying out the current study the following observations were made;

1. Information on contractors especially on status of registration and performances are not readily available and accessible to all stakeholders related to the construction industry of Malaysia. It is thought to be useful if such information is made available and accessible, perhaps at no or minimal cost, thus enabling the key stakeholders to possess information for decision making on matters related to tendering and appointment of contractors and researchers to have the necessary information about the contracting services and the construction industry of Malaysia.
2. In the past and up to the time of writing this piece of work, the system of registration of contractors appears to have little or no enforcement over the informal or the casual sector of the construction industry of Malaysia, i.e. those sectors such as construction works in the rural areas and in the squatter areas of most Malaysian cities. In addition to works being done by themselves i.e. self-build or built under the villagers' cooperation concept *(gotong royong)*, there are also works of maintenance and renovation in nature that were undertaken by odd jobbers or small unregistered contractors that have either escaped or been administratively excluded from any kind of enforcement by the CIDB.
3. There is a lack of properly structured training scheme to train individuals and entrepreneurs to become fully skilled and knowledgeable contractors.
4. With the advent of Concession Contracts such as the Private Finance Initiative (PFI) contracting firms are leading the mandatory Special Purpose Vehicles or SPVs. In addition to designing, funding and constructing an infrastructure, the SPV is also expected to maintain and run the completed facility. However, a formal and systematic approach on how SPVs are assessed especially their expertise in carrying out maintenance works is lacking. Perhaps, there is a need for a separate registration system for SPVs.
5. The 1RoC is not the one and only system of registration of contractors for Malaysia as a whole. In Sabah there is PUKONSA and in Sarawak UPK. It is considered to be most appropriate that these other systems of registration of contractors should be integrated under the 1RoC.

CONCLUSION

The implementation of the 1RoC since October 2012 means that there is now a one stop

registration services for all contractors in Malaysia. The 1RoC, although it sounds as if it is an entirely new system of registration of contractors, is actually a makeover of the CIDB system of registration of contractors. With the 1RoC the PKK system of registration of contractor is no longer valid and that the authority of the PKK to register contractors for public tenders and works has been rescinded.

The initiative by the Government to implement the 1RoC is a step in the right direction. In addition, the style adopted by the Government, through efforts initiated and implemented by the CIDB, in facilitating the PKK registered contractors to migrate to 1RoC and by adding more areas of specialization of works for contractors to register are commendable.

Notwithstanding the fact that the abolishment of the dual system of registration of contractors came in late but the initiative in the implementation of the 1RoC augurs well for the future development of the contracting services and the construction industry of Malaysia. Consequently, further and in-depth studies are required.

REFERENCES

CIDB (1999). *Registration Requirements and Procedures*. Kuala Lumpur: CIDB.

Khairuddin Abdul Rashid (1998). *The Processes of Construction Procurement in Malaysia: Identification of Constraints and Development of Proposed Strategies in the Context of Vision 2020.* Unpublished PhD Thesis, NTU, UK.

Khairuddin Abdul Rashid (2002). *Construction Procurement in Malaysia. Processes and Systems. Constraints and Strategies*. Kuala Lumpur: IIUM.

Ministry of Finance (2012). Arahan Perbendaharaan Pindaan Bil. 3/2012. Ref:S/K.KEW/PK/D/1100/000000/10/31 Jld.33 SK.3(9) dated 8th October 2012.

Ministry of Finance (2012). Surat Pekeliling Perbendaharaan Bil. 6/2012. Ref:S/K.KEW/PK/D/1100/000000/10/31 Jld.33 SK.3(10) dated 8th October 2012.

CIDB *Sistem Satu Pendaftaran Kontraktor (SSPK)*. Online: https://www.cidb.gov.my/cidbweb/index.php?option=com_content&view=article&id=276:sistem-satu-pendaftaran-kontraktor-sspk&catid=37&Itemid=275&lang=en, accessed 20th June 2013.

Pusat Khidmat Kontraktor, PKK. Online: PKK at http://www.pkk.kkr.gov.my, accessed 20th June 2013.

List of Specializations for Contractor Registration

Category B Building Construction		Category CE Civil Engineering Construction		Category ME Mechanical and Electrical			
Specialization	**Description**	**Specialization**	**Description**	**Specialization**	**Description**	**Specialization**	**Description**
B01	IBS: Prefabricated concrete system *IBS: Sistem konkrit pasang siap*	CE01	Road and pavement construction *Pembinaan jalan dan pavemen*	M01	Air conditioning system *Sistem hawa dingin*	E01	Sound system *Sistem bunyi*
B02	IBS: Steel frame system *IBS: Sistem kerangka keluli*	CE02	Bridge construction *Pembinaan Jambatan*	M02	Fire prevention and protection system *Sistem pencegahan dan perlindungan kebakaran*	E02	Safety and surveillance system *Sistem pengawasan dan keselamatan*
B03	Restoration and conservation *Pemulihan dan pemuliharaan*	CE03	Marine structures *Struktur Merin*	M03	Lift and escalator *Lift dan escalator*	E03	Automation system *Sistem automasi bangunan*
B04	General building works *Kerja am bangunan*	CE04	Dams *Empangan*	M04	Building automation system *Sistem automasi bangunan*	E04	Low voltage installation *Pemasangan voltan rendah*
B05	Piling works *Kerja cerucuk*	CE05	Tunnels and underpinnings *Terowong dan sokong bawah*	M05	System for workshops, plants, quarries, etc. *Sistem untuk bengkel, kilang kuari dan sebagainya*	E05	High voltage installation *Pemasangan voltan tinggi*
B06	Concrete repair works *Kerja pembaikan konkrit*	CE06	Flood drainage control system *Sistem kawalan banjir*	M06	Medical equipment *Peralatan perubatan*	E06	Special lighting system *Sistem pencahayaan khas*
B07	Interior decoration *Hiasan dalaman*	CE07	Railway tracks *Trek keretapi*	M07	Kitchen equipment *Peralatan dapur*	E07	Internal telecommunication system *Sistem telekomunikasi dalaman*

Category B Building Construction		Category CE Civil Engineering Construction		Category ME Mechanical and Electrical			
Specialization	**Description**	**Specialization**	**Description**	**Specialization**	**Description**	**Specialization**	**Description**
B08	Water proof material *Pemasangan bahan kalis air*	CE08	Slope protection system and soil stabilisation *Sistem perlindungan cerun*	M08	Heat restoration system *Sistem pemulihan haba*	E08	External telecommunication system *Sistem telekomunisasi luaran*
B09	Landscaping *Lanskap*	CE09	Oil or gas pipelines *Saluran paip minyak atau gas*	M09	Mechanical based compression aand generation *Pemampatan dan penjanaan berasaskan mekanikal*	E09	Various special equipment *Pelbagai peralatan khas*
B10	Internal pipeline installation *Pemasangan paip air dalaman*	CE10	Piling work *Kerja cerucuk*	M10	Coolant for power generation *Pendingin untuk kuasa penjanaan*	E10	Specific area panel *Panel kawalan khusus*
B11	Signage installation *Pemasangan tanda*	CE11	Concrete repair work *Kerja pembaikan konkrit*	M11	Special construction and treatment *Pembinaan dan rawatan khusus*	E11	General electrical works *Kerja am elektrik*
B12	Aluminium/steel and glass works *Kerja aluminium/keluli dan kaca*	CE12	Soil investigation works *Kerja penyiasatan tanah*	M12	Special plant *Loji khusus*	E12	Electrical billboards *Papan tanda elektrik*
B13	Tile installation and rendering works *Pemasangan jubin dan kerja lepaan*	CE13	Signage installation *Pemasangan tanda*	M13	Drilling operations *Pengedalian gerudian*	E13	Train communication system *Sistem telekomunikasi keretapi*
B14	Paint works *Kerja cat*	CE14	Landscaping *Landskap*	M14	Pollution control system *Sistem kawalan pencemaran*	E14	Computer network cable *Kabel rangkaian computer*

Category B Building Construction		**Category CE Civil Engineering Construction**		**Category ME Mechanical and Electrical**			
Specialization	**Description**	**Specialization**	**Description**	**Specialization**	**Description**	**Specialization**	**Description**
B15	Roof installation and metal cladding *Pemasangan bumbung dan cladding logam*	CE15	Offshore works *Kerja-kerja pesisir*	M15	Various mechanical equipment *Kelengkapan mekanikal pelbagai*		
B16	Construction and installation of pool equipment *Pembinaan dan pemasangan kelenkapan kolam renang*	CE16	Underwater construction and maintenance works *Kerja-kerja pembinaan dan penyeggaraan bawah air*	M16	Tower crane *Kren menara*		
B17	Pre-stress and post-tension works *Kerja prestressing dan post tensioning*	CE17	Airports *Lapangan terbang*	M17	Laundry equipment *Peralatan dobi*		
B18	Metal works *Kerja logam*	CE18	Reclamation works *Kerja tebus guna*	M18	Hot water system *Sistem air panas*		
B19	IBS: Formwork system *IBS: sistem formwork*	CE19	Sewerage system *Sistem pebentungan*	M19	Plant equipment installation *Pemasangan kelengkapan loji*		
B20	Internal gas pipeline installation *Pemasangan paip gas dalam bangunan*	CE20	Water supply system *Sistem bekalan air*	M20	General mechanical maintenance *Penyenggaraan am mekanikal*		
B21	Scaffolding installation Pemasangan perancah	CE21	General civil engineering works Kerja-kerja am kejuruteraan awam	M21	Kimpalan landasan keretapi		
B22	IBS: Block system IBS: Sistem blok	CE22	Syntheic game filed track Trek padang permainan sintetik				

Category B Building Construction		Category CE Civil Engineering Construction		Category ME Mechanical and Electrical			
Specialization	**Description**	**Specialization**	**Description**	**Specialization**	**Description**	**Specialization**	**Description**
B23	IBS: Wood frame system IBS: Sistem kerangka kayu	CE23	Pre-stress and post-tension works Kerja prestressing dan post tensioning				
B24	Building maintenance works Kerja penyenggaraan bangunan	CE24	Civil engineering structures Struktur kejuruteraan awam				
B25	Private pipe connection to sewer Penyambungan paip persendirian ke pembetong	CE25	Rock blasting works Kerja meletup batu				
B26	Demolition works Kerja meroboh	CE26	Sculpting Struktur berukir				
B27	Water supply system and sewerage system maintenance service Perkhidmatan penyengaraan sistem bekalan air atau sistem pembentungan	CE27	Heat insulation/refractory works Kerja penebatan haba/refractory				
B28	Miscellaneous works Kerja ubahsuai	CE28	Special cast system Sistem acuan khusus				
		CE29	Scaffolding installation Pemasangan perencah				
		CE30	Soil stabilisation, subterranean drainage works Kerja penstabilan tanah, penyaliran bawah tanah				
		CE31	Civil engineering telecommunications works Kerjakejuruteraan awan telekomunikasi				

Category B Building Construction		Category CE Civil Engineering Construction		Category ME Mechanical and Electrical			
Specialization	**Description**	**Specialization**	**Description**	**Specialization**	**Description**	**Specialization**	**Description**
		CE32	Civil engineering maintenance works Kerja penyelenggaraan keju-ruteraan awam				
		CE33	Drilling for underground water, geophysics study Penggerudian untuk air bawah tanah				
		CE34	Pre-cast concrete installation work Kerja pemasangan konkrit pa tuang				
		CE35	Concrete test Ujian konkrit				
		CE36	Soil works Kerja tanah				
		CE37	Power station chimney works Kerja serombong stesen kuasa				
		CE38	Sewerage system mainte-nance Penyenggaraan sistem pen-bentongan				
		CE39	Water supply system mainte-nance Penyelengaraan sistem bekalan air				
		CE40	Excavation Pengorekan				
		CE41	Building ponds for breeding Kerja membina kolam air untuk ternakan				

Category B Building Construction		Category CE Civil Engineering Construction		Category ME Mechanical and Electrical			
Specialization	**Description**	**Specialization**	**Description**	**Specialization**	**Description**	**Specialization**	**Description**
		CE42	Membuat isyarat dan menge-cat jalan				
		CE43	Membuat pengadang dan lain-lain kerja untuk jalan				

(Source: CIDB Registration Requirements and Procedure, Annexure 2B)

Endnotes

[1] Prior to the setting up of the PKK the public authority that registers contractors was the Public Works Department of Malaysia (Jabatan Kerja Raya Malaysia). In addition, other public departments and agencies and private bodies such as the Pertubuhan Arkitek Malaysia (PAM) also maintain their respective system of registration of contractors (Khairuddin, 2002).

[2] https://www.cidb.gov.my and http://www.pkk.kkr.gov.my

[3] Information on the criteria to be a *Bumiputera* status contractor is available in the Ministry of Finance's Circulars, SPP 4/1995.

[4] Information on the authority of the PKK is available in the Ministry of Finance's Circulars, SPP 6/1984, 14/2002 and 6/2010.

[5] A full description of the areas of specialization of works is available in Ketua Pengarah Kerja Raya (1992).

[6] Refer to CIDB (1999) "Registration requirements and procedures."

[7] The full list of categories and areas of specialization is available from the CIDB website at https://www.cidb.gov.my and is appended at the back of this paper.

[8] Refer to CIDB (2012) "Garis Panduan Perolehan Kerajaan Di Bawah Sistem Satu Pendaftaran Kontraktor (SSPK), online https://www.cidb.gov.my accessed 23rd June 2013. Senarai Pengkhususan Dalam SSPK is published by the CIDB. Its use herein is with permission.

QUANTITY SURVEYORS AND THEIR COMPETENCIES IN THE PROVISION OF PFI SERVICES

Samer Shahedza Khairuddin[1] and Khairuddin Abdul Rashid[2]
[1] Independent consultant and graduate student
[2] Lecturer, Department of Quantity Surveying, Head of Procurement and Project Delivery System Research Unit, Kulliyyah of Architecture & Environmental Design (KAED), International Islamic University Malaysia (IIUM), Jalan Gombak, P.O. Box 10, 50728 Kuala Lumpur

Abstract
This paper concerns Quantity Surveyors and their competencies in the provision of PFI services. It begins with the respective overviews on the quantity surveying profession and Public Private Partnership (PPP) in Malaysia. Generally, QSs are engaged to provide construction related professional services including procurement, costing and contractual advisory services. PPP was utilized as a compliment to the conventional procurement approach, in the provision of public infrastructure and services, initially in 1983 via Privatization, and subsequently in 2006 via the Private Finance Initiative or PFI. Among the key reasons why the government adopted PPP include constraints in the public purse and to meet the demand for higher level quality in public infrastructure and services. In the context of PPP projects, past studies suggested that Malaysian professionals including QSs do not adequately possess the appropriate skills and expertise to provide such services including PFI. In an attempt to better understand the competency levels of QSs in general and in relation to PFI services a study employing the method of content analysis of three past studies on the subject matter was conducted. From the content analysis a total of seven (7) main competencies and their respective forty six (46) sub-competencies were identified. Thereafter data obtained from these past studies was micro-analysed and contrasted with the QSs professional services as promoted by the Board of Quantity Surveyors Malaysia (BQSM). The key outcomes of the analysis revealed the presence of a relationship between the competencies of QS professional services and PFI services implying QSs are reasonably well positioned to acquire those PFI skills and therefore are able to provide high quality PFI services; and the presence of a 'competency gap' in each of the seven PFI (7) main competencies. The latter implies that the QS profession in actuality suffers from what can be referred to as a 'multi-dimensional deficiency'. In the light of the presence of 'multi-dimensional deficiency' in the provision of PFI services among QSs, the paper recommends that the QS profession should consider initiating a structured and holistic approach in capacity building for its members.

Keywords: *Construction; Competency; Concession; Infrastructure; PPP; PFI; Quantity Surveyors*

INTRODUCTION

A Quantity Surveyor (QS) is a financial advisor to a client of a construction project. His responsibilities, in a typical construction work, include advising the client on the most appropriate system of procurement to be used for his project, preparing cost estimates, tender documents, calling, evaluating and awarding tender on behalf of the client, administering the contract including evaluating and recommending interim payments, evaluating of variations and preparing and finalizing the contract's account (RISM; available at: www.rism.org.my/ accessed on 24th June 2013).

The services offered by QSs are not confined to projects that are procured in the conventional way. Increasingly, and in tandem with the continuous and upward trends in the use of non-conventional procurement systems, QSs are expected to provide quality services to their clients including for projects procured via the Private Finance Initiative (PFI) or other

concession based projects (Samer, 2012).

Essentially, PFI is a procurement approach whereby a public sector agency works together with a private sector entity to deliver public services on behalf of the Government. Under a typical PFI arrangement, the private sector entity will design, build, finance, operate and maintain (DBFOM) a public facility and deliver services to the public. In return, the Government will make periodic payments otherwise known as user-fees to the private sector entity. The quantum to be paid in each payment is linked to the quality of services provided by the private sector entity and it has to be agreed between the public sector agency and the private sector entity as provided for in a typical 20 to 30 years concession agreement (Government of Malaysia, 9th MP, 2006).

The use of PFI in Malaysia began in 2006 under the 9th Malaysia Plan (9th MP, 2006-2010). Since the implementation of the 10th Malaysia Plan (10th MP, 2011-2015) the use of PFI appears to be on the rise, as evident from the amount of money and the number of projects being identified as to be implemented by the Government. For instance, under the 10th MP, 52 high impact projects worth RM62.7 billion have been identified to be implemented via the PFI route with a sum of RM20 billion allocated as a facilitation fund to bridge the viability gap.

Studies on the identification of competencies of key construction related professionals including QSs in the provision of PFI services have been carried out by Nursyazwani (2008), Khairuddin (2009) and Samer (2012). These different studies however provided a consistent outcome i.e. each study identified the presence of a 'competency gap' between the competencies the professionals should possess if they are to provide PFI services as opposed to the competencies they actually possessed.

Given the Government's continuous endeavour to develop Malaysia, the procurement approach adopted includes PFI (UKAS, 2010) and that given the professional roles and functions played by QSs in project implementation including in PFI projects, inevitably, the services of QSs would be required. Consequently, a study to ascertain the competency levels of QSs in the delivery of PFI services is considered timely. However, the current study differs to the three previous studies as it aims to extend the scope with the introduction of a new variable i.e. QSs professional services as promoted by the Board of Quantity Surveyors Malaysia (BQSM). The objective of the current study is to determine whether the QSs PFI competencies are consistent with the QSs professional services as promoted by BQSM.

The paper is structured into five parts. The first part introduces the paper. This is followed by a literature review on quantity surveying, PFI and previous studies on competencies thereof. The third and fourth parts describe the methodology used and the presentation and discussion of the results respectively. The final part of the paper, part five, concludes with suggestions for consideration by the QSs profession.

LITERATURE REVIEW

Quantity Surveyors' Professional Services

According to the Royal Institution of Surveyors Malaysia (RISM, 2013) a QS "is a construction professional, he or she is qualified and adequately trained to advise on all aspects of construction costs, financial and contractual administration. He or she is an expert on the cost and management of construction projects, whether building, civil or heavy engineering." The profession is governed by statute namely the Quantity Surveyors Act 1967. According to BQSM, services offered by consulting QSs can be divided into two categories which are basic services and additional services. The following are the services:

Basic services

1. Preparation of preliminary estimates and cost plans
2. Preparation of Bills of Quantities and other Tender Documents
3. Preparation of Tender Reports including pricing the Bills of Quantities for an estimate and Contract Documents
4. Preparation of Tender Documents, Tender Reports and Contract Documents for Prime Cost and Provisional items other than those under the charge of Mechanical and Electrical Consultants
5. Valuation of works in progress for Interim valuation/Certificates including variation
6. Preparation of Final Accounts.

Additional services

1. Preparation of Feasibility studies including Income/Expenditure Cash Flow
2. Preparation of Final Costs for Contracts based on Provisional Bills of Quantities
3. Pricing of Bills of Quantities or Pricing and agreeing Schedule of Rates
4. Re-measurement of the whole or part of the Building Works, if required
5. Preparation and attendance for Arbitration/Litigation
6. Preparation of Documents and Reports for Prequalification of Contractors.

As a requirement stipulated by the Quantity Surveyors Act 1967, QSs can practice their profession and charge the appropriate fees only if they are registered with the BQSM. The scope and types of services and fees payable are detailed out in the Board of Quantity Surveyors' Memorandum of Agreement for the Provision of Professional Quantity Surveying Services (BQSM; available online at: www.bqsm.gov.my/images/pdf/moa.pdf, accessed 24th June 2013). Thus, it can be inferred that QSs have indispensable roles to play towards ensuring successful completion of construction projects (Neoh, 2003).

Based on the BQSM (website accessed 24th June 2014), there are currently 1,026 Registered Quantity Surveyors in Malaysia, 1,397 Registered Graduate Quantity Surveyors and 338 professional Quantity Surveying Practices.

Private Finance Initiative (PFI)

PFI is defined by the Government as "the transfer to the private sector the responsibility to finance and manage a package of capital investment and services including the construction, management, maintenance, refurbishment and replacement of public sector asset … which creates a standalone business. The private sector will create the asset and deliver a service to the public sector client. In return, the private sector will receive payment … commensurate with the levels, quality and timeliness of the service provision throughout the concession period. The structure of the lease rental payment for PFI projects will guarantee a total return to the concessionaire's capital investment expenditures including financing cost repayment and profit to investment. The asset and facilities will be transferred to the public sector at the expiry of the concession period" (9th MP, 2006).

The Government's rationale for Malaysia to adopt PFI includes to relieve their financial and administrative burden, improve efficiency and productivity, facilitate economic growth, reduce the size and presence of the public sector in the economy, and to help meet the national economic policy targets (EPU, 2006).

According to Khairuddin (2012) the Malaysian PFI may be traced back to 1983 when privatization was first introduced. In 2006 (9th MP, 2006-2010), new strategies including the implementation of Government procurements via the PFI, aimed at streamlining privatization, were introduced. In 2010 (10th MP, 2011-2015) the PFI policy is given a 'make-over' and labelled as 'new wave PFI'. Learning from past mistakes in implementing privatization and PFI, the new wave PFI contains relatively clear, robust, detailed and transparent framework on the concept and method of procurement.

In 2010 and under the Tenth Malaysia Plan (10th MP, 2011-2015) RM63 billion was allocated for PPP projects and RM20 billion in facilitation fund. The facilitating fund is aimed at bridging the viability gap of projects (UKAS, 2009). Massuan (2012) suggested that the modalities used for the PPP and PFI projects include BOT, BOO, BLT, BLMT, BLMOT and Land Swap.

Typically, parties involved in PFI projects are, on the one hand the public sector agency that acts as the principal, and on the other hand the concessionaire, usually in the form of a consortium of several companies representing the contractor, designers (architects, engineers and QSs), financiers, facilities management services provider, etc. The consortium of companies forming the concessionaire is commonly referred to as the Special Purpose Vehicle or SPV.

The implementation of PFI is not without opposition and criticism. Among the more notable ones include the relatively low-level of readiness of key players to implement PFI projects. While in general the key players of the construction industry of Malaysia are aware and have basic understanding of the workings of PFI (Nursyazwani, 2008; Marna, 2010 and Nursham, 2011) but according to several authors (Nursyazwani, 2008; Khairuddin, 2009; Samer, 2012) there is a mismatch between the key areas of competencies required and the availability of experts in possession of those competencies.

Competencies in the Provision of PFI Services

In essence there are two types of competencies namely 'core competencies' and 'individual competencies'. Core competencies are also known as organizational driven competencies. Individual competencies refer to 'set of skills that an individual must possess in order to be capable of satisfactory performing a specified job' (Illias et al., 2010).

The current study is concerned with individual competencies. Specifically it concerns the competencies of construction related professionals, in the current study the QSs, in the provision of PFI services. According to Lamb and Merna, (2004), PFI competencies mainly fall into three categories i.e. technical, financial and legal. Other authors have expanded this with the inclusion of value for money (VfM) (Roshana et al, 2009; RICS, 2011) and people skills (RICS, 2003) as among the key PFI competencies.

Previous works by Nursyazwani (2008) and Khairuddin (2009) have identified a set of seven (7) main competencies required by key players of the construction industry, including QSs, towards successful delivery of PFI services. The seven main competencies are: technical, financial, legal, hard and soft skills, contractual, experience and Value for Money (VfM). These main competencies are further sub-divided into their respective sub-competencies. In all, Nursyazwani (2008) and Khairuddin (2009) have compiled a list comprising of forty-six sub-competencies. In a subsequent study, Samer (2012) applied these competencies on the QS profession to discover their level of competency. Interestingly, these different studies provided a consistent outcome i.e. each study identified the presence of a 'competency gap' between the competencies the professionals should possess if they are to provide PFI services as opposed to the competencies they actually possessed.

The 'competency gap' identified by Nursyazwani (2008) and Khairuddin (2009) is as illustrated by Figure 1. Referring to Figure 1 there appears to be a mismatch between the competencies they should possess (represented by the outer lines in the spider web diagram) and competencies they possess (represented by the inner lines). Competencies facing the highest constraints are legal, contractual and VfM (where their respective scores were <50) while the other main competencies namely technical, financial and hard and soft skills are considered to be merely satisfactory (their respective scores were between 50 and 60).

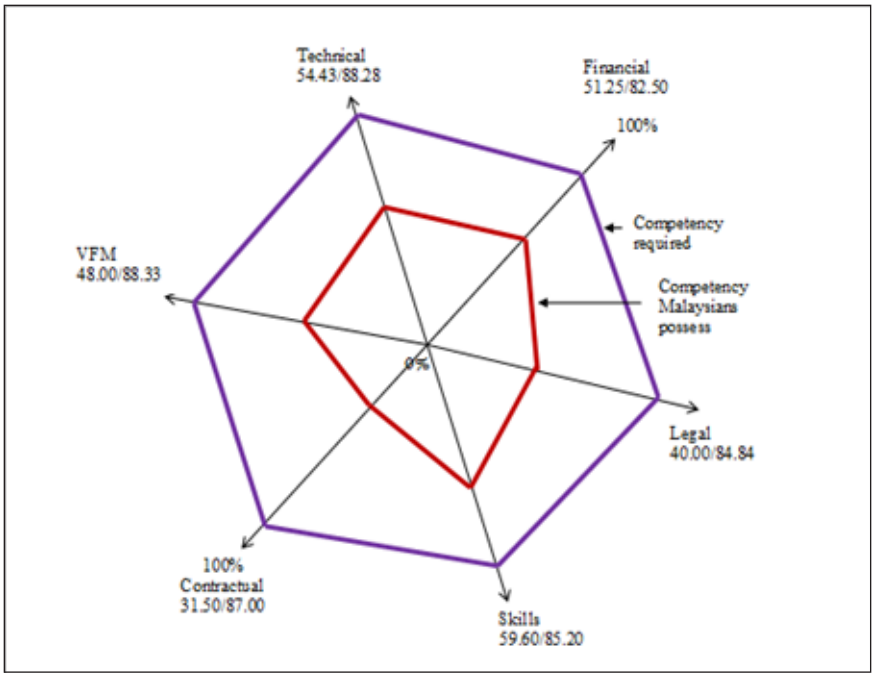


Figure 1. The Competency gap (Source: Nursyazwani, 2008)

The 'competency gap' identified by the Samer (2012) is as illustrated in Figure 2. Samer's study, with QSs as the primary respondents, however, showed that the gap is much narrower, thus suggesting that PFI competencies in possession by the QSs are greater in relative to the other key players reported in the previous works by Nursyazwani (2008) and Khairuddin (2009). In addition, such an outcome may also reflect the latter timing of the study whereby PFI have been introduced longer thus QSs are more familiar and therefore have an added advantage as opposed to the other professionals acting as respondents for the previous studies. Nonetheless, 'competency gaps' remain with the critical nodes found to be experience, financial and VfM with respective scores below 65 while other main competencies have higher scores of 65 to 75.

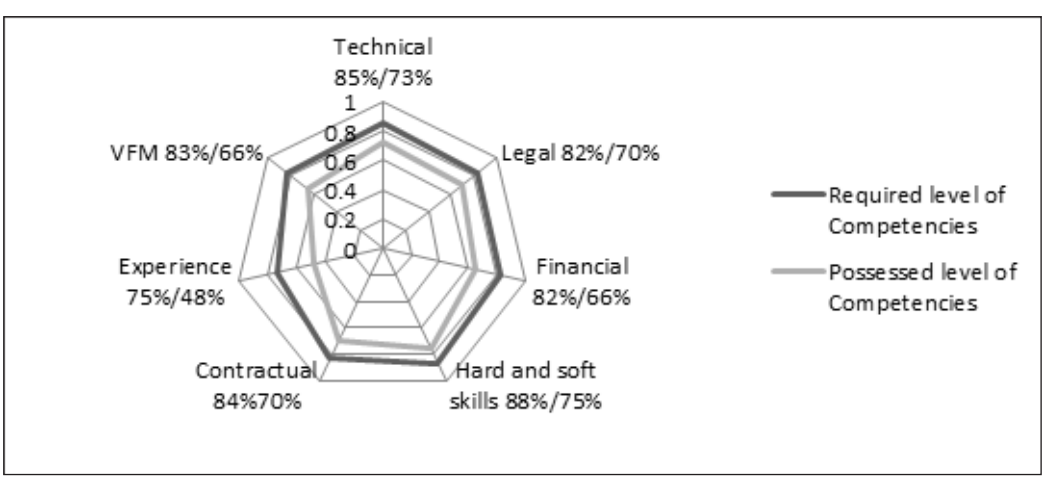


Figure 2. The PFI Competency Gap of QS Professionals (Source: Samer, 2012)

METHODOLOGY

This paper reports on a study that extends the scope of the works of Nursyazwani (2008), Khairuddin (2009) and Samer (2012) as aforementioned. While these studies were limited to PFI competencies and their possession by the professionals of the construction industry including QSs, the current study introduces a new variable i.e. QSs professional services as promoted by BQSM. The objective of the current study is to determine whether the QSs PFI competencies are consistent with the QSs professional services as promoted by BQSM.

The methodology adopted can be divided into three stages where the first stage is concerned with identifying past studies related to the subject topic, the second on extending the scope of previous studies by introducing a new variable: QSs professional services, and the final stage towards illustrating a new outlook of the subject.

The first stage includes review of literature on past studies about the subject matter. Two (2) papers from the works of Nursyazwani (2008) and Samer (2012) were identified relevant and analysed further. The outcome of the literature review has been presented in part two of this paper.

The second stage aims to represent QS professional services against PFI competencies. Thus, a review of professional services is relevant within the context to establish the inferred relationship between the two variables. The BQSM website was sourced as the main point of reference at: www.bqsm.com.my. In an attempt to provide a meaningful context the QSs' key professional services, both basic and additional as promoted by BQSM, are presented alongside the PFI competencies identified by Nursyazwani (2008), Khairuddin (2009) and Samer (2012). With this, it is found that their services as explicitly stated by BQSM can be grouped accordingly while tacit PFI skills such as hard and soft services and working experiences which are not stated explicitly by BQSM are however necessary for QSs in their line of work dealing within a multi-disciplinary environment. A full list of the seven (7) main competencies, their respective forty-six (46) sub-competencies and QS professional services are as indicated in Table 2.

Referring to Table 1 it was found that six (6) out of seven (7) PFI main competencies were consistent with QSs professional services with four (4) categories explicitly stated by BQSM represented and two (2) categories reasonably implied. Therefore, it is inferred that their education and thus qualification positions QSs to be in possession of these competencies. The underlying principle would be that in order for QSs to provide professional services as stated by BQSM, they should be in full possession of said competencies (or at 100%). Since a relationship between the two has been established, there should undoubtedly be no apparent shortfall between QSs professional services and PFI competencies.

The final stage is the micro-analysis of the results from Samer's (2012) study on QSs' PFI competencies. Samer's (2012) study, carried out via questionnaire survey and face to face interviews, concerned the identification and perceived possession of key PFI competencies and services of QSs. A total of 31 qualified and registered QSs responded to the survey. The respondents were randomly selected from the list of QSs registered with BQSM. The

responding QSs were mainly from QS consulting firms and academic institutions; their current work positions diverse, i.e. ranging from senior principal to executives and lectures; and the majority having more than 10 years' work experience.

From Samer's (2012) works, the aggregate Relative Indices (RI) of each of the seven identified competencies and the possession thereof by the QSs were calculated. Assuming that the QSs are in full possession of competencies for the QSs services, since those services are promoted by the BQSM, each of the seven main QS competencies should have their RI score as 1.00. Consequently, the differences between the RI scores of the QS competencies, the PFI identified and possessed thereof by the QSs were computed. The outcome of the computation was then subjected to the half-adjusting principle (see Ke et al, 2010) thus, facilitating the resulting differences to be categorized as per Table 1. The results of the micro-analysis are presented and illustrated in Tables 3 and 4 and Figure 3 respectively.

Table 1. The half-adjusting principle

RI Scores	Deficiency Category
≥0.8	Very Poor
≥0.6 < 0.8	Poor
≥0.4 < 0.6	Mild
≥0.2< 0.4	Slightly poor
<0.2	Minor

(Source: Modified from Ke et al., 2010)

Table 2. Competencies in the Provision of PFI Services and QS Professional Services

Main competencies	Sub-competencies Basic		QS Professional Services	
			Additional	
Technical	*Design* *Construction cost* *Tendering* *Operation and maintenance cost* *LCC*	*Resource capabilities* *Construction method* *Output requirements and specifications* *Technical advise*	*Preliminary estimates & cost plans* *Bills of Quantities & tender documents* *Tender reports*	*Preparation of Prequalification of contractors documents* *Re-measurement (if required)* *Pricing of Bills of Quantities* *Final costs based on Provisional Bills of Quantities*
Legal	*Land issue* *Construction and service phases* *Payment* *Termination and compensation*	*Force majeure* *Risk allocation and risk transfer* *Legal feasibility of project* *Appropriate procurement route*	*Valuation of works (Interim valuation/certificates)* *Contract documents*	-
Financial	*Unitary payment* *Financial plan* *Loan performance* *Cash flow*	*Audit financial models* *Financial proposals* *Bankability of PFI contracts*	*Final account*	*Feasibility studies (Income/Expenditure cash flow)*
Hard and soft skills	*Negotiating* *People*	*Process* *Technical knowledge*	*Tacit skills and expertise*	
Contractual	*Planning and development stages* *Contract terms* *Payment mechanisms* *Insurances* *Mobilization and handover*	*Contract administration* *Review and monitoring risk* *Communications* *Change order and variation* *Benchmarking and market testing*	*Variation works*	*Preparation and attendance for Arbitration/ Litigation*
Experience	*Working experience in PFI projects*		*Tacit skills and expertise*	
Value for Money (VfM)	*Fit purpose* *Efficiency in managing operation and maintenance* *Competition and private sector management skills*	*Use of new technology* *Risk transfer* *LCC* *Performance measurement and incentives*	-	-

(Source: Modified from Nursyazwani, 2008 and Samer, 2012)

RESULTS AND DISCUSSION

Detailed examination of Table 3 and Figure 3 revealed a new outlook i.e. contrary to the general notion that in relation to the QS profession there should be no shortfall between professional services and PFI competencies, the results suggest that the presence of shortfall does exist. In addition, the presence of the shortfall appears to be multi-dimensional, i.e. more than one area of main competencies.

Table 3. Aggregate RI on Professional Services and PFI Competencies of QSs

Main competencies	Aggregated RI		
	Professional Services	PFI Competencies	
	Required	Required	Possessed
Technical	1.00	0.85	0.72
Legal	1.00	0.82	0.70
Financial	1.00	0.82	0.65
Hard and soft skills	1.00	0.87	0.75
Contractual	1.00	0.83	0.69
Experience	1.00	0.74	0.48
VFM	1.00	0.83	0.65

(Source: Modified From Samer, 2012)

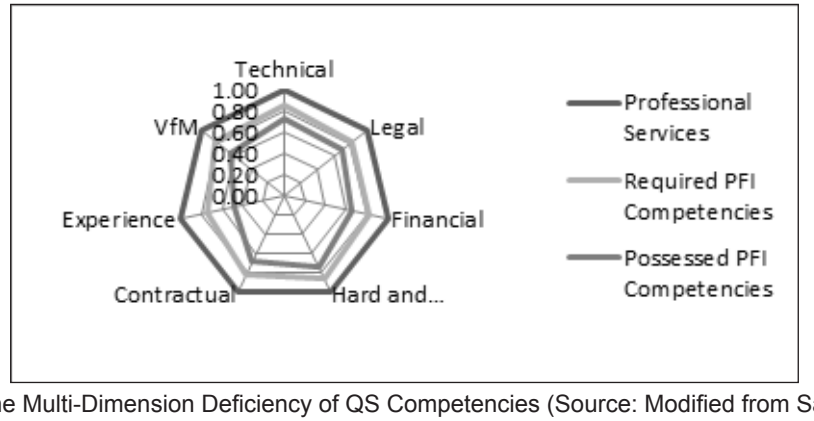


Figure 3. The Multi-Dimension Deficiency of QS Competencies (Source: Modified from Samer, 2012)

To further illustrate the identified shortfall, the cumulative shortfall between essential QS professional services against the required and possessed of PFI competencies were tabulated (Table 4). A total deficiency for each area of main competency was thus identified. The resulting statistics were then subjected to the half-adjusting principle (see Ke et al, 2010, see Table 1) thus, facilitating the resulting differences or shortfall in competencies to be categorized as per Table 4.

Table 4. Shortfall of QS Professional services against perceived and professed PFI competencies

Main Competencies	Professional services vs PFI Competencies				
	Ideal	Perceived shortfall	Self-admission shortfall	Nett shortfall	Deficiency category
Technical	1.00	0.15	0.28	0.28	Slightly poor deficiency
Legal	1.00	0.18	0.30	0.30	Slightly poor deficiency
Financial	1.00	0.18	0.35	0.35	Slightly poor deficiency
Hard and soft skills	1.00	0.13	0.25	0.25	Slightly poor deficiency
Contractual	1.00	0.17	0.31	0.31	Slightly poor deficiency
Experience	1.00	0.26	0.52	0.52	Mild deficiency
VFM	1.00	0.17	0.35	0.35	Slightly poor deficiency

Referring to Table 4, the RI scores for all seven PFI main competencies among QSs show a net shortfall in competencies. In addition, it is found that one main competency recorded a 'mild' deficiency (value $\geq 0.4 < 0.6$), i.e. "experience" while six other main competencies were considered 'slightly poor' deficiency (value $\geq 0.2 < 0.4$). Thus, an overall professional deficiency is apparent within the QS profession in so far as the provision of PFI services is concerned.

The presence of deficiencies in all the seven main areas of competencies in the provision of PFI services among the QSs suggests that the QS profession suffers from what could be referred to as 'multi-dimensional deficiency'. The 'multi-dimensional deficiency' is exhibited clearly when all nodes representing the key competencies indicate a shortfall between the professed essential QSs skills (BQSM) against the required and possessed PFI competencies. Indeed, QSs suggested a lower required competency for PFI services for all nodes as opposed to professional services however; they appeared to have admitted to be in a much lower possession of these skills. Consequently, the results suggest a professed deficiency in competencies is present within the profession.

CONCLUSION

This study attempted to present an extension of previous works on PFI competencies (removed references) towards a new outlook in the on-going discussion of QSs competencies in PFI services. Drawing from the professed QSs professional services as stated by BQSM, the current study has established the relationship between the competencies of QS professional services and PFI services. Therefore, it appears that QSs are reasonably well positioned to acquire them through their qualifications and thus provide high quality PFI services.

Going beyond this discussion; this paper has discovered that the profession is, in reality, suffering from what may be referred to as 'multi-dimensional deficiencies'. Indeed, observing the QSs professional services against PFI competencies reveal that no main competencies match the self-professed QS professional services. The majority competencies were considered as 'slightly poor' i.e. six main competencies while only one competency indicated a 'mild' deficiency. Overall the levels of deficiency found is not significant since no categories were considered 'very poor' or 'poor' which reiterate the earlier argument that QSs are indeed well positioned to provide high quality PFI services. However, the results implied, high quality PFI

services, under the present situation may not be achievable. Hence, suggesting a dilemma is emerging within the QS profession.

The findings from the current study are considered significant, if taken positively, as they provide basis for the QS profession to assess itself and to move forward. In addition, as the majority of PFI competencies were considered 'slightly poor', it could be said that the QS profession is on the right direction towards acquiring full competencies for PFI services. Consequently, it is recommended that powers that be and academics within the QS profession consider initiating a structured and holistic approach for training and capacity building for members of the profession and that curricula for the training of QSs be re-visited and where appropriate adjusted accordingly.

Limitation that exists in the current study is that it is based on secondary data of the previous study of which this paper micro analysed (removed reference). Thus, the findings provided herein may not reflect the current scenario. Therefore, it is also recommended that the authors conduct further study to determine whether the same can be said for current QSs.

REFERENCES

EPU (2006). History of Privatization Programme. http://www.epu.jpm.my/New%20Folder/application%20and%20approval/priva.htm accessed 13th December 2006.

Government of Malaysia (2006). Ninth Malaysia Plan (2006-2010).

Government of Malaysia (2011). Tenth Malaysia Plan (2011-2015).

Holt. G.D., (1997), Construction Research Questionnaires and Attitude Measurement: Relative Index or Mean?, Construction Procurement, Vol. 3 No.2, 88-96

Illias Said, Mohd Wira Mohd Safie, Abdelnaser Omran, (2010). The Competency Requirement for Quantity Surveyors: Enhancing Contionous Professional Development; ACTA *Technical Corviniensis* – Bulletin of Engineering

Ke, Y., Wang, S., Chan, A.P., and Lam T.I., (2010). Preferred risk allocation in China's public-private partnership (PPP) projects, *International Journal of Project Management*, 28, 482-492

Khairuddin Abdul Rashid (2009). Understanding Private Finance Initiative (PFI). Kuala Lumpur: ScholarMind Publishing.

Khairuddin Abdul Rashid (2012). Understanding the Malaysian PPP. In Winch, G.M and Onishi,M, (2012*). Taking Stock of PPP and PFI around the World.* London: ACCA, 75-89.

Lamb D., Merna T., (2004). A Guide to the Procurement of Privately Financed Projects: an Indicative Assessment of the Procurement Process, Thomas Telford Publishing

Marna Marof (2010). A Comparative Study on the Processes of PFI and Conventional Procurement in Malaysia. Unpublished undergraduate dissertation, International Islamic University Malaysia.

Massuan Ahamad (2012). UKAS Roles and PPP Approaches. Presentation at the IIUM-Toyo University Seminar on PPP, IIUM, 13th January 2012.

Neoh Cheng Aik (2003). The Roles and Functions of the Quantity Surveyor from the Perspective of the Engineers. In Khairuddin Abdul Rashid (2003). Quantity Surveying. A New Paradigm. Petaling Jaya: Pearson, 179-187.

Nursham Melati Nurasidi (2011). *Malaysian Contractors' Understanding of PFI*. Unpublished undergraduate dissertation, International Islamic University Malaysia.

Nursyazwani Mohd Sofi (2008). *Identification of Key Competencies and Assessing if Malaysian Professional possesses those Competencies in the Provision of PFI Services*. Unpublished undergraduate dissertation, International Islamic University Malaysia.

RICS (2003). Project Management and the Private Finance Initiative, London, United Kingdom RICS Research, (2011). The Future of Private Initiative and Public Private Partnership http://www.rics.org/site/downloadfeed.aspx?fileID=9846&fileExtension=PDF accessed 24th June 2014

Roshana T., Abdul Hadi Nawawi., Aini Jaapar, Kharizam Ismail, (2009). The Malaysian Private Finance Initiative and Value for Money, Asian Social Science, Vol.5 No.3 pp.103-111

Samer Shahedza Khairuddin (2012). *Assessing Malaysian Quantity Surveyors' Competence Toward the Provision of PFI Services*. Unpublished undergraduate dissertation, Universiti Teknologi MARA.

UKAS, (2009). Public Private Partnership (PPP) Guideline Putrajaya Public-Private Partnership Unit, Prime Minister Department

UKAS, (2012). Public Private Partnership (PPP) Guideline Putrajaya Public-Private Partnership Unit, Prime Minister Department

BQSM at http://www.bqsm.gov.my/, accessed 24th June 2014.

Royal Institute of Surveyors Malaysia at http://www.rism.org.my/, accessed on 24th June 2014.

GUIDE TO AUTHORS

Aims and Scope:

The Malaysian Construction Research Journal (MCRJ) is the journal dedicated to the documentation of R&D achievements and technological development relevant to the construction industry within Malaysia and elsewhere in the world. It is a collation of research papers and other academic publications produced by researchers, practitioners, industrialists, academicians, and all those involved in the construction industry. The papers cover a wide spectrum encompassing building technology, materials science, information technology, environment, quality, economics and many relevant disciplines that can contribute to the enhancement of knowledge in the construction field. The MCRJ aspire to become the premier communication media amongst knowledge professionals in the construction industry and shall hopefully, breach the knowledge gap currently prevalent between and amongst the knowledge producers and the construction practitioners.

Articles submitted will be reviewed and accepted on the understanding that they have not been published elsewhere. The authors have to fill the Declaration of the Authors form and return the form via fax to the secretariat. The length of articles should be between 3,500 and 8,000 words or approximately 8 – 15 printed pages (final version). The manuscripts should be written in English. The original manuscript should be typed one sided, single-spacing, single column with font of 11 point (Times New Roman). Paper size should be of Executive (18.42 cm x 26.67 cm) with 2 cm margins on the left, right and bottom and 3 cm for the top. Authors can submit the manuscript:

- By e-mail to maria@cidb.gov.my / hazim@cidb.gov.my / foo@cidb.gov.my
- By hardcopy and softcopy in Microsoft-Word format to MCRJ Secretariat:

Malaysian Construction Research Journal (MCRJ)
Construction Research Institute of Malaysia (CREAM)
MAKMAL KERJA RAYA MALAYSIA
1st Floor, Block E, Lot 8,
Jalan Chan Sow Lin, 55200 Kuala Lumpur
MALAYSIA

Tel. : (6)03 – 9281 0800
Fax : (6)03 – 9282 4800
Website : www.cream.my

Type of fonts: All text, drawing, graph must be written using Times New Roman
Language: Follow the spelling of the Oxford English Dictionary.
Size/Page Setup: Executive (18.42 cm x 26.67 cm)
Paper title: Arial, 16.

CODIFICATION AND APPLICATION OF SEMI-LOOF ELEMENTS FOR COMPLEX STRUCTURES

Author's name (full name): Arial, 9pt. should follow below the title.

Jamalodin Noorzaei[1], Mohd. Saleh Jaafar, Abdul Waleed Thanoon, Wong Jern Nee

Affiliation (including post codes): Arial, 9pt. Use numbers to indicate affiliations.

[1]Department of Civil Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia

Abstract: Arial Bold, 9pt. Left and right indent 0.64 cm.

Abstract: it should be single paragraph of about 100 – 250 words.

Keywords: Times New Roman Bold, 9pt (Italic). Left and right indent 0.64 cm.

Keywords: *Cooling tower; Finite element code; Folded plate; Semiloof shell; Semiloof beam*

Body Text: Times New Roman, 11 pt. All paragraph must be differentiate by 0.64 cm tab.

Heading 1: Arial Bold + Upper Case, 11pt.
Heading 2: Arial Bold + Lower Case, 11pt.
Heading 3: Arial Italic + Lower Case, 11pt.

Units: All units and abbreviations of dimensions should conform to SI standards.

Figures: Figures should be in box with line width 0.5pt. All illustrations and photographs must be numbered consecutively as it appears in the text and accompanied with appropriate captions below them.

Figures caption: Arial Bold + Arial, 9pt. should be written below the figures.

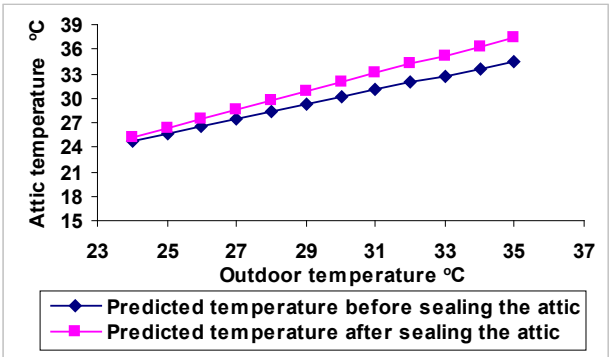


Figure 8. Computed attic temperature with sealed and ventilated attic

Tables: Arial, 8pt. Table should be incorporated in the text.

Table caption: Arial Bold + Arial, 9pt. Caption should be written above the table.

Table Line: 0.5pt.

Table 1. Recommended/Acceptable Physical water quality criteria

Paramaeter	Raw Water Quality	Drinking Water Quality
Total coliform (MPN/100ml)	500	0
Turbidity (NTU)	1000	5
Color (Hazen)	300	15
pH	5.5-9.0	6.5-9.0

(Source: Twort et al. 1985; MWA,1994)

Reference: Times New Roman, 11pt. Left indent 0.64 cm, first line left indent – 0.64 cm. Reference should be cited in the text as follows: "Berdahl and Bretz (1997) found…" or "(Bower et al. 1998)". References should be listed in alphabetical order, on separate sheets from the text. In the list of References, the titles of periodicals should be given in full, while for books should state the title, place of publication, name of publisher, and indication of edition.

Journal

Sze, K. Y. (1994) Simple Semi-Loof Element for Analysing Folded-Plate Structures. *Journal of Engineering Mechanics*, 120(1):120-134.

Books

Skumatz, L. A. (1993) Variable Rate for Municipal Solid Waste: Implementation, Experience, Economics and Legislation. Los Angeles: Reason Foundation, 157 pp.

Thesis

Wong, A. H. H. (1993) *Susceptibility To Soft Rot Decay In Copper-Chrome-Arsenic Treated and Untreated Malaysian Hardwoods*. Ph.D. Thesis, University of Oxford. 341 pp.

Chapter in book

Johan, R. (1999) Fire Management Plan For The Peat Swamp Forest Reserve Of North Selangor and

Pahang. In Chin T.Y. and Havmoller, P. (eds) *Sustainable Management of Peat Swamp Forests in Peninsular Malaysia* Vol II: Impacts. Kuala Lumpur: Forestry Department Malaysia, 81-147.

Proceedings

Siti Hawa, H., Yong, C. B. and Wan Hamidon W. B. (2004) Butt Joint In Dry Board As Crack Arrester. *Proceeding of 22nd Conference of ASEAN Federation of Engineering Organisation* (CAFEO 22). Myanmar, 55-64.

MCRJ Volume 18 | No.1 | 2016

Contents

ISSN 1985-3807

9 771985 380005