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INTEGRATING SYSTEM THINKING IN INDUSTRIALISED BUILDING SYSTEM (IBS) IN MALAYSIA

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Abstract

In the Malaysian context, IBS refers to the prefabrication of building components and off-site construction operations. Its goal is to develop a better building for the client. The Malaysian government has made tremendous efforts to introduce and practise these standards among all building professionals. Although some construction industry members are interested in this approach, most are not. When IBS is used, the design is limited from an architectural perspective. Due to its modular increments, IBS delivers low design flexibility and minimal design innovation. These issues arise from the restriction of knowledge and poor coordination between different professionals and manufacturers. Thus, this research is focused on improving the architects' perception. This research aims to identify system thinking that helps improve architects' design by incorporating IBS. Several researchers have proposed System Thinking incorporating IBS to aid architect's design. These design concepts provide a flexible idea while designing with IBS. This research aims to identify a system thinking that improves architects' design by incorporating IBS in Malaysia. System thinking from various contexts was identified through a literature review. The study adopted a quantitative method. A questionnaire survey was administered to gauge the acceptance of this new design concept among Malaysian architects. The data was analysed using descriptive statistics. The outcome of this research can assist in the design process and positively change the architect's perception of utilising IBS.

Keywords: Architect, Building Information modelling (BIM), Flexibility, Industrialised building system (IBS), System thinking.

1. Introduction

Industrialised Building System (IBS) is the term to represent the prefabrication and industrialised construction concept in the construction industry in Malaysia. In a building construction process using the idea of mass-production of industrialised systems, building components are produced at the factory or on-site, under a controlled environment, including its management and assembly. IBS implements proper coordination through meticulous planning and integration process. In Malaysia, IBS is widely used by the government to represent industrialisation in construction. However, the term covers an extensive scope of applications, including on-site systems, and one can hardly distinguish it from conventional construction practice [1].

The government has begun implementing the IBS construction method in Malaysia's public and private development projects. IBS Roadmap 2011-2015 has outlined a target for public sector building projects to achieve a 70% IBS score and a 50% IBS score for private projects [2]. According to Construction Industry Transformation Plan (CITP) 2016-2020 report, only 24% of targeted public projects have achieved 70% of IBS, while 14% of targeted private projects have achieved 50% [2], as shown in Fig. 1. Although the government's effort is evident in the projected development of CITP, yet there are projects developed utilising conventional or traditional methods other than IBS.

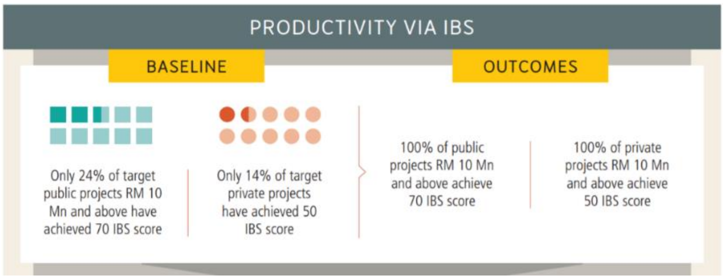

Fig. 1. Implementation of IBS construction scoring target [2].

The term IBS used in Malaysia represents a few attributes such as method approach and process; product, system, and technology; industrialised production; transportation and assembly technique; on-site fabrication, mass-production; structured planning and standardisation; and integration [1]. Thus, IBS is defined as a construction technique where components are manufactured in a controlled environment on-site or off-site, transported, positioned, and assembled into structures with minimal site works and varies from the traditional process of construction [3]. IBS construction process employs prefabrication of building components, emphasising standardisation with an increment size, referred to as a modular component, to achieve mass production.

Problem statement

In Malaysia's architectural industry, IBS is not a favoured choice among architects because of factors such as limited creativity by modular incremental units, low flexibility, monotonous and stifled design results, and others [4]. According to the Construction Industry Development Board (CIDB) report, IBS is not preferred among architects because it restricts design and architectural expression innovation. Furthermore, building components must adhere to certain modular increment units when determining room sizes. One of the key issues driving architects in Malaysia to forego using IBS is the requirement to design with the manufacturer's input.

However, international architectural firms like "Office for Metropolitan Architecture" (OMA) from Dutch and "Bjarke Ingels Group" (BIG) from Denmark have incorporated IBS or prefabricated building components in their design with innovative and outstanding outcomes that are exemplary [5]. Thus, it is unclear if Malaysian architects explored the possibilities of IBS in their designs or if the system is inefficient in the Malaysian setting. How IBS can be implemented in architecture design, especially modern improvements, must be decided during the design stage. Thus, adopting system thinking in the initial stages of architectural design leads to diverse forms and efficient solutions [4]. Therefore, a new system of thinking will improve and enhance the outcome of architectural design in Malaysia.

This study aimed to explore the possibility of incorporating system thinking in the design process to encourage Malaysian architects to adopt IBS. Therefore, this study embarked on the following research questions:

- Can architects use system thinking to incorporate IBS into their design process?
- What is the awareness level of IBS among architects?
- How can architects achieve flexibility through system thinking in the design process with IBS?
- Will system thinking improve the acceptance of IBS among architects?

2. Literature Review and Framework

2.1. Architect's creativity barrier

The industrialisation Building System (IBS) is a cross-professional system that requires every profession's attention. History has proven that industrialised building is more than just a design that solves technical issues. It is a more complex outcome for all professions, such as political roles, rise, and fall of economic and sociological constraints, and is manipulated by practical and intellectual problem solving [6]. Since implementing IBS in building construction, designers have struggled to obtain the desired result because of the limitations of available technology and the desired outcome of IBS, which establishes a systematic construction process [3].

The CIDB report [7] stated that IBS is not preferred among architects because it restricts design and architectural expression creativity. The creativity of architects is limited as they must conform to specific modular incremental units when designing the sizes of rooms. There is also a lack of IBS design knowledge among designers in the industry. Most IBS products are based on proprietary systems due to a lack of standardisation. As a result, the designer must be conversant with the various systems available on the market for diverse programs. CIDB also reported vague definitions of components qualifying as IBS and lacking in the standard post major problems for architects. The lack of architects' training on incorporating IBS into building designs forced manufacturing and assembly redesign, leading to delays [2, 8].

Table 1 summarises the challenges architects face using IBS in their projects. First, detailing or 'jointing problem' was discussed by five authors, followed by lack of IBS knowledge, standardisation of building components, and design according to the manufacturer, discussed by the four authors. The least discussed issues were monotonous and stifled creativity and low flexibility.

Table 1. Factors affecting the adoption of IBS in architect's design.

Factors affecting the adoption of IBS in architect's design	Authors					
	Kamar et al. [1]	CIDB [2]	Ali et al. [3]	Jaganathan et al. [4]	Onyeizu et al. [9]	Haron et al. [10]
Increment unit and standardisation of component	/	/	/		/	
Monotonous and stifles creativity				/		/
The lack of IBS knowledge	/		/	/	/	
Design according to manufacturing	/	/	/		/	
Jointing problem	/		/	/	/	/
Low flexibility			/	/		

2.2. Architectural design flexibility

Flexibility has been evident in architectural design since the Architectural Modernism Movement. Corbusier made the most profound statement on flexibility by designing the Dom-Ino House [11] using an open-plan system. The deconstruction of a building is a factor that architects must consider. It aims to make design principles more adaptable so that buildings can be used for various purposes and environmental conditions at any time.

Flexibility in architectural design is related to spatial flexibility. In IBS, flexibility can be achieved through prefabricated building elements, usually in a cubic grid system. Furthermore, flexibility in architectural design deals with the physical forms, including configurations, connections, shapes, and orientation. Thus, the architects demand flexibility in spatial design and building forms in IBS. Can the prefabricated building elements provide these flexibilities? Various definitions of flexibility in building relating to IBS are shown in Table 2.

Table 2. Definition of flexibility.

Author	Definition of Flexibility
Till and Schneider [12]	A building that can adapt to the changing needs of users.
Hertzberger et al. [13]	Changefulness is permanent and can be used without having to change itself.
Smith [14]	A building that can respond to the volatility.
Jaganathan et al. [4]	Flexibility is the ability of a unit to respond to the changes necessitated by the client, design, and manufacturing requirements.
Shahbazi et al. [15]	Ability to adapt to new conditions and changes in variability, the ability to deal with the changing condition, and the ability to change easily.

2.3. System thinking

To achieve flexibility in IBS, it is crucial to incorporate system thinking in architectural design [4]. The 'system' refers to the interconnection of different elements. This study focuses on the information, processes, and materials used to construct buildings and physical environments such as houses, apartments, or urban spaces. System Structure (2.3.1) and Integrated Model (2.3.2) in the IBS construction industry includes many stakeholders, which include architects, contractors, manufacturers, and others. It involves different documents and information for designing and constructing, lacking [4, 14, 16, 17], resulting in a complex industrial process. Therefore, system thinking, integrating these documents and information to form a hierarchy among each other, is needed to reduce the complexity for an architect during the design stage [4,18,19].

2.3.1. System structure

System Structure is proposed to conceptualise a systemic level in architecture and construction, like a platform development, which governs the architectural design and general construction systems [18, 19]. A system structure can be defined as a way buildings are put together as a combination of thought (ideas) and then represented as an abstract ('system') [19]. This concept is derived from the elements of architectural creation, that architectural design is a combination of thought, process, and matter (physical attributes) [4, 18, 19]. System structure addresses how the architectural whole is put together suitably as an assembly of what the IBS industry can do in the future.

2.3.2. Integrated model

Model refers to an intermediary tool that displays a focused view of a system seen on a specific abstraction or complexity level; a model in system structure is organised structurally as a set of configurations of the subsystem in a building (main system) in the form of patterns [18, 19]. These patterns can be interpreted as a hierarchical relationship between building components or a system structure tier. Thus, System Structure is represented as a model that attempts to establish the concept of a system view on building and architectural design by using flexible constituent elements with varying degrees of integrated complexity [19]. The concept of product architecture and supply chain is used to structure the system. The physical structure of a product's constituent elements is referred to as its architecture. Meanwhile, the supply chain refers to the structure of the flow of the process, materials, and operators [18, 19]. To achieve flexibility in design, the constituent concept of System Structure allows changes according to a specific purpose or context.

System Structure elaborated the classification of levels based on the production system construction and combined with the supply chain model. An off-site and on-site production integration into one single-tier hierarchy system is proposed as a tiers structure (T1-5), as shown in Fig. 2. Figure 3 refers to lower tier numbers expressing a higher system of complexity downstream in the supply chain. In comparison, higher tier numbers represent simpler systems upstream.

Furthermore, these tiers can be categorised based on building methods, using two matrices; product attributes and process characteristics [20, 21], as illustrated in Fig. 4.

The first matrix of product standardisation and volumes describes the product's features in terms of standardisation and production quantities. The second matrix is the degree of off-site production which describes the characteristics of the process in terms of the degree of off-site production or the amount of value-added off-site. The tier structure in System Structure is then classified and defined in detail, as shown in Table 3.

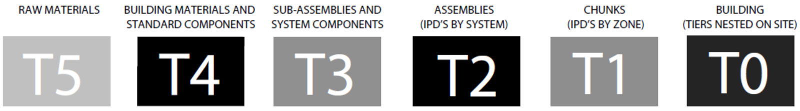

Fig. 2. System structure model: Expression of the system level with new tiers [19].

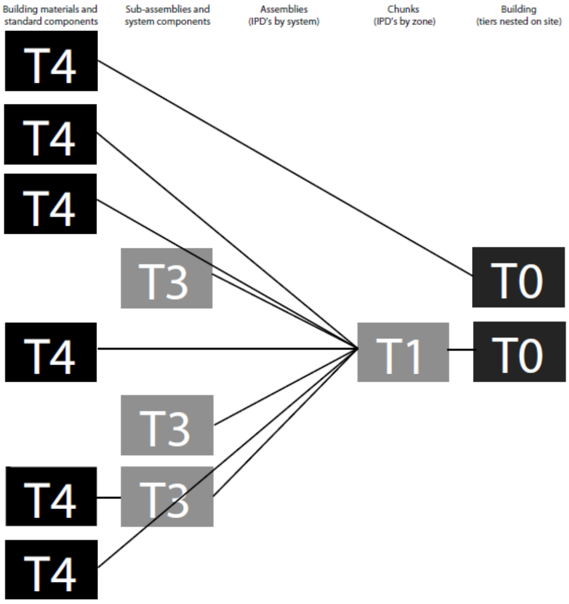

Fig. 3. Conventional prefabrication system [19].

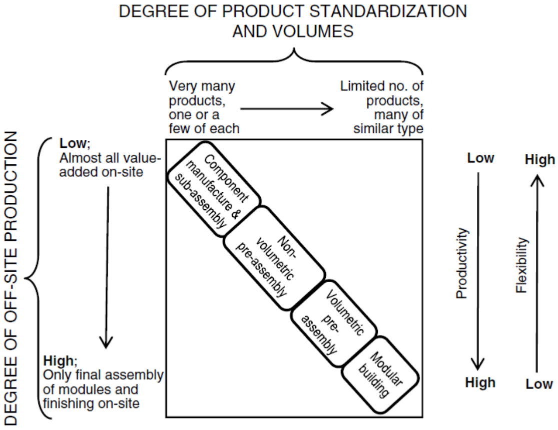

Fig. 4. Classification matrix for the production system in construction [20].

Table 3. Classification and definition of tier system in system structure in relation to the production system in construction.

Tier No. / Classification	System Structure [18, 19]		Classification of Production Systems in Construction [20, 21]		
	Definition	Example	Classification	Definition	Example
Tier 5 (T5) Building material	Manufactured raw materials as one single or a composite material, raw materials are seldom used in a non-processed manner in a building.	Concrete and aluminium.	-	-	-
Tier 4 (T4) Building components	An assembled component - a simple custom-made component of one or few materials or a standard technical device.	Polycarbonate plates, internal wall panels, paint, bolts, and fasteners.	Component manufacture and subassembly	Individual building components are manufactured off-site, offering the highest flexibility.	Column and beam.
Tier 3 (T3) Subassembly system	An integrated assembly of materials or components to create a subsystem.	Curtain wall panels, door and frames, electrical fixtures, and louvers.	Non-volumetric Preassembly	These preassembled units do not create usable space	Cooling system, structural frame, and partition wall.
Tier 2 (T2) Assembly	The integrated assembly of materials or components often encompasses one or a few subsystems in their entirety.	Staircase, partition walls, façade panels, and balcony.			
Tier 1 (T1) chunk	A large volumetric element can integrate a wide range of subsystems or parts if these subsystems are integrated into the building.	Bedroom, living room, and toilet pod	Volumetric preassembly	Volumes of specific parts in the building are produced off-site and assembled on-site within an independent structural frame.	Toilet pods and shower rooms.
Tier 0 (T0) building	-	-	Modular building	These preassembled volumetric units by themselves or when connected to an actual building.	-

2.3.3. Digital Industrialised Building System (IBS) - Building Information Modelling (BIM)

The digitalisation of the Industrialised Building System (IBS) and system thinking is not new. It is implemented in construction practice as Building Information Modelling (BIM). The architecture object mentioned [22] has the potential for full BIM support as it bridges the transformation challenges that usually occur between architecture, engineering, and production during a design process. The delivery of spatial models to complement traditional element-based models is more easily enabled. It is compulsory in BIM delivery specifications, for example, the Construction - Operations Building Information Exchange (COBie) guide and the Common National Requirements for Building Information Modelling (coBIM) series [22]. BIM environments offer output based on standard elements in a spatial architecture view while interacting with the engineering view. Vibaek [19] mentioned that the system structure is more beneficial as it turns into a digital piece of software through a model [22], as in BIM. The model represents the System Structure. The “model” refers to the analytical structure for simplifying the possibility of industrialised construction. The model is used to produce theoretical scenarios and analyse empirical evidence. The model does not address the issue of architectural quality directly. Instead, it aids architectural design work by reducing complexity in focus as an intermediate model, increasing the architectural quality. A model is a tool that explains the potential of industrialised construction in architectural design.

2.3.4. Theoretical framework

The theoretical framework in Fig. 5, shows the entire literature review structure to identify a system structure suitable to promote design flexibility for architects. The IBS is a construction method demonstrating a solid structural bond to architectural design through its structure. It directly affects the way architects design and the outcome of a building. The effect comes from the attributes of IBS. Flexibility is a key factor in architectural design that can encourage architects to use IBS. The literature review focuses on building component flexibility. Architects can use components to create innovative designs. The proposed system structure is system thinking in architectural design to conceptualise a systemic level in architecture and construction that lies between general construction techniques and specific architectural results. 'System Structure' establishes a system view on buildings and architectural design that uses flexible constituent elements with differing levels of integrated complexity. It is a process of breaking down building into smaller components and labelling it with different tiers. Distinct tiers of components can be combined to generate different outputs, allowing for design versatility.

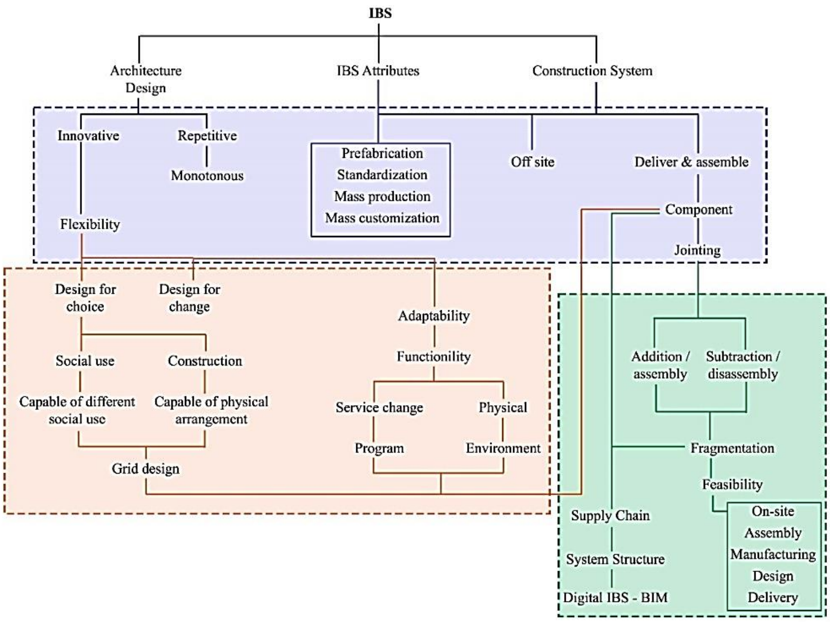

Fig. 5. Theoretical framework for integrating system thinking in IBS.

3. Research Methodology

This paper used a quantitative research method using a questionnaire survey to assess the suitability for architects to integrate system thinking in IBS projects. A survey questionnaire can provide a numeric description of a population's trends, attitudes, or opinions. All the items in the questionnaire were measured with a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The questionnaire had 4 sections, including demographic information, the IBS project information, perception of IBS, and the Systems Structure used in Malaysia (T4-T1). A total of 107 practising architects in Malaysia responded to the questionnaire. Statistical Package for the Social Sciences (SPSS version 20) was used to analyse the data. In addition, descriptive statistical analysis was used to analyse the data by interpreting mean scores and standard deviation.

4. Results and Discussion

The result and discussion describe the perception of IBS and the application of System Structure. First, the data collected are analysed statistically to interpret the mean score of participants' perception of each item, as presented in Table 4. Next, the mean score was interpreted into the participants' low, medium, and high scores. Mean scores ranging from 1.00 to 2.33 indicate that each statement is low or negative. Meanwhile, a mean score of 2.34 to 3.66 indicates a medium or neutral perception. Finally, the mean score is between 3.67 and 5.00, indicating the participants have a high or positive perception of the statements.

Table 4. Interpretation of mean score.

Mean Score	Interpretation
1.00 to 2.33	Low
2.34 to 3.66	Medium
3.67 to 5.00	High

This study had 107 participants. Participants include 57% assistant architects, 35% graduate architects, and 7.5% professional architects. All the participants have prior experience working on IBS projects at the design stage. Approximately 70% have less than 5 years of experience working with IBS, while 29.9% have 6 to 11 years of experience. Participants must be involved in the IBS project at the design stage for the data collected to be valid for this study. The sample comprises 61.7% of participants engaged in less than 5 IBS projects, while 38.3% have been involved in 6 to 10 projects.

The participants have diverse experiences with the IBS project. In terms of project type, 95.3% of participants have worked on residential projects with IBS. In comparison, 72.9% have worked on commercial projects, 29.9% have worked on industrial projects, and 7.5% have worked on institutional projects. IBS has been the most used for residential and commercial buildings as mass production is the practice for residential and commercial buildings. Most participants, 91.6%, have applied the precast system in their projects, making it the most popular construction type among all methods. This was followed by the mixed method project of 79.4%, 49.5% applied the steel frame systems, and the formwork system was the least used (39.3%).

Participants' perception of restriction of IBS in the design process was scored highest (M=3.85, SD=0.79), followed by the familiarity with the term IBS (M=3.74, SD=0.86). This finding indicates that participants familiar with IBS agreed that IBS restricted architectural design. The awareness of government enforcement of the IBS project has a medium score of (M=3.46, SD=0.83). At the same time, the awareness of standardisation of IBS has a medium score (M=2.78, SD=1.11), with a higher standard deviation indicating the scores were inconsistent among participants. The item IBS provides flexibility to architecture design scored the second lowest (M=2.21, SD=0.70), while implementing IBS into projects was scored the (M=2.14, SD=0.81). Findings revealed that the participants were not convinced that IBS could provide architectural design flexibility and had negative opinions about implementing IBS in their projects. The results for factors affecting the adoption of IBS in architecture design, the item, incremental unit, and standardisation of the component were scored the highest (M=3.87, SD=0.54), followed by design according to manufacturing (M=3.79, 0.66) and joint problem (M=3.64, SD=0.75) respectively. The statistics indicate that these three items have had the most impact on adopting IBS in architectural design. Furthermore, monotonous and stifles creativity (M=3.58, SD=0.73), lack of IBS knowledge was scored medium (M=2.98, SD=1.09) and similarly limited choice of materials (M=2.57, SD=0.63), while limited options of IBS construction system was the scored the lowest (M=2.25, SD=0.69).

According to scholars, system thinking helps to systemise the process and information. Architectural design is about components and architectural knowledge integrated to form a building [4, 13, 18]. The result might be based on the current perception of architects toward the IBS construction. The lack of knowledge, information, and documentation of building components and details has become a norm. Therefore, architects prefer to design traditional methods and are unwilling to explore other methods of designing. Table 5 describes the participants' perception of using T4, building materials and standard components in achieving flexibility in design was scored (M=3.51, SD=0.87).

Table 5. Tier 4 (T4) – Building material and standard component.

No.	Item	Mean	Std. Deviation
1	**More choices of building materials and standard components allow the architect to achieve the desired design outcome.**	3.88	0.798
2	**Choices of building materials and components result in a more controllable outcome during the construction process.**	3.81	0.837
3	**A designing architect must have choices for materials and components rather than standardised by manufacturers.**	3.46	0.905
4	**The selection of materials and standard components will influence the design outcome.**	2.88	0.923
	Average Mean Score	**3.51**	**0.867**

Table 6 shows the participants' perception of T3, sub-assemblies and system components of IBS in design flexibility (M=3.56, SD=0.87). Most of the time, material selection has always been a task for architects to handle when designing with any construction methods. To achieve the design, the architect must understand every aspect and detail to ensure every component works upon assembling. With the help of system thinking, things get organised accordingly on a constituent level to avoid missing links. Besides, the medium used to acquire this knowledge has not been discussed entirely throughout this research. Nonetheless, the medium has become an important factor that directly impacts the use of system thinking. As a result, the medium should be easily accessible by anyone at any time.

Table 6. Tier 3 (T3) – Sub-assemblies and system components.

No.	Item	Mean	Std. Deviation
1	**Architects must understand the compatibility of sub-assemblies and system components.**	3.82	0.765
2	**Having control over a smaller system when designing allow for flexibility.**	3.71	0.785
3	**Understanding the assembly of smaller systems helps improve design flexibility.**	3.15	1.038
	Average Mean Score	**3.56**	**0.871**

The questionnaire survey indicates that building components related to these structures are more critical to architectural design while dealing with design flexibility. Participants have a high perception of having control over the sizes and other small details, allowing for more design flexibility. Architects seem to understand the importance of integrating different elements and components into the flexible design. This model is closely related to the current IBS implemented, whereby the architects can choose from various components. This model is closely related to the current IBS implemented, whereby the architects can choose from various components and sizes according to their needs. This critical aspect can be amplified through system thinking and must be implemented in all the tiers. Table 7 describes participants' scores (M=3.47, SD=0.93) for assembly; dimensions, details, structure, and variety will improve the design flexibility.

Table 7. Tier 2 (T2) – Assemblies.

No.	Item	Mean	Std. Deviation
1	**Control over the sizes and other trivial details allows for more design flexibility.**	3.71	1.092
2	**Identifying the compatibility for each component for their assembly process helps reduce design failure during the construction process.**	3.27	0.861
3	**The constituent structure allows architects to produce their building components with various combinations from the lower tier.**	3.69	0.923
4	**Integrating lower tiers allows architects to adopt IBS more structured, improving the architectural design.**	3.19	0.821
	Average Mean Score	**3.47**	**0.930**

Based on the results of T1 (Table 8), it can be concluded that in architectural design, chunks of building elements such as a bedroom or toilet pod are less interesting than other tiers. This was scored as medium but the lowest (M=3.32, SD=0.93), but participants still have a positive perception of T1 and that the constituent elements will help to improve overall architecture design, although not so much on design flexibility. In Malaysia, volumetric construction components are rarely employed due to a lack of technology. Therefore, many researchers do not include T1 in the surveys. However, architects should focus on volumetric IBS as it produces better quality and is under better control. It is also the most sustainable IBS method, where the entire block can be reused.

Table 8. Tier 1 (T1) – Chunks.

No.	Item	Mean	Std. Deviation
1	**This category represents the final prefabrication process (under roof) with the constituent structure of system structure, which allows architects to achieve their desired outcome with IBS.**	3.43	1.024
2	**Chunks of a building made it possible for architects to manage the variety of combinations from the lower tier, from the choice of material to the assembly process, to achieve a better architectural design.**	2.89	0.916
3	**A variety of combinations from integration with different tiers improve the design flexibility**.	3.64	0.853
	Average Mean Score	**3.32**	**0.934**

As a conclusion of the survey, 3 questions were answered by participants. First, the importance for architects to shift towards using BIM was a high score (M=4.02, SD=0.92). The importance of a controlled environment for the design process to achieve the desired outcome has a medium score (M=3.29, SD=0.89). Finally, system structure can increase the adoption of IBS was scored medium (M=3.20, SD=0.91). The findings and discussions are listed according to the research questions for this study in Table 9.

Table 9. Discussion in relation to research questions.

Research Question	Literature Review	Data Collected	Discussion
1. What is the awareness level of IBS among architects?	The awareness level of IBS is low, resulting in low adoption of IBS.	The awareness level of IBS is medium. Participants understand what IBS is but do not want to adopt it.	Architects are aware of IBS's importance but are unwilling to adopt the changes or acquire new skills. This unwillingness has hindered the architects from adopting IBS.
2. How can architects achieve flexibility through system thinking in the design process with IBS?	System Structure, architects, can achieve flexibility when designing with IBS at its fundamental level.	Participants have a medium perception of System Structure, providing flexibility when designing with IBS.	Architects can achieve design flexibility through the fundamental structure of system structure. In addition, it oversees the entire process of checking the compatibility of components and elements.
	Tier 4 (T4): An assembled component is a simple custom-made component of a few materials or a standard technical device.	Participants have a medium perception of T4 will provide flexibility.	Standardised components by the manufacturer meet the requirement of the architectural design. The manufacturer provides various choices. The design has standard materials and components but having more options will improve the architectural design.

	Tier 3 (T3)	An integrated assembly of materials or components to create a subsystem.	Participants have a medium perception of T3 will provide flexibility.	To achieve the design, the architect must understand every aspect and detail to ensure everything works when assembled. Then, with the help of system thinking, things get organised at a constituent level to avoid missing links.
	Tier 2 (T2)	An integrated assembly of materials or components often encompasses one or a few subsystems in their entirety.	Participants have a medium perception of T2 will provide flexibility.	Building components related to these structures are more critical to architectural design ideas while dealing with design flexibility. In addition, participants have a high perception of having control over the sizes and other trivial details, allowing for more design flexibility.
	Tier 1 (T1)	A large volumetric element can integrate a wide range of subsystems or parts if integrated into the building.	Participants who have a low perception of T1 is seeking flexibility.	The chunks of building elements, such as a bedroom or toilet pod, are not interesting to architects compared to other tiers due to the immaturity of technology compared with other IBS methods and constricting design flexibility.
3. Will system thinking improve acceptance of IBS among architects?	Architects can achieve better thinking, hence increasing the usability of IBS.		Participants have a medium perception of system thinking and thus might accept IBS. However, initiatives to improve the knowledge and skills need to be instilled in architects and other industry members to increase the adoption of IBS.	The fundamental elements will help improve overall architectural design and flexibility, given that the architects can control different building components and elements. System thinking will be used. System thinking is used in BIM, thus providing a higher chance of incorporating IBS.

5. Conclusion

Based on the data collected, participants have a medium perception of the application of system structure and the flexibility it can provide for architectural design. According to Malaysian architects, this research has identified that system thinking will enable architects to design with IBS at a medium level. However, architects' opinion of IBS restricting the design process can be addressed by providing specified training to gain knowledge, skills, and technology related to IBS. Thus, it may encourage better adoption of IBS in their projects.

The study revealed that using system thinking can increase the adoption rate of IBS in Malaysia. Additionally, it suggests that practising architects must accept change and acquire new knowledge on IBS classification (Tiers) of raw materials and composites, building components and elements, collaboration with built environment experts and manufacturers, construction processes, technology, and BIM. Moreover, this form of knowledge and its accessibility must be accessible to the public to reduce miscommunication. Therefore, IBS is being taught in various built environment programmes in Malaysian higher educational institutions to allow graduates and young professionals to be familiar with this system. This will also enable easy adoption of IBS in the built environment.

BIM bridges the transformation problems that usually occur between IBS construction parties and the production view in a design process. Although the model does not deal directly with the issue of architectural quality, it supports the architectural design work by decreasing complexity as an intermediate model, thus enhancing the probability of architectural quality. Similarly, participants positively perceive the shift toward BIM while incorporating system structure in the data collected.

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