Cawangan Perak

6th UNDERGRADUATE SEMINAR ON BUILT ENVIRONMENT AND TECHNOLOGY (USBET) 2023

SUSTAINABLE BUILT ENVIRONMENT

25 - 27 SEPTEMBER 2023

E-PROCEEDING

USBET 2023

e-Proceeding

6th UNDERGRADUATE SEMINAR ON BUILT ENVIRONMENT AND TECHNOLOGY (USBET) 2023

SUSTAINABLE BUILT ENVIRONMENT

Published by,
Department Of Built Environment Studies And Technology
Faculty Of Architecture, Planning & Surveying
Universiti Teknologi MARA Perak Branch, Seri Iskandar Campus
usbet.fspuperak@gmail.com

eISSN 2821-3076

9 7 7 2 8 2 1 3 0 7 0 0 2

02 October 2023 | Perak, Malaysia
Universiti Teknologi MARA, Perak Branch, Seri Iskandar Campus

Editors-in-Chief

6th Undergraduate Seminar on Built Environment and Technology 2023

- E- Proceedings-

Organized by,

College of Built Environment (KAB) UiTM Perak Branch

BUILDING INDUSTRIAL SYSTEMS (IBS) EFFECTIVENESS INFLUENCE ON BUILDING MAINTENANCE COST

Najmi Zulkefli[1], Mohd Dzulkarnaen Sulaiman[1*], Maria Elia[1]

[1]Department of Built Environment Studies and Technology,
College of Built Environment, Universiti Teknologi MARA Perak Branch, Seri Iskandar Campus, 32610, Seri Iskandar Perak, Malaysia

Zulnajmi268@gmail.com , *mohdd208@uitm.edu.my, nuyaa.asyaa@gmail.com

ABSTRACT

In the construction industry, the efficiency of Industrialized Building Systems (IBS) has become a critical concern, especially regarding its impact on building maintenance costs. This paper aims to study the effectiveness of IBS and its maintenance costs, particularly concerning remedial efforts. The research objectives include identifying the types of IBS defects, estimating their maintenance costs, and determining the frequency of defects related to IBS. The study utilized a quantitative survey method for data collection, where a questionnaire was distributed via WhatsApp to building facility teams in three selected case studies. The chosen case studies were Boon Siew Honda Sdn Bhd, HP Malaysia Manufacturing Sdn Bhd, and Panasonic Automotive Systems Malaysia Sdn Bhd (PASMY), all located in Pulau Pinang. The findings of this study offer valuable insights into the types and frequency of defects found in IBS structures. This information helps to better understand common issues, enabling the development of preventive measures and maintenance strategies. Ultimately, the research aims to enhance the effectiveness and cost-efficiency of IBS in construction practices.

Keywords: *The industrialised building system (IBS)*, *Defect*, *Maintenance*

INTRODUCTION

The industrialised building system (IBS) is defined by the mass manufacturing of all building elements, including walls, slabs, beams, columns, and stairs, either in factories or on construction sites under stringent quality control. Another definition by Esa and Nuruddin (1998) claimed that IBS is a continuum that starts with the employment of craftspeople for all aspects of building and ends with a system that uses manufactured output to reduce resource waste and increase value for end users. (Junid, 1986) clarified that the industrialised process through which the components are designed, planned, manufactured, delivered, and installed on site is included in the IBS in the construction sector.

LITERATURE REVIEW

Building on-site using components or elements manufactured in series in facilities is referred to as a "industrialised system." These elements include items like ceilings, floors, walls, columns, and beams. The final pieces are created by appropriately joining them together during assembly and construction on the site. However, it is acknowledged that the IBS is the sole method for bridging the supply-demand gap. (Rollet,1986). IBS offers a fast construction duration since it uses components that don't need on-site labour. And the reason for this is because the prefabricated parts are supplied on-site after being created in a controlled setting with a uniform size. Because foundation work at the site and the casting of a precast element in a factory can be done concurrently, and because the only work required on site is the installation of IBS components, less time is needed for construction (R. Taherkhani,2018). Waleed et al.1997 stated that to achieve the Malaysian plan target using the present conventional building system, since each worker typically only completes one home each year, this will need a large staff. A major component in the increase in the cost of the home overall is the growing cost of labour. The labor cost has increased to 30% of the construction cost as compared with 10% a few years ago (Friedman and Cammalleri,1993). Additionally, the site's poor quality control prevents the achievement of the requisite quality. The mass manufacturing of housing with strict quality control is needed to solve the current issues.

Definition of Defect

Generally, a defect under a construction contract is work that is not performed in accordance with the requirements of the construction contract. Assessing what a defect is requires an examination of the terms of the contract to understand what was required of the contractor. Relevant provisions may include terms as to quality, workmanship, design, and materials as well as specifications and drawings.

Category and Type of IBS

According to Badir and Razali,1998, the fully prefabricated building approach may be divided into two groups. The first is factory producing off-site prefabricated, while the second is factory producing on-site prefabricated. In order to hoist the floor and roof slabs into position when the columns and jacking equipment are in place, on-site precasting entails casting the slabs on top of one another. Cast precast components at or close to the building site help to transmit some of the factory's benefits to the site, and in certain cases, they show to be the most efficient technique both financially and organizationally. Off-site fabrication involves casting or prepping part or all of the building's components away from their ultimate locations. Achieving high product quality is made simpler by moving building processes to a factory, where suppliers and supplies are considerably better and may come in economically huge loads. Four IBS categories make up the completely prefabricated building technique. These include load-bearing blocks, sandwich panels, precast concrete, and steel frames.

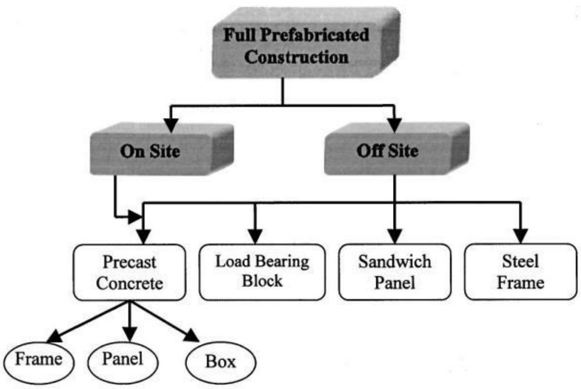

Figure 1

Precast Concrete

Precast concrete construction systems are utilised all over the globe, and they may be divided into three main categories: frame or post and beam system, panel system, and box system (Majzub, 1977). It is notable that all three of these groupings can be built on- or off-site. Precast concrete components offer versatility and adaptability in construction. They can be designed and manufactured to meet specific project requirements, including custom shapes, sizes, and finishes. The use of precast architectural panels allows for the creation of visually appealing facades and aesthetic enhancements. Additionally, precast concrete systems can be easily integrated with other building systems, such as steel frames, to create hybrid construction methods that capitalize on the strengths of each material. The frame system is a common construction method involving a concrete framework consisting of columns and beams that serve as the structural skeleton of a building. This grid of beams and columns supports various building elements such as floors, walls, roof, and cladding. Precast concrete frameworks are often used in low-rise and single- story buildings, where concrete members are delivered to the construction site and assembled using cranes. To enhance the concrete's tensile strength, reinforcement steel (rebar) is used to maintain tension. Rebar is textured for better adhesion to the concrete. The IBS (Industrialized Building System) panel system is a cost-effective and easy-to-install solution for constructing walls. These non-load-bearing walls are designed to withstand wind loads and are cast with a sturdy base, eliminating the need for additional foundation work during installation. The panels do not require plastering and are connected using mortar-filled mesh rings. They are environmentally friendly, made with fake sand to reduce environmental impact and noise pollution. The IBS panel system allows for quick casting of the necessary number of walls. The sandwich panel system involves a low-density core material bonded to thin, high-strength front materials, creating a layered structural system. These panels offer excellent strength with minimal material usage, making them suitable for walls, roofs, and floors in housing construction. The core material prevents compression and buckling, acting as a supporting element between the two facings. Sandwich panels are known for their structural strength, insulating properties, and affordability.

Load-Bearing Block

Load bearing or structural masonry is a part of modern method of construction process which is called as Industrialised Building System (IBS). Fundamentally, this system was designed to carry the imposed, dead load from the building, wind load from the outside and soil pressure. (Azlinda Ramli et al., 2014). This system uses cast hollow blocks that may be made from a number of materials, including thick polystyrene, lightweight concrete, stabilised mud, and concrete. The construction blocks often interlock in four directions to help untrained employees place them. To create a system building structure, the blocks are dry-stacked and stabilised using a variety of techniques. (Yau and Kheong,1996).

Steel Frame

This system is compatible with most other building materials. Steel is a sustainable material that is lightweight, robust, and solid structurally. Plumbing and electrical wiring may be fitted fast and effectively thanks to the frame's prepunched holes. (Sang et al,1996). Commonly utilized with precast concrete slabs, steel columns and beams. Generally involves site casting, and therefore subjected to structural quality control. Tunnel forms, tilt-up systems, beam and columns moulding forms It offer high quality finishes and fast construction with less site labour and material requirement

Sandwich Panel

A low-density core material is bonded to and functionally integrated with relatively thin, high-strength front materials to create a sandwich panel system, which is a layered structural system. The sandwich panel offers outstanding strength for the quantity of material utilised whether used as a wall, roof, or floor element in housing. To prevent compression and buckling in a load-bearing wall, the two facings function as thin columns that are continually supported by the core material. (Friedman and Cammalleri, 1993). Since the core insulating layer is sandwiched between two metal sheets, they get their nickname "sandwich." By supporting the surrounding layers, the core layer creates a composite block with a high level of structural strength. Sandwich panels are well-liked not just for their structural strength and insulating capabilities, but also for their affordability.

Surface Cracking

Surface cracks can occur on precast concrete elements, and they are often caused by shrinkage, improper curing, or inadequate reinforcement. These cracks can affect the aesthetic appearance of the building and, if not properly addressed, may lead to structural integrity issues over time.

Dampness

It typically arises from faulty joint connections between precast components or inadequate waterproofing measures. Water infiltration can cause damage to the building's interior, leading to deterioration of finishes, mold growth, and potential structural problems if left unattended.

Honeycomb

It refers to the detachment of concrete fragments from the surface of precast elements. It can be caused by poor concrete quality, inadequate curing, or exposure to environmental factors such as freeze-thaw cycles. Spalling not only affects the appearance of the elements but also compromises their durability and strength.

Chip-Off

Chip-off is another defect observed in IBS, where small pieces of concrete break off from the surface of precast components. This can occur due to improper handling during transportation or installation, insufficient bonding between layers, or the use of low-quality materials. Chip-off defects can affect the visual appeal and long-term performance of the building.

METHODOLOGY

The research methodology employed a quantitative approach using a questionnaire survey to collect data from 38 respondents working in various roles within the facilities and maintenance sector.

CASE STUDY

The survey of the case study was conducted in Batu Kawan and Seberang Perai, Pulau Pinang, Malaysia. The study focused on three plant which is Honda Bon Siew, HP Malaysia Manufacturing Sdn Bhd, and Panasonic Automotive Systems Malaysia Sdn Bhd (PASMY). Out of 14 respondents from Honda Bon Siew, 10 participated in the study. From HP Malaysia Manufacturing Sdn Bhd, 14 respondents took part out of a total of 18. Lastly, 14 out of 16 respondents from Panasonic Automotive Systems Malaysia Sdn Bhd (PASMY) were included. In total, the survey gathered data from 38 respondents across the three case studies.

Gender

Table 1: Gender

Gender	Number of Respondents	Percentage
Male	34	89.5%
Female	4	10.5%

A total of 38 respondents participated in the survey. Out of these, 34 respondents, accounting for 89.5% of the total, identified as male, while 4 respondents, representing 10.5%, identified as female.

Working experience

Table 2: Working experience.

Working experience	Number of Respondents	Percentage
1-5 years	14	36.8%
6-10 years	15	39.5%
11-15 years	6	15.8%
16-20 years	3	7.9%
>21 years	0	0.0%

The survey reveals the distribution of respondents' working experience. The majority (39.5%) had 6-10 years of experience, followed by 1-5 years (36.8%). Smaller percentages had 11-15 years (15.8%) and 16-20 years (7.9%) of experience. Surprisingly, no respondents had more than 21 years of working experience.

Element that prone to defect

Table 3: Elements that prone to defects

Elements	Number of Respondents	Percentage
Wall	34	89.5%
Column	15	39.5%
Beam	14	36.8%
Slab	10	10.0%
Drain	1	2.6%

The data reveals the frequency of reported defects among the respondents. The most common issue was related to walls, with 34 respondents (89.5% of the total) experiencing problems in this area. Columns followed with 15 individuals (39.5%) identifying issues, and beams were mentioned by 14 individuals (36.8%). Slabs had a lower frequency, with 10 respondents (10%) reporting defects, while drains had the lowest, with only 1 respondent (2.6%) reporting issues.

Common defects in the building

Table 4: common defects in the building

Defects	Number of Respondents	Percentage
Dampness	25	65.8%
Crack	34	89.5%
Honeycomb	15	39.5%
Chip-off	15	39.5%
Sinking	1	2.6%

The data reveals the frequency of commonly reported defects in the building. The most frequently reported defect is cracked, with 34 respondents (89.5%) identifying this issue. Dampness is the next most common defect, reported by 65.8% of respondents (25 individuals). Both honeycomb and chip-off defects were reported by 39.5% of respondents (15 individuals). The sinking was the least commonly reported defect, mentioned by only 2.6% of respondents (1 individual).

Frequency the dampness occurs.

Table 5: Frequency the defects occur.

Dampness	Number of Respondents	Percentage
In a few days	2	7.1%
In a few weeks	2	7.1%
In a few months	12	42.9%
In a few years	12	42.9%

Among the 28 respondents, 2 individuals (7.1%) reported experiencing dampness occurring within a few days, while another 2 respondents (7.1%) indicated dampness becoming noticeable within a few weeks. Furthermore, a significant proportion of respondents, comprising 12 individuals (42.9%) each, reported dampness issues occurring over longer durations. This includes dampness becoming noticeable within a few months and dampness developing gradually over a few years.

Frequency the crack occur

Table 6: Frequency the defects occur (crack).

Crack	Number of Respondents	Percentage
In a few days	1	2.9%
In a few weeks	2	5.7%
In a few months	6	17.1%
In a few years	26	74.3%

The data reveals that the majority of respondents, accounting for 74.3%, reported experiencing crack defects in the building over a period of a few years. Additionally, a significant portion of respondents, comprising 17.1%, reported crack defects occurring within a few months. In comparison, the occurrence of cracks within a few days and a few weeks was less prevalent, with 2.9% and 5.7% of respondents, respectively, reporting such occurrences. Rapid onset of cracks in such short time frames appears to be relatively uncommon based on the data.

Frequency the honeycomb occur

Table 7: Frequency the defects occur (Honeycomb)

Honeycomb	Number of Respondents	Percentage
In a few days	1	4.5%
In a few weeks	4	18.2%
In a few months	6	27.3%
In a few years	11	50.0%

The data reveals that most respondents, accounting for 50.0%, reported experiencing honeycomb defects in the building over a period of a few years. Additionally, a significant portion of respondents, comprising 27.3%, reported honeycomb defects occurring within a few months. In comparison, the occurrence of honeycomb within a few days and a few weeks was relatively less prevalent, with 4.5% and 18.2% of respondents, respectively, reporting such occurrences.

Frequency the chip-off occur

Table 8: Frequency the defects occur (Chip-off)

Chip-off	Number of Respondents	Percentage
In a few days	0	0.0%
In a few weeks	2	9.5%
In a few months	4	19.0%
In a few years	15	71.4%

The data reveals that the majority of respondents, accounting for 71.4%, reported chip-off defects in the building occurring over a period of a few years. Additionally, a significant portion of respondents, comprising 19.0%, reported chip-off defects occurring within a few months. Lastly, among the respondents, 9.5% (2 individuals) reported chip-off defects occurring within a few weeks. This suggests that a small number of instances of chip-off may become noticeable relatively soon after the initial construction or during the early stages of the building's lifespan.

Estimated cost for maintenance work for 1 years

CASE STUDY	ESTIMATED COST (RM)
• HONDA BON SIEW, BATU KAWAN, PULAU PINANG	RM 1,700,000.00
• HP MALAYSIA MANUFACTURING SDN BHD, BATU KAWAN, PULAU PINANG	RM1,200,000.00
• PANASONIC AUTOMOTIVE SYSTEMS MALAYSIA SDN BHD (PASMY), SEBERANG PERAI, PULAU PINANG	RM 1,400,000

The data analysis reveals the estimated cost for maintenance work for 1 year at three different case study locations: Honda Bon Siew in Batu Kawan, Pulau Pinang; HP Malaysia Manufacturing Sdn Bhd in Batu Kawan, Pulau Pinang; and Panasonic Automotive Systems Malaysia Sdn Bhd (PASMY) in Seberang Perai, Pulau Pinang. The costs are as follows: RM 1,700,000.00 for Honda Bon Siew, RM 1,200,000.00 for HP Malaysia Manufacturing, and RM 1,400,000.00 for Panasonic Automotive Systems Malaysia.

CONCLUSION

In conclusion, the case study focused on the industrialized building system (IBS) and the frequency of reported defects in buildings constructed using IBS techniques. The majority of respondents had 6-10 years of working experience. The most commonly reported defects were cracked walls (89.5%) and dampness issues (65.8%), followed by honeycomb and chip-off defects (39.5%). The least common defect was sinking, reported by only one respondent. These defects can occur over different timeframes, with most defects being noticeable within a few years. The estimated cost for maintenance work for one year, based on the data provided, is approximately the costs are as follows: RM 1,700,000.00 for Honda Bon Siew, RM 1,200,000.00 for HP Malaysia Manufacturing, and RM 1,400,000.00 for Panasonic Automotive Systems Malaysia.Overall, the study demonstrates the significant impact of effective quality control and maintenance practices on the long-term performance and maintenance costs of buildings constructed using Industrialised Building Systems (IBS).

ACKNOWLEDGEMENT

Assalamualaikum W.B.T. First and foremost, I would like to say Alhamdulillah and express my utmost gratitude to Allah S.W.T. for the blessing that He has given me to overcome the obstacles and hard work in completing this assignment. To Sir Mohd Dzulkarnaen Bin Sudirman, my supervisor, I would like to convey my profound gratitude for his ongoing assistance with this work as well as for his persistence, inspiration, passion, and vast knowledge. His advice was helpful to me the entire time I was working on this task. I also extend my sincere thanks to my parents and friends for their unwavering support, encouragement, and belief in my abilities. Their presence and encouragement have been a constant source of motivation throughout this journey. I am truly grateful to all the people who have contributed to this assignment, directly or indirectly. Your assistance and guidance have been invaluable, and I cannot thank you enough for being a part of this journey. May Allah bless you all abundantly. Thank you, everyone, for making this achievement possible.

REFERENCES

Tam, V. W. Y., Tam, C. M., Zeng, S. X., & Ng, W. C. Y. (2007). Towards adoption of prefabrication in construction. Building and Environment, https://sci-hub.se/http://dx.doi.org/10.1016/j.buildenv.2006.10.003

Chiang, Y.-H., Hon-Wan Chan, E., & Ka-Leung Lok, L. (2006). *Prefabrication and barriers to entry—a case study of public housing and institutional buildings in Hong Kong. Habitat International,* *https://scihub.se/http://dx.doi.org/10.1016/j.habitatint.2004.12.004*

Gibb, A.G., 1999. *Off-site fabrication: prefabrication, pre-assembly and modularisation*..https://books.google.com.my/books?hl=id&lr=&id=uTiN_aGtXzwC&oi=fnd&pg=PR13&dq=+Off-site+fabrication:+prefabrication,+pre-assembly+and+modularisation&ots=QSvEOOBXmt&sig=McSM4w8LMLwf1RCl09bihX9WJuY&redir_esc=y#v=onepage&q=Off-site%20fabrication%3A%20prefabrication%2C%20pre-assembly%20and%20modularisation&f=false

Massofia Md Ali, Nor Haslinda Abas, Haryanti Mohd Affandi, & Abas, A. (2018, September). *Factors impeding the industrialized building system (IBS) implementation of building construction in Malaysia*. ResearchGate; Engg Journals Publications. https://www.researchgate.net/publication/327903338_Factors_impeding_the_industrialized_building_system_IBS_implementation_of_building_construction_in_Malaysia

Jaillon, L., & Chi Sun Poon. (2008, September). Sustainable construction aspects of using *prefabrication in dense urban environment: A Hong Kong case study*. ResearchGate; Taylor & Francis (Routledge). https://www.researchgate.net/publication/23546726_Sustainable_construction_aspects_of_using_prefabrication_in_dense_urban_environment_A_Hong_Kong_case_study

Polat, Gul (2008). Factors Affecting the Use of Precast Concrete Systems in the United States. Journal of Construction Engineering and Management, 134(3), 169–178. doi:10.1061/(asce)0733-9364(2008)134:3(169)

Massofia Md Ali, Nor Haslinda Abas, Haryanti Mohd Affandi, & Abas, A. (2018, September). *Factors impeding the industrialized building system (IBS) implementation of building construction in Malaysia*. ResearchGate; Engg Journals Publications. https://www.researchgate.net/publication/327903338_Factors_impeding_the_industrialized_building_system_IBS_implementation_of_building_construction_in_Malaysia

Eren, O. (n.d.). *Box Construction Systems Application Principles*. https://www.irbnet.de/daten/iconda/CIB17555.pdf

Pradeepa .S, Jayaraman, A., Soni, L., & Medha. (2016, October). *An Introductionto Precast RCC Wall Panels*. ResearchGate; unknown. https://www.researchgate.net/publication/320689019_An_Introduction_to_Precast_RCC_Wall_Panels

Business Bliss FZE. (2023, January 16). Industrialised Building System: Precast Concrete Elements. Ukessays.com; UK Essays. https://www.ukessays.com/essays/construction/industrialised-building-system-by-using-precast-concrete-elements-construction-essay.php

Azlinda Ramli, Abdullah, C. S., & Mohd. (2014, April). *Definition and new directions of IBS Load Bearing Masonry (LBM) System In Construction Industry*. Researchgate; Unknown

Pejabat Perpustakaan
Librarian Office

Universiti Teknologi MARA
Cawangan Perak
Kampus Seri Iskandar
32610 Bandar Baru Seri Iskandar,
Perak Darul Ridzuan, MALAYSIA
Tel: (+605) 374 2093/2453 Faks: (+605) 374 2299

UNIVERSITI TEKNOLOGI MARA

Surat kami : 700-KPK (PRP.UP.1/20/1)
Tarikh : 20 Januari 2023

Prof. Madya Dr. Nur Hisham Ibrahim
Rektor
Universiti Teknologi MARA
Cawangan Perak

Tuan,

PERMOHONAN KELULUSAN MEMUAT NAIK PENERBITAN UiTM CAWANGAN PERAK MELALUI REPOSITORI INSTITUSI UiTM (IR)

Perkara di atas adalah dirujuk.

2. Adalah dimaklumkan bahawa pihak kami ingin memohon kelulusan tuan untuk mengimbas (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna perpustakaan terhadap semua maklumat yang terkandung di dalam penerbitan melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak tuan dalam perkara ini amat dihargai.

Sekian, terima kasih.

"BERKHIDMAT UNTUK NEGARA"

Saya yang menjalankan amanah,

SITI BASRIYAH SHAIK BAHARUDIN
Timbalan Ketua Pustakawan

nar

Setuju.

27.1.2023

PROF. MADYA DR. NUR HISHAM IBRAHIM
REKTOR
UNIVERSITI TEKNOLOGI MARA
CAWANGAN PERAK
KAMPUS SERI ISKANDAR