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A STUDY ON FACTORS AFFECTING THE IMPLEMENTATION OF INDUSTRIALIZED BUILDING SYSTEM (IBS) ON HIGH-RISE CONSTRUCTION IN DEVELOPING REGIONS OF MALAYSIA

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ABSTRACT. The objectives of this paper are to investigate the suitability of IBS and to propose a new framework to improve IBS on high-rise construction project in undeveloped area of Malaysia. Data were collected through online questionnaire from G7 contractors (Central Region and East Coast). The results showed that reduction in construction duration is the main factor affecting the implementation of IBS in Central Region whilst capability and capacity to implement IBS is the main problem in East Coast region. Government support is needed to the successful implementation of IBS.

KEYWORDS: Industrialized Building System, High-rise Construction, Developing Regions

1. INTRODUCTION

Industrialized Building System (IBS) is an advanced construction technology implemented in construction industry to make the construction more efficient. Malaysian construction industry is experiencing a migration from traditional construction method to mechanized method.

As mentioned by (Eldemery, 2007), the land value is increased gradually, high-rise building is playing vital role to maximize the usage of land when land is scarce. In the other hand, limited land space in cities may restricts the development of construction. In order to solve this problem, this study will promote the implementation of IBS more focus on undeveloped regions with high-rise buildings to seek more development space.

However, implementation of IBS in undeveloped regions may consists of limitations. Consequently, most of the contractors and the consultants have no confidence to implement IBS especially for construction in undeveloped regions even the developers do not take risks due to construction in rural areas may not that profitable. According to (Ernawati et al., 2014), the construction companies in rural areas struggle for survival with limited resources. Hence, this study will propose solutions to overcome the problems recently encountered and help to achieve successful implementation of IBS in the future.

There are three main research objectives can serve to guide the activities of research: (1) To identify the factors affecting the implementation of IBS; (2) To investigate the factors affecting the implementation of IBS; (3) To propose measures for successful implementation of IBS in Malaysia.

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INTI JOURNAL
Vol.2, 2018 (10)

Meanwhile, in order to complete current research, there are some research questions that have been used to guide to conduct this study and achieve the objectives of current study: **(**1) What are the factors affect the implementation of IBS on high-rise constructions in the undeveloped regions?**;** (2) What are the solutions to overcome the weakness of IBS?; (3) Is the IBS suitable and profitable on high-rise constructions in undeveloped regions?

2. LITERATURE REVIEW

According to Construction Industry Development Board (CIDB, 2003), the IBS in Malaysia can be classified into 5 main common classifications namely precast concrete framed buildings, steel formwork system, steel framing system, prefabricated timber framing system and blockwork system, refer to Table 2.1. (Thanoon et al., 2003) mentioned that these systems can be further categorized into 3 main framing components according to the geometrical configuration such as linear or skeleton systems,

Categories of IBS	**Structural Aspects**
Precast concrete framing, panel and box system	Precast concrete beams, columns, wall, slabs, 3-D components, permanent concrete formworks, etc
Steel formwork system	Tunnel forms, tilt-up systems, columns and beams moulding forms and permanent steel formworks
Steel framing system	Steel columns, beams, portal frame systems and roof trusses
Prefabricated timber framing system	Prefabricated timber trusses, beams and columns, roof trusses, etc
Blockwork system	Interlocking concrete masonry units and lightweight concrete blocks

planar or panel systems and three dimensional or box system.

Table 2.1: Types of IBS and its structural aspects (Source: Construction Industry Development Board, 2003)

(Abedi et al., 2011) has mentioned that the Malaysian government put efforts in creating the first and second IBS Roadmap for Malaysia construction industry to produce speedy, high quality and cost effective construction products in order to compete with the global construction market. Currently, the IBS technology of Malaysian construction industry is advanced by modifying IBS technologies captured from foreign practices. According to (Racheal, 2015), the Construction Industry Development Board (CIDB) reported that there was about 70% of private projects and 42% of public projects use IBS technology in year 2015.

According to (Tam et al., 2007; CIDB, 2003b; Hassim et al., 2009; Abedi et al., 2011), IBS technology has been identified as a potential method to improve overall construction performance, benefiting construction projects with several advantages such as reduction of unskilled labour and foreign workers, less waste generation, reduce carbon emission to improve environmental performance, better quality of prefabricated products and durable with less defect, reduce overall construction costs, improve efficiency and productivity, reduce construction time with speed construction technique and improve site health and safety.

In contrast, according to the study done by (Hassim et al., 2009; Tam et al., 2007) IBS technology may be accompanied by several shortcomings such as higher initial construction cost, inflexible for changes of design, lack of integration in design stage, market monopoly, limited site space for placing

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Vol.2, 2018 (10)

prefabricated products, defects occurs without skillful jointing, experts and skilled labours required, time consuming in transportation.

3. RESEARCH METHODOLOGY

The target respondents are G7 contractors in Central Region Malaysia (Klang Valley, developed region) and East Coast Malaysia (Pahang, Kelantan and Terengganu, undeveloped region) registered under Construction Industry Development Board (CIDB). Based on the list of G7 contractors registered under CIDB and listed in Malaysia IBS Directory, there are 1535 numbers of G7 contractors available in Central Region Malaysia while 495 numbers of G7 contractors available in East Coast Malaysia. Since there are huge number of G7 contractors available in Malaysian construction industry and due to limited resource and time constraint, it is necessary to screen through list of G7 contractors who has adopted IBS to exclude unnecessary respondents who does not have experience of IBS to provide data and information which is as accurate as possible, there are 496 G7 contractors in Central Region Malaysia and 322 G7 contractors in East Coast Malaysia adopted IBS technology before.

The sample size can be generated by using Sample Size Calculator. Considering confident level is 95% and confident interval (margin of error) is 5%, the sampling size needed for Central Regions Malaysia is 217 while for East Coast Malaysia is 175. There are 10% additional respondents which are extra 40 added in this survey to avoid the occasion of not meeting expected response rate. There are 239 out of 496 numbers of G7 IBS contractors in Central Region Malaysia while 193 out of 322 G7 IBS contractors in East Coast Malaysia have been chosen as shown in Table 3.1.

Location	**G7 Contractor**	**G7 IBS Contractor (screened)**	**Sample Size Need**	**Expected Response (30% Response Rate)**
Central Region	1535	496	217 + 21 = 239	66
East Coast	495	322	175 + 18 =193	53

Table 3.1: Summary of the target respondents

Part A of the questionnaire is about general questions which include location of the company, opinion and experience of implementing IBS technology. The questions in Part A is set with check box manner. Part B is mostly with closed-ended questions in five point likert scale about the possibilities of the factors affecting implementation of IBS and measures to overcome current limitations of IBS. Part C consists of some open-ended questions which have been set to obtain different opinions from each target respondent in order to improve the findings and conclusion of this study, discussing about the problem faced to implement IBS technology, giving suggestions of new measures to encourage usage of IBS technology and opinion about future trends of IBS implementation in Malaysia.

The IBM SPSS, Statdisk and Microsoft Excel were adopted to analyze the data collected. The response rate is tabulated in Table 3.2.

Target Respondent	**Number of Questionnaire Sent**	**Number of Expected Response**	**Expected Response Rate**	**Number of Response**	**Response Rate**
Central Region G7 IBS Contractors	239	66	30%	39	16.32%

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INTI JOURNAL
Vol.2, 2018 (10)

East Coast G7 IBS Contractors	193	53	30%	24	12.44%

Table 3.2: Summary of number of response and response rate

4. FINDINGS AND DISCUSSION

4.1 Mean and Ranking

From Table 4.1 (Central Region), the three main factors are: (1) C3 (Construction duration will be reduced as speed construction (Mean= 4.05)), (2) D3 (Company is lack of IBS manufacturer near to the construction site (Mean= 4.05)), and (3) A1 (Imposed extra expenses in transportation (Mean= 3.97)). In their perspectives, factor in term of time is most important.

OVERALL RII AND RANKING OF FACTORS IN OVERALL

Rank Within Overall Group	Rank Within Group	Code	Factor	Overall RII (%)	Mean
1	1	C3	Construction duration will be reduced as speed construction of IBS	81.03	4.05
1	1	D3	Company is lack of IBS manufacturer near to the construction site	81.03	4.05
2	1	A1	Extra expenses in transportation	79.49	3.97
3	2	C1	Time consuming due to inconvenience of poor transportation system	76.92	3.85
3	1	B2	Quality of IBS products consistently meet the standard requirements	76.92	3.85
4	2	A6	IBS components are expensive as unpopular	73.33	3.67
5	2	D5	Company is less awarded by IBS projects	72.31	3.62
6	3	A3	Unable to reduce overall construction cost & reduce profit margin	68.72	3.44
7	4	A2	Extra expenses in employment of skilled labours and professionals	68.21	3.41
8	3	D2	Company is lack of knowledgeable employees and labours	64.62	3.23
9	4	D4	Company is lack of experience of IBS high-rise construction	64.10	3.21
10	5	A5	More maintenance cost throughout building life-cycle	63.59	3.18
11	2	B4	Design may not flexible for high-rise construction when using IBS	62.56	3.13
12	5	D1	Company is lack of capital to implement IBS	60.51	3.03
13	3	B1	High level of construction risks when using IBS on high-rise construction	60.00	3.00
14	3	C2	Construction project may delays as failure of IBS implementation	58.97	2.95
14	6	A4	Affordable high-rise construction has high demand and profitable	58.97	2.95
15	4	B3	More defects occur after completion of construction	49.74	2.48

Table 4.1: Ranking of overall factors by G7 contractors in Central Region

eISSN: 2600-7920
INTI JOURNAL
Vol.2, 2018 (10)

From Table 4.2 (East Coast), the three main factors are: (1) D5 (Company less awarded by IBS projects (Mean= 4.50)), (2) D2 (Lack of knowledgeable employee and labours (Mean= 4.17)), and (3) C3 (Construction duration will be reduced as speed construction (Mean= 4.17)). In their perspectives, internal factors related to capability and capacity to implement IBS is most important.

Rank Within Overall Group	Rank Within Group	Code	Factor	Overall RII (%)	Mean
1	1	D5	Company is less awarded by IBS projects	90.00	4.50
2	1	C3	Construction duration will be reduced as speed construction of IBS	83.33	4.17
2	2	D2	Company is lack of knowledgeable employees and labours	83.33	4.17
3	1	A2	Extra expenses in employment of skilled labours and professionals	82.50	4.13
3	1	A6	IBS components are expensive as unpopular	82.50	4.13
4	3	D3	Company is lack of IBS manufacturer near to the construction site	80.83	4.04
4	3	D1	Company is lack of capital to implement IBS	80.83	4.04
5	2	A5	More maintenance cost throughout building life-cycle	80.00	4.00
6	4	D4	Company is lack of experience of IBS high-rise construction	75.83	3.79
7	3	A3	Unable to reduce overall construction cost & reduce profit margin	75.00	3.75
8	4	A1	Extra expenses in transportation	73.33	3.67
9	1	B1	High level of construction risks when using IBS on high-rise construction	68.33	3.42
10	2	C1	Time consuming due to inconvenience of poor transportation system	66.67	3.33
11	5	A4	Affordable high-rise construction has high demand and profitable	64.17	3.21
12	2	B4	Design may not flexible for high-rise construction when using IBS	63.33	3.17
13	3	C2	Construction project may delays as failure of IBS implementation	61.67	3.08
13	3	B2	Quality of IBS products consistently meet the standard requirements	61.67	3.08
14	4	B3	More defects occur after completion of construction	60.00	3.00

Table 4.2: Ranking of overall factors by G7 contractors in East Coast

Result of the research done by (Kamar et al., 2014) has been shown the top three reasons of contractor adopting IBS are speed construction, quality assurance and project able to finish on time. Study conducted by (Nawi et al., 2015) also found that key factors of implementing IBS in private projects are able to shorten the construction period and render a deluxe quality of construction.

(Kamar et al., 2014) explained that cost is the main limitation to hinder contractor to adopt IBS with low confidence. Secondly, capital investment such as moulds, installation and handling machineries reduce profit margin of the contractor. (Jabbar, 2016) has also stated in his research, although IBS theoretically offers high productivity and cost-savings, house prices could be lowered only when the system reaches economies of scale in Malaysia where there are tax incentives provided and rebates for the raw materials. Supported by the research of (Kamaruddin et al., 2013), capital cost, maintenance cost and operation cost of the mechanization and automation affect the implementation of IBS. It proved that implementing IBS needs massive capital throughout all the stages of construction project. It involved expenses in employing experts during design stage. Moreover, it needs expenses in transportation, maintaining and operating machineries used for IBS components' installation. These cost factors require considerable attention if fully implement IBS in Malaysian construction projects.

eISSN: 2600-7920
INTI JOURNAL
Vol.2, 2018 (10)

4.2 t-test for One Sample Mean

From Table 4.3, factor A1, factor A2, factor A3, factor A6, factor B2, factor C1, factor C3, factor D2, factor D3 and factor D5 are statistically significant for the G7 IBS contractor in Central Region at a= 0.05. Furthermore, factor A4, factor B1, factor B3 and factor C2 are disqualified to be participated in this test as the average means are less than 3.00.

Factor	**a= 0.05**	**a= 0.01**	**a= 0.001**
A1	Reject H_0	Reject H_0	Reject H_0
A2	Reject H_0	Fail to reject H_0	Fail to reject H_0
A3	Reject H_0	Reject H_0	Fail to reject H_0
A4	Disqualified	Disqualified	Disqualified
A5	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
A6	Reject H_0	Reject H_0	Reject H_0
B1	Disqualified	Disqualified	Disqualified
B2	Reject H_0	Reject H_0	Reject H_0
B3	Disqualified	Disqualified	Disqualified
B4	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C1	Reject H_0	Reject H_0	Reject H_0
C2	Disqualified	Disqualified	Disqualified
C3	Reject H_0	Reject H_0	Reject H_0
D1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
D2	Reject H_0	Reject H_0	Reject H_0
D3	Reject H_0	Reject H_0	Reject H_0
D4	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
D5	Reject H_0	Reject H_0	Reject H_0

Table 4.3: Summary of output from t-test (one sample mean) for Central Region

From Table 4.4, all the measures are statistically significant for the G7 IBS contractor in Central Region at a= 0.05 except measure E7. Moreover, all the measures are qualified to be tested as their average means are greater than 3.00.

Measure	**a= 0.05**	**a= 0.01**	**a= 0.001**
E1	Reject H_0	Reject H_0	Reject H_0
E2	Reject H_0	Reject H_0	Reject H_0
E3	Reject H_0	Fail to reject H_0	Fail to reject H_0
E4	Reject H_0	Fail to reject H_0	Fail to reject H_0
E5	Reject H_0	Fail to reject H_0	Fail to reject H_0
E6	Reject H_0	Fail to reject H_0	Fail to reject H_0
E7	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E8	Reject H_0	Reject H_0	Reject H_0
E9	Reject H_0	Reject H_0	Reject H_0

Table 4.4: Summary of output from t-test (one sample mean) for Central Region

eISSN: 2600-7920
INTI JOURNAL
Vol.2, 2018 (10)

From Table 4.5, factor A1, factor A2, factor A3, factor A5, factor A6, factor C3, factor D1, factor D2, factor D3, factor D4 and factor D5 are statistically significant for the G7 IBS contractor in East Coast at a= 0.05. However, factor B3 is disqualified to be participated in this test as the average means are less than 3.00.

Factor	**a= 0.05**	**a= 0.01**	**a= 0.001**
A1	Reject H_0	Reject H_0	Reject H_0
A2	Reject H_0	Reject H_0	Reject H_0
A3	Reject H_0	Reject H_0	Fail to reject H_0
A4	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
A5	Reject H_0	Reject H_0	Reject H_0
A6	Reject H_0	Reject H_0	Reject H_0
B1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
B2	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
B3	Disqualified	Disqualified	Disqualified
B4	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C2	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C3	Reject H_0	Reject H_0	Reject H_0
D1	Reject H_0	Reject H_0	Reject H_0
D2	Reject H_0	Reject H_0	Reject H_0
D3	Reject H_0	Reject H_0	Reject H_0
D4	Reject H_0	Reject H_0	Reject H_0
D5	Reject H_0	Reject H_0	Reject H_0

Table 4.5: Summary of output of t-test (one sample mean) for East Coast

From Table 4.6, all the measures are statistically significant for the G7 IBS contractors in Central Region at a= 0.05 except measure E8. Measures E6 and E7 are disqualified to be tested as their average means are less than 3.00.

Measure	**a= 0.05**	**a= 0.01**	**a= 0.001**
E1	Reject H_0	Reject H_0	Reject H_0
E2	Reject H_0	Reject H_0	Reject H_0
E3	Reject H_0	Reject H_0	Reject H_0
E4	Reject H_0	Reject H_0	Reject H_0
E5	Reject H_0	Fail to reject H_0	Fail to reject H_0
E6	Disqualified	Disqualified	Disqualified
E7	Disqualified	Disqualified	Disqualified
E8	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E9	Reject H_0	Reject H_0	Reject H_0

Table 4.6: Summary of output from t-test (one sample mean) for East Coast

eISSN: 2600-7920
INTI JOURNAL
Vol.2, 2018 (10)

4.3 t-test for Two Independent Sample Means

Major findings from Table 4.7 (Output from t-test for 2 independent sample means):

(1) No significant difference in perceptions between the 2 regions for factors: A1, A3, A4, A6, B1, B3, B4, C1, C2, C3, D3, E1, E2, E3, E5, E6 and E8 at α= 0.05.

(2) There is statistically difference in perceptions between the 2 regions for the following factors: A2, A5, B2, D1, D2, D4, D5, E4, E7 and E9 at α= 0.05.

Factor	**a= 0.05**	**a= 0.01**	**a= 0.001**
A1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
A2	Reject H_0	Fail to reject H_0	Fail to reject H_0
A3	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
A4	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
A5	Reject H_0	Reject H_0	Fail to reject H_0
A6	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
B1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
B2	Reject H_0	Reject H_0	Fail to reject H_0
B3	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
B4	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C2	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
C3	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
D1	Reject H_0	Reject H_0	Reject H_0
D2	Reject H_0	Reject H_0	Reject H_0
D3	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
D4	Reject H_0	Fail to reject H_0	Fail to reject H_0
D5	Reject H_0	Reject H_0	Reject H_0
Measure	**a= 0.05**	**a= 0.01**	**a= 0.001**
E1	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E2	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E3	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E4	Reject H_0	Reject H_0	Fail to reject H_0
E5	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E6	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E7	Reject H_0	Fail to reject H_0	Fail to reject H_0
E8	Fail to reject H_0	Fail to reject H_0	Fail to reject H_0
E9	Reject H_0	Fail to reject H_0	Fail to reject H_0

Table 4.7: Summary of output from t-test (two independent sample means)

eISSN: 2600-7920
INTI JOURNAL
Vol.2, 2018 (10)

5. CONCLUSION

The present research has achieved the three main objectives: (1) To identify the factors affecting the implementation of IBS; (2) To investigate the factors affecting the implementation of IBS; (3) To propose measures for successful implementation of IBS in Malaysia, which are stated in earlier section and proven by the data collected.

In conclusion, the most significant factor affecting the implementation of IBS on high-rise construction is: construction duration will be reduced (C3). To ensure the successful implementation of IBS, the following measures must be taken: (1) The use of more advanced transportation system (E1); (2) Government must provide incentives for high-rise construction (E5); (3) To train more IBS professionals (E2).

This study has achieved the research aim, contributing to Malaysian construction industry by providing the measures for successful IBS implementation in future. The findings and results of data provide effort as a recommendation for other researcher. Meanwhile, providing better understanding for the contractors and profession in factors that affecting implementation of IBS on high-rise construction project in undeveloped regions of Malaysia.

eISSN: 2600-7920
INTI JOURNAL
Vol.2, 2018 (10)

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