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## Building information modelling in Malaysian industrialised building system

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**Abstract.** The growing demand of housing has prompted the Malaysian construction practitioners to realize the benefits of Industrialised Building System (IBS). Despite its advantages, IBS in Malaysia is plagued partly due to inefficient adoption strategy and lack of awareness among the practitioners. Hence Building Information Modelling (BIM) is introduced to facilitate the life-cycle of the project by eliminating construction inefficiencies. The aim of the study is to evaluate the BIM functions in relation to Malaysian IBS work process. In order to achieve the aim, the effectiveness of IBS and BIM implementation in Malaysia were identified. The data is collected through interview sessions with seven (7) IBS-BIM practitioners. Data from the interview were analysed using Content Analysis, summative approach. From the analysis, it was found that there were 4 BIM functions (clash detection, visualization, shop drawing, coordination) are able to integrate in 3 IBS work process (initial work, component production and installation). The causal relationship of IBS-BIM was formulated through linear equation method tabulated from content analysis results. The causal relationship of IBS-BIM explained BIM integrated functions in relation to IBS work flow. This study is essential to assist IBS practitioners to strategies their strategies in enhancing its productivity through the BIM implementation.

*Keywords*— Building Information Modelling; Industrialised Building System; Malaysia.



## 1. Introduction

The construction industry in Malaysia continues to growth since the independent in 1957. Malaysian construction industry has developed from low-tech, labour intensive, craft-based industry to the higher level of technologies implementation [1] [2]. Industrialized Building System (IBS) seem to be an effective method to enhance building quality and performance [3]. However, imprecise strategic decisions in the IBS work flow have led to major problem in cost overrun [4]. As results, Building Information Modelling (BIM) is introduced to enhance the IBS performance in time, cost and quality matters.

BIM is one of the technologies that able to facilitate design, digital representation, scheduling of the project and also control the project in terms of cost and time [5]. Moreover, BIM is a platform to improve the communication between the stakeholders which help to facilitate interaction of different stakeholders in the different stages of design, manufactured, delivering, assembling and operational process [6] [7].

In Malaysia, Construction Industry Development Board (CIDB) has proposed BIM to be integrated in every construction project, and made BIM compulsory for project amount more than RM10mil and above. Similarly to IBS industry, BIM is proposed to be integrated in IBS work flow as it is capable to increase the support for standardization of prefabrication elements [8]. In addition, BIM is able to handle multiple resources and information simultaneously. Complexity in the construction of IBS occurs due the communication deficiency between manufacturing industry and construction industry [9]. Therefore, appropriate technology like BIM is indeed to close up the gap between industries. This study is carried out to evaluate the implementation of BIM in IBS industry in Malaysia. Therefore, this study will be carried out by determine the IBS work process in accordance to BIM functions.

## 2. Industrialized Building System in Malaysia

The number of the construction project that has implemented the IBS system in Malaysia has increased over the years. This can be seen from increasing numbers of IBS manufactured factories from 15 factories in 2009 to 36 factories in 2011. One of the reasons to adopt IBS is the system could reduce construction period, enhance human resources and reduce the wastage of construction material. There are work process in IBS, namely initial works, components production at the factory, transportation of product to the construction site, installation and finishing [10].

- a) Initial Work - Design stage where including conceptual, preliminary design, final design, tender preparation and construction administration [11].
- b) Manufacturing- the component of production comes from the manufacturing process which generally taking place at a specialized facility [12].
- c) Transport- Usually, in Malaysia mode of transportation use to lift the building component is by trucks or trailers, and rail or barge [13].
- d) Installation- Assemble process plays the major role in IBS. The compatible in every piece of component help to reduce on-site construction work [14].
- e) Finishing- IBS components are prefabricated with a considerable amount of finishing work such as wall and floor finishing, electrical wiring and fixtures, kitchen cupboard, plumbing pipes and windows frames. Hence, prefabrication system helps to minimize the amount of skilled workers needed on the construction site [15].

Eventually, the transition of construction method from conventional to IBS has increased of the economic growth in the construction industry from 5.2% in 2010 to the expected growth of 11% in 2013 which stimulated to the growth of Gross Domestic Product (GDP) [17].

BIM implementation in the construction industry has widely explored in numerous studies. BIM offers various useful applications in order to achieve success of the projects such as visualization of construction schedules, detection of construction conflicts, planning of resource utilization, detection of structural safety problems, analysis of workspace congestion, optimization of site layouts, discovery of

inconsistencies among scheduling activities, monitoring of progress discrepancies, discovery of spatial-related hazards, and generation of construction schedules [8]. Despite all the benefit, the implementation of BIM in IBS need to explore as well. By linking the five (5) IBS work processes and the BIM function, this study aims at enhancing the IBS performance through BIM implementation.

The traditional process of precast, the engineering details and fabrication information for precast concrete structures is only defined after the selection of a precast fabricator and the architectural contract drawings are completed before a precast fabricator is selected, building components seldom incorporate fabrication process considerations during the architectural design stage. The format like DWG/DXF, SAT, IGES, etc. in earlier stage allows of most geometric shape [15]. A common problem like losing data corruption that requires manual correction combined with other manual methods has led to significant AEC inefficiencies and costs [19].

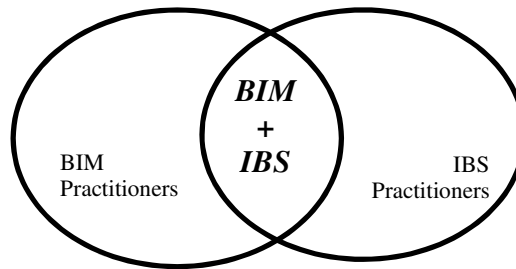
BIM offers a process of re-engineering to enhance the automation in IBS in terms of quality and productivity performance. In order for collaboration to be efficient and effective, it needs to address design intent, fabrication and other production details, and the interface between systems, such as connections and pass-through. These are all potentially available, with proper use of BIM technology. Thus, table 1 shows the potential of BIM to drive the IBS industry in improving the imperative as far as increasing the productivity.

**Table 1.** The Potential of Bim in Ibs Work Process

| <b>IBS Work Process</b>     | <b>Current Implementation of IBS</b>   | <b>BIM Potential</b>  |
|-----------------------------|--|---|
| <b>Initial Work</b>         | Fragmentation in IBS project has been criticized as the obstacle to achieve effective communication and integration between the design and construction team in IBS projects [9] | Helps the practitioners in improving the visualization, communication, and integration in construction operations [16].         |
| <b>Component Production</b> | The design considered the jointing system, sequences in the assembly process and the flexibility to make sure the assembly process could be done safely and quickly [14].        | BIM identifies potential problems such as the design intent, integrity of the model, and the reliability of documentation [17]. |
| <b>Transportation</b>       | Coordination and production scheduling do not match the Just In Time installation. [18].   | BIM-based scheduling approach is used to collaborate with stakeholders in managing the route or transporting the panel [18].    |
| <b>Installation</b>         | High precision is required in IBS construction. Local professional and contractor are lacked of knowledge and experience [9].  | Element could be extracted from systems, assemblies, and sequences of a facility [19].  |
| <b>Finishing</b>            | Poor maintenance management or repairing maintenance method [20].  | BIM provide adequate strategic decision making to analyse information in improving the maintenance project outcomes [14].       |

### 3. Research Methodology

Qualitative approach is selected in this study, this is mainly due to limited BIM practitioners in Malaysian IBS industry, the sampling population is shown in Fig 1. Based on the studies done by [20] and [21], majority of the IBS practitioners were involved in precast construction. Therefore, this study is focusing in Malaysian IBS precast industry only. The interview questions are developed based on the BIM function that fit into IBS work process.



**Figure 1.** Sampling Population

The interviewees were selected from the IBS precast industry in Malaysia who practice BIM in their organization. Seven (7) interviewees were selected from developer, contractor and consultant firms. Mason 2010 [23] suggested a minimum of 6 interviewees for qualitative analysis, meanwhile examine on the saturation of the interviews. However, it is suggested that the greater number of interviewees is able to ensure the defensibility of the data. But it is subjected to the availability of the population sampling. The collected data are analysed through content analysis by summative approach.

Qualitative content analysis has been defined as a subjective interpretation research method for the content of text data through the systematic classification process of coding and identifying themes or patterns [22]. The content analysis emphasizes an integrated view of the texts and their specific contexts. In other words, qualitative content analysis involves a process designed to raw data into categories or themes according to valid inference and interpretation. After the raw data is obtained, the themes and categories emerge from the data through the examination and constant comparison.

The predetermined keywords were identified from literature study. The keywords from the interviewees script is started from identifying the quotes, coding and categorizing the code accordingly. The analysis is done by evaluate the frequency the appearance of keywords [22]. Based on the perception of IBS-BIM practitioners, the causal relationship between the BIM functions and IBS process is produced.

### 4. Data Analysis and Discussion

The utilization of BIM function from perspective of IBS-BIM practitioner throughout the 5 IBS work processes which are initial works, components production at the factory, transported to the construction site, installation, and finishing as per discussed by [10]. The interview result is shown in the Table 3.

Shows the respondents background which comprises of architect, engineer, and drafter.

**Table 2.** Respondents Profile

| Respondent                     | 1         | 2 | 3                          | 4 | 5 | 6                   | 7           |
|--------------------------------|-----------|---|----------------------------|---|---|---------------------|-------------|
| <b>Position</b>                | Architect |   | Senior Structural Engineer |   |   | Structural Engineer |             |
| <b>IBS Experiences (years)</b> | 12        | 3 | 3                          | 4 | 2 | 5                   | 3           |
| <b>BIM Experiences (years)</b> | 6         | 3 | 2                          | 2 | 1 | 2                   | 1           |
| <b>Discipline</b>              | Developer |   | Consultant                 |   |   |                     | Manufacture |

Based on the result in table 3, the respondents agreed that BIM is utilized the most in initial phase, component production and installation process. Respondent 3 stated that BIM is convenient in initial phase for preparation of shop drawing coordination such as structural, architecture, mechanical and electrical and plumbing. During the manufacturing process of IBS components, BIM tool is a computer-aided to support precast concrete design. The utilization of BIM may enhance the understanding of coordination and sequencing of assembling the IBS components. However, none of the respondents mentioned about the utilization of BIM in transportation of the components. During the transportation phase, there are a few considerations such as the length of a volumetric unit which is should not exceed 12m and 4.5m heightand etc. The vehicles are not allowed to enter highway system if the materials had exceeded the limitations [21]. Therefore, the limitations should be taken into consideration during the design phase.

**Table 3. The Potential of BIM in IBS Work Process**

| IBS Work Process     | Respondent 1 | Respondent 2 | Respondent 3 | Respondent 4 | Respondent 5 | Respondent 6 | Respondent 7 | Frequency | %   | Remark       |
|----------------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-----------|-----|--------------|
|                      |              |              |              |              |              |              |              |           |     | (≥ 80%)      |
| Initial Work         | 1            | 1            | 1            | 1            | 1            | 1            | 1            | 7-Jul     | 100 | Accepted     |
| Component Production | 1            | 1            | 1            | 0            | 1            | 1            | 1            | 7-Jun     | 86  | Accepted     |
| Transportation       | 0            | 0            | 0            | 0            | 0            | 0            | 0            | 0/7       | 0   | Not Accepted |
| Installation         | 1            | 1            | 1            | 0            | 1            | 1            | 1            | 7-Jun     | 86  | Accepted     |
| Finishing            | 1            | 0            | 0            | 0            | 0            | 0            | 0            | 7-Jan     | 14  | Not Accepted |

Overall, 100% of the respondents think that the design process takes less time with BIM. This could be attributed to the fact that BIM projects require less time to set up during the early design phases. There was a consensus that the quality of the drawing produced is improved by applying BIM. One of the major benefits of BIM is coordinated drawings; any information requires change in the drawing done to the model is propagated at the BIM database, therefore the information simultaneously received by the stakeholders.

Respondents also agreed that these improvements are recognized as benefits in the construction phase as well as in overall project costs. There are considerable differences in the value added to the IBS project integrate BIM usage into their workflow. Improvement can be seen by the way of presenting design visualization and discipline coordination. The small or large reductions add up to an overall reduction that is noticeable and impacts return on investment. The survey results suggest that time reduction is possible for all types of project team members and at all phases of the project.

Effective utilization of technology is able to increase the efficiency in performing variety of tasks such as visualization, construction simulation, and improving the accuracy of documentation. Successful implementation of BIM depends on collective adoption of BIM across the different disciplines and support by the stakeholder. From the literature, BIM functions seems able to cope with the deficiency in

IBS work process and close up the gap between discipline. BIM offers several useful functions that contribute to positive perception in construction practitioner [21].

Table 4 shows the function of BIM that adopted during the IBS stages. There are 6 functions of BIM that have been mention during the interview.

**Table 4.** BIM Function Adopted in IBS Work Process

| Keywords                          | Respondent |   |   |   |   |   |   | Frequency | %   | Remark<br>(≥ 80%) |
|-----------------------------------|------------|---|---|---|---|---|---|-----------|-----|-------------------|
|                                   | 1          | 2 | 3 | 4 | 5 | 6 | 7 |           |     |                   |
| Clash Detection                   | 1          | 1 | 1 | 1 | 1 | 1 | 1 | 7-Jul     | 100 | Accepted          |
| Prepare Shop Drawing/ Fabrication | 1          | 1 | 1 | 0 | 1 | 1 | 1 | 7-Jun     | 86  | Accepted          |
| Visualization                     | 1          | 0 | 1 | 1 | 1 | 1 | 1 | 7-Jun     | 86  | Accepted          |
| Coordination                      | 1          | 1 | 0 | 1 | 1 | 1 | 1 | 7-Jun     | 86  | Accepted          |
| Improve Construction Sequence     | 1          | 0 | 1 | 0 | 1 | 0 | 0 | 7-Mar     | 43  | Not Accepted      |
| Improve Scheduling and Planning   | 1          | 0 | 0 | 0 | 0 | 0 | 0 | 7-Jan     | 14  | Not Accepted      |

- i. BIM in Clash Detection- From the perception of the consultant engineer, the clash detection helps in ensuring that the component of IBS have a precise size and dimension that fit the installation perfectly. The architect agreed that BIM helps in filter the design model before the shop drawing proceed to the next stage.
- ii. BIM in Preparation of Shop Drawing-A senior structural engineer agreed that BIM is a good platform for information exchange in ensuring the quality of the drawing.
- iii. BIM in Visualization- 3D architectural visualization in BIM allows the architect to visualize the asset that relevant for visual aesthetics in the initial stages.



- iv. BIM Coordination- Respondent 4 agreed that coordination in composite model allows the stakeholders to check the models and support the collaboration of information sharing between different disciplines.
- v. BIM in Construction Sequencing-Respondent 1 stated that BIM provide sequencing of layered which user able to understand about the structural, MEP with all the information required. However, this function only has been mentioned by the first respondent only.
- vi. BIM in Scheduling and Planning- According to the architect, the sequence of work in construction process in BIM will assist in generating schedule. However, this function only has been mentioned by the first respondent only.

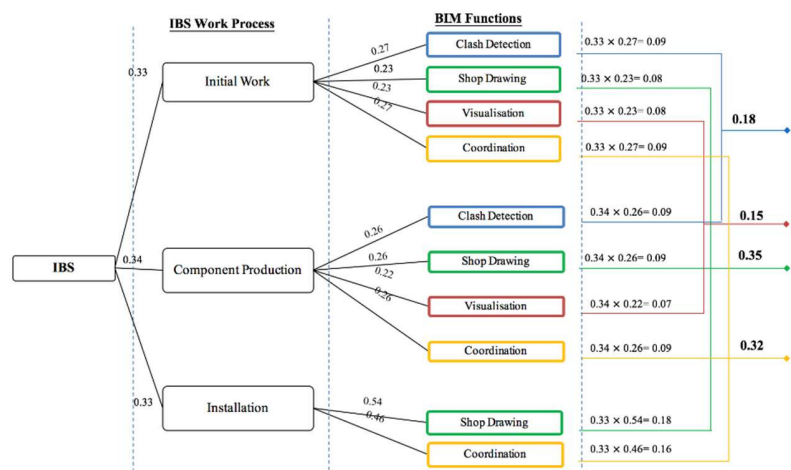
Implementing BIM effectively required significant changes in the work flow. Thus, it appears that the IBS industry could benefit from the adoption of BIM in the organizational through a revolution in BIM technology [21]. The capability of BIM function in meeting the IBS practitioner's needs is summarized according to the IBS process and BIM function.

**Table 5. Weightage of Bim Functions Adopted InIbs Work Process**

| Initial Works                     |              |   |   |   |   |   |   |     |           |          |
|-----------------------------------|--------------|---|---|---|---|---|---|-----|-----------|----------|
| BIM Function                      | Relationship |   |   |   |   |   |   | %   | Weightage | Remarks  |
|                                   | 1            | 2 | 3 | 4 | 5 | 6 | 7 |     |           |          |
| Clash Detection                   | √            | √ | √ | √ | √ | √ | √ | 100 | 0.27      | Accepted |
| Shop Drawing/Fabrication          | √            | √ | √ |   | √ | √ | √ | 86  | 0.23      | Accepted |
| Visualisation                     | √            |   | √ | √ | √ | √ | √ | 86  | 0.23      | Accepted |
| Coordination of Work              | √            | √ | √ | √ | √ | √ | √ | 100 | 0.27      | Accepted |
| Total                             |              |   |   |   |   |   |   | 372 |           | 1        |
| Component Production Work Process |              |   |   |   |   |   |   |     |           |          |
| BIM Function                      | Relationship |   |   |   |   |   |   | %   | Weightage | Remarks  |
|                                   | 1            | 2 | 3 | 4 | 5 | 6 | 7 |     |           |          |
| Clash Detection                   |              | √ | √ |   | √ | √ | √ | 86  | 0.26      | Accepted |
| Shop Drawing/Fabrication          | √            | √ | √ |   | √ | √ | √ | 86  | 0.26      | Accepted |
| Visualisation                     | √            |   |   |   | √ | √ | √ | 72  | 0.22      | Accepted |
| Coordination of Work              | √            | √ |   |   | √ | √ | √ | 86  | 0.26      | Accepted |
| Total                             |              |   |   |   |   |   |   | 330 |           | 1        |
| Installation Work Process         |              |   |   |   |   |   |   |     |           |          |
| BIM Function                      | Relationship |   |   |   |   |   |   | %   | Weightage | Remarks  |
|                                   | 1            | 2 | 3 | 4 | 5 | 6 | 7 |     |           |          |
| Shop Drawing/Fabrication          | √            | √ | √ |   | √ | √ | √ | 86  | 0.54      | Accepted |
| Coordination of Work              | √            | √ |   |   | √ | √ | √ | 72  | 0.46      | Accepted |
| Total                             |              |   |   |   |   |   |   | 158 |           | 1        |

The relationship between BIM function with the IBS work process are determine by the percentage of BIM function during the IBS work process. The shop drawing in BIM recorded the highest weightage value of application which is 0.35, utilized during the initial process, component production and installation process. BIM enhance the quality of drawing by using model and data to the design work, and erection.

Coordination in BIM with weightage value of 0.32 are utilize during initial work, component production and installation process. Clash detection is fully utilized by design team during the initial work process and components productions for designing precast concrete have weightage value 0.18. This proved that clash detection only be utilized in the designing process. The fourth BIM function is visualization with weightage value of 0.15, this function fully utilized the initial work and component production process. Visualization improves the model and makes it presentable for client to understand the model and project.



**Figure 2.** Relationship of IBS work process and BIM function

Time, cost and money are project management item that need to be control during the project. The effectiveness of BIM function give significantly improves performance and outputs across the work process. In the short term, by applying BIM during the initial work able to increase the quality of the drawing and model. In addition, application of BIM in the component production process could increase the quality of the component. The most critical part of IBS is the connection between components as it controls the IBS manufacturing, assembly and also during the use of the buildings performance. IBS components demand a precision dimensioning and proper planning in order to reduce the on-site problem.

Continuous application of BIM in the IBS work process will give the continuous improvement toward the project which helping the economic aspects of the project. The increasing quality of shop of drawing during the initial work stage will lead to increasing quality of the IBS component during the manufacturing process. Thus, the problem during construction could be reduced which lead in eliminating time for rework or extension of time during construction process. Besides time, eliminating rework could save the material resources.

## 5. Conclusion

This study is done by the adoption of BIM functions in IBS work process: initial, component production, transportation, installation and finishing. The utilization of BIM are actually applied during in 3 work process which are initial work, manufacturing process and installation. By correlate the IBS process and

the BIM function, the BIM functions in IBS work process can be appreciate thoroughly. Among the 4 BIM functions, shop drawing have the highest weightage (0.35) followed by coordination of work (0.34), clash detection (0.18) and visualisation (0.15). Besides, this study is essential to raise awareness of BIM adoption in enhancing construction industry performance.

## 6. Acknowledgment

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