

THE EFFECT OF DIFFERENT INDUSTRIALIZED BUILDING SYSTEM (IBS)
CONSTRUCTION METHODS COMPARED TO THE CONVENTIONAL
METHOD ON OCCUPATIONAL SAFETY AND HEALTH (OSH) INDUSTRY
RISKS IN CONSTRUCTION

MOHAMAD ARIFF BIN MOHD AMIN

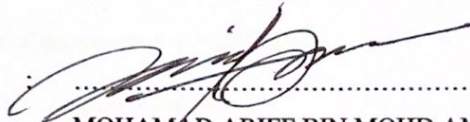
A project report submitted in partial
fulfillment of the requirement for the award of the
Master of Civil Engineering




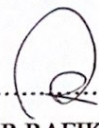
Faculty of Civil Engineering and Built Environment
Universiti Tun Hussein Onn Malaysia

JANUARY 2021

I hereby declare that the work in this project report is my own except for quotations and summaries which I have duly acknowledged.

Student : 
MOHAMAD ARIFF BIN MOHD AMIN
Date : 21/1/2021

Supervisor : 
TS DR NOR HASLINDA BINTI ABAS
Date : 21/1/2021

Co-Supervisor: 
DR RAFIKULLAH BIN DERAMAN
Date : 21/1/2021



PTTAUTHM
PERPUSTAKAAN TUNKU TUN AMINAH

To my beloved mother and father,

My wife, Puteri Natasya Mazenan

And my son, Mohamad Adam Rayyan

Thank you for always supporting and encouraging me to finish my study,

And always pray for my success.

Alhamdulillah.



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

ACKNOWLEDGEMENT

First of all, I would like to express my sincere gratitude to my supervisor and co-supervisor of this study, Ts. Dr. Nor Haslinda binti Abas and Dr. Rafikullah bin Deraman for the continuous support of my master study, for their patience, motivation, enthusiasm and immense knowledge. Their guidance helped me in all the time of study and writing of this thesis. Without their support and guidance, this project notable progress in a proper way.

Besides, I want to thank my both parents and wife for their prayers, supports, patience and encouragement. I appreciated for receiving their supports and prayers during completing this study. I am also indebted to all assessment panels for their valuable critics and advices during this study.

My sincere thanks also go to Universiti Tun Hussein Onn Malaysia (UTHM) for providing me grant during this study. Besides, I also thanked to all the respondents for giving their cooperation and time for this study. It gave me an opportunity to have better understanding about the safety and health.



ABSTRACT

The construction industry is known for the hazardous physical working conditions and high risk of accidents because of the nature of the workplace activities. It is one of the most dangerous business sectors compared to the other industries. The accident cases in construction industry contribute to the rises statistics of accidents in Malaysia. Therefore, IBS construction has been suggested to replace the many initiatives that could be implemented to improve OSH performance due to frequent accidents as a substitute for the traditional construction methods. Improving the performance of the construction industry has pushed forward the need for innovation and adopting new construction methods and technologies in the industry. This study aims to analyze and validate the impact of major activities of the IBS construction method which are prefabricated steel framing system, prefabricated timber framing system and formwork system. This study involved a field observation to on-site that use these 3 types of IBS as a residential building construction method. The data was collected through interviews with the safety and health officers, other than observed the operations involved in each type of IBS method to determine the major activities and OSH risks associated throughout the construction process of the IBS. Next, the activities and the risks involved in each activity were tabulated before it was analyzed and validated with the competent professionals. The findings revealed that the major activities in the prefabricated timber framing system and formwork system have low risk compared to the conventional method. Meanwhile, majority of the activities involved in the prefabricated steel framing system has high risk compared to the conventional method. Moreover, 2 methods have introduced new activities which are prefabricated steel framing system (2 new activities) and prefabricated timber framing system (4 new activities). Therefore, this study offered a better understanding of the risk/hazard of IBS construction method and the effect the IBS towards safety and health.



PERPUSTAKAAN TUNKU TUN AMINAH

ABSTRAK

Industri pembinaan terkenal kerana keadaan kerjanya yang berbahaya dan berisiko tinggi untuk berlakunya kemalangan. Ia adalah salah satu industri yang paling berbahaya berbanding dengan industri lain kerana aktiviti kerjanya. Kes kemalangan dalam industri pembinaan menyumbang kepada peningkatan statistik kemalangan yang berlaku di Malaysia. Oleh itu, pembinaan IBS telah dicadangkan sebagai pengganti kepada kaedah pembinaan tradisional sebagai inisiatif yang boleh dilaksanakan untuk meningkatkan prestasi OSH disebabkan oleh kemalangan yang kerap berlaku. Memperbaiki prestasi industri pembinaan telah mendorong kepada inovasi serta kaedah dan teknologi pembinaan baru dalam industri. Tujuan kajian ini adalah untuk menganalisis dan mengesahkan impak aktiviti-aktiviti utama kaedah pembinaan IBS yang merupakan sistem prafabrikasi kerangka keluli, sistem prafabrikasi kerangka kayu dan sistem acuan. Kajian ini melibatkan pemerhatian lapangan di tapak pembinaan yang menggunakan 3 jenis IBS untuk pembinaan bangunan kediaman. Data tersebut dikumpulkan melalui temubual bersama pegawai keselamatan dan kesihatan, selain memerhatikan operasi yang terlibat dalam setiap jenis IBS untuk menentukan aktiviti utama dan risiko OSH yang terlibat sepanjang proses pembinaan IBS. Kemudian, aktiviti dan risiko yang terlibat dalam setiap aktiviti diterbitkan sebelum dianalisis dan disahkan oleh pakar bagi setiap kaedah pembinaan IBS. Hasil kajian mendapati bahawa, aktiviti utama dalam sistem prafabrikasi kerangka kayu dan sistem acuan mempunyai risiko yang rendah berbanding dengan kaedah konvensional. Sementara itu, sistem prafabrikasi keluli mempunyai risiko yang lebih tinggi berbanding kaedah konvensional. Tambahan lagi, 2 kaedah memperkenalkan aktiviti baru iaitu sistem prafabrikasi kerangka keluli (2 aktiviti) serta sistem prafabrikasi kerangka kayu (4 aktiviti baru). Oleh itu, kajian ini memberi pemahaman terhadap risiko/bahaya di dalam pembinaan IBS serta kesan IBS terhadap kesihatan dan keselamatan.



PTA UTeM
PERPUSTAKAAN TUNKU TUN AMINAH

TABLES OF CONTENTS

TITLE	i
DECLARATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
TABLES OF CONTENTS	vii
LIST OF FIGURES	xii
LIST OF TABLES	xiv
LIST OF SYMBOLS AND ABBREVIATIONS	xviii
CHAPTER 1 INTRODUCTION	1
1.1 Introduction	1
1.2 Problem statement	3
1.3 Objectives of study	4
1.4 Scopes of study	4
1.5 Significance of study	5
CHAPTER 2 LITERATURE REVIEW	6
2.1 Introduction	6
2.2 Method of building construction in Malaysia	6
2.2.1 Conventional method	7
2.2.2 Industrialized building system (IBS) method	8



2.2.2.1	History of IBS implementation	11
2.2.2.2	Classification of IBS system	15
2.2.3	Differences between conventional and IBS method	21
2.3	Overview of accident statistic in construction industry	23
2.3.1	Accident statistic	23
2.3.2	Fatality rate based on type of accident	26
2.4	Safety in Malaysia construction industry	31
2.5	Occupational Safety and Health Legislation	33
2.5.1	Occupational Safety and Health Act 1994	33
2.5.2	Factories and Machinery Act (FMA) 1967	34
2.5.3	Factories and Machinery (Building Operation of Work Engineering and Construction (BOWEC)) 1986	35
2.6	Initiatives to improve OSH performance	35
2.6.1	Safety performance measurement	35
2.6.2	Designing for safety	36
2.6.3	Benefits of practicing OSH	37
2.7	The relative safety of IBS	38
2.8	Previous study	38
2.8.1	Development of risk assessment tool using energy damage model concept and argumentation theory for evaluating industrialized building systems (IBS) occupational safety and health (OSH) risks – Abas (2015)	38
2.8.2	The effect of IBS construction on occupational health and safety - McKay, 2010	41
2.9	Summary	42
CHAPTER 3 RESEARCH METHODOLOGY		44
3.1	Introduction	44



3.2	Research design	45
3.2.1	Phase 1 - Data collection	46
3.2.1.1	Field observation	47
3.2.1.2	Interview	47
3.2.1.3	Document analysis	48
3.2.2	Phase 2 - Data analysis	48
3.2.3	Phase 3 - Validation of comparison table	49
3.2.3.1	Stage 1: Validation of data from interview	49
3.2.3.2	Stage 2: Consensus decision making	52

CHAPTER 4 RESULT AND DISCUSSION **53**

4.1	Introduction	53
4.2	Phase 1 - Data gathering	53
4.2.1	Case study 1 – Prefabricated steel framing system	54
4.2.1.1	Background of the project	54
4.2.1.2	Process associated risk involved in ‘delivery’ works	56
4.2.1.3	Process associated risk involved in ‘pre in-situ’ works	57
4.2.1.4	Process associated risk involved in ‘component installation’ works	57
4.2.1.5	Process associated risk involved in ‘in-situ’ works	58
4.2.2	Case study 2 – Prefabricated timber framing system	58
4.2.2.1	Background of the project	59
4.2.2.2	Process associated risk involved in ‘delivery’ works	61
4.2.2.3	Process associated risk involved in ‘pre in-situ’ works	62



4.2.2.4	Process associated risk involved in 'component installation' works	62
4.2.3	Case study 3 – Formwork system	62
4.2.3.1	Background of the project	62
4.2.3.2	Process and associated risks involved in the 'delivery' works	65
4.2.3.3	Process and associated risks involved in the 'pre in-situ' works	66
4.2.3.4	Process and associated risks involved in the 'component installation' works	66
4.3	Phase 2 - Comparison of IBS method and conventional method	66
4.3.1	Overview of comparison	67
4.3.2	Comparison between conventional and prefabricated steel framing system	69
4.3.3	Comparison between conventional and prefabricated timber framing system	70
4.3.4	Comparison between conventional and formwork system	71
4.3.5	Discussion	70
4.4	Phase 3 - Validation of data	71
4.4.1	Validation interview procedure	72
4.4.2	Prefabricated steel framing system	73
4.4.3	Prefabricated timber framing system	74
4.4.4	Formwork system	75
4.5	Consensus decision-making on the comparison for different IBS methods with conventional construction	78
4.5.1	Prefabricated steel framing system	77
4.5.2	Prefabricated timber framing system	78



4.5.3	Formwork system	79
4.6	Conclusion of result	79
4.6.1	Prefabrication steel framing system	79
4.6.2	Prefabrication timber framing system	80
4.6.3	Formwork system	82
4.7	New activity found compare to conventional method	83
4.7.1	Prefabricated steel framing system	83
4.7.2	Prefabricated timber framing system	84
CHAPTER 5	CONCLUSION AND RECOMMENDATION	86
5.1	Conclusion	86
5.2	Contribution to industry	87
5.3	Limitation	87
5.4	Recommendation	88
	REFERENCES	89
	APPENDIX A	96
	APPENDIX B	97
	APPENDIX C	98
	APPENDIX D	101
	APPENDIX E	102
	APPENDIX F	117



LIST OF FIGURES

1.1	Fatality accidents from 2015 to 2019 in the construction industry (DOSH, 2020)	2
2.1	Types of construction method (Haron, Hassim, Kadir, & Jaafar, 2005)	7
2.2	Main stages of conventional construction (Ross, Cartwright, Novakovic, 2006)	8
2.3	Main stages of IBS construction (Ross et al., 2006)	9
2.4	Large panel systems	16
2.5	Components of precast reinforced concrete frame (Osman, 2017)	17
2.6	Formwork system in IBS construction	18
2.7	Steel framing system in IBS construction	19
2.8	Prefabricated timber framing system in IBS construction	19
2.9	Blockwork system in IBS construction	20
2.10	Innovative system in IBS construction	21
2.11	Dirty and untidy construction site (Mydin, Sani, & Phius, 2014)	22
2.12	Organised IBS construction site (Mydin, Sani, & Phius, 2014)	22
2.13	Accident statistic for construction and overall industry from 2015 to 2019 (DOSH, 2020)	24
2.14	Accident statistic for construction by category (DOSH, 2020)	25
2.15	Major types of accidents at construction sites (Lee et al., 2018)	27
2.16	Benefit of improving occupational safety and health (Lee et al., 2018)	37
3.1	Flow of methodology	45
3.2	Conventional and IBS processes (Abas, 2015)	49
4.1	The project under construction	54
4.2	Progress of construction work	55
4.3	The logs was cutting into the block process	59



4.4	Process of mortise and tenon cutting	59
4.5	Timber framing at the factory	60
4.6	The architectural features of the system	60
4.7	One of block of apartment	63
4.8	The project under construction	63
4.9	The construction on progress	64



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF TABLES

2.1	Categorization of IBS components	11
2.2	IBS and Component Classification (CIDB, 2014)	15
2.3	National occupational accident and fatality rate (DOSH, 2019)	24
2.4	Types of accident and its description (Cham, 2011; Hamid & Misnan, 2017)	28
2.5	Frequency of Types of Accident (DOSH, 2019)	29
2.6	Frequency of the Causes of Accident (DOSH, 2019)	30
2.7	In-situ concrete and masonry method (Abas, 2015)	39
3.1	Number of invitation for validation of data	50
3.2	Part of table for validation of data	51
3.3	Part of rate and opinion given by expert	52
4.1	Risk for delivery during the prefabricated steel framing system method	55
4.2	Risk for pre-in-situ works using prefabricated steel framing system method	56
4.3	Risk for component installation works using a prefabricated steel framing method	57
4.4	Risk for in-situ works using a prefabricated steel framing method	58
4.5	Risk for delivery during the timber framing system method	61
4.6	Risk for pre in-situ works using the timber framing system method	61
4.7	Risk for component installation works using a timber framing method	62
4.8	Risk for delivery during the formwork system method	64
4.9	Risk for pre in- situ works using a formwork system method	65
4.10	Risk for component installation works using a formwork system method	66
4.11	Overview of comparison for each method	67



4.12	Demographic profile of the respondents	72
4.13	Summary of comparison for prefabricated steel framing system	73
4.14	Summary of comparison for prefabricated timber framing system	74
4.15	Summary of comparison for formwork system	76
4.16	Discrepancy of result for prefabricated steel framing system	77
4.17	Agreement result of consensus decision-making for prefabricated steel framing system	77
4.18	Discrepancy of result for prefabricated timber framing system	78
4.19	Agreement result from consensus decision-making for prefabricated timber framing system	78
4.20	Discrepancy of result for formwork system	79
4.21	Agreement result of consensus decision-making for formwork system	79
4.22	Final comparison before and after consensus decision-making for prefabricated steel framing system result	80
4.23	Final comparison before and after consensus decision-making for prefabricated timber framing system result	82
4.24	Final comparison before and after consensus decision-making for formwork system result	83
4.25	New risk of prefabricated steel framing system	84
4.26	New risk of prefabricated timber framing system	85



LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	Questionnaire of respondent's personal background	96
B	Research project overview for respondent	97
C1	Mapping process activities involved in prefabricated steel framing system	98
C2	Mapping process activities involved in prefabricated timber framing system	99
C3	Mapping process activities involved in formwork system	100
D	Invitation to participate in Master Research Project	101
E1	Initial comparison between conventional method and prefabricated steel framing system	102
E2	Initial comparison between conventional method and prefabricated timber framing system	108
E3	Initial comparison between conventional method and formwork system	113
F1	Comparison table of conventional method and prefabricated steel framing system (Respondent 1-3)	117
F2	Comparison table of conventional method and prefabricated timber framing system (Respondent 4-6)	126



APPENDIX	TITLE	PAGE
F3	Comparison table of conventional method and formwork system (Respondent 7-9)	132



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

LIST OF SYMBOLS AND ABBREVIATIONS

A	-	Additional risk
BOWEC	-	Building Operation of Work Engineering and Construction
C	-	More controllable
CIDB	-	Construction Industry Development Board Malaysia
CIMP	-	Construction Industry Master Plan
CITP	-	Construction Industry Transformation Programme
DOSH	-	Department of Occupational Safety and Health
FMA	-	Factories and Machinery Act
IBS	-	Industrialized Building System
LC	-	Less serious consequence
LL	-	Less likely
MC	-	More serious consequence
ML	-	More likely
OSH	-	Occupational Safety and Health
OSHA	-	Occupational Safety and Health Act
R	-	Risk removed
S	-	No change
SOCISO	-	Social Security Organization



CHAPTER 1

INTRODUCTION

1.1 Introduction

The construction industry is one of the important sectors in developing Malaysia to achieve strong economic growth and to chart its course (Asan & Akasah, 2015). It can contribute to our country's economy and able to improve our competitiveness. However, aligned with economic growth, the construction industry also contributed to the high accident rate. The construction industry is known for the hazardous physical working conditions and high risk of accidents. It is due to the nature of the workplace activities which is one of the most dangerous business sectors compared to the other industries (Hassanein & Hanna, 2008; Rahman, 2015).

Statistics from the Department of Occupational Safety and Health (DOSH) records, stated that 6,562 cases of accidents were reported in the construction industry in 2019, compared to 3,345 cases in 2015. It shows an increment of 96.17% which indicated the serious problems in the construction industry. Including the unreported cases, the statistic would be much higher than become the concern in the industry. Despite this, the death average for five years of this industry in Malaysia is 94 employees per year from 2015 to 2019. The trend of fatality to construction workers has risen from 2015 until 2018 as shown in Figure 1.1. The trend of fatality decreased to 72 cases in 2019. However, the fatalities recorded are still high and unacceptable as compared to the other developed countries.

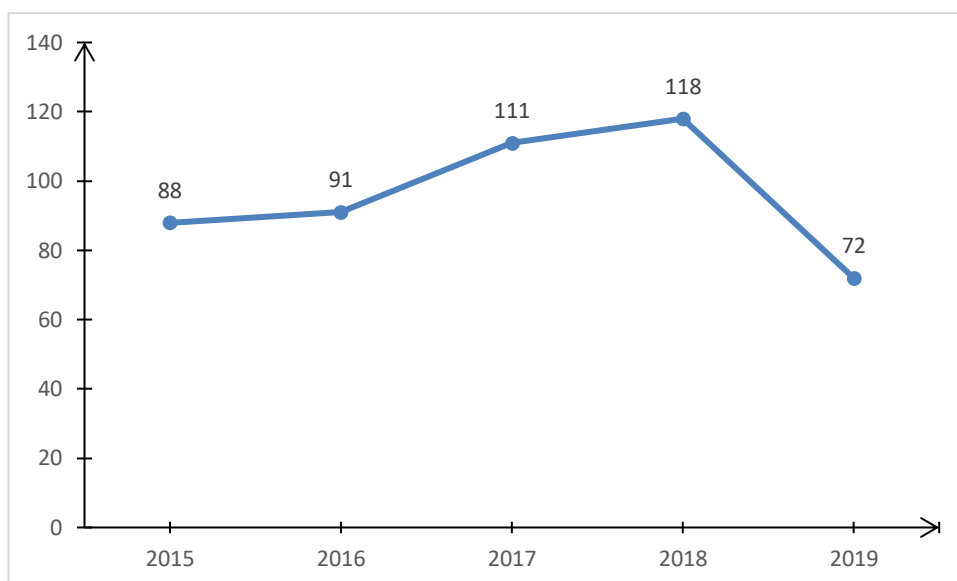


Figure 1.1: Fatality accidents from 2015 to 2019 in the construction industry (DOSH, 2020)

Accidents occur frequently on the construction site, and certain models of accident incidence or prevention have neglected to consider the types of accidents on the building site, although highlighting the various types of accidents that occur on the building site is prevalent (Ng *et al.*, 2012). Accidents are defined as unplanned or unintentional events that result in harm or loss to personnel, property, production or nearly anything that has some inherent value such as targets. Worldwide has identified the construction industry as one of the most hazardous industries and falls from height as a leading cause of fatalities in the construction industry (Hamid *et al.*, 2019). This is due to the current practices in the construction industry which often take place outdoors under conditions that are not advantageous to OSH.

IBS construction was suggested as a replacement for traditional construction methods due to frequent accidents, which could be implemented to improve OSH performance (CIDB, 2007, 2008). The Government of Malaysia is strongly supporting the adoption of IBS and facilitating a paradigm change in the building sector from a conventional to an industrialized approach because of this situation (Abas, 2015). This is demonstrated by the enactment of the Construction Industry Master Plan (CIMP) 2006-2015, which explicitly mentions IBS and its implementation through IBS Roadmaps. To date, the importance of IBS in improving construction industry is highlighted under the Construction Industry Transformation Programme (CITP) 2016-2020 (CITP, 2015). IBS offers better productivity, quality and safety, and can further

help towards a better construction industry, as well as enhance the global competitiveness Malaysian construction industry (Yusof, 2016).

The implementation of IBS has changed the nature of activities, which are different from traditional processes. In IBS, the process is industrialized by which components of a building are conceived, planned, fabricated, transported to and then erected on site (Junid, 1986). Even though several studies are indicating IBS can significantly reduce OSH risks in traditional construction (McKay, 2010). UK government studies like Egan (1998) described the IBS method as a tool for improving health and safety efficiency, but there is a continuing need to resolve the lack of information about the IBS method and its impacts. Awareness concerning the identification of workplace safety and health risks is required at the IBS system factory. Thus, this study aims to investigate the effect of IBS methods on construction OSH risk.

1.2 Problem statement

In Malaysia, safety performance in the construction industry has lagged behind most other industries as evidenced by its disproportionately high rate of accidents and is proven by the report produced by SOCSO Annual report. Statistics reveal between 4,500 and 5,000 cases of construction site accidents every year, with a further average of 80 and 90 fatalities per year (Foo, 2005). According to the Social Security Organization (SOCSO) report in 2000, the case fatality rate in the construction industry in Malaysia was more than 3 times of all other workplaces, 3.3% in the construction sector compared to all other workplaces of 1.1% (SOCSO, 2000). The latest statistic in 2019 indicates that among 4108 accidents reported in the construction industry, 116 cases resulted in a fatality while 977 in permanent disabilities. Meanwhile, the number of fatalities recorded by DOSH (2016) indicated that there are 313 construction workers died due to accidents at the construction site in Malaysia from 2013 to 2015. This high accident and fatality rate has caused concern among industry players.

Some researchers suggest that IBS is safer than traditional in a way that the work location can be shifted to a lower hazard environment (Toole and Gambatese, 2008) and from the field to the factory which allows better control of the hazards

(Gibb, 1999; Toole and Gambatese, 2008). This is supported by McKay (2010) who found that off-site can significantly reduce OSH risks in traditional construction and Gangoelles et al. (2010) who found that the safety risk level of designing an in-situ concrete structure is twice that of the safety risk level of designing a precast (IBS) structure. The implementation of IBS in Malaysia is one of the initiatives of the industry to improve its poor OSH performance (Master Plan for Occupational Safety and Health in the Construction Industry 2005-2010). However, the extent of IBS impact upon safety and health in construction is still doubtful.

McKay (2010) has studied the OSH risk associated with IBS and found that IBS can significantly reduce OSH risk in traditional construction in the UK. However, there is no real investigation of the activities and risks between IBS and conventional construction methods and strategies. Therefore, this study explores how IBS impacts on safety and health by a detailed study of the activities and risks between IBS and conventional construction methods, based on McKay's (2010) method of study.

1.3 Objectives of study

The objectives of this study are:

- i. To identify the risk of the IBS construction process;
- ii. To analyze the risk between conventional and IBS construction methods; and
- iii. To validate the risk of Industrialized Building System (IBS) methods

1.4 Scopes of study

This study covers 3 types of IBS which are prefabricated steel framing system, prefabricated timber framing system and formwork system and focused on the major activities of the construction process in IBS residential buildings which only cover for structure and building envelope. Data has been collected during on-going construction projects, which used the selected construction approaches in order to observe the process involved and to identify the associated OSH risks. The collection of data starts with field observation on three different IBS system construction sites. During the observation, a significant amount of time has been spent directly observing the



PTTA UTHM
PERPUSTAKAAN TUNKU TUN AMINAH

activities and process operations of each case. Site visits have been undertaken to directly observe and document the identified tasks, workstations, equipment and tools in use.

1.5 Significance of study

The Malaysian construction industry has a poor record in OSH performance, as evidenced by the high number of accidents sustained. IBS is suggested as one of the initiatives to improve OSH performance, as it offers process change from traditional to more factory-based methods. This study intends to compare the risk between a conventional method and industrialized building system method that can assess the OSH risks for different construction approaches in the IBS system.

Besides, since the construction industry in Malaysia is actively implementing IBS as an alternative to the traditional construction method, addressing the issue of health and safety in IBS construction is vital because it will affect the industry. This study provides a robust method for comparing OSH risks for different construction approaches which cover the scope of Malaysia's construction industry.



PTTA UTM
PERPUSTAKAAN TUNKU TUN AMINAH

REFERENCES

- Abas, N. H. (2015). Development of a Knowledge-Based Energy Damage Model to Assess Occupational Health and Safety (OHS) Construction Risks in Malaysia Development of a Knowledge-Based Energy Damage Model to Assess Occupational Health and Safety (OHS) Construction Risks.
- Ahmed, T. (2016). Delays in Construction Project, (August).
- Asan, A., & Akasah, Z. A. (2015). Developing an Accident Causation Model for Accident Prevention at Building Construction Sites. *InCIEC 2014*, 273–285.
- Badir, Y. F., Razali, A. K. M., & Hashim, A. H. (2002). Industrialized building system (IBS) in Malaysia. *Journal of Architectural Engineering*, 8(1), 19–23.
- Badir, Y., & Razali, A. (1998). Theory of classification: Its application and Badir-Razali building system classification. *Journal Institute Engineering Malaysia*, 10.
- Baharuddin, A., Rahman, A., & Omar, W. (2006). Issues and Challenges in the Implementation of Industrialised Building Systems in Malaysia, (September), 5–6.
- Bakri, A., Zin, R. M., Misnan, M. S., & Hakim, A. (2006). Occupational safety and health (OSH) management systems: Towards development of safety and health culture. *In Proceedings of the 6th Asia-Pacific Structural Engineering and Construction Conference (APSEC 2006)*. Kuala Lumpur, Malaysia.
- Baxendale, Tony, & Jones, O. (2000). Construction design and management safety regulations in practice - progress on implementation. *International Journal of Project Management* 18, 1, 33–40.
- Cavaye, A. L. M. (1996). Case study research: A multi-faceted research approach for IS. *Information Systems Journal*, 6, 227–242.
- Cham, W. S. (2011). *Quantitative approach to site accident in Malaysia*. Universiti Tunku Abdul Rahman.
- CIDB. (2003). *Industrialized Building System (IBS) Roadmap 2003 - 2010*. Construction Industry Development Board (CIDB), Kuala Lumpur.



- CIDB. (2005). IBS Survey 2005: Survey on Malaysian Architects. Kuala Lumpur.
- CIDB. (2006). *Construction Industry Master Plan (CIMP 2006-2015)*. Kuala Lumpur, Malaysia: Construction Industry Development Board.
- CIDB. (2007). *Malaysian Construction Outlook 2007*. Kuala Lumpur.
- CIDB. (2008). Master Plan for Occupational Safety and Health in the Construction Industry 2005-2010. Kuala Lumpur, Malaysia: Construction Industry Development Board (CIDB).
- CIDB. (2014). *An Introduction of Industrialised Building System*. Construction Industry Development Board (CIDB), Kuala Lumpur.
- CIDB. (2016). *Industrialised building system: The path to enhanced productivity*. Construction Industry Development Board (CIDB), Kuala Lumpur.
- CIDB. (2018). Construction Industry Development Board Malaysia.
- Cooke, R. M. (1997). Uncertainty modelling: examples and issues. *Safety Science*, 26(1–2), 49–60.
- D.J. Edwards, & J. N. (2002). The State of Health and Safety in the UK Construction Industry with a Focus on Plant Operators. *Structural Survey*, 20(2), 78–87.
- Das, S. (2015). Occupational fatalities in the construction sector: A medico-legal viewpoint. *Medicolegal Journal*, 83(2), 93–97.
- DOSH. (2019). *National Occupational Accident and Fatality Rate*. Department of Safety and Health (DOSH), Kuala Lumpur.
- DOSH. (2020). *Occupational Accident Statistics*. Department of Safety and Health (DOSH), Kuala Lumpur.
- DOSM. (2019). *Demographic statistics, Malaysia*. Department of Safety and Health (DOSH), Kuala Lumpur.
- Egan, J. (1998). *Rethinking construction, report of the construction task force on the scope for improving the quality and efficiency of UK construction industry*. London.
- Esa, H., & Nuruddin, M. M. (1998). *Policy on industrialized building system*. Kuala Lumpur.
- Fatih, Y., & Celebi, U. B. (2015). The Importance of Safety in Construction Sector : Costs of Occupational Accidents in Construction Sites The Importance of Safety in Construction Sector : Costs of Occupational Accidents in Construction Sites. *International Journal of Economics and Business Research*, 6(April), 25–37.
- Flynn, L. (2001). *Framing the moment*. Building Design and Construction.



- Foo, C. L. (2005). Budgeting for Occupational Safety and Health Management and its Implementation. *MBAM Annual Safety Conference*.
- Gambatese, J. A., Behm, M., & Rajendran, S. (2008). Design's role in construction accident causality and prevention: perspectives from an expert panel. *Safety Science*, 46(4), 675–691.
- Gangolles, M., Casals, M., Forcada, N., Roca, X., & Fuertes, A. (2010). Mitigating construction safety risks using prevention through design. *Journal of Safety Research*, 41, 107–122.
- Gillham, B. (2000). Case study research methods. *London: Continuum*.
- Hamid, A. R. A., Noor Azmi, M. R. A., Aminudin, E., Jaya, R. P., Zakaria, R., Zawawi, A. M. M., ... Saar, C. C. (2019). Causes of fatal construction accidents in Malaysia. *IOP Conference Series: Earth and Environmental Science*, 220.
- Hamid, R. A., & Misnan, M. S. (2017). Analysis of Fatal Building Construction Accidents : Cases and Causes. *Journal of Multidisciplinary Engineering Science and Technology (JMEST)*, 4(8), 8030–8040.
- Haron, N. A., Hassim, S., Kadir, M. R. A., & Jaafar, M. S. (2005). Building Costing Comparison Between Conventional and Framework System. *Journal of Technology*, 43(B).
- Hassanein, A. A. G., & Hanna, R. S. (2008). Safety Performance in the Egyptian Construction Industry, (June), 451–456.
- Hassim, S., Jaafar, M. S., & Sazalli, S. A. A. H. (2009). The contractor perception towers IBS risk in construction project in malaysia.pdf.
- Health and Safety Executive (HSE). (2006). *Health and Safety in Construction. Health and Safety in Construction HSG150*.
- Heap, Y. C., & Thuan, S. L. (2014). Accidents in Malaysian Construction Industry: Statistical Data and Court Cases. *International Journal of Occupational Safety and Ergonomics*, 20(3).
- Hovden, J., Abrechtsen, E., & Herrera, I. A. (2010). Is There a Need for New Theories, Models and Approaches to Occupational Accident Prevention? *Safety Science*, 48(8), 950–956.
- IBS Roadmap 2011-2015. 2010. (2010). Construction Industry Development Board (CIDB). Kuala Lumpur, Malaysia.
- Irumba, R. (2014). Spatial Analysis of Construction Accidents in Kampala, Uganda. *Safety Science*, 64, 109–120.



- Ismail, Z., & Rahim, A. A. (2009). *Implementing built environment research findings in developing country - the case of East and Southern Africa. International Symposium on Construction in Developing Economies: Commonalities among Diversities.*
- Jeffrey, J., & Douglas, I. (1994). Safety Performance of the United Kingdom Construction Industry. *Proceedings of the Fifth Annual Rinker International Conference Focusing on Construction Safety and Loss Control*, 233–253.
- Junid, S. M. S. (1986). Industrialised Building System. *Proceedings of UNESCO/FEISEAP Regional Workshop.*
- Kadir, M. R. A., Lee, W. P., Jaafar, M. S., Sapuan, S. M., & Ali, A. A. A. (2006). Construction performance comparison between conventional and industrialised building systems in Malaysia.
- Korman, R. (2001). Wanted: New Ideas. Panel Ponders Ways to end Accidents and Health Hazards. *Engineering News-Record*, 26–29.
- Lee, H. C. B., Chen, J. C., & Fo, K. W. (2018). Accidents in Construction Sites: A Study on the Causes Preventive Approaches to Mitigate Accident Rate. *INTI Journal*, 1(3), 1–12.
- Leedy, P., & Ormrod, J. (2001). *Practical research: planning and design (7th editio.)*. New Jersey: Prentice-Hall.
- Lessing, J., Stehn, L., & Ekholm, A. (2002). Industrialised housing : definition and categorization of the concept.
- Lin, J., & Mills, A. (2001). Measuring the occupational health and safety performance of construction companies in Australia. *Facilities*, 19(3/4), 131–138.
- McKay, L. J. (2010). The Effect Of Offsite Construction On Occupational Health and Safety.
- Mehra, C., & Mannan, S. M. A. (2016). Importance of Safety in Indian Construction. *5th International Conference on Recent Trends in Engineering, Science & Management*, 461–468.
- Mohamad Kamar, K. A. (2010). *The critical success factors and readiness of contractors in adopting Industrialised Building System (IBS) construction.* University of Salford.
- Mohammad M.F. (2013). Construction Environment: Adopting IBS Construction Approach Towards Achieving Sustainable Development. *Procedia - Social and Behavioral Sciences*, 85, 8–15.



- Musa M.F.; Mohammad M.F.; Yusof, M. R. and M. R. (2015). The Way Forward for Industrialised Building System (IBS) in Malaysia. *Springer Singapore, 14*, 163–175.
- Musa M.F.; Yusof M.R.; Mohammad M.F. and Mahbub R. (2014). Characteristics of Modular Construction: Meeting the Needs of Sustainability and Innovation. *Colloquium on Humanities, Science and Engineering (CHUSER 2014). IEEE, Penang, Malaysia.*, 216–221.
- Musa M.F. and Mohammad M.F. (2015). Adopting Modular Construction through IBS Approach. *LAP LAMBERT Academic Publishing.*
- Mydin, M. A. O., Sani, N., & Phius, A. F. (2014). Investigation of Industrialised Building System Performance in Comparison to Conventional Construction Method. *MATEC Web of Conferences, 1*, 1–6.
- Mydin, M. A. O., Sani, N., & Taib, M. (2014). Industrialised Building System in Malaysia : A Review. *MATEC Web of Conferences, 1002*, 1–9.
- Nawi, M. N. M., Mydin, M. A. O., Nursal, A. T., Nifa, F. A. A., & Bahaudin, A. Y. (2015). Payment issues in Malaysia Industrialised Building System (IBS). *Advances in Environmental Biology, 9(4)*, 185–188.
- Ng, K., Laurlund, A., Howell, G., & Lancos, G. (2012). Lean safety: Using leading indicators of safety incidents to improve construction safety. In I. D. Tommelein & C. L. Pasquire (Eds.), *Proceedings for the 20th Annual Conference of the International Group for Lean Construction: Are We Near a Tipping Point?*
- Nkem, A. N., Hassim, M. H., & Kidam, K. (2015). Relationship between Unsafe Acts/ Condition and Accidents in Construction Company in Nigeria. *Jurnal Teknologi (Sciences & Engineering), 75(6)*, 73–77.
- Orji, S. E., Nwachukwu, L. N., & Enebe, C. E. (2016). Hazards in Building Construction Sites and Safety Precautions in Enugu Metropolis, Enugu State. *Imperial Journal of Interdisciplinary Research (IJIR), 2(1)*.
- Osman, A. (2017). *Precast concrete structures*. Paradigm.
- Pan, W., Gibb, A. G. F., & Dainty, A. R. J. (2007). Perspectives of UK housebuilders on the use of offsite modern methods of construction. *Construction Management and Economics, 25(2)*, 183–194.
- Pan, W., Gibb, A. G. F., & Dainty, A. R. J. (2012). Strategies for integrating the use of offsite production technologies in housebuilding. *JCEM, 138(11)*, 1331–1340.



- Petersen, D. (1980). *Analyzing Safety Performance*. New York, USA: Garland STPM Press.
- Poon, S. W., Tang, S. L., & Wong, F. K. W. (2008). *Management and economics of construction safety in Hong Kong*. Hong Kong University Press.
- Rahim, A. A., & Qureshi, S. L. (2018). A review of IBS implementation in Malaysia and Singapore. *Journal of the Malaysian Institute of Planners*, 16(2), 323–333.
- Rahman, R. A. (2015). Managing Safety at Work Issues in Construction Works in Malaysia: A Proposal for Legislative Reform, 9(13), 108–121. <https://doi.org/10.5539/mas.v9n13p108>
- Ren, H. (1994). Risk Lifecycle and Risk Relationships on Construction Projects. *International Journal of Project Management*, 12(2), 68–74.
- RMIT. (2009). *Guide to Best Practice for Safety Construction: Design Stage*. Melbourne.
- Rojas, E. M., & Aramvareekul, P. (2003). Labor Productivity Drivers and Opportunities in the Construction Industry. *Journal of Management in Engineering*, 2(1), 78–82.
- Ross, K., Cartwright, P., & Novakovic, O. (2006). *A guide to modern methods of construction*. NHBC Foundation.
- Samad, A. A. A. (2009). *The Use of Industrialised Building Systems in The Malaysian Construction Industry (R&D Perspectives)* (1st ed.). Johor: Universiti Tun Hussein Onn Malaysia.
- Sarja, A. (1998). Integrated life cycle design of materials and structures.
- Smith, G. R., & Arnold, T. M. (1996). Safety performance measurement for masonry construction. In L. M. Alves Dias & R. J. Coble (Eds.), *Implementation of Safety and Health on Construction Sites, Proceedings of the First International Conference CIB Working Commission*, 103–114.
- SOCISO. (2000). *Annual report for 2000*. Social Security Organisation (SOCISO), Kuala Lumpur.
- Spangenberg, S. (2010). *Large Construction Projects and Injury Prevention*. Doctoral Thesis of National Research Centre for the Working Environment. University of Aalborg.
- Szymberski, R. (1997). Construction Project Safety Planning. *TAPPI Journal*, 42, 569–586.



- Thanoon W.A.M., Peng L.W., Kadir M.R.A., J. M. S. and S. M. . (2003). The Experiences of Malaysia and Other Countries in Industrialised Building System (IBS). *International Conference on Industrialised Building Systems. Kuala Lumpur, Malaysia.*
- Trikha, D. N., & Ali, A. A. A. (2004). Industrialised Building System. *Kuala Lumpur: Universiti Putra Malaysia Press, 1.*
- Umeokafor, N., Evaggelinos, K., S. Lundy, Isaac, D., Allan, S., Igwegbe, O., ... Umeadi, B. (2014). The Pattern of Occupational Accidents, Injuries, Accident Causal Factors and Intervention in Nigerian Factories. *Developing Country Studies, 4(15).*
- Warszawski, A. (1999). *Industrialised and automated building systems.* Technion-Israel Institute of Technology, E and FN Spon.
- Weeks, J. L. (2011). Health and Safety Hazards in the Construction Industry. In *Occupational Health and Safety.* Retrieved from <https://www.scribd.com/document/207967526/>
- Yin, R. K. (1994). *Case study research: design and methods.* Thousand Oaks, CA: Sage.
- Yin, R. K. (2009). *Case Study Research: Design and Methods (4th Editio.)* ((4th Editi). Los Angeles, California: Sage Publications Inc.
- Yusof, M. R. (2016). Industrialized Building System Plan of Work. *International Soft Science Conference 2016.*

