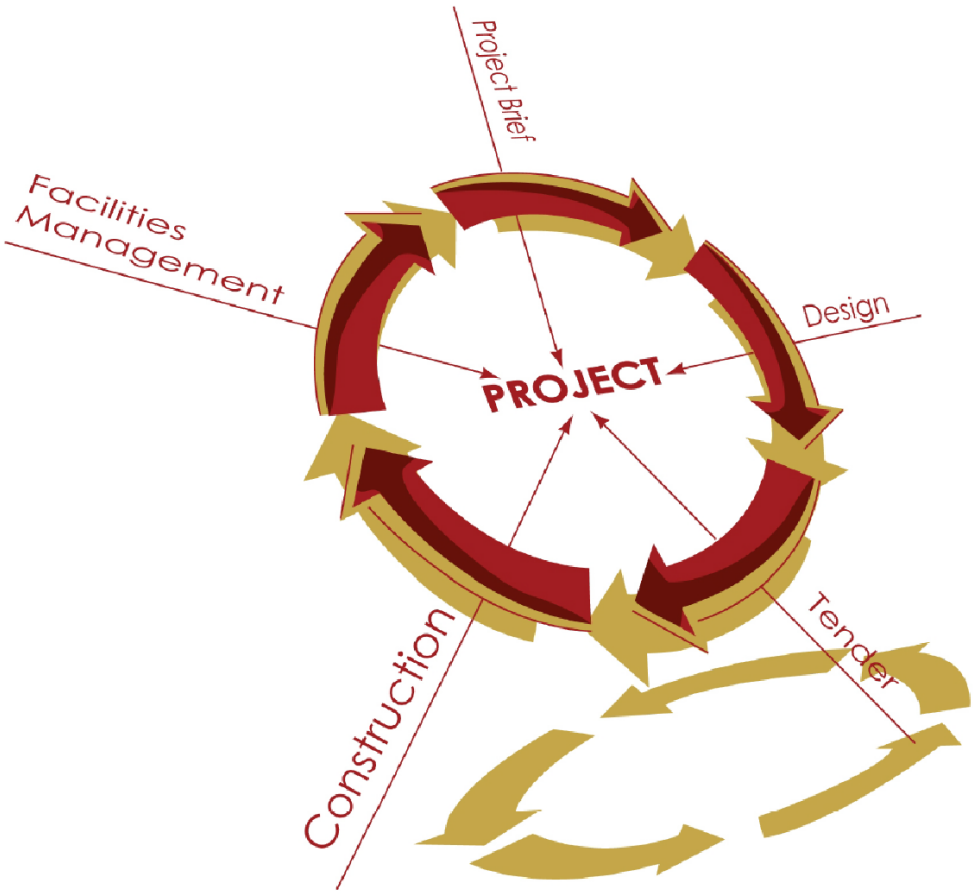
MCRJ SPECIAL ISSUE Volume 20 | No. 3 | 2023 eISSN 2590 - 4140

Malaysian Construction Research Journal

6TH INTERNATIONAL CONFERENCE ON RESEARCH METHODOLOGY FOR BUILT ENVIRONMENT AND ENGINEERING 2023 (ICRMBEE 2023)



CREAM CONSTRUCTION RESEARCH INSTITUTE OF MALAYSIA
CIDB MALAYSIA

MALAYSIAN CONSTRUCTION RESEARCH JOURNAL (MCRJ)

SPECIAL ISSUE Vol. 20 | No. 3 | 2023

6TH INTERNATIONAL CONFERENCE ON RESEARCH METHODOLOGY FOR BUILT ENVIRONMENT AND ENGINEERING 2023 (ICRMBEE 2023)

The Malaysian Construction Research Journal is indexed in
Scopus Elsevier and ASEAN Citation Index (ACI)

eISSN No.: 2590 – 4140

Construction Research Institute of Malaysia (CREAM)
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Introduction

This special issue is compiled in conjunction with the International Conference on Research Methodology for Built Environment and Engineering (ICRMBEE 2023) is to be held on 28th February – 2nd. Mac 2023 at the King Mongkut Institute of Technology Ladkrabang, Bangkok, Thailand. ICRMBEE is the first international conference that will focus on the method adopted in the area of built environment and engineering. The College of Built Environment, Universiti Teknologi MARA, Shah Alam, Malaysia will organize this conference with the theme, 'Synergizing Inclusivity and Sufficiency Towards Sustainable Built Environment and Engineering Research' and co-organized by Faculty of Architecture, King Mongkut Institute of Technology Ladkrabang, Bangkok, Thailand. In recent years, the concept of sustainability has gained significant attention across various fields, including built environment and engineering. As we strive to create a better future for our planet, it is crucial to explore ways to foster inclusivity and sufficiency within these disciplines.

The built environment and engineering play a vital role in shaping our surroundings, impacting our quality of life, and influencing the sustainable development of societies. Inclusivity entails ensuring that all individuals, regardless of their background, have equal access to the benefits and opportunities provided by these sectors. Sufficiency, on the other hand, emphasizes the efficient use of resources, minimizing waste, and promoting sustainable practices. This special issue aims to delve into the intersection between inclusivity and sufficiency within the context of the built environment and engineering research. By synergizing these two concepts, we can uncover innovative strategies, technologies, and policies that promote sustainable development while ensuring that no one is left behind.

We hope that this special issue will serve as a platform for knowledge exchange, inspire new collaborations, and contribute to the advancement of research and practices that synergize inclusivity and sufficiency towards a sustainable built environment and engineering.

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Editorial Advisory Board

Secretariat Special Issue

Editorial

Welcome from the Editors

Welcome to this special issue in Malaysian Construction Research Journal (MCRJ) for the International Conference on Research Methodology for Built Environment and Engineering (ICRMBEE 2023). We would like to express our sincere gratitude to our contributing authors, reviewers, organizers and readers.

This special issue in MCRJ for ICRMBEE 2023 contains twenty (20) profound papers that explore the theme "Synergizing Inclusivity and Sufficiency Towards Sustainable Built Environment and Engineering Research." This issue aims to highlight the importance of sustainability, inclusivity, and sufficiency in the fields of built environment and engineering. It calls for innovative strategies, technologies, and policies that promote sustainable development while ensuring equal access and opportunities for all individuals. The special issue will cover a wide range of topics, including inclusive design, sustainable construction, energy-efficient systems, water and waste management, social equity, and circular economy.

Nur Aisyah Azmi et al., have studied the adoption of BIM in FM is evolving, starting with the design, construction, maintenance, and operating phases of a building's life cycle for better organised, systematic, and flexible building information management. However, BIM research for facility management is still in its infancy, and implementation in this field is even less widespread. There is a demand to produce an up-to-date information concerning the barriers of integrating BIM with FM. Therefore, this paper conducts a systematic literature review (SLR) based on twenty (20) research publications produced from 2018 to 2022 on BIM integration in FM to examine on its implementation barriers. Selection of articles using Preferred Reporting Items for Systematic Reviews and Meta - Analyses (PRISMA) was implemented in this study. The results show similar patterns and areas of research from four (4) insights: people, process, technology, and legal -related issues, together with the in-depth barriers of implementing BIM in FM based on these prevalent areas.

Tung Xhi Zhuan et al., the contractors' sustainable practices during a project 's construction phase and their significance to their competitiveness. The associated impacts on the environment are usually focused during the occupation phase, therefore, the early stages such as in construction should become the main focus, especially contractors, to implement optimum sustainability strategies. There are 14 sustainable practices for the construction site such as energy efficiency, reduce, reuse, recycling methods, and others. Eight (8) types of competitive advantage were found to consist of a higher return on investment, easily recognised by people higher profit, chances of getting projects, and others. Two hundred and fifty -two (252) contractors from G1 – G7 are involved in collecting their standpoints through a questionnaire survey. Statistical Package for the Social Science (SPSS) was adopted by conducting the Frequency Analysis, Factor Analysis, and Correlation. This study found that the most potential sustainable practice is the 'reduce method' due to it is effective and efficient to achieve a low production of construction waste that meets the purpose of sustainability. While the improved image is found as the top potential competitive advantage for contractors when implementing sustainable practices to have a good corporate image to expand their businesses further. A positive correlation was also found that indicated that sustainable practices would lead to the competitiveness of contractors. As sustainable practices are

becoming more crucial, this study provides insight for contractors to foresee the benefits of adopting sustainable practices to increase their project competitiveness further.

Phattranis Suphavarophas et al., have explored the transformative potential of generative design in architectural practice. Generative design is an approach to architectural design that harnesses algorithms and computational power to enable the exploration of alternative design possibilities. This study aims to showcase the process and potential of generative design. The Willis Tower Shading Analysis serves as a case study to evaluate the effectiveness of generative design in shading analysis. The research employed a four-step methodology, including 3D modelling, shadow analysis, variable numerical value generation, and the display and selection of design options. By manipulating variables such as building area, shadow area, overshadowing by neighbouring buildings, and overshadowing of parks, the study generated 45 design options. The findings potential of generative design to efficiently explore diverse design alternatives. Generative design enhances the architectural design process by providing time-saving capabilities, fostering creative design outcomes, and enabling optimization across various design criteria. However, it is essential to note that generative design does not replace the role of architects but rather complements their expertise. The research contributes to advancing architectural design practices and emphasizes the importance of computational tools in transforming the design process.

Nurul Nabilah White et al., have explained on post-colonial buildings exhibit the persisting impact of colonization across periods and geographical regions. Post-colonial buildings in Malaysia's urban and suburban areas are often found in abandoned or dilapidated states. Their neglect is predominantly due to a lack of purpose in modern settings. In answer to this, interior designers can take responsibility for their revival by promoting new ideologies for these buildings. By providing an in-depth examination of the potential revitalisation strategies for abandoned and dilapidated buildings of historical importance, the building’s character can be conserved. Adaptive reuse is a new discipline of retrofitting an existing building's interior, encompassing the renovation and restoration processes in preparation for renewed use. This practice is becoming an essential element of modern interior design and architecture. Adaptive reuse utilises a combination of restoring and modernising existing buildings, allowing them to oblige contemporary practices whilst preserving features from the past. These methods have lower consumption of building materials and waste in comparison with new-build projects, thus reducing the environmental impact of the development. This paper recommends a new preliminary stage of interior design guidelines that incorporates the observation of existing materials and finishes.

Nurul Shakila Khalid et al., have identified to assess the spatial development of KL Sentral using the node-place model introduced by Luca Bertolini. KL Sentral was chosen as the case of transit - oriented development to evaluate the station 's spatial performance by balancing the node and place value of the station, besides using the TOD index. Direct observation was also conducted in KL Sentral to observe passengers' movement patterns and activities, including in the station building and surrounding areas within an 800-metre radius. The result of this study provides theoretical support for node -place value and TOD performance indicators for KL Sentral because, to be a successful TOD station, the system 's node and place functions must be strongly balanced to achieve a high impact on the station. Besides, it facilitates comparability among other stations and assists decision -making and actions in developing Malaysia's railway stations.

Nurul Asyiqin Abdul Razak et al., have showed on the construction industry has regretfully been associated with numerous disputes namely of construction claims due to delay. The concern of delay may lead to further distress in particular of claim for loss and expense. Despite the high number of claims for loss and expense, rejections for its approval often occur. Hence, this paper is aimed to identify issues pertaining to the claim for loss and expense from the perspectives of professional quantity surveyors within the Malaysian construction industry to further delve deeper into the compensation failure in acquiring compensation claims for loss and expense. The research adopted a cross -sectional survey analysis among quantity surveyors registered under the Board of Quantity Surveyor Malaysia (BQSM) as professional practitioners for construction claims. Findings have found two leading causes resulting in claim rejection documentation and contractual issues. Therefore, it is imperative for measures in obtaining successful claim applications for loss and expense to be identified.

Nurul Nabihah Zainal Abidin et al., have discussed the unprecedented COVID -19 pandemic outbreak has affected the world's population and disrupted the global way of life. The new normal is taking over the way of doing things including in real estate business dealings. The pandemic challenges have required new strategy and opportunity to be implemented to sustain the estate agency performance in real estate industry. Therefore, the research objectives are identifying the challenges face by estate agents and to assess the challenging challenges during pandemic COVID -19. The methodology includes literature review and synthesis to explore the current situation of pandemic challenges. The challenges found through the exploration of literature search formed the evidence of the pandemic disruptions in estate agency practice. Another perspective of the content analysis focused on assessing the challenging challenges of the estate agency in accordance with the second research objective. As a conclusion, content analysis on the related literature provides insight for the arousal of new strategies and opportunities to sustain the estate agency performance in real estate industry during COVID- 19 pandemic.

Tengku Anis Qarihah Raja Abdul Kadir et al., have identified on the local rules of architecture that carry identities of the climatic and cultural character beyond the variations, proportions, and visual appearances. The thesis takes apart the elements of vocabulary and form to identify cases that embodied local aesthetic parameters without compromising the prevalent colonial stylistic changes. It then tests these rules and templates with architectural practitioners. The study not only helps to define the terms "generic" and "variant" in a categorization based on archetypes and variants, but it also helps to construct guidance on an architectural style that spans traditional to classical. It further suggests generic rules and frameworks of design and composition, which can be used for public buildings and identity-making in urbanscape and developing guidelines, and regulations of language derived from the essences of the tradition and past forms of the Malay world.

Ezatul Sharida Ahmad Termizi et al., have presented on the conflict that arises in Public Finance Initiative (PFI) within the PPP framework. Through a qualitative approach, the study examines previous research and literature to develop a conceptual framework. Various databases were reviewed, leading to the identification of 17 causes of conflict in PFI projects, which were categorized into three main causes: behavior-related, contract agreement-related, and technical-related conflicts. The study highlights three types of conflict, namely opportunistic and adversarial behavior, as well as resource unavailability.

Conflict management strategies and attributes of relationship quality emerged as crucial aspects of PFI projects. The long-term nature of PFI contracts, spanning 15 to 25 years, poses challenges in maintaining relationships between the private and public sectors.

Nur Hidayah Zakaria et al., Envi-MET, a valuable tool for simulating wind speed around buildings, yielded promising results with an R2 of 0.8186, a relative bias of -0.0775, and an RMSE of 0.2578, indicating acceptable agreement with ground observations. The study revealed that factors beyond building height contribute to destruction; reduced friction with surface features amplifies wind speed. For instance, at 13 meters, wind speed reaches 3.5 m/s, impacting the toll way building's roof and ceiling. High wind speeds exert increased force, causing pressure differentials and potential damage to structures. This study underscores the broader impact of wind on construction and its role in influencing wind speed variations.

Nur Adilla Abd Rahaman et al., have explained on Site Essence and Sensing (SES) method is a new approach that support students to perform a systematic process of site study in interior design work. Initially, site study practices were performed based on architectural and urban planning work method. However, it was noticed that the current approach used has less impact on site appreciation and lacking of understanding towards the integration of site findings and the design process. Therefore, the objective of this research is to produce a framework of SES method, which is believed to be applicable approach for site study in interior design work. A site experimental was carried out by 60 students from Semester 5 of the Bachelor's Degree in Interior Architecture, using a systematic design approach by applying both current site study method and the actual needs of interior design works. This method found that in order to conduct a quality site study for interior design projects, it is necessary to have a comprehensive grasp of the site's essence via both tangible and intangible site values. Findings from this site experiment, suggested for a new SES method framework as the advancement approach for site study in interior design work. This study projected to contribute a better insight of site study not just for academic purposes but may also be applicable to the interior design practices.

Nur Maizura Ahmad Noorhani et al., have discussed of examining how interior designers can acquire project management expertise, to effectively address the previous argument. During the phase of data collection, a total of fourteen key respondents were interviewed in order to identify any existing gaps. The activities of professional groups in the field of interior design were also examined. There exists a notable disparity in project management knowledge and skills between interior design higher education and the practical application of interior design. The most effective approach to bridging the gap in project management skills among interior designers has been identified as a combination of education and practical experience. The skills and knowledge necessary for the practise of interior design, which should be encouraged by professional associations in the field, were also identified. However, it is advisable to undertake additional research in order to develop and enhance the curriculum for interior design in higher education.

Farah Nazira Juhari et al., have studied significant implications as it sheds light on the long -term effects of capital intensity and market regulation on labour productivity in the construction industry. By investigating the relationship between capital intensity, market regulation, and labour productivity, the study contributes to the existing literature on

productivity in the construction sector. The findings have the potential to assist policymakers and industry stakeholders in formulating effective strategies to enhance labour productivity for construction firms in a sustainable manner. Overall, the article emphasizes the importance of addressing the productivity challenges in the construction industry and provides valuable insights that can foster long-term growth and competitiveness in the sector.

Natapon Anusorntharangkul et al., focuses on understanding the identity of Chanthaburi Province to develop an interior design approach for small hotels while also investigating tourists' perceptions of environmental design. This research employs a qualitative approach combined with quantitative analysis. The research tools include conducting in -depth interviews with two sample groups to identify the design factors that effectively convey spatial identity and to examine environments that represent spatial identities. Based on design theory, the findings indicate that integrated designs should possess functional characteristics that align with user behavior and needs. Principles of interior layout facilitate ease of use by allocating space effectively. Moreover, designs should take human proportions into account. Distinctive colors can successfully convey a clear spatial identity, ensuring a customer -friendly environment. Materials utilized should prioritize safety and durability. These results contribute to developing practical designs that align with the research objectives.

Khadijah Ali et al., have focuses on the Royal Malaysian Navy's (RMN) dearth of pro-psycho-behavioral organizational commitment. This study examines the relationship between spatial experience and psycho behavioral orientation, formulates the contextual correlation, and develops a psycho-behavioural inclination model (P-BIM) of spatial experience as well as a public sector conducive ecosystem (EKSA) dimension toward organizational commitment. In this study, the EKSA dimensions of behaviour, general psycho-behavioural inclination, spatial context, and multi-directional associations between spatial experience and psycho-behaviour will be assessed using a mixed-methods methodology. The findings will fulfil the RMN's mission to improve and create satisfaction, belonging, and commitment among Navy personnel; improve spatial planning quality towards a healthier spatial experience for stakeholders; promote Navy Officer psycho behavioral disposition; and decrease RMN training and disciplinary costs. The methodology will assist government programs in achieving a balance between social, environmental, and health welfare.

Nur Nazura Abd Razak et al., have explained on data quality assurance (QA) for terrestrial laser scanner (TLS) by investigating a method that is applicable for outdoor on-site data quality assurance. Through point -based self -calibration method, this research has systematically reduced the required surface dimensions for target distribution. The results showed that with a surface dimension of 3.6m (width) x 1.2m (height) for target distribution, the derived calibration parameters improved the accuracy of raw TLS data by up to 57%. However, statistical analysis and synthetic errors experiments indicated disagreement with the derivation of calibration parameters for angular measurement. Thus, the study concluded that the minimum network configuration for TLS self -calibration is only applicable for deriving errors in range measurement, quantifying the sensitivity of this method in improving TLS systematic errors.

Farrah Zuhaira Ismail et al., have demonstrated on all the UN-OWG indicators and factors of SDG 11 towards sustainable urban development in selected ASEAN nations of Malaysia, Indonesia and Thailand. The aims in this research are to evaluate the implementation level using indicators and factors of ways in making cities function differently today's economically challenged municipality administrations without expanding the additional costs.

Ridzuan Saedin et al., have presented on the fundamental premise of BIM revolves around facilitating collaboration across diverse project teams throughout the entirety of a project's lifecycle. Despite the Malaysian construction industry's ambitions to integrate BIM into public projects exceeding RM10 million in value, the utilisation of BIM remains vague in public projects financed by the Royal Malaysia Air Force (RMAF) and overseen by the Malaysian Public Works Department (PWD). As a result, the primary objective of this paper is to investigate the present awareness of BIM among project teams within the RMAF. A survey in the form of a questionnaire has been disseminated to project teams engaged in public building projects across Malaysia, funded by the RMAF. This research adopted descriptive data analysis using a combination of manual calculation of maturity level score and Statistical Package for the Social Sciences (SPSS). Findings indicate a significant majority of project teams within the RMAF exhibit limited awareness of BIM implementation. Consequently, further investigation is needed to examine the underlying factors contributing to this conspicuous lack of awareness within the teams, with corresponding suggestions for enhancement. From there, this could help public officers like RMAF to have a better awareness of how to adopt modern construction practices which enhance a country's standing on the global stage.

Ahmed Mohammed Salem Balfaqih et al., have studied on the BIM adoption in Saudi AECO industry and its influencing factors. A literature review was carried out to study the adoption of BIM and its significant benefits throughout a project's lifecycle, in addition to its challenges and the influencing factors. A quantitative research approach was adopted using questionnaire surveys to collect data from G4 and G5 contractors in Saudi Arabia. Descriptive statistics were used to analyse the data obtained from the surveys. The findings show that stakeholders are generally aware of the potential benefits BIM can provide during pre-construction, construction, and post-construction phases, including accuracy of technical drawings and visualization, details of construction progress, and a sufficient database for the client and project team. However, several challenges were discovered which limit the implementation of BIM, such as a lack of BIM education and training, poor collaboration, cost and time, lack of available expertise, resistance to change, and lack of publicity. In order to push the construction players to implement BIM, external and internal factors have been found to influence them, including enhancing the publicity of potential BIM methods, providing standards and guidelines, training for staff, and securing the necessary resources to adopt BIM. The study concludes that the implementation of BIM in construction projects in Saudi Arabia has the potential to enhance project performance in terms of time, cost, and quality, and overcome common issues associated with these factors throughout all stages of a project.

Mohd Faiz Abd Rahman et al., have studied on highlight the return of investment and cost risks that possibly encounter during the life span of the buildings or infrastructures. Besides green building, "green highway" or "green road" is among the emerging concern in sustainable construction. The establishment of Green Highway & Road (H&R) Rating Tools such as Malaysia Green Highway Index (MyGHI), offers multi-criteria of sustainable initiatives that count towards the score of the green certification of H&R. This paper aims to establish relationship of life cycle costing components to the green highway projects using the highways certified by MyGHI to identify relationships between LCC components and the green highway's criteria cost. A questionnaire survey of 65 respondents was conducted. Friedman's Test and Spearman's Correlation Coefficient Analysis were used to validate LCC component and establish the relationship. Then PLS-SEM was used to validate the correlation coefficient of cost component towards total LCC of green criteria. Results show that the energy efficiency green criteria cost have a positive and significant relationship except for capital, maintenance, and replacement costs. This study innovation is novel in terms of an alternative for reducing the negative perception of green highways and exceptionally facilitates decision-making, hence, aiding the H&R stakeholders in foreseeing the green highway cost benefits.

A SYSTEMATIC REVIEW ON BARRIERS IN INTEGRATING BUILDING INFORMATION MODELLING (BIM) IN FACILITIES MANAGEMENT

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Abstract
Building Information Modelling (BIM) and Facilities Management (FM) systems can be utilized to create a digital repository for each building component for the management of buildings, facilities, and other fixed assets. The adoption of BIM in FM is evolving, starting with the design, construction, maintenance, and operating phases of a building's life cycle for better organized, systematic, and flexible building information management. However, BIM research for facility management is still in its infancy, and implementation in this field is even less widespread. There is a demand to produce an up-to-date information concerning the barriers of integrating BIM with FM. Therefore, this paper conducts a systematic literature review (SLR) based on twenty (20) research publications produced from 2018 to 2022 on BIM integration in FM to examine its implementation barriers. The results show similar patterns and areas of research from four (4) insights: people, process, technology, and legal- related issues, together with the in-depth barriers of implementing BIM in FM based on these prevalent areas. The identification of these barriers can help the facility managers and authorities to successfully integrate BIM in FM which would further lead to a better performance and maintenance in asset management.

Keywords: *BIM; Facility Management; Maintenance; Challenges; Issues; Barriers; Integration*

INTRODUCTION

Facilities Management (FM), which is characterized as the administration of both physical and non-physical facilities as well as variable business requirements, has become one of the industries with the greatest rate of advancement throughout time. FM personnel often invest a lot of time and effort gathering data from various hardcopy and electronic documents during the maintenance and operations stage of building maintenance (S. T. Matarneh et al., 2019). Consequently, it has resulted into inadequate maintenance management and drastically decreased stakeholder satisfaction, thereby negatively effecting the success of building maintenance (S. T. Matarneh et al., 2019). Multiple new technology systems, data repositories, and database management systems, such as building energy management systems (BEMS), building automation systems (BAS), computerized maintenance management system (CMMS), computer aided facilities management (CAFM), and document management system (DMS), simplify the integration and management of information (Matarneh et al., 2019; Marmo et al., 2019). Nonetheless, such system requires manual data entry, which might lead to error-prone procedures (Matarneh et al., 2019). Additionally, handover of data to the FM phase is protracted until the building phase is complete, and information is often conveyed in non-digital or manual formats. It is extremely challenging for stakeholders and facility personnel to verify whether the necessary data is included during the handover due to the late transfer of unstructured data (Patacas et al., 2015; Wen, Tang & Ho, 2020). Certain information must be transmitted to FM systems, which is a costly and time-consuming process. As a result, it may take longer than anticipated before the

building functions to its full potential (Patacas et al., 2015; Wen, Tang & Ho, 2020; Matarneh et al., 2018; Dijmarescu & Christopher, 2021).

According to Marmo et al. (2019) BIM technology offers FM practitioners a favourable environment for information sharing. Even though BIM usage continues to rise in Malaysia, little studies has been conducted, particularly on BIM-FM integration. According to studies, using BIM in the FM could offer numerous of advantages (Ariffin, Mustafa and Sapri, 2023). The automated procedure, where connection between BIM-FM offers a chance for data transmission and updates through the 6D BIM model, is one advantage of BIM integration with FM. Whereas according to Nicał and Wodyński, (2016) 6D BIM principally geared on enhancing FM practices' efficacy, which appears to intersect with the building's life-cycle performance. In order provide precise data and enhance maintenance procedures, the integration process will enable quick and effective access to information on all facility components. Facilities managers need to have a solid understanding of the building information modelling (BIM) process and the value BIM data may bring during the operational phase as prospective important stakeholders in BIM projects.

By offering a systematic platform for diverse data sources as opposed to an accessible data interface, BIM offers a great opportunity to improve facility management information (Marmo et al., 2019; Matarneh et al., 2019). Previous research has shown that BIM could be used as a unified digital application of a built asset to streamline the design, construction, and operation phases (Samsuddin & Ahmad Zaini, 2022; Patacas, Dawood & Kassem, 2020; Kiviniemi & Codinhoto, 2014; Matarneh & Elghaish, 2021). However, there are still barriers to the incorporation of BIM into FM, such as a lack of knowledge on the kind of information required by the FM personnel throughout the maintenance and operation stages and the process to transmit this data to current systems (Samsuddin & Ahmad Zaini, 2022; Patacas, Dawood & Kassem, 2020; Kiviniemi & Codinhoto, 2014; Matarneh & Elghaish, 2021).

Diverse operation and maintenance practitioners working on various types of facilities, the BIM data requirements can also vary. As a result, there is a horizontal and sequential flow of information between these levels. Controlling the quality, applicability, and accuracy of this information is essential, particularly for efficient decision-making throughout the operation and maintenance (O&M) phase (Ariffin, Mustafa and Sapri, 2023). Evaluation of the information quality (IQ) of the BIM model for facility management is therefore one of the most challenging tasks for owners after project handover. Unfortunately, the majority of BIM data are created during the design and construction phases, leading to a number of quality issues, including incorrect, insufficient, or unnecessary data.

Moreover, the absence of a framework that tackles the complete BIM for FM process continues to limit the adoption of BIM into FM (Kiviniemi & Codinhoto, 2014; Patacas, Dawood & Kassem, 2020; Samsuddin & Ahmad Zaini, 2022; Becerik-Gerber et al., 2012). Even though BIM technology has developed to an extent of widespread acceptance, numerous BIM for FM implementation issues still exist. To integrate BIM into FM successfully and sustainably, it is critical to overcome these obstacles (Becerik-Gerber et al., 2012; Kiviniemi & Codinhoto, 2014; Patacas, Dawood & Kassem, 2020). Hence, the goal of this research is to conduct a thorough review of potential barriers to integrate BIM into FM.

Facilities Management (FM)

FM can be described in several ways, like asset management and finance, operations and maintenance, and prompt implementation of management and planning techniques (Abdullah et al., 2013). According to the most recent standard ISO 41001:2018 Facility Management – Management System, facility management is a management function that combines people, place, and process within the built environment to enhance people's quality of life and business's performance (Babinsk & Apanaviien, 2020). Facility employees and staff frequently need entry to the facility in order to carry out inspection and maintenance tasks. Facility employees frequently use paper or note cards, which could result in one of the biggest issues in the FM sector, the massive volume of data that needs to be captured and stored during the lifecycle of the facility (Naghshbandi, 2016). The issues become increasingly difficult during design and construction and, consequently, escalate throughout the lifecycle of the facility as information is necessary for enabling efficient and effective building maintenance and daily operations. Additionally, it increases the lifecycle cost, which accounts for 75–85% of the whole lifecycle (Muhammad & Mustapa, 2020). The fragmentation of information is the fundamental reason why the FM sector presently battles with information management (Doumbouya, Gao & Guan, 2016; Arayici, Onyenobi & Egbu, 2010; Dixit et al., 2019).

Due to low recognition of FM, real estate organizations currently manage properties as a whole. Only one industry which is healthcare has embraced FM to a large extent (Kamaruzzaman et al., 2018). FM was first introduced to Malaysian operations in this industry in 1997. As a result of the government's 1989 launch of the Excellent Work Culture Movement to promote excellent service in the public sector, an administrative directive titled "Guidelines for Strategies for Quality Improvement in the Public Service" was adopted in 1992 (Kamaruzzaman et al., 2018). The Malaysian government has not structured its FM development or execution despite the measures that have been taken. Unlike other nations where the IFMA, BIFM, and Facility Management Association of Australia have been established to recognize FM, the Malaysian Association of Facilities Management (MAFM) is still unknown to the general public and other professionals. The organization was founded in 2001, but as of 2014, neither anything remarkable nor any meaningful efforts have been taken to develop the local FM profession.

Meanwhile, about 60% of a facility's overall lifecycle costs are related to operations. Maintenance and repair related tasks have dominated operations (Liu & Issa, 2013). The O&M phase is the longest in the building lifetime, which is widely recognized. This period of time is the most pricey because all buildings need funds on work, materials, upkeep, and renovations. O&M expenses are said to account for 85% of the project's overall costs (Altohami et al., 2021). It is apparent there are demands and opportunities for the FM business to advance further with strategic plans and actions by the government, despite the lower acceptance and acknowledgement of FM service within the Malaysian setting. One basic factor that needs to be prioritized, for instance, is the emphasis on service delivery.

Building Information Modelling (BIM) in FM

The construction industry is starting to recognize the relevance of BIM in FM, which offers synchronized, consistent, and calculable building information management across the

design, construction, maintenance, and operation phases of a building's life cycle. A diversity of FM practices, including commissioning and closeout, quality control and assurance, energy management, maintenance and repair, and space management, could leverage from the data obtained through a BIM process and stored in a BIM-compliant database (Becerik-Gerber et al., 2012; Dijmarescu & Christopher, 2021). Incorporating facility data across the term of a facility's lifecycle is the goal of BIM for FM in order to achieve a secure, healthy, productive and effective workplace (Muhammad & Mustapa, 2020). BIM and FM technologies can be integrated as a digital repository for each building component to manage buildings, facilities, and other fixed assets (Abdullah et al., 2013). BIM provides the initial information to FM systems and assists FM operations with its analysis tools, visualization capabilities, and other features. Easily generate FM techniques in a centralized network database using BIM software. In these network databases, superfluous data or information will be removed, and 3D geometric building data will be linked based on FM function and utility in supporting building activities (Becerik-Gerber et al., 2012; Wong, Ge & He, 2018).

Additionally, for managing buildings, facilities, and other fixed assets, Building Information Modelling in conjunction with FM system can be incorporated as a digital repository for each building component (Abdullah et al., 2013). Whereas the main goal for improving FM performance in Malaysia is now the holistic approach to integrate effort and collective responsibility. Through its analysis tools, visualization skills, and preliminary information delivery to FM systems, BIM aids FM functions. The FM approaches can be quickly constructed in a centralized network database by using BIM software. The unnecessary data or information will be deleted from these network databases, and the 3D geometric data building will be connected via FM function and use in assisting construction activities. Although 3D geometry is frequently thought of in the context of BIM, the essential characteristics of BIM in FM processes are those that relate to data management, storage, sharing, and interchange in FM tasks (Munir et al., 2019). The most common BIM application area in FM is tracking maintenance and repair activities, (Tezel et al., 2022). Building and sustaining digital assets and monitoring energy usage are the second most prominent BIM applications in FM.

However, there is scant information available, and BIM's implementation in FM is still in its early stages (Muhammad & Mustapa, 2020). Contrary to the design and construction stages, there is limited BIM utilization during the FM phase (Hilal, Maqsood & Abdekhodaee, 2019). It is believed the implementation of BIM in FM is perceived to be hampered by a number of challenges, including compatibility issues between BIM and the FM system, understanding the FM principles for BIM adoption, and costs (Samsuddin & Ahmad Zaini, 2022; Patacas, Dawood & Kassem, 2020; Kiviniemi & Codinhoto, 2014; Matarneh & Elghaish, 2021). Despite widespread agreement among professionals and researchers regarding the potential advantages of BIM in FM, there is still a great deal of uncertainty surrounding of how to use BIM successfully and to what extent BIM may resolve FM difficulties (Hilal, Maqsood & Abdekhodaee, 2019). Determining the elements impeding the incorporation of BIM into FM processes necessitates the identification of barriers to the integration. According to the 2017 UK BIM Report, which states that the adoption of BIM consists of numerous basic components, including people, process, policy, and technology, four (4) domains of hurdles have been identified (Ahmad Jamal et al., 2019).

METHODOLOGY

In this study, the barriers to BIM adoption in FM operations were identified and assessed using a systematic review methodology. The review stages approach recommended by Kouchaksaraei and Karl (2019) was used for conducting this study. It also met the selection criteria established by Moher et al. (2009). The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flowchart for the process of selecting the studies is shown in Figure 1. The search and selection methods used in this systematic literature review are discussed in depth below.

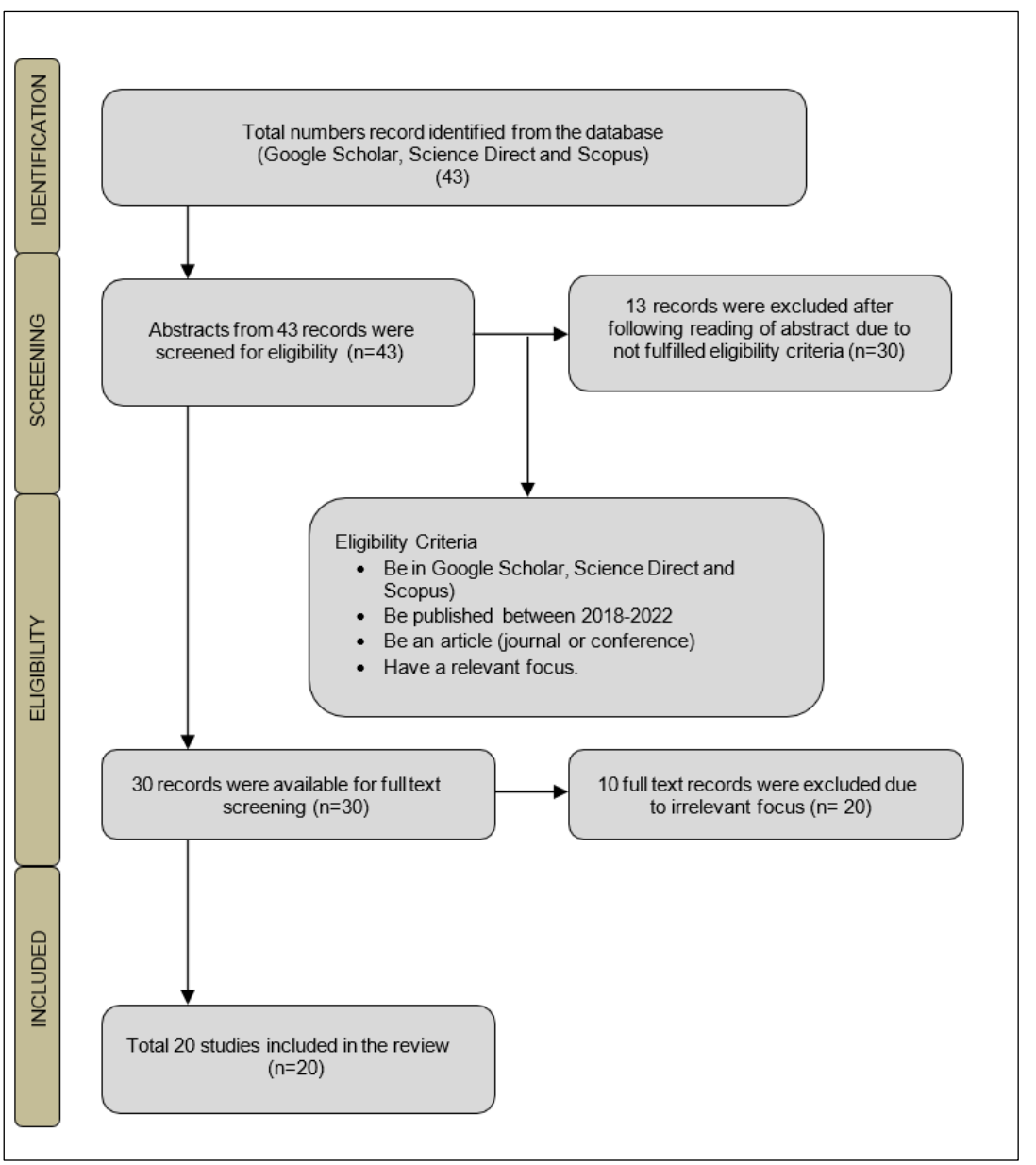

Figure 1. PRISMA Diagram of BIM in FM

Inclusion Criteria

All publication's keywords represent the research's primary concepts (Hsin-Ning & Pei-Chun, 2010). The technique included looking for terms related to "BIM in Facilities Management" as well as exploring the terms "BIM in Building Maintenance," "BIM in Asset Management," and "Digitalization in FM" separately. The systematic review includes studies from chosen databases that were written in English, published between 2018 and 2022, and published in peer-reviewed journals and conference proceedings to ensure that all published methods were included. According to Santini (2018), if the most current citation is older than five years, this may indicate that an exhaustive, up-to-date assessment of the literature has not been done.

Search Strategy

Numerous studies on the topic were obtained through the use of three distinct database platforms such as Google Scholar, Science Direct, and Scopus. Due to the vast number of publications on Google Scholar that forbade searches on keywords and abstracts, the search for terms was restricted to publication titles in optimizing the research methods and evaluating studies relevant to the defined scope. Each study was examined independently by a panel of peers, and its acceptability was determined in accordance with the acceptance criteria for BIM-based construction projects. The papers were analysed to identify barriers to BIM integration in FM. Thus, duplicate publications from multiple databases were eliminated from the findings obtained. Therefore, the initial sorting was performed by merely reading the titles.

Systematic Review and Content Analysis

Based on the finalized papers, the hurdles of integrating BIM in FM were analysed critically, and the created themes were gleaned from prior research in the field. This section presents four distinct interactions of barriers to integrating BIM into FM, based on growing evidence from research and practice. By analysing the content of secondary data sources, including current academic literature, the literature review was undertaken. Following that, the literature artefacts were gathered and analysed to establish the appropriate issue classes. Figure 1 depicts the protocol for the systematic review that was adopted (Dresch, Lacerda & Miguel, 2015).

RESULTS AND FINDINGS

As shown in Table 1, the barriers to integrating BIM in FM were split into four (4) key domains of people, process, technology, and legal issues in accordance with the systematic literature review (SLR) conducted.

Table 1. Barriers of Integrating BIM in FM

	PROCESS					PEOPLE					TECHNOLOGY			LEGAL	
	Lack of methods and tools	Gap on the BIM use from the design and construction stages to FM and operations	Lack of FM professionals' engagement in early project	Data within BIM for FM is not fully exploited	Converting captured as-built building data, updating information and handling of uncertain data	Lack of skills within existing FM	Owners and FM professionals still fear investment and commitment to digitalise their facilities	Lack of collaborative working approach	Lack of competitors in the market	Insufficient understanding	Data transfer between BIM is not a smooth process	Interoperability which is caused by the expense of manual data entry	Cost of the technology is high	Government has not regulated the implementation of BIM in FM	Lack of supervision, government assistance
(Omayer and Selim, 2022)	/	/					/								
(Samsuddin and Ahmad Zaini, 2022)	/					/				/					/
(Ariffin, Mustafa and Sapri, 2021)						/	/		/						
(Mannino and Dejaco, 2021)							/								
(Imanina, Fadzil and Yahya, 2021)									/	/	/	/	/		
(Altohami et al., 2021)	/				/										
(Dijmarescu and Christopher, 2021)						/	/								
(Munir et al., 2020)						/		/	/	/					
(Demirdöğen, Işik and Arayici, 2020)	/										/				
(Stride et al., 2020)	/	/					/								
(Crippa et al., 2020)	/														
(Wen, Tang and Ho, 2020)	/														
(Koch, Hansen and Jacobsen, 2019)				/	/							/			
(Marmo et al., 2019)							/								
(Che Ibrahim et al., 2019)								/							
(Wanigarathna et al., 2019)		/													
(Hilal, Maqsood and Abdekhodaee, 2019)			/			/						/			
(Miettinen et al., 2018)	/	/								/	/	/		/	
(Carbonari, Stravoravdis and Gausden, 2018)			/												
(Lewis, Deke Smith and Whittaker, 2018)				/			/				/				

DISCUSSIONS

Upon comprehensively reviewing the literature, the four (4) primary issues highlighted are intended to guide and encourage future research in all involved domains. Based on previous research (Miettinen et al., 2018; Demirdoen, Işik & Arayici, 2020; and Wanigarathna et al., 2019), the process-related domain has become the primary concern in the BIM-FM integration process, as BIM applications have not been extensively integrated into facilities management practice due to a lack of implemented strategies and tools. The main reason for the slow growth of implementing BIM in FM is the lack of a fundamental process identified in acquiring all the information necessary throughout the project lifecycle of operational delivery and assets management plan (Dijmarescu & Christopher, 2021; Hilal, Maqsood & Abdekhodaee, 2019). Further, there were gaps in the integration of BIM from the design and construction stages to FM and operations due to the absence of early project participation by FM professionals (Miettinen et al., 2018; Wanigarathna et al., 2019. Hilal, Maqsood and Abdekhodaee, 2019; Carbonari, Stravoravdis & Gausden, 2018). The BIM-FM integration should provide a repository of facilities data early in the process to enable FM across the whole building life cycle (Ariffin, Mustafa & Sapri, 2021). Patacas, Dawood, and Kassem (2020), Wanigarathna et al. (2019), and Crippa et al. (2020) discovered that the knowledge of decision support contained in the data for BIM implementation in FM is not thoroughly examined. Consequently, it is inefficient to leverage large semantic data to improve the performance of a building. These challenges are exacerbated by the difficulties in understanding ambiguous data, updating data, and converting as-built building data of existing structures (Koch, Hansen & Jacobsen, 2019; Altohami et al., 2021). Subsequently, the lack of procedures for updating the intended model with as-built data, in which the tasks and responsibilities for delivering the data and maintaining the model are not clearly defined, is thus one of the major issues with integrating BIM in FM (Altohami et al., 2021; Wen, Tang & Ho, 2020).

Regarding people-related issues, the most significant barrier to implementing BIM adoption and its data transfer is a scarcity of capabilities in the existing FM (Dijmarescu & Christopher, 2021; Dijmarescu & Christopher, 2021; Munir et al., 2020; Hilal, Maqsood, and Abdekhodaee (2019); Ariffin, Mustafa, and Sapri, 2021; Samsuddin & Ahmad Zaini). The problem is that facility owners and managers are reluctant to make the requisite investments and time commitments to digitalize their facilities (Marmo et al., 2019; Dijmarescu & Christopher, 2021; Lewis, Deke Smith & Whittaker, 2018; Ariffin, Mustafa & Sapri, 2021; Mannino & Dejaco, 2021). Together these problems interact to provide a virtuous cycle that hinders BIM adoption in FM. To maintain its value for the building and its owners, BIM for FM application requires constant maintenance, which creates a significant challenge. Even if there is a growing desire to use BIM as a platform for information exchange, there is still a problem with information sharing among project teams in BIM projects. The lack of a collaborative strategy among construction professionals may be a cause in this issue. (Che Ibrahim et al., 2019; Munir et al., 2020; Dixit et al., 2019). Since most professionals operate in silos, they are unable to fully comprehend how to utilize BIM in FM, which results in information fragmentation among them (Munir et al., 2020; Imanina, Fadzil & Yahya, 2021; Matarneh et al., 2018; Samsuddin & Ahmad Zaini, 2022). The majority of FM organizations lack a complete grasp of the data and paperwork required for the integration process, according to Ariffin, Mustafa, and Sapri (2021), Samsuddin and Ahmad Zaini (2022), and Munir et al. (2020). In order to effectively utilized and extend digital BIM outputs, personnel

expertise is required. Gradually, the significance of possessing a comprehensive understanding of BIM-FM terminology and information will increase communication with other stakeholders in BIM projects, primarily for the transmission of project data.

Furthermore, the integration of BIM in FM has been hampered by technological hurdles. It was discovered by Demirdoen, Işik, and Arayici (2020) and Patacas, Dawood, and Kassem (2020) that data transmission between BIM and other platforms is not always flawless. Hence, industry experts must gather information about the opportunity for seamless data transfer between BIM and FM systems in order to reduce the duplication of work involved in producing BIM outputs that do not match the inputs of FM systems. Different software is utilized in construction and facilities, making data transfer difficult (Miettinen et al., 2018; Lewis, Deke Smith & Whittaker, 2018; Parn, Edwards & Sing, 2017; Imanina, Fadzil & Yahya, 2021). Interoperability issues slowed the transfer of FM information throughout the handover phase, despite the fact that the BIM model contained the data required by the FM staff. Even though the project's engineers and architects had created naming conventions and were extra careful about interoperability problems between various software programmes from the beginning, they eventually encountered unexpected problems (Hilal, Maqsood & Abdekhodaee, 2019; Imanina, Fadzil & Yahya, 2021; Koch, Hansen & Jacobsen, 2019; Matarneh et al., 2018). As a result, the problems led to redundant data entry, data verification, and idle labour spent searching for valuable data that was frequently unavailable (Matarneh et al., 2018).

Another factor that makes BIM integration difficult is the government' inability to regulate the adoption of BIM in FM practice. Samsuddin and Ahmad Zaini (2022) stated that although the majority of construction organizations are conversant with the BIM concept, the lack of monitoring and government backing for BIM implementation in FM is a major factor in the technology's delayed uptake. The industry appears to be adopting BIM in FM more slowly than anticipated due to the lack of government regulation, despite projections that both integrations would be gradual and staged (Miettinen et al., 2018).

CONCLUSIONS AND RECOMMENDATION

The systematic literature review procedure has been detailed with sufficient precision for the results to be reliable and independently repeatable. Incorporating screening, evaluation, and literature research improved the reviews' validity, reliability, reproducibility, and quality. Four (4) major issues of process, people, technological, and legal challenges have been discovered as a result of the review. This study indicates several aspects from these four domains that are relevant in terms of the barriers and difficulties connected with BIM integration in FM. During the process of integrating BIM into FM, it is of the utmost importance to provide direction by way of adequate guidelines. Academic and professional societies have indicated interest in the process of integrating BIM into facilities management, which has the potential to enhance the performance of facilities management. For the successful integration of BIM into facilities management, there must be a systematic transfer of data during the handover to facilities management.

This analysis has confirmed that inadequate skills among FM-related parties may be the most significant barrier to integrating BIM into FM. It is considered that the owners' hesitation to invest in digitalizing the facilities was caused by their knowledge of the advantages of BIM

and FM integration. In addition, the integration of BIM in FM has also encountered considerable challenges due to technological issues. The review found that there was a problem with the inconsistent data transfer of up-to-date data from various BIM- FM procedures. Moreover, there were financial challenges, since the client sought the most cost-effective alternatives while building a facility. The circumstances may diminish the relevance of the decisions and activities that facility managers examine throughout the design phase. Further, legal concerns have received the least attention throughout the study, underlining the government's inadequate guidelines for the implementation of BIM in FM, which is linked to integration barriers.

This paper confirmed that BIM-FM integration presents substantial challenges, necessitating additional research for a successful merger. This research is projected to enable facility management organizations and other relevant authorities in using BIM in FM efficiently, consequently enhancing asset management effectiveness. However, the database platforms utilized in this research restrict the amount of available data (Google Scholar, Science Direct and Scopus). In order to present a more fair perspective on the issues, additional studies must be undertaken. Future research on the solutions to the difficulties should also include a more extensive systematic evaluation of the literature, which may be strengthened by investigating specific barriers for specific projects in order to elucidate additional consequential elements.

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SUSTAINABLE PRACTICES OF CONTRACTORS FOR ENHANCING COMPETITIVENESS IN CONSTRUCTION

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Abstract
Due to construction activities, excessive resource consumption and climate change have become critical issues for countries such as Malaysia, which has a scarce supply of water and electricity issues. Contractors are among the important construction stakeholders that play a crucial role in promoting sustainability by minimising environmental impacts while maximising their contribution to the economy. This paper aims to investigate the sustainable practices and competitiveness of contractors. Two hundred fifty-two (252) contractors from G1 to G7 are participating in a questionnaire survey to capture their perspectives. Frequency Analysis, Factor Analysis, and Correlation Analysis were performed using Statistical Package for the Social Science (SPSS). This study reveals that the 'reduce' method is the most promising sustainable practice due to its effectiveness and efficiency in achieving low construction waste production that fulfils the goal of sustainability. While the better image is identified as the top possible competitive advantage for contractors when employing sustainable practices to maintain a positive corporate reputation to broaden their company further. A positive correlation was also discovered, indicating that the sustainable practices of contractors would contribute to their competitiveness. As sustainable practices become increasingly important, this study gives knowledge for contractors to anticipate the benefits of implementing sustainable practices in order to boost their project competitiveness.

Keywords: *Contractor's competitiveness; Sustainable Practice; Construction Site; Malaysia*

INTRODUCTION

The construction phase is said to be given insufficient attention despite playing a role of fundamental importance for the benefit of the environment (Cruz et al., 2019). The implication of construction activities produces undesirable remnants and is considered the main contributor to environmental pollution (Malik et al., 2019). For this reason, sustainable practices are of major concern in the construction stage due to the huge energy consumption which later has a large contribution towards the emission of carbon dioxide (CO_2), becoming one of the major reasons for global warming that harm public health and welfare (Tang et al., 2020). The construction is estimated to have substantial environmental implications due to the creation of 35-40% of CO_2, 40% of raw materials and 25% of timber consumption, 40% of solid waste production which contributes to 40% of overall energy production, and 16% of water usage worldwide (Durdyev et al., 2021). This shows that sustainability in the construction site has to receive broad attention, especially from the stakeholders of the construction projects, as it has become a worldwide concern nowadays.

Moreover, the habit of reusing and recycling construction waste on the construction site is still at its early stage and has not been well established. According to the data from Construction Industry Development Board (CIDB) Malaysia, the total C & D waste generated in Peninsular Malaysia is at the amount of 271,948 tons while the total recycled is only 37263.51 tons. This demonstrated that the C & D waste recycling rates are still at a low rate

with only 13.7% (CIDB, 2021). A study conducted by Phoya (2018) highlighted that the level of implementation of sustainable practices is still unsatisfactory with a relatively low index ranging from 20 – 30%. Numerous chemicals and materials used in construction activities contaminate water sources, while excavation, grading, and emission from fuel- powered equipment and machinery frequently pollute the air. While the management of water efficiency and air quality on construction sites is still considered to be in its infancy.

Therefore, the implementation of sustainable practices would bring numerous positive outcomes for the contractors, especially during the recent economic recession, resulting in increased competition and changing the nature of some businesses. The increased competition forced organizations to submit lower bids for contracts (Abidin & Shariffuddin, 2019). In this circumstance, improvement in sustainable practices during the construction phase might be helpful as a source of competitive advantage leading to more efficient processes, improvement in productivity, and lower costs of compliance to decrease the project costs and obtain further recognition and market opportunities (Rajabi et al., 2021). This study aims to investigate the contractor's sustainable practices and competitiveness. This will provide insight into the potential implementation of sustainability during the construction stage by all the contractors in Malaysia's construction industry.

CONTRACTOR'S SUSTAINABLE PRACTICES IN CONSTRUCTION SITE

Previous research has found that energy-intensive issues on construction sites consist of lighting, construction containers, equipment containers, cranes, and small machines. Other uses of electricity include drying clothes, drying concrete, and storage of building materials. Several recent studies highlighted temporary structures such as offices, dressing rooms, or storage bring a significant source of energy consumption at construction sites and they must maintain at a suitable temperature under work environment regulations (Palm and Byrngelson, 2023).

Construction and demolition (C&D) waste is also generated during construction activities which should be properly managed (Kabirifar et al., 2020; Zhang et al., 2021). Minimising waste has various advantages, including producing cash by collecting some materials, lowering expenses by acquiring fewer resources, lowering the cost of transportation of created garbage, and most crucially, lowering CO_2 emissions (Kabirifar et al., 2020). Furthermore, most of the C & D waste can be reused no matter whether these materials are used according to their original purposes or even if they are being used for another function (Kabirifar et al., 2020). C&D waste also can be recycled which involves the action of repurposing old stuff to create new materials and products (Huang et al., 2018; Kabirifar et al., 2020).

Contractors also should pay close attention to the noise and vibration pollution. Noise pollution occurred on the construction site due to the long-term production of various types of sounds during a project's construction phase. Occupational Safety and Health Administration (OSHA) also mentioned that any noise above the limit of 90 decibels (dBA) might harm human physical or mental health. Tools and machinery used during the construction phase of a project for piling, excavating, welding, or even the transportation of materials produce irresistible noise (Feng et al., 2020). Additionally, during construction activities, there is diverse machinery and equipment used in the construction site with no shielding provided around them. Most of the tools and machinery need to travel and move

within the site, thus inducing vibrations that annoy and affect human comfort (Zou et al., 2020). Construction activities such as piling, excavation, demolition able to induce high level of vibration which pose an adverse impact on surrounding environments especially to residents (Wang et al., 2021). Therefore, contractor shall monitor the induced-vibration by collecting and recording the vibration data or using the portable device seismographs and vibrometers as a method of measuring the vibration (Meng et al., 2023).

Since there is a large amount of dust is emitted during construction activities, especially during the process of earthwork, this has become another sustainable practice that should be a concern for the contractor. The construction phase mostly involves large machinery and equipment for excavation, back-filling of soil, and transportation of construction materials from one place to another (Luo et al., 2021). Other ways to avoid dust on a building site include using water to clean up the site, soil irrigation, watering the dirt, and wetting objects before sweeping or cutting with a saw. The use of dust screens and local exhaust ventilation is another useful technology that contractors could apply in their construction sites to control dust (Kaluarachchi et al., 2021).

Other than that, all construction requiring building permits must include a tree preservation plan that clearly defines the building activity area and the tree preservation area. However, if tree removal permission is granted, there will inevitably be a need for tree replacement, with the quantity and type of replacement trees being heavily dependent on the amount of protection offered to the three destroyed (Pike et al., 2021). Furthermore, building activities use a large amount of land, necessitating a great of attention to limit the negative effects of construction on mother nature (Bamgbade et al., 2019). As a result, each new project should incorporate biodiversity programs such as providing animal habitats such as living roofs, nest boxes, and landscapes. Loss of habitat due to construction activities would finally lead to the loss of biodiversity which does not just affect the living organisms such as plants and animals, but also the ecosystem to protect our environment from natural disasters caused by the effects of climate change (Opoku, 2019).

Lastly, construction transportation is often overlooked even though they are important that contribute to useful solutions to reduce environmental impact. Construction is strongly reliant on logistics and transportation for materials and services which accounted for 60-80% of overall construction works. The lack of sharing information with suppliers leads the operator to drive the vehicles to a different address and arrive at the wrong time which leads to extra journeys. Besides, when the contractor has a lack of planning with the deliverable of materials, it leads to many deliveries and generates waste due to the non-negligible number of vehicles arriving. This issue eventually led to the need for double handling, storing, sorting, and larger storage (Sezer et al., 2021).

CONTRACTOR'S COMPETITIVENESS FOR SUSTAINABLE PRACTICES

Contractor with a favourable attitude towards sustainable practices throughout the construction phase will benefit from a greater return on investment. This is supported by Khalfan et al. (2015) which found that 75% of contractors felt that sustainable practices on building sites will provide a greater return on investment. Sustainable practices such as managing construction waste using reduce, reuse and recycle would significantly cut the cost

of a building project. This is because there is less involvement in transporting and dumping those construction waste in remote landfills (Akbarnezhad & Xiao, 2017).

Other than that, contractors who are practicing sustainable practices in optimizing the utilization of resources and materials are being prioritised in the selection process. People can quickly recognise potential contractors with the skills to properly manage resources efficiently and provide them with new market prospects (Garba et al., 2016). Sustainable practices throughout the construction phase of any project will gain recognition and popularity from construction stakeholders including the clients to reduce its undesirable environmental impact (Yin et al., 2018). Hence, the positive attitude of contractors towards sustainable practices would be highly demanded by clients as one step closer to a sustainable built environment.

Considering implementing sustainable practices in the construction site involves the participation of construction stakeholders especially between the client and the contractors. There are long-term benefits for both of them once they agree to practice sustainability. The clients are willing to pay initial higher prices for sustainable practices to have a better quality of outcomes with less maintenance work in the future. In contrast, the contractors are equipped with the knowledge of sustainability on the construction site and try to maximise the implementation throughout the construction phase (Khalfan et al., 2015). For example, one of the keys to maximising a contractor's earnings and income is to minimise transportation on the construction site by efficient waste management and use of waste to a certain amount before disposing of it to the landfill. It contributed to lower transportation costs, resulting in increased profits for contractors (Silva et al., 2017). Hence, implementing sustainable practices in terms of minimizing the cost of transportation would lead to lower bids for a project, thus increasing the chance of contractors winning projects and remaining competitive.

Meanwhile, construction phase sustainable practices also would lead to an increase in productivity, a more efficient construction process, and lower costs of compliance, thus reducing the initial costs of the construction projects which makes the contractors easily get a project (Rajabi et al., 2021). Increasing productivity by implementing sustainable development practices could be relevant in the context of resource efficiency, thus reducing the possibility of project time overruns which would then result in delays in construction work if sustainable development goals could not be met (Sabri et al., 2021). Sustainable practices also may keep construction safe, cleaner, and neat allowing construction workers to get on with their work properly (Sapuay, 2016). It therefore assists contractors in gaining a good reputation from owners and may be a source of advantages in competition among contractors with advances in building site sustainability (Tan et al., 2015).

Contractors with knowledge of sustainable practices are getting more attention globally to contribute to a more sustainable built environment (Yin et al., 2018). Initiatives such as well-managing resources of labours and machineries in contractors' overall business plan would ensure the contractors make a maximum profit while achieving sustainable development concepts in their projects (Liyin et al., 2006). Most importantly, sustainable practices benefit contractors not just in terms of cost savings, but also in terms of strengthening their corporate image. Hence, contractors would get more projects and

consideration from clients by having a good image while handling the construction projects (Ofori, 2000).

Contactors that use sustainable practices during construction would significantly enhance their level of expertise, allowing them to effectively bid on a project. Because of the rising need for contractors to implement sustainable policies during construction, contractor's approaches to sustainable construction have become a critical element for clients in determining the tender winner (Tan et al., 2011). Potential contractors who are capable of completing the projects with sustainable implementation initiatives within the optimum life cycle cost are preferable, thus having a higher chance to qualify for a construction project (Gurgun & Koc, 2020). Sustainable practices of utilizing inputs the construction projects such as raw materials, labours, and energy productively would result in enhanced resource productivity, making contractors' organizations more competitive, not less (Tan et al., 2015).

Other than that, the implementation of sustainable practices throughout the construction phase has been found to lead to an improvement in the indoor quality of the construction site (Darko et al., 2017). In addition, the implementation of sustainable practice through the utilisation of skilled and educated labour has the potential to enhance the overall project quality. This, in turn, can streamline the execution of high-quality and sustainable construction across various projects (Tabassi et al., 2016). The high quality of construction is essential for meeting customer satisfaction and establishing a positive reputation for contractors. This eventually enhances their competitiveness and likelihood of securing future contracts (Williams et al., 2015).

The incorporation of sustainable practices in building projects has been found to facilitate the attainment of planning permission for contractors (Tabassi et al., 2016). The expeditious approval process by local authorities may lead to the prompt commencement of building projects, therefore bolstering the efficiency of construction and high-quality value by the clients. Besides, well-managed construction waste and pollutants would result in an increase in the productivity of the construction workers by 2 to 3% due to the improved workplace environment. A clean and free of pollutants construction site would get the construction workers to feel fresh and motivated to accomplish their tasks (Darko et al., 2017). An increase in productivity would facilitate the contractors to eliminate the possibility of delay in projects, thus keeping their promises as in the signed contract. Contractors would also have a higher chance and competitiveness to compete for more potential projects to further expand their businesses.

METHODOLOGY

The distribution of a questionnaire was conducted using a Google form which was sent to contractors from grades G1-G7. The research area encompasses the regions of Johor, Selangor and Kuala Lumpur. Johor is among the top three states in Malaysia which is having the most total contractors registered. Additionally, according to Star News, Johor state is strategically located and most of the major construction developments are taking place. Besides, both of the places in Selangor and Kuala Lumpur are highly developed and have major constructions with most of the headquarters located there. The population of G1-G7 contractors in the three selected regions is reported to be 50,061, as obtained from the Contractor Finder in CIDB Centralised Information System (CIMS) (CIDB, 2021). A

projected sample size of 381 has been determined based on the guidelines provided by Krejcie and Morgan (1970). Consequently, a collective of 252 participants effectively responded for three months. The survey encompasses a series of closed-ended which comprise both multiple-choice and Likert scale questions.

The data collected is analysed by using the software Statistical Package for the Social Science (SPSS) to conduct the Frequency Analysis to analyse the demographic information. Moreover, SPSS software is also used to conduct Factor Analysis to specifically analyse the data obtained for the contractor's sustainability practices, and the contractor's competitiveness. Spearman Correlation analysis is added as part of analysis to gain the significance between the two items. Factor Analysis was used help to priorities the potential implementation of sustainable practices and contractors' competitiveness. It is conducted based on two protocols. The first protocol is to select a rotational and extraction method by using Principal Component Analysis (PCA) with Varimax rotation. Then, the factor loading value was determined, with criteria values of 0.50 and higher being retained (Pallant, 2014). The PCA assisted in determining the number of factors to explain that are frequently used to describe the information acquired in an empirical summary. In terms of the rotational approach based on Varimax, it was chosen because it is simple to read and report and it maximises high item loading while minimizing low item loading. Furthermore, orthogonal rotation based on Varimax assumes that one factor is unrelated to the other (Costello and Osborne, 2005).

RESULTS AND DISCUSSION

Demographic Background

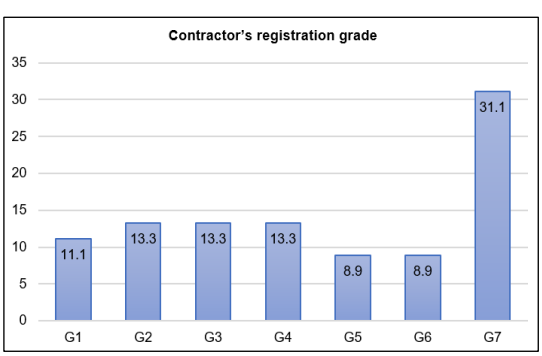

Figure 1. Contractor's Grade

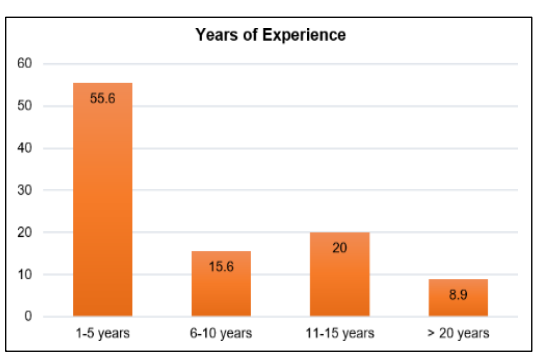

Figure 2. Contractor's Experience

Figure 1 presents an overview of the respondent's registration grades. The survey results indicate that 11.1% of the participants belong to G1, while 13.3% are from G2, G3, and G4. Additionally, 8.9% are affiliated with G5 and G6. Finally, it is worth noting that the biggest percentage of responses was obtained from the G7. The variation in the allocation of contractors across different grades might be attributed to the need to get diverse perspectives. While Figure 2 depicts the distribution of respondent's years of experience in the construction business. The analysis reveals that 55.6% were contractors with 1-5 years of experience. It is noteworthy that 15.6% of contractors possessed 6-10 years of experience, while 20% had 11-15 years of experience. Finally, a wealth of experience beyond two decades constitutes around 8.9% of the total sample. The significance of the respondent's experience lies in its ability to

establish the credibility of the collected data, given that a majority of the respondents possess a specific background and expertise in construction.

Based on the data presented in Figure 3, a majority of the participants, comprising 60% reported having prior involvement in sustainable practices. This suggests that there is a positive trajectory in the adoption of sustainable practices in specific regions. In contrast, a significant proportion of respondents which is 33.3% indicated their intention to embrace sustainable practices in the near future. The potential reason might be attributed to significant hurdles encountered, notably the absence of enough finances. Furthermore, 6.7% of respondents expressed their lack of interest in engaging in sustainable practices. Although most of the respondents had a certain experience in implementing sustainable construction practices, it is still important to increase the awareness level of the respondents towards the transformation and encourage more grades of contractors to be involved in sustainable practices as part of their responsibility in future projects.

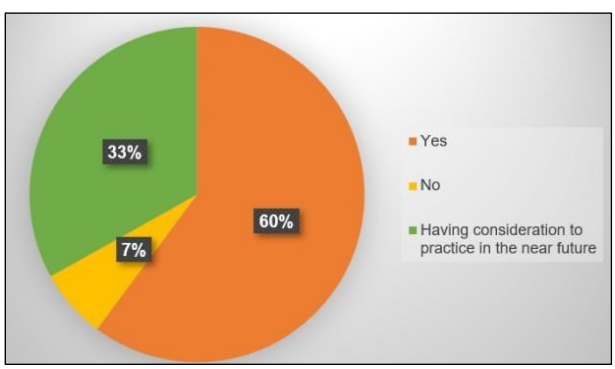

Figure 3. Percentage of Contractor's Involvement in Sustainable Practices

Contractor's Sustainable Practices at Construction Site

In this section, respondents were requested to provide ratings for the sustainable practices that possess the potential to be adopted in construction to reduce the harmful impacts that a construction project would contribute. The factor loading of each type of potential sustainable construction practice which arrange according to the highest loading to the lowest loading is shown in Figure 4.

According to the findings presented in Figure 4, the sustainable practice with the largest potential for implementation was identified as the 'reduce' method by a factor loading of 0.829. The need to manage the waste on the construction site by first reducing the waste is inevitable. The implementation of a reduction effort is often regarded as the most effective and efficient approach to achieving minimal creation of waste throughout the construction phase. Furthermore, it is worth noting that the reduction method may be consistently used throughout the entirety of the construction life cycle, commencing with the initial planning phase. (Hasmori et al., 2020). Another possible sustainable practice is reusing the building waste before its disposal with a factor loading of 0.790. To mitigate the depletion of natural resources and safeguard the environment, the implementation of the reduction and reuse method seems more efficacious compared to other sustainable practices (Kabirifar et al., 2020). According to the research done by Hasmori et al. (2020), waste cannot be eliminated,

even in the most sustainable construction site. There is unavoidable waste that needs to be reused, such as broken bricks or concrete. The aforementioned construction wastes could be reused as a sub-grade of the access road to the construction site instead of disposing it directly to the landfill. Moreover, to avoid depleting natural resources and protect our environment, reduction, and reuse are the most effective strategies compared with other sustainable construction practices.

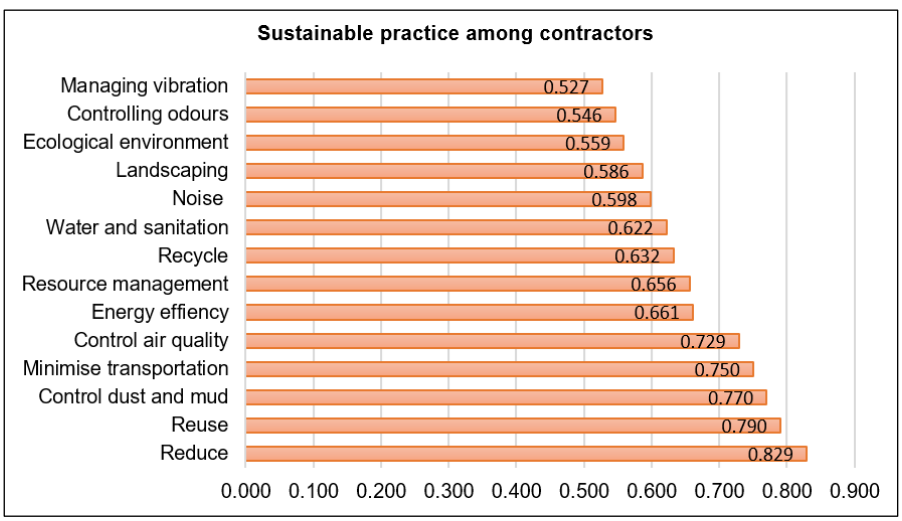

Figure 4. Construction Site Sustainable Practices

Utilisation of a mobile truck wheel wash facility and the installation of huge façade safety nets has been identified as the third most promising sustainable practice to manage dust and mud with a factor loading of 0.770. The implementation of a mobile truck tire wash facility as a means to efficiently clean a large number of vehicles before they depart from the site (Li and Wang, 2016). The affordable pricing of the expansive façade safety nets has garnered attention from contractors who seek to employ them for safeguarding adjacent spaces from potential hazards such as falling debris and dust particles. As stated by Luo et al. (2021), a large amount of dust is emitted during construction activity, especially during the process of earthwork, as it involves large machinery and equipment. On the other hand, mud is also produced during the rainy season at the construction site which carries soil particles away in the form of dust. The fourth possible sustainable practice to be applied with a factor loading of 0.750 is decreasing on-site transportation and minimizing journey distance. Contractors must strategically pick the suppliers that are readily accessible nearby, hence mitigating the necessity for extensive transportation of these materials across vast distances.

The implementation of air quality control, with a factor loading of 0.729, was identified as the fifth possible sustainable practice. The potential cause of this issue may be attributed to the emission of dangerous and poisonous gases into the surrounding environment as a result of various operations conducted on the site. Hence it is imperative to minimize activities that contribute to emissions of gases from building materials, excavation, and grading of the construction area, cleaning agents as well as the use of fuel-powered equipment (Phoya, 2018). Purchasing nearby construction materials is one way to control air quality, thus providing a clean and healthy environment for construction workers besides protecting our natural environment from unnecessary pollution.

Since the Environmental Protection Agency (EPA) argued that the energy used in the construction site does not fulfil the criterion of sustainability, it is necessary to practice energy efficiency among contractors to reduce inefficient energy consumption. The outcome of the analysis indicated that 'Energy Efficiency' was identified as the sixth most promising sustainable practice, with a factor loading of 0.661. The significant consumption of energy during the building phase is attributed to the operation of machinery tools during construction (Tumminia et al., 2018). Besides, the implementation of sustainable practices ranks the protection of the biological environment, including adherence to biodiversity schemes, odour control, and management of vibration pollution, as having the lowest priority. These practices have a factor loading of 0.559, 0.546, and 0.527, respectively. A deficiency in comprehension exists among building industry specialists in Malaysia regarding an effective biodiversity strategy aimed at safeguarding natural habitats (Opoku, 2019). In relation to the management of odours, particularly those arising from the release of gases by transport systems, Malaysia has recently implemented more stringent regulations on exhaust emissions. However, there is a limited level of awareness and understanding among construction professionals regarding the mitigation of emissions from vehicles operating at construction sites (Sofwan and Latif, 2021). Moreover, the implementation of vibration dampers as a means of mitigating vibration pollution is mostly applicable to extensive surfaces that experience significant levels of vibration (Owoyemi et al., 2016).

Competitiveness of Contractors Based on Sustainable Practices

In this section, respondents were requested to rate the competitiveness that a contractor may achieve by taking into account sustainable practices in a project. The perspectives on each competitiveness as shown in Figure 5.

Figure 5. Competitiveness of Sustainable Construction Practices

Figure 5 illustrates the many viewpoints on competitiveness. According to the findings of an online questionnaire, out of the eight possible factors contributing to competitiveness, the highest level of agreement was seen for the enhanced image established via the implementation of sustainable practices in the construction industry. The obtained factor loading is 0.818. The incorporation of sustainable practices by contractors to mitigate the adverse impacts of building on the natural environment would contribute to the cultivation of a positive reputation. The use of sustainable practices by contractors, aimed at conserving the

natural environment, signifies a departure from a pure focus on profit maximisation. This commitment to environmental stewardship enhances their project competitiveness and fosters a positive impression and image. The criteria of higher quality projects had the second highest level of agreement, as indicated by a factor loading of 0.798. Developers or owners greatly value the need of ensuring the excellent quality of any building project. The incorporation of sustainable practices, including the integration of indoor quality measures, throughout the building phase would provide improved project performance. Hence, the establishment of an environmentally sustainable and pollution-free site is highly advantageous for both customers and developers, since it increases the likelihood of contractors being awarded future projects.

The factor loading of 0.780 indicates that higher competency was identified as the third influential factor affecting the degree of competitiveness among contractors. Contractors that implement sustainable practices during construction work may significantly enhance their level of expertise within the construction sector, hence increasing their chances of successfully securing project bids. Sustainably delivering a construction project has now emerged as one of the considerations for the project owner. Along with the development of the Green Building (GB) industry, the ability of the contractors to experience sustainably completing a construction project seems much more important. Contractors should apply sustainable practices and have good communication with the other stakeholders to ensure the smooth execution of the project (Li et al., 2019). Therefore, the involvement of contractors in sustainable construction practices would bring enormous benefits to them, thus possessing a higher competency in the challenging industry nowadays.

On the other hand, elements such as increased return on investment, enhanced project productivity, and augmented profitability are the determinants that might impact the competitiveness of a contractor. Each component has obtained loading scores of 0.718, 0.677, and 0.648, respectively. Despite the potential for contractors to get a greater return on investment through the adoption of sustainable practices, their perception remains focused on the substantial benefits in terms of environmental and social elements, rather than financial gains. Moreover, there is a diminished inclination towards sustainable building practices due to the potential necessity for an extended time of adjustment to novel management approaches at construction sites, which might potentially impede production levels. The majority of participants also neglected to take into account the factor of increased profitability, as it is perceived to be a benefit that materialises over the long term.

The Relationship Between Sustainable Practices and Competitiveness

The study revealed that the sustainable practices implemented by the contractor were somewhat beneficial and had a statistically significant linear association ($r = 0.45$, $p < 0.001$), hence contributing to their competitive advantage. The outcome is displayed in Table 1. This finding demonstrates a positive correlation between the rise in sustainable practices and the competitiveness of contractors, with a moderate link ranging from ±0.5 to ±0.7.

Table 1. Correlation Between Contractor's Sustainable Practices and Competitiveness

Correlations				
			Contractors Sustainable Practice	**Competitiveness**
Spearman's Rho	Contractors Sustainable Practice	Correlation Coefficient	1.000	.515**
		Sig. (2-tailed)	.	.000
		N	252	252
	Competitiveness of Contractor	Correlation Coefficient	.515**	1.000
		Sig. (2-tailed)	.000	.
		N	252	252

**. Correlation is significant at the 0.01 level (2-tailed)

CONCLUSION

The findings indicated that the three most promising sustainable practices were waste reduction, reuse, and the management of dust and muck. It is evident that a majority of contractors exhibit a preference for embracing sustainable practices. Additionally, the findings of the study revealed that the three most significant factors contributing to competitiveness were enhanced reputation, superior project quality, and increased expertise. This observation suggests that the adoption of sustainable practices can contribute to the contractors' ability to improve the competitiveness of their businesses. This can be achieved via the cultivation of a positive corporate image and the delivery of high-quality projects that demonstrate a high level of competence. Finally, the findings also demonstrate a noteworthy association between sustainable practices and competitiveness, underscoring the significance for contractors to strategically assess their skills and enhance their business model in order to get a greater number of projects within the prevailing competitive landscape of the construction sector.

There are several strategies to accelerate the implementation of sustainable practices to increase the level of competitiveness. Improving policies by introducing stricter standards and regulations, particularly in the construction contracts to highlight the importance of sustainable practices would greatly help the contractors to obey the guideline. Secondly, establishing a legal framework and enforcement of laws would ultimately attract awareness from the contractors to participate more in adopting sustainable practices, balancing the long-term benefits with short-term resources. Moreover, rebates or other kinds of incentives help overcome the issue of financial constraints, especially for small and medium-sized construction firms in Malaysia.

On the other hand, collaboration with industry bodies or professional organizations would increase contractors' exposure to more available projects that have implemented sustainable practices and have successfully shown the outcomes of adopting sustainable practices. It would help to convince the contractors to adopt sustainable practices. The contractors also may need to have a consistent educational program that could expose them to the latest sustainable construction methods, technologies, and materials that are considered useful to accelerate the implementation of sustainable practices. Certificates for financial benefits also seem important to motivate and encourage the contractors to move toward sustainable practices.

This study is hope could be further enhanced by establishing a model to obtain a more comprehensive relationship by establishing other factors as a mediator effect such as green behaviour, attitude of contractors and economic conditions to appraise the local contractors towards globalization in the construction industry based on sustainable practices.

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TRANSFORMING THE ARCHITECTURAL DESIGN PROCESS: GENERATIVE DESIGN FOR ALTERNATIVE CREATION – A CASE STUDY OF WILLIS TOWER SHADING ANALYSIS

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Abstract
This research study explores the transformative potential of generative design in architectural practice. Generative design is an approach to architectural design that harnesses algorithms and computational power to enable the exploration of alternative design possibilities. However, its current adoption falls short of its potential, particularly in Thailand. Its usage is confined to a limited circle, and architectural students are not acquainted with the concept of generative design. This observation underscores the novelty of generative design within the Thai context. This study aims to showcase the process and potential of generative design by repeat experiment methodology through a case study of Willis Tower shading analysis. The research employed a four-step method, including 3D modelling, shadow analysis, variable numerical value generation, and the display and selection of design options. By manipulating variables such as building area, shadow area, overshadowing by neighbouring buildings, and overshadowing of parks, the study generated 45 design options. The findings potential of generative design to efficiently explore diverse design alternatives. Generative design enhances the architectural design process by providing time-saving capabilities, fostering creative design outcomes, and enabling optimisation across various design criteria. However, it is essential to note that generative design does not replace the role of architects but rather complements their expertise. The research contributes to advancing architectural design practices and emphasises the importance of computational tools in transforming the design process.

Keywords: *Architectural Design; Generative Design; Computational Design; Shading Analysis; Design Process*

INTRODUCTION

Generative design boasts significant potential across multiple academic fields and presents opportunities for utilization in architecture. However, its current adoption falls short of its potential, particularly in Thailand. Its usage is confined to a limited circle, and architectural students are not acquainted with the concept of generative design. In the context of academic research, a search was conducted for generative design and architecture on August 15, 2023. No pertinent scholarly articles were found within the Thai-Journal Citation Index Center (TCI), a national organization responsible for curating and maintaining the Thai-Journal Citation Index database, housing high- quality academic journals published in Thailand. This observation underscores the novelty of generative design within the Thai context. Therefore, conducting research transforming the architectural design process: a generative design for alternative creation by repeat experiment methodology through a case study of Willis tower shading analysis.

The emergence and expansion of Computational Design signified a significant shift towards computational methods in architectural design, fundamentally transforming conventional design processes that relied heavily on manual drafting. Presently, Computational Design disrupts and rejuvenates established architectural design norms and

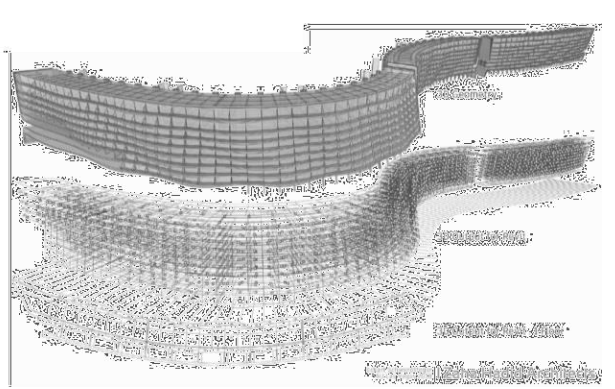
practices. Computational design offers a range of benefits, including convenience, precision, facilitation of interpersonal communication, and the ability to undertake intricate and innovative design tasks such as drafting, visual representations, 3D modelling, and simulations (M Rocker, I, 2006).

Computational design is a methodology that employs algorithms and parameters in conjunction with advanced computer processing to address design challenges. It involves translating each stage of the designer's process into computer code using programming languages. The utilisation of advanced computational techniques, such as generative design and artificial intelligence, significantly enhances the outcomes of the architectural design process and minimises errors (Ramage M., 2022). As a result, computer-based design is gaining greater acceptance among designers due to its efficiency and accessibility.

Generative design is a dynamic process of design exploration. Designers or engineers input specific design objectives into generative design software and various parameters such as performance criteria, spatial requirements, material options, manufacturing techniques, and cost limitations. The software then systematically explores and generates many design alternatives by considering all possible permutations. The software identifies successful design solutions and filters out ineffective ones through iterative testing and learning from each iteration. This iterative approach lets designers quickly explore various possibilities and refine their designs based on the software's feedback (Autodesk, 2022).

In addition to generating design alternatives, the generative design process has the potential to produce exceptional and unexpected solutions that are often not generated through conventional approaches. Generative design has been widely applied across various industries, including automobile and product design. For instance, in architectural design, the Autodesk office in Toronto utilised generative design software to collect data on work styles and location preferences from employees and managers.

This data was then processed using six measurable parameters: adjacency preference, work style, interconnectivity, productivity, natural light, and exterior views. By leveraging generative design, the office was able to optimise the design based on these parameters and create a workspace that aligned with the preferences and needs of its occupants (Souza E., 2020). Figure 1 showed generative design outcomes of Autodesk offices.



(Source: Autodesk University, 2022)

Figure 1. Custom Computational Workflows for BIM Design Implementation

Figure 2. Generative Design for The MaRS Autodesk Office Project (Autodesk University, 2022)

The popularity and effectiveness of computational design, including the application of generative design, have presented an opportunity for a new approach to architectural design. In this study, the focus is on examining the productive design process as a means of creating alternative architectural designs. Generative design involves using algorithms and computational power to explore numerous design possibilities and generate innovative solutions. By leveraging this approach, architects can push the boundaries of traditional design methods and explore unconventional design options.

The Willis Tower Shading Analysis serves as a context for this study. The shading analysis is a crucial aspect of architectural design. By employing generative design techniques, architects can quickly evaluate multiple design iterations and identify the most effective shading strategies for the Willis Tower. This study aims to showcase the process and potential of generative design as an alternative approach to architectural design. Using computational tools, architects can optimise the design process, enhance creativity, and uncover design solutions that might need to be noticed with traditional methods. Ultimately, this research advances architectural design practices and opens up new possibilities for future design approaches.

RESEARCH QUESTION

Integrating generative design processes in architecture has opened up new possibilities for designers by leveraging algorithms and computational tools. This has created opportunities for architects to explore a broader spectrum of design alternatives quickly and efficiently. Examining its underlying workflow and methodologies is crucial to understand how generative design achieves this. By doing so, we can gain insights into how generative design processes facilitate the creation of diverse architectural design options. Therefore, the research question is: How does the generative design process create alternative ways of architectural design?

LITERATURE REVIEW

Generative Design

Generative design is a methodology driven by specific goals and simulations, utilising software and computational algorithms to generate geometric designs that meet user-defined requirements. A typical generative design model comprises three essential components: geometry generation, design analysis and evaluation, and automated iteration loops. These components combine to generate and refine designs, allowing for iterative improvements and optimisation based on the specified goals and constraints. (nTopology, 2022) Designers decide on input algorithms and source code for alternative design solutions, and the process could be reversed for the designer's required options.

Generative design in architecture is an innovative design approach that allows designers to explore and uncover unforeseen and innovative design solutions. It enables them to navigate the trade-offs between high-performing designs by specifying constraints and goals rather than focusing solely on predetermined forms. This approach emphasises a collaborative co-design process between humans and computers, where designers and computational algorithms work together to generate design options that fulfil the desired objectives. (Autodesk University, 2022) Generative design is a computational design process that involves coding using computer languages like Python or utilising specialised computer software such as Autodesk Revit and Dynamo, as well as Rhinoceros 3D and Grasshopper. These tools and languages enable designers to leverage algorithms and computational power to generate and explore design alternatives based on specified parameters, constraints, and objectives.

Generative Design Case Study

Generative design in architecture offers diverse capabilities and opportunities for exploring alternative design options across various disciplines based on the specific requirements of designers. A comprehensive literature review has identified numerous research works applying generative design processes in architectural design, focusing on areas such as energy efficiency, building life cycles, and related aspects. These studies primarily emphasise experimental research that investigates the process and outcomes of generative design. By searching on July 14, 2023, using the Scopus database, which is widely recognised as a comprehensive research database, and employing relevant keywords ("Generative Design" AND "Architecture"), a total of 340 articles were identified spanning the period from 1985 to 2023. Figure 3 representation indicates a substantial increase in articles over time, reflecting the growing popularity and adoption of computational design practices in architecture. The graph shows a significant growth rate, particularly after the year 2000, which coincides with the advancements in computer technology and software development. Furthermore, there is a continuous and steep rise in the graph, with the highest number of research papers recorded in 2021, aligning with the Artificial Intelligence (AI) technology trend. This demonstrates the increasing growth and popularity of generative design in architecture.

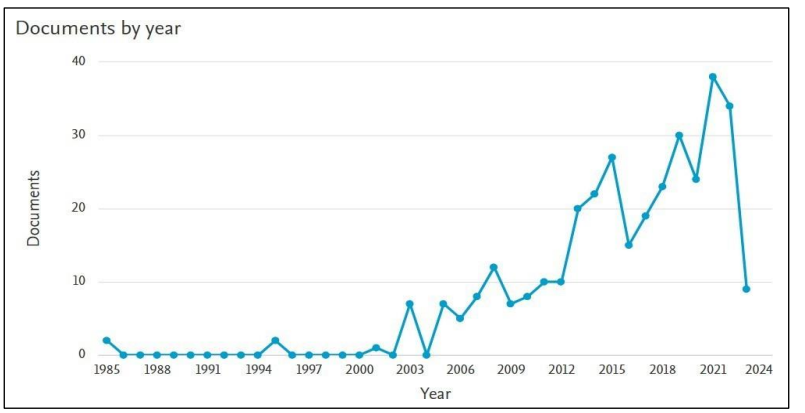


Figure 3. Searching for Publications Related to Generic Design for Architecture in The Scopus Database

A literature review search was conducted to identify relevant research studies to explore the characteristics and potential applications of generative design within the architectural field. The selection process involved reviewing the literature and analysing various factors, including Case Study, Tools, Variables, Objectives, and Research Summary, as presented in Table 1, Generative Design Case Study. The primary aim of this investigation was to assess the feasibility of implementing generative design and identify the opportunities it presents for architectural practice. The research studies were carefully chosen to provide diverse characteristics and objectives.

Table 1. Generative Design Case Study

Authors	Case Study	Tools	Variables	Objective	Research Summary
Zhang, J., Liu, N., & Wang, S. (2021)	Typical floor plans in northern cities in China.	- Rhino and Grasshopper plug-ins - Ladybug and Honeybee (energy simulation)	- numeric parameter: areas, width/depth, etc. - Parameters cannot be numerically described, such as the relationships between rooms.	Parametric generative design method for residences via the combination of parametric generative design and the performance-oriented green residential design process.	The total load of the generated optimal design scheme decreased by 4.2% and 15.8% compared with the original design scheme and the scheme with the highest energy consumption.
Schwartz, Y., Raslan, R., Korolija, I., & Mumovic, D. (2021)	Typical two- story building 6.0 × 14.6 m. in London.	- Python + EPPY (Generate building) - NSGA-II (calculate embodied CO_2 & costs) - EnergyPlus (thermal simulation)	Embodied CO_2 and costs.	This study presents a computational tool that automates the generation of optimal building designs concerning their Life Cycle Carbon Footprint (LCCF) and Life Cycle Costs (LCC).	Optimal buildings had significantly lower life cycle costs and carbon footprint, with the operational stage having the most significant environmental impact but a secondary impact on life cycle cost. The study also presented a year-by-year and life cycle stages analysis of CO_2 emissions and cost.
As, I., Pal, S., & Basu, P. (2018)	15 Homes from a larger data set of design schemes from Arcbazar.com (online competition platform).	Deep neural network (DNN)	Subjective evaluation scores of 15 homes in the data set, based on liveability and sleep ability function targets.	Main objectives were to discover essential design elements, create new designs based on user requirements, evaluate feasibility, and explore GANs for unique variations.	The preliminary results are promising and serve as an initial validation for using graph-processing deep neural network (DNN) or deep learning applications to generate novel conceptual designs.
Wilkinson, S., & Hanna, S. (2014).	10 real buildings were selected from Google Earth in height from 124-508 meters, based on their unique architectural design features.	Training an Artificial Neural Network (ANN)	Model shape vector variables: height (vertical position of the vertex), normal (normal components of the vertex), curvature (standard deviation of the vertex normal in each independent ring)	Demonstrate a new approach to approximating wind pressure on tall buildings for the application of generative design exploration and optimisation.	Compared to FFD solver, solution approximation using a conventional CFD solver offers benefits. The final model-based test verified pressure distribution against the simulation. Some under-prediction of negative pressures was observed, but overall patterning and distribution remain consistent.

Authors	Case Study	Tools	Variables	Objective	Research Summary
Gan, V. J. (2022).	BIM 3D model length of 8800 mm and width of 10,500 mm, respectively, total floor area of 81sq.m.	Autodesk Revit, Dynamo Studio and Generative Design Tool	Room, Space position, Room centre coordinate, Room Area, Connectivity, Derived from the adjacency matrix	Purpose of automatically generating and planning design options for modular construction.	The system is tested in optimising a modularised flat to examine its applicability for planning the spatial organisation of modular off-site construction.
Berquist, J., Tessier, A., O'Brien, W., Attar, R., & Khan, A. (2017)	The Canal Building, located on Carleton University Campus	- A Matlab program (HVAC process generating) EnergyPlus simulations	The type of room, room load requirements, room orientation, and room adjacency when grouping rooms into thermal zones.	Algorithms methodology to create and evaluate novel HVAC system designs during the conceptual phase, leading to more optimal solutions.	The article explores algorithmic zoning strategies based on room factors and VAV sizes, replicating the design of an existing building while considering trade-offs and evaluation criteria.
Vahdatikhaki, F., Salimzadeh, N., & Hammad, A. (2022)	The building of the John Molson School of Business (JMSB) of Concordia University	Revit software Rhinoceros Grasshopper software and Ladybug	The location of PV modules on the building surfaces, size, tilt, and pan angles were considered in the simulation of solar radiation.	Optimising the layout of PV modules on high- rise building skins, considering factors such as study period, profit margin, harvested energy, and cost.	A generative design framework produced more cost-effective and energy-revenue- generating solutions than baseline scenarios, with the consistent orientation of solar panels being the optimal choice in most cases.

Case Study: In the Case Study section of the research samples, various types of buildings were examined, including both public and residential buildings. The general building included The Canal Building, situated on the Carleton University Campus, and the building of John Molson School of Business (JMSB) at Concordia University, with 10 unique architectural designs. As for the residential buildings, the focus was on a two-story design, 15 Homes from Arcbazar.com (online competition platform). In other studies, the investigation was explicitly on typical floor plans for single-story units within multi-story buildings. And BIM 3D model length of 8800 mm and width of 10,500 mm, respectively, total floor area of 81sq.m. These case studies encompassed different geographical locations, such as Canada (The Canal Building and JMSB), London (a two-story building), and northern cities in China (typical floor plans for residences).

Tool: The studies in generative design employed various tools to support the research process. Design and modelling tools like Rhino and Grasshopper plug-ins, Autodesk Revit, Dynamo Studio, and the Generative Design Tool. Energy simulation tools include Ladybug and Honeybee for energy simulation and EnergyPlus for thermal simulation. Programming and scripting tools with Python + EPPY, NSGA-II, and the Matlab program. Neural network tools, namely Deep Neural Network (DNN) and Artificial Neural Network (ANN). Overall, the combination of these tools empowered researchers to explore innovative design solutions, considering factors such as energy efficiency, environmental impact, and cost- effectiveness.

Variables: The studies consider variables in generative design can be categorised as follows: 1. Numeric parameters: These variables can be quantitatively described and include parameters such as areas, width/depth, height (in the case of model shape vector), PV module size, tilt, and pan angles. 2. Parameters that cannot be numerically described: These variables involve qualitative or non-numeric aspects and include relationships between rooms, embodied CO_2, costs, and the location of PV modules on building surfaces.

Objective: The case study's deliberate selection of a diverse range of research projects highlights the clear versatility of generative design. This variety of purposes, which showcase the capabilities of generative design, can be summarised and categorised as follows, Development of a parametric generative design method for residences integrating

performance-oriented green residential design, Identification of essential design elements and creation of new designs based on user requirements, Approximation of wind pressure on tall buildings for generative design exploration and optimisation, Automatic generation and planning of design options for modular construction, Utilization of genetic algorithms for creating and evaluating HVAC system designs, and Optimization of PV module layout on high-rise building skins.

Research Summary: In summary, the selected case study illustrates the vast potential of generative design in multiple applications, including architecture, engineering, sustainability design, energy optimisation, and system designs. The findings highlight the transformative capabilities of generative design, showcasing its ability to revolutionise architectural practices and drive innovation in various domains.

Essential issues are considered from the literature review of a Generative Design Case Study related to architectural design, which was selected from a diverse range of research objectives. These include case studies, tools, variables, objectives, and research conclusions. The selected case study examples show the relationship between objectives and tool utilization. The variables play a significant role in the Generative Design process. This examination reveals opportunities for potential applications of Generative Design in various domains.

RESEARCH METHODOLOGY

This experimental research applied the generative design structure of Rhinoceros 3D software and Grasshopper using repeat experiment methodology through case study of Willis Tower Shading Analysis and learning from Generative Design in Grasshopper by Digital Design Unit - TU Darmstadt YouTube Chanel. The chosen case study was based on its clear and easily comprehensible methods, making it accessible for beginners to understand the generative design process. The intention was to enable beginners to create commands and enhance their understanding of generative design by improving the command set and variables. The case study was a valuable resource for beginners to grasp generative design's fundamental concepts and practical application.

The Willis Tower is a skyscraper in Chicago, Illinois, United States. Its architectural configuration is characterized by a distinctive arrangement of nine square "tubes" grouped in a 3×3 matrix formation. However, the scope of this research endeavors to harness the unique attribute of the nine square tubes for design exploration. In conjunction with this focus, the research defines its own contextual parameters, stipulating distinct environmental considerations and prescribing specific vertical dimensions of 30m, 60m, and 90m. These prescribed dimensions serve as a controlled setting within which to simulate and investigate the generative design process.

The objective of the study was to explore various tower shading models. The study focused on nine sorted tubes alternating in automation tower heights of 30, 60, and 90 meters. Examples of these heights include configurations like 30-30-30-30-30-30-30-30-60 and 30-30-30-30-30-30-30-60-90. Design options were generated through the generative design process, incorporating selected variables such as building area, shadow area, overshadowing by neighbouring buildings, and overshadowing of parks. The Willis Tower Shading Analysis

comprised four main steps. First, a 3D model and shadow analysis were conducted. Next, variable numerical values were generated, and options were displayed and selected. Finally, output data from the selection process was obtained. Rhinoceros 3D Software and Grasshopper will be the primary research tools for creating a generative design process in this research. These tools were chosen due to their flexibility and ease of learning, particularly for beginner users. Grasshopper, as a plugin for Rhinoceros, enables the creation of programs through a visual programming approach. Components are added to a canvas, and their outputs are connected to the inputs of subsequent components, resembling conventional flow charts and graphical programming languages. It should be noted that this approach does not involve the use of conventional (linear) programming languages for defining images, thereby excluding most graphics editors from consideration. (Myers BA., 1986)

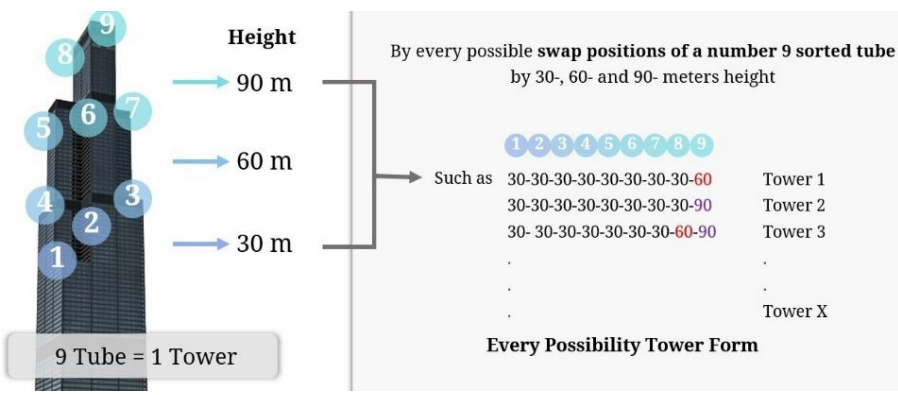


Figure 4. Finding All Possible Various Design Towers and Shadings

RESEARCH RESULTS

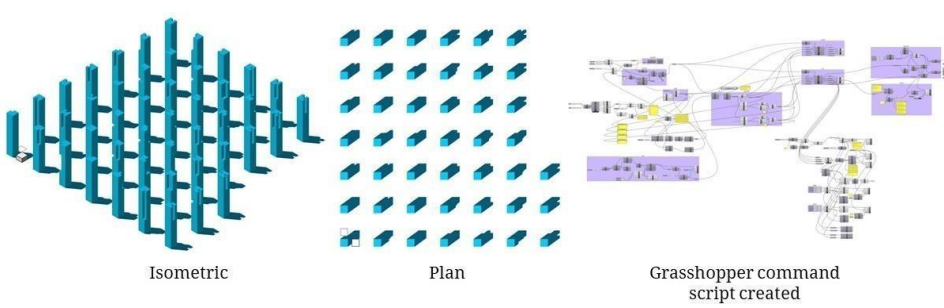


Figure 5. Isometric (Left), Plan (Middle), Grasshopper Script (Right) of 45 Design Options Results

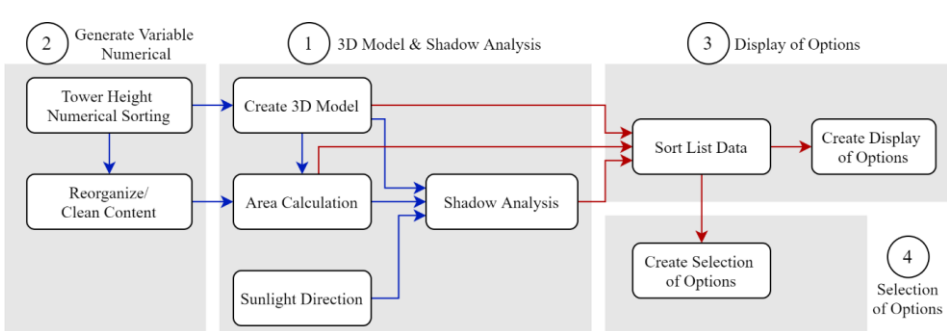


Figure 6. Creation of Willis Tower Shading Analysis for Generative Design

This research utilised Rhinoceros 3D Software and Grasshopper, generative design software tools, to conduct the Willis Tower Shading Analysis. The investigation resulted in the generation of 45 design options (Figure 5). The findings were presented and organised based on the four steps of the Willis Tower Shading Analysis: 1. 3D model and shadow analysis, 2. Generate variable numerical, 3. Display and Selection Options, and 4. Selection output data process (Figure 6).

1. 3D model and shadow analysis: The 3D model and shadow analysis phase involved inputs such as the 3D model itself, area calculations, and the direction of sunlight to facilitate shadow analysis. The outputs derived from this process included calculating the shadow area and assessing overshadowing effects on the surrounding environment. Figure 7 shows the surrounding of the main Willis Tower building (the blue building) is encompassed by a neighbouring building (the grey square buildings situated beside the main blue building) and a park (which is delineated as a square framed area on the ground) (Figure 7).

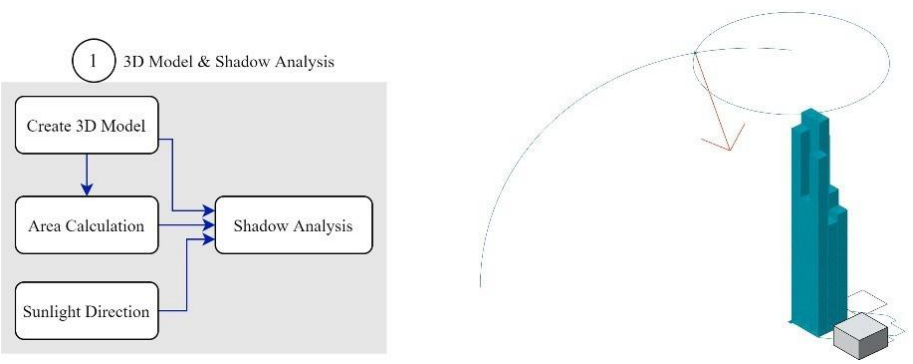


Figure 7. 3D Model & Shadow Analysis

2. Generate variable numerical: In generating numerical values for the variables, the inputs of the 3D model were adjusted by incorporating numerical data or tower height values. Specifically, the tower heights were arranged in a sorted sequence comprising nine tubes with heights of 30, 60, and 90 meters. An example of such a sorted tower height configuration is 30-30-30-30-30-30-30-30-60, and another example is 30-30-30-30-30-30- 30-60-90. Figure 8 presents the results of adjusting using numerical data or tower height values, resulting in the display of various building designs (Figure 8).

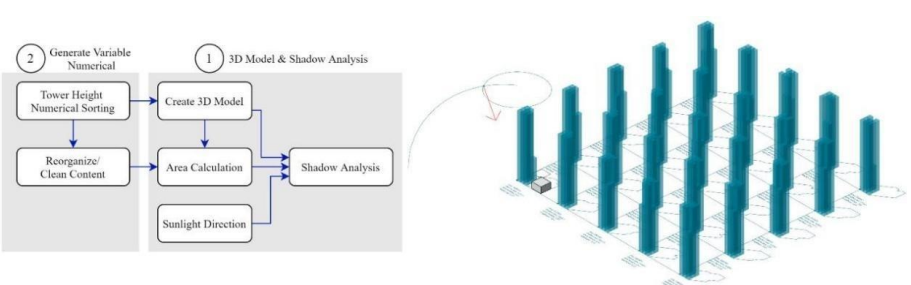


Figure 8. Generate Variable Numerical

3. Display and Selection Options: The design options generated through the generative design process were presented in the display and selection options process, showcasing the grid area and command code associated with each option. From these displaying options,

specific design aspects, including building area, shadow area, overshadowing by neighbouring building, and park overshadowing, were considered for selection and further analysis. Figure 9 shows all potential building forms based on the predefined criteria for the shadow analysis. The outcomes of the shadow analysis have resulted in a total of 45 building design options (Figure 9).

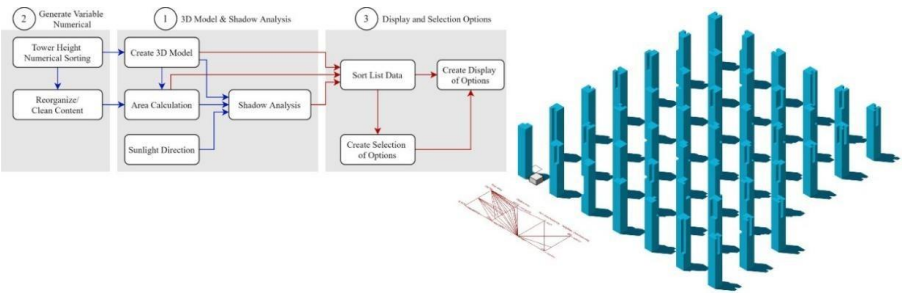


Figure 9. Display and Selection Options

4. Selection output data process: The selection output data process is the selection of design options for further application. Criteria used to select the option are the building design with shadow over the neighbour building and park overshadowing. Users can choose whether to optimize for the minimum or maximum of these criteria. After adjusting the values, the system will display the results, indicating which type of building aligns with the chosen criteria. As shown in the sample image, an experimental selection of three options was carried out: the Maximum Shadow Area option (Left), the Minimum Neighbouring Building Overshadowing option (Middle), and the Maximum Park Overshadowing option (Right) (Figure 10).

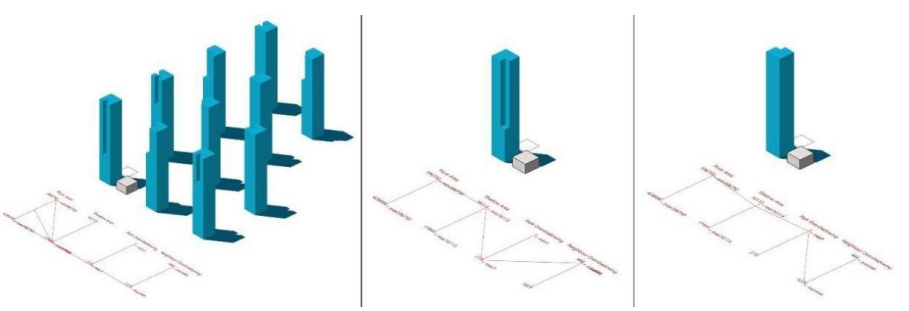


Figure 10. Maximum Shadow Area Option (Left), Minimum Neighbour Building Overshadowing Option (Middle), Maximum Park Overshadowing Option (Right)

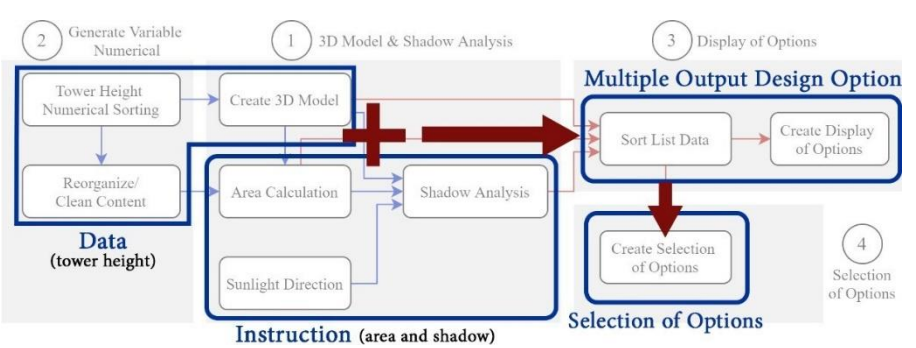


Figure 11. Simplified Process

The results of this study have improved our understanding of the generative design process. By creating 45 design options using the Willis Shading Analysis (Figure 6), the study has simplified process (Figure 11) for better comprehension. The aim is to make the steps of generative design more user-friendly and visually accessible, facilitating a clearer understanding of the process and the generation of design options.

DISCUSSION

The Results from This Experimental Study

The findings of this experimental study align with the conclusions drawn from the literature review. It was determined that the generative design process can be based on inputs and outputs. Comparing the workflow established in this study with other research in the literature review section of this article, it was observed that designers often use a reverse process when the generated design options do not meet their requirements. However, the literature review needed specific information regarding input data and instructions for completing the generative design process and selecting the final design option. Furthermore, variables such as the sorted height of the building, building area, shadow area, neighbour building overshadowing, and park overshadowing were identified as essential factors for generating multiple design options. The generative design process enables the generation of multiple alternatives that can be applied to various variables. This process can be tailored to include suitable variables that result in various options for design purposes and other tasks seeking optimal outcomes. Generative design presents an opportunity for the present and future, offering increased possibilities for finding innovative solutions.

Generative Design Transforming The Architectural Design Process

In modern architectural practice, the design process consists of several stages that are integral to the traditional approach of architects. These stages include pre-design, schematic design, design development, construction documents, and construction administration. During the pre-design stage, architects gather and analyse relevant information to understand site conditions, client requirements, and project goals. This information serves as the foundation for subsequent design phases. In the pre-design stage, architects gather information and analyse site conditions, client requirements, and project goals. Schematic design focuses on generating initial concepts and exploring spatial arrangements. Design development refines the selected concept, considering materials and structural systems. Construction documents involve preparing technical documents and drawings for permits and bids. During construction administration, architects oversee the construction process and address any issues. These stages ensure a comprehensive and systematic approach to architectural design adjustments. Each of these stages is essential in the overall design process, ensuring a comprehensive and systematic approach to architectural design.

Generative design can actively participate in the pre-design and schematic design stages. Architects can then proceed to the design development stage, where generative design can play a role, albeit to a lesser extent. In most cases, architects still rely on their judgment and expertise to make decisions and further develop architectural design. Integrating generative design into the architectural process can result in several outcomes, such as increased design exploration, improved efficiency in generating design options, and enhanced consideration of

multiple design variables. It is crucial to recognise that generative design does not entirely replace the role of architects. Instead, it complements their expertise and decision-making process during the design development phase. Architects remain essential in evaluating and refining the design solutions generated by generative design, ensuring they align with project requirements and meet aesthetic and functional goals.

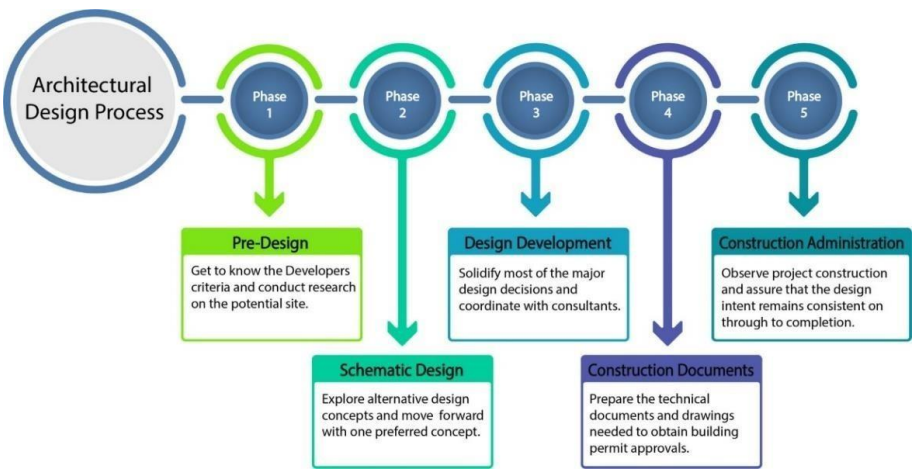


Figure 12. Architectural Design Process (BC Architects, 2020)

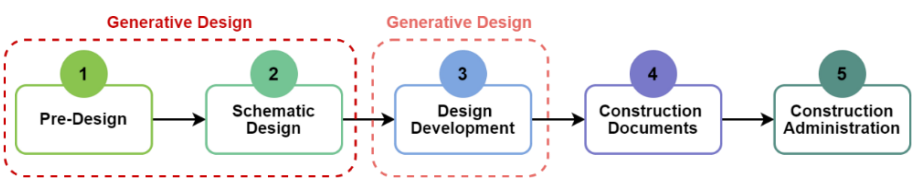


Figure 13. Generative Design in The Architectural Design Process

The Capabilities of Generative Design

In this experimental study, the results highlighted the capabilities of generative design in changing the design process. Several opportunities for its practical application were identified:

1. Time-saving in the design process: Generative design can process and generate various design options efficiently. This saves time compared to traditional design methods that may involve manual exploration of limited options.

2. Creative design outcomes: Generative design allows for diverse design options, providing opportunities to discover new and innovative design solutions beyond what individuals or small groups may envision. For example, in this study, the variation of tower height by altering variables led to many unique building forms. This exemplifies the creative potential of generative design through parameterisation.

3. Applicability across different content and categories: Generative design can be applied to various aspects of architecture, such as form and space, function, and sustainability. Its ability to manipulate variables allows for categorisation into numeric variables (e.g., areas

and width/depth) and non-numeric variables (e.g., room relationships). This versatility will enable architects to explore and optimise designs based on different criteria.

4. Improved design efficiency: By defining selection criteria, generative design can assist in identifying the best design options according to the designer's requirements. For example, in this study, selecting designs with the least shadowing over neighbouring buildings and maximum park overshadowing demonstrated the potential to improve design efficiency. Additionally, generative design can be used to optimise energy-efficient designs.

The experimental study highlighted the capabilities of generative design in changing the design process. The opportunities for its practical application include time-saving, creative design outcomes, applicability across different content and categories, and improved design efficiency. Its applicability spans other aspects of architecture, allowing for exploration and optimisation based on various criteria.

CONCLUSION

Generative Design for Alternative Creation

In conclusion, this study repeats the experiment methodology through a case study of Willis tower shading analysis produced various design options for nine sorted tubes of different heights. A total of 45 design options were generated using the generative design process, considering variables such as building area, shadow area, neighbour building overshadowing, and park overshadowing. The generative design process proved efficient, practical, and easily adaptable for analysis. The generative design process proved efficient, practical, and easily adaptable for analysis. Furthermore, it allowed data input and instructions to generate multiple output design options, with the flexibility to reverse the process to meet the designer's requirements (Figure 14). The researchers have discovered that the generative design process allows architects to perceive various alternative patterns that could emerge in a building and offers many design options. The selected design results can serve as a starting point for designers to develop detailed architectural designs further. The generative design process offers the flexibility to adjust variables based on user requirements, allowing for a wide range of design output options. This process involves inputting relevant data, providing instructions, and iteratively selecting options to refine the design. It empowers designers to explore various possibilities and refine their designs according to specific project needs.

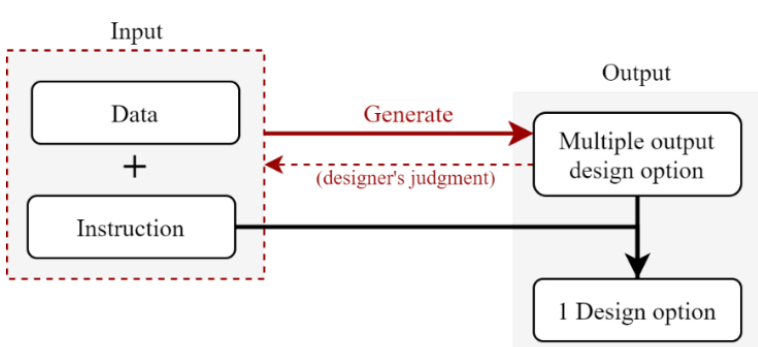


Figure 14. Generative Design Workflow

This study's main challenge was comprehending the generative design process and its instructions, which required repeated experimentation and case studies. The practical approach involved modifying instructions and variables to gain a better understanding. However, this experimental research provided a foundational knowledge of generative design. To further enhance the field, future studies should explore the program's parameters, components, and instruction languages, such as Python, to create a broader range of writing instruction codes. This will contribute to advancing the capabilities and flexibility of generative design methodologies.

Furthermore, compared to previous studies, the researchers have identified several critical factors that need to be considered during the option selection process for design. These factors include the project's intended usage objectives, the contextual surroundings of the area, as well as local regulations and requirements. Consequently, the researchers anticipate that they will attain a heightened and more comprehensive comprehension of the factors inherent to the generation of alternate possibilities and the subsequent selection of design configurations. Equipped with this augmented understanding, their objective is to advocate for advancing an increasingly comprehensive generative design methodology.

FUTURE RESEARCH

Future research should focus on bridging the gap between architectural knowledge and generative design. Despite the increasing popularity, accessibility, and efficiency of computer-aided design, there remains a lack of consistent integration between architectural knowledge and generative design. Organising and categorising knowledge in these two areas is necessary to understand their relationship better and facilitate their combined utilisation. By establishing a knowledge system and categorising relevant information, users can easily navigate and find application points for generative design. This will enable improved implementation and utilisation of generative design in architectural practice. Furthermore, generative design presents numerous additional opportunities within architectural design and finds application in various domains. These encompass sustainability, energy conservation, property valuation assessments, and other areas within the architectural sphere. Generative design has the potential to deeply enrich and broaden its applicability across architectural contexts, enabling profound and expansive utilisation.

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A STUDY OF ADAPTIVE REUSE PROCEDURES IN A POST-COLONIAL KUANTAN SHOPHOUSE

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Abstract
Post-colonial buildings exhibit the persisting impact of colonization across periods and geographical regions. Post-colonial buildings in Malaysia's urban and suburban areas are often found in abandoned or dilapidated states. Their neglect is predominantly due to a lack of purpose in modern settings. In answer to this, interior designers can take responsibility for their revival by promoting new ideologies for these buildings. By providing an in-depth examination of the potential revitalisation strategies for abandoned and dilapidated buildings of historical importance, the building's character can be conserved. Adaptive reuse is a new discipline of retrofitting an existing building's interior, encompassing the renovation and restoration processes in preparation for renewed use. This practice is becoming an essential element of modern interior design and architecture. Adaptive reuse utilises a combination of restoring and modernising existing buildings, allowing them to oblige contemporary practices whilst preserving features from the past. These methods have lower consumption of building materials and waste in comparison with new-build projects, thus reducing the environmental impact of the development. This paper recommends a new preliminary stage of interior design guidelines that incorporates the observation of existing materials and finishes.

Keywords: *Adaptive reuse; post-colonial shophouse; interior design*

INTRODUCTION

Heritage buildings in Malaysia's urban and suburban areas are often found in an abandoned or dilapidated state. Additionally, escalating demographic, financial, and environmental issues place constraints on new construction projects (Said, S. Y., 2013) In answer to this, interior architects are putting more focus on the transformation and adaptation of existing buildings in their new designs (Hasan, H. S. M., 2019). However, currently, there are limited resources available to use as guidance during this process. Adaptive reuse is a new discipline of retrofitting an existing building's interior, encompassing the renovation and restoration processes in preparation for renewed use (Lorek, E., 2022).

This practice is becoming an essential element of modern architecture, providing guidelines on how to investigate the first design strategies for recycling an abandoned building. This project aims to provide an in-depth response to the 2019 New Straits Times article (Babulal, V., 2019) examining the possibility of revival strategies for buildings of historical importance in Malaysia, by investigating the preliminary interior design stages of a shophouse in Kuantan by *MUKA* Design Society.

LITERATURE REVIEW

Many unique examples of Malaysia's architecturally significant buildings currently lie in abandoned and derelict states (BERNAMA, 2021). The revival of these sites through carefully planned restoration and re-purposing can give new life to a building and the surrounding area (Zolkafli, U. K., 2019).

The conventional process for utilising these sites is to demolish and rebuild a new one to suit the modern needs of the Community, however, the adaptive reuse method can preserve existing buildings and features while suitably fulfilling contemporary requirements in a more stimulating manner - if the necessary creativity is applied (Zahraa Adil Abdulameer, 2020). In response to this, 'REVIVAL' architectural design focuses on conserving original themes, features and characteristics of buildings while offering a modernised and alternative use for a space that would otherwise have been lost.

Revival projects look to assist the Malaysia City Councils, Tourism Malaysia, the 2030 Agenda for Sustainable Development and The Twelfth Malaysian Plan (12MP), by contributing interesting, significant and memorable landmarks within the country, drawing tourists and local visitors to the area (Qureshi, A. K., 2020).

History reveals that there are several examples of historically significant buildings that have been repurposed, demonstrating the concept's applicability to sustainability in terms of economic impact, public relations potential and the effectiveness of current urban assets. The experts concurred that adaptive reuse enhances a building's time, creates a safe and healthy atmosphere, and gives the decision-making process direction (Aigwi, I. E., 2022). A study in Auckland suggested that there are two actions that need to consider, one is the community has to optimize the protection of the buildings by adaptive reuse, and two is the new community has to support conservators to shelter the historical buildings (Cordan, Ö., Dinçay, D., 2014).

Protecting existing structures and buildings is critical to the environment. Using technologies can improve interior spatial design issues. The idea of an adaptive reuse proposal has to achieve preservation protections especially the character of the building. The primary focus of these proposals are buildings' aesthetic values, culture, and structure (Devitasari, A., Suprapti, A., 2021). The alteration via adaptive reuse will cause major changes in building typology. It can occur conversion in the character as well. The principles design needed to be in line to escalate the functions of the building (Plevoets, B., 2014). Historic buildings have not developed much attention so far which is frequently expressed in and via their interior aspects (Camocini, B., 2017).

Citizens' environment in this modern era had occurred a big impact on construction. The building crisis starts with incomplete and neglected projects. (Ahn, Y. K., 2007), For the historical buildings, maintenance deficiency, and limited budget is the main reason they left in abandonment. (Ling, T. C., 2020), High dampness and other factors generate many British colonial buildings to decay especially in Malaysia, the precision of selecting authentic materials and composition and maintenance are vital to protecting colonial buildings (Said, S. Y., 2013).

There are many types of colonial buildings in Malaysia has been gazetted as historical buildings. These buildings implemented restoration based on UK design principles for heritage buildings.

There are many post-colonial buildings that are still non-gazette due to many circumstances. Those buildings are being renovated within uncontrollable situations and create unattractive aesthetic values (Shalunts, G., 2011).

Architectural typology can identify the character of the elements of the building. This method can perceive the character of the building such as the facade (Armstrong, G., 2023). Adaptive reuse utilises a combination of restoring and modernising existing buildings, allowing them to attend to contemporary uses while preserving features from the past. These methods have lower consumption of the building materials and waste associated with new-build projects, effectively reducing the environmental impact of the development.

A new framework that incorporates the innovative and flexible aspects of adaptive reuse in an easily comprehensible set of guidelines. The proposed planning tool will assist in the management of adaptive reuse projects, guiding the transition into the modern community, academic or professional environments. This planning tool will be promoted as a guide to be followed for achieving sustainable developments in a local and Community context. As with all construction methods, adaptive reuse comes with advantages and disadvantages, all of which will be analysed.

Due to its ability to extend a building's useful life and promote the recycling of embodied energy, adaptive reuse is seen as a kind of sustainable development (Bullen and Love, 2010). The most ecologically friendly strategy for the preservation of historic structures and urban renewal is frequently regarded as adaptive reuse. Accordingly, and as claimed by Fisher-Gewirtzman (2016), adaptive reuse is a beneficial approach that entails reviving post-industrial cities by fostering future ideas via remain the design character of each building, adapting post-industrial landscapes, reshaping the urban fabric of contracting cities, reducing urban sprawl. In each of these cases, addressing issues or underuse is the primary motivator for adaptive reuse. Urban planners may apply adaptive reuse strategies to create low-carbon cities (Aigwi et al., 2020). The built environment is the single greatest energy user and the largest emitter of carbon dioxide and other greenhouse gas emissions, according to a Bullen's (2007) research.

According to estimates, the global built environment contributes one-third of greenhouse gas emissions and uses up to 40% of all energy generated (Cutieru, 2021). Another research by Bullen and Love (2010) reveals that up to 48% of the solid trash produced throughout a building's existence is created during demolition. In this sense, encouraging the reuse of existing structures helps both meet the needs of the present and future generations by preventing their demolition and reconstruction (Sugden, 2018). Sustainable adaptive reuse would be linked to "reduce, reuse, recycle" programs on a city-wide scale in an effort to strengthen carbon-neutral cities, the circular economy, and overall urban resilience. According to Korhonen et al. (2018), the circular economy denotes a strategy for economic growth that promotes both sustainable environmental development and economic growth. Repurposing existing structures simply illustrates meeting the needs of both current and future generations. By utilising the residual embedded energy in ancient buildings, adaptive reuse of buildings decreases the need for building destruction and lowers the disposal of solid waste from old structures.

Similarly to this, avoiding building demolition is thought to preserve important legacy assets and, as a result, help achieve sociocultural sustainability. However, adaptive reuse is still outside the mainstream of planning and thinking, and there is little available literature on the subject. In order to meaningfully contribute to the idea of sustainable and resilient cities, comprehending vacancy as a component of urban research is not fully unpacked. This study

set out to investigate the relationship between sustainable adaptive reuse, rates of building deterioration in underutilized areas, the impact on urban living, different types of building treatment, and the overall impact of vacancy on cities (Muhammad, A., Harun, 2017).

The purpose of this method study is to preserve and maintain the building's reputation and history including the fabric of an old building through appropriate preservation methods. By this preservation method, the building is able to lengthen the persistence function of the building and maintain the business operation. The adaptive reuse process is an addition to the old building. Referring to that an old building in Malaysia remains operative and purposeful accordingly to National Heritage Act 645. Referring to the National Heritage Department of Malaysia, the measurement of the preservation of an old building practised today is split into five works: survey overview, dilapidation survey, documentation, preservation works, and maintenance plan.

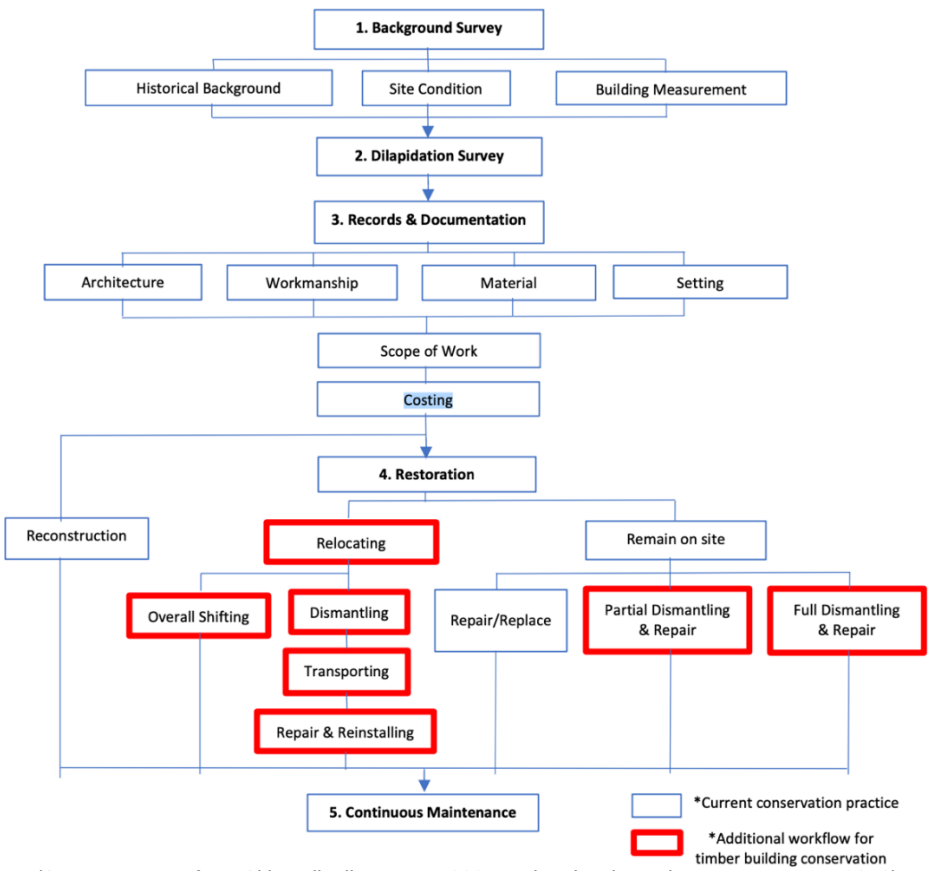
However, the frameworks of these procedures are general and apply more to preservation work done on-site, additional work has been done on this measurement, they are including, on-site photographs, and proposing new fabric and materials that suitable to the building. The preservation methods are included maintenance (protection), renovation, restoration and adaptive reuse, typically a requirement for this process is more than one work among those processes. Adaptive reuse is one of the methods of maintaining and examining an old building from being ruined or reconditioned without strategies management and well planning. This adaptive reuse contains certain works for preserving the existing condition of old buildings as well as sustaining their cultural values around the site areas.

Information regarding the building's location, history, major assets, present state, and former owner may all be gleaned via a background assessment performed early on based on National Heritage Department. A practitioner of building reinstallation describes the overview survey as looking at the building's condition in its original location to ensure the suitability of new sites in terms of area size, the building's overall dimension, topography, natural lighting, and other factors. As recommended by UNESCO, the Burra Charter, and the New Zealand Charter, the new site should also offer a context that is consistent with cultural heritage and values.

i. Dilapidation Survey: To determine the extent of the building's deterioration, a dilapidation survey was done in the following phase. The building's basic structure, floor space, wall portion, and roof are all included by the dilapidation survey. This will affect whether or not to submit the suggested conservation technique. Building defect levels are designed to guarantee that buildings that will be moved and dismantled may survive any process-related intervention. It also decides which construction component to reuse or repeat based on the survey results. The outcome of the examination will determine whether or not the building may be termed mobile. Buildings that are excessively weak as a result of degradation should not be relocated since doing so would need extensive replacement of damaged components.

ii. Records and paperwork A measured drawing is created for use as a guide for the whole construction process, from demolition to installation. Each building component's drawing has been prepared. The extent of work, methods, and techniques of building conservation is also determined by the specified drawing measures required in the supporting

documentation, which has an impact on cost estimations by National Heritage Department. The documents in many forms of media, such as photographs, videos, drawings, etc., are equally crucial as support to guarantee the building's authenticity. The design, construction, materials, and surroundings of a building are all considered when discussing its authenticity. Setting includes the interior and external design of the building being authentic and reflecting the cultural values of the area (Brown, A., 2014).



(Source: Extract from Siti Norlizaiha Harun, 2005 and Malaysia Heritage Department, 2016)

Figure 1. Malay Traditional Building Conservation Approach Framework

iii. Restoration Projects At this point, it is essential to enlist the help of professional woodworkers and conventional building specialists. Work should be based on advised criteria, which include reports on pre-conservation, ongoing conservation, and post-conservation. A specialist in the reinstallation of traditional buildings in Malaysia, the traditional Malay vernacular building is taken down in the same order as it was built, starting with the roof components and moving on to the floor walls before removing the main structure. Each component of the structure should be marked with permanent ink before the demolition process begins so that it may be recognized during the reinstallation work later (Yaman, R., Ali, K., 2021). Shortly after the deconstruction work is completed and before the reinstallation work begins, the appropriate design with dimensions for each component is created. In the translocation project, it is predicted that certain pieces would be lost or damaged. As a result, documents like component samples and measured drawings are used to recreate missing parts.

iv. Ongoing Maintenance: Maintenance plans are offered as a future guide to make sure the building is periodically managed and maintained correctly using the right approach and methodology. It is intended to carry out routine maintenance. Plans for maintaining traditional Malay structures should include a strong emphasis on measures against moisture, which is the primary cause of wood degradation. On wood, moisture encourages the development of fungus, which can damage dark stains and eventually cause rot. Traditional Malay buildings are constructed with floors elevated from the ground, as opposed to brick structures, to better withstand the tropical environment. However, in the majority of situations in Malaysia, problems with water dampness in traditional structures are caused by poor roof care. Rain and dewaters seep into the building's structure through the roof's leaks. As a result, for buildings, roof care needs to be serious. Figure 4 depicts how a 100-year-old Chengal column (Neobalanocarpus Heimii) from Negeri Sembilan's Seri Menanti Palace (Istana Seri Menanti) perished as a result of moisture intrusion from roof leaks.

The restriction of the building's movement load should also be taken into account when planning maintenance procedures for buildings. In Malaysia, there are preserved traditional structures that regulate building loads by permitting a set number of guests to enter at once. This study also aims to define design standards for IBS (Industrialize Building System) elements that have advantages and disadvantages in Malaysia's interior building market. This study suggests that others will benefit from the knowledge and information that is readily available on IBS components for interior building. This study also creates new design standards that are advantageous to designers that use IBS site components. Long-term use of this research will result in a collection of recommendations and new information that might promote user and CIDB usage (Yaman, R., Ali, K., 2019).

The article's goal is to assess the factors that should be taken into account when considering whether to reuse existing structures in an adaptable manner. Reusing a structure via refurbishment is consistent with the idea of sustainability since it allows a building to be used for longer without incurring major financial costs. The idea is connected to the circular economy hypothesis, which contends that by creating a network of closed-loop processes, where waste from one process is utilized as a raw material for another, raw material consumption, trash production, and energy losses may all be reduced to the absolute minimum. In order to determine whether to reuse a building, the article addresses factors that local governments, municipalities, architects, and designers should take into account. Technical, economic, social, geographical, and environmental factors were categorized. We investigated the preferences of existing and future practitioners who would be involved in the adaptive reuse of buildings in relation to the criteria in order to accomplish the main purpose. A survey approach was used to validate the most important criteria (Lorek, E., 2022).

METHODOLOGY

The methodology of this study involved observation of the physical characteristics of *MUKA* design society shophouses in the case studies, along with visual documentation; photography and videography and note-taking. Other recent researches on the *MUKA* design society that conducted a similar methodology are the studies by Brooker and Sally Stone, Rereading (2018). The scope of the study is within the visibility of the observed physical and social context of the case studies and does not involve perspectives from the visitors.

The outcomes defined from this review and the existing building case studies will inform the following proposals for the implementation of adaptive reuse methods on selected heritage building interiors across Malaysia. The compilation of case studies and literature findings will be used to determine specific applications for adaptive reuse in building design and concept.

FINDING AND RESULT

MUKA design society is located at 37, Jalan Besar, 2500. *MUKA* Coffee Cafe is a project that started in 2019 and was also during the beginning of the COVID-19 outbreak. The planning of *MUKA* took considerable time especially when the Covid 19 outbreak was first detected and identified in China. The plan was further dragged and slowed down and this affected the planning of *MUKA*.

According to Majlis Perbandaraan Kuantan, Pahang (MPK) the state council of Kuantan, the building was built in 1940. Before the renovation, the condition of the existing building's exterior and interior elements was that of dilapidation. Throughout the restoration process, he opted to retain as many existing features as possible. This serves two functions. The first is sustainability, which is achieved through the reuse of materials, and the second is the retention of character, which retains the strong physical that makes it a recognisable element in the city.

The design juxtaposition between old and new materials is what makes this cafe's interior distinctive. To resolve the utmost applicable adaptive reuse approach for post-colonial buildings, environmental attentions need to be considered.

Table 1 shows the area, space and interior element that has changed, and remain element. The decisions for the material selections remain is depending on the condition. There are 2 floors of the existing building, the first floor consists; of a façade, hall, kitchen/storage and rear court. There 11 basic interior materials have been identified. About 19% on the ground floor remain using the same material and finishes, 54% were mixed integrated between existing and new material proposals, and 27% were changed totally.

Table 1. Evaluation of Alterations Conducted to Interior Elements

Area	Space	Interior Element	Remain	Mix	Complete Replacement
Ground Floor	Façade / Entrance	Door and Window			/
	Hall / Living	Floor		/	
		Wall	/		
		Ceiling		/	
		Stairs and Baluster		/	
	Kitchen/ Storage				/
	Rear Court				/
1st Floor	Front Room	Window Panel			/
		Floor		/	
		Wall Ceiling	/		
	Corridor				/
	Backroom			/	
	Rear Court Roof	Trusses		/	/

On the first floor, 12% remain the existing material and finishes, 50% were co-material and 38% were total changed due to replacing the right material.

Figure 2. Images of The Ground Floor Condition Before Renovation

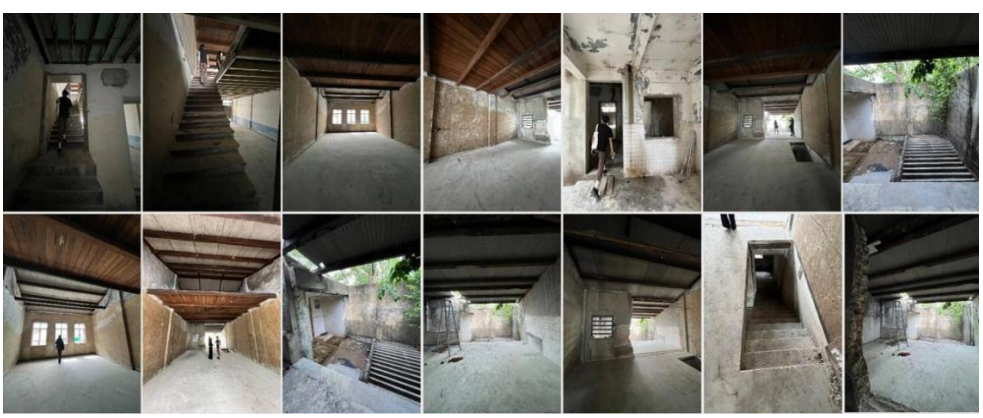


Figure 3. Images of The First-Floor Condition Before Renovation

CONCLUSIONS AND RECOMMENDATIONS

Before purchasing the building by the new owner, the shophouse had remained closed for several years, with no occupancy or business being conducted despite the popularity of the area in which it's located.

Following the opening of the renovated café, the number of daily shop patrons has been high and consistent in comparison to neighbouring businesses of similar purpose.

The transformation of the front-facing façade into an attractive and characterful entrance has enticed passing customers to explore more. The conservation of over two-thirds of the original materials throughout the shophouse ensures that the building's ambience remains tethered to its past, and the use of interior space which caters to modern functionalities encourages repeat visits.

To truly gauge the effectiveness of the adaptive reuse strategy utilised in the *MUKA* shophouse project, this study would recommend a data-gathering exercise be conducted to assess the opinions of patrons of neighbouring cafes where an adaptive reuse strategy was not employed. The results can then be compared to measure the success of the adaptive reuse method based on public opinion.

To support the findings from this study, a corresponding investigation into the types of interior design materials used could be conducted. This would provide a comprehensive analysis of the most suitable materials to use in adaptive reuse projects and act as the foundation for a set of design guidelines to be developed.

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APPLICATION OF THE NODE-PLACE MODEL TO EXPLORE THE SPATIAL DEVELOPMENT OF KL SENTRAL IN MALAYSIA

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Abstract
The basic principle of railway development is that a railway station is not merely a node where people change modes of transport but also a place where spatial concentrations of high-value activity in and around station areas are recognised. This paper aims to assess the spatial development of KL Sentral using the node-place model introduced by Luca Bertolini. KL Sentral was chosen as the case study of transit-oriented development in Malaysia to evaluate the station's spatial performance by balancing the node and place value of the station, besides using the TOD index. Direct observation was also conducted in KL Sentral to observe passengers' movement patterns and activities, including in the station building and surrounding areas within an 800-metre radius. The result of this study provides theoretical support for node-place value and TOD performance indicators for KL Sentral. It facilitates comparability among other stations and assists decision-making and actions in developing Malaysia's railway stations.

Keywords: *Railway Development; TOD; Node Place; Spatial Development*

INTRODUCTION

Conventionally, urban infrastructure has demonstrated railway stations as transportation functions, movement, or development. However, interest has evolved recently in developing railway stations to integrate with their surroundings - more than just interchanges where passengers transit from one mode to another. This shift in perspective acknowledges the potential of railway stations to serve as vibrant and multifunctional spaces, going beyond their basic transportation functions. Instead, they are seen as key nodes that can stimulate economic activity, social interactions, and the overall spatial development of their surroundings. That is, rail station areas are increasingly perceived as where there is interchange, stops, activity, and destination (Hale, 2013). It is also perceived as an urban fabric beyond as a transportation infrastructure (Banerjee & Saha, 2022; Zacharias et al., 2011). This entails that the stations are perceived as nodes of connectors - connect people to transportation and infrastructure, people to surroundings, and people to people (Cao, 2022).

Rail stations are not only defined as places where trains arrive and depart, but they are also reinforcing their interconnective function. In urban development, railway infrastructure has been promoted as a catalyst for broad development agendas such as urban regeneration and revitalization, as well as a focus for cities aiming to boost their status and image as liveable, and sustainable cities (Alexander & Hamilton, 2015). Through conceptualization of space as socially constructed, station development can be understood as part of placemaking strategies that help to rejuvenate the streets, (re) produce urban spaces, and, in turn, shape discourses about the city image (Muriby, 2007; Viet Anh, n.d.). Here, urban design in the transportation context is imperative in maintaining the visual, functional, and physical links between station concourses, streets, malls, squares, and landmarks (Abdul Latip et al., 2023).

Technically, it can be observed that urban design shapes the public realm at the intersection of architecture and urban planning, from macro to micro scale, which demonstrates that urban design should move beyond land use and spatial planning into movement analysis and cross-sectional design.

The success of a dynamic urban space is determined by how well it connects with the surrounding. The Next American Metropolis by Peter Calthorpe (1993) addresses the transit-oriented development (TOD) concept, an architect, urban planner, and the founder of American TOD. In his book, a mixed-use neighbourhood that is "within an average 600m walking distance of a transit stop and core business centre" is what Calthorpe called a TOD. TOD make it convenient for people and employees to travel by transit, foot, bicycle, or car by integrating residential, retail, office, and open space in a walkable environment (Calthorpe, 1993). TOD has the greatest opportunity to incorporate urban design in infrastructure projects to create an appealing public space with a diverse potential for economic and social activities (Abdul Latip et al., 2023). This phenomenon will then be related to wider contextual factors to focus on planning and designing a station as a node and place. However, the elements of TOD involve the tension between the role of a railway station as a node in a regional transportation network and, at the same time, the station's role as a place in a neighbourhood context (Yang et al., 2022). A key node-place tension exists between the station's role as an access point for people arriving by public transport, cars or foot and its station area to create a pleasant place.

Many design issues abound here, including the station's footprint in the community, the integration of the customer services counter into the station itself, and the location of parking and drop-off bays (Caset, 2019). Beyond urban design issues, the node's function in the transportation network and the type of place it is in the region are important factors to be concerned about (Singh et al., 2017). The discussion in this paper picks up this subject and deals with KL Sentral. KL Sentral, the largest transit hub in Malaysia and a TOD reference, as a case study for this paper, will be judged on its contribution to place and transport infrastructure using the node-place theory by Luca Bertolini. This paper aims to define the terms "node of networks" and "place in the city" with two (2) objectives. Firstly, the paper reviews the theory of TOD and the node-place model. Secondly, the theory has examined its spatial functions, which affect the station's attraction and movement. The spatial functions explain how KL Sentral serves primarily in the transportation network in Klang Valley, and the neighbourhood explicitly links the node-place model.

LITERATURE REVIEW

TOD and The Node-Place Model

It remains necessary to examine the integrations between land use and transportation in TOD areas under a systematic framework (Bertolini, 2008). Both integrations can describe station areas through the node-place model as an analytical tool. The node-place model introduced by Bertolini in 1991 is an analytical framework to systematically assess transit stations in a transport network (Caset, 2019). The qualities of the station area can be quantified in the way of indicators within the index of node, place, and design (Chorus & Bertolini, 2011; Monajem & Ekram Nosratian, 2015; Olaru et al., 2019). According to Chorus & Bertolini (2011), a railway station has two basic functions: node and place. Node is a train

access point and will increase to other transportation networks (see Figure 1a). While the place is a specific section of the city with a concentration of infrastructure but also diversified buildings and open spaces (see Figure 1b).

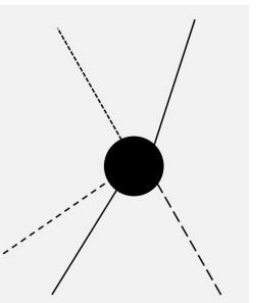


Figure 1a. Diagram of Station as a Node

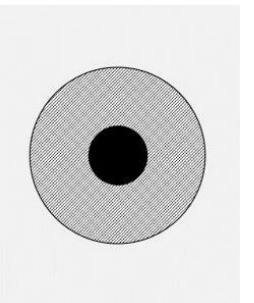


Figure 1b. Diagram of Station as a Place

Bertolini (1996) illustrates five (5) associations between node and place dimensions: dependency, accessibility, stress, unsustained node, and unsustained place. As shown in Figure 2, the station's network accessibility is shown by the y- axis (node), while the x- axis represents the station's land uses (place) (Bertolini, 1996). The x- value indicators also include the number of residents and employers in several economic sectors at station areas and create diverse activities (Bertolini, 1996, 2008). It thus contributes to the potential of actual human interaction as there are more activities present. Considering that the higher the number of people who can get to the station, the greater the potential for interaction (Bertolini, 1999).

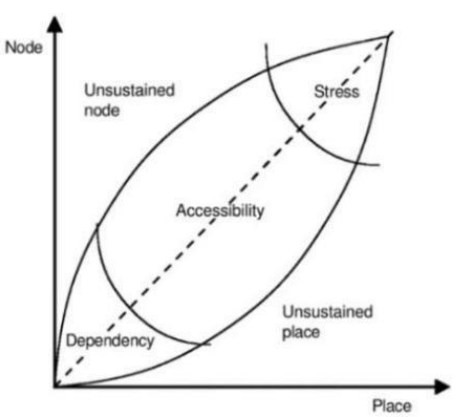


Figure 2. The Node-Place Model by Bertolini (1999) to Balance Accessibility and Station Area

The model suggests that a balance must be present or will develop between node and place functions for railway stations. Balance refers to a dynamic search for equilibrium rather than a state of static equilibrium (Caset et al., 2017). A station above the diagonal is where the potential for passenger interaction has not been fully realized despite high connectivity in the rail network. This situation is called an unsustained node (above the middle line). A station is an unbalanced place or node if its node and place values are unmatched. The unsustained node, in turn, demonstrates the opposite situation, the unbalanced place and node. The unbalanced nodes refer to where the transport systems are relatively more developed than the urban activities around the station areas. An unbalanced station area thus has a significantly strong relative position in the node or the place value. The station is a balance station where

the node and place value are matched, but over configuration or under the configuration of node and place value, or where both the node and the place have been used to the fullest would result in stress or dependence. Stressed station areas have a relatively strong position on node and place value. Further development in these areas may become problematic as multiple claims on the limited space can easily cause conflicts.

REVIEW THE CASE OF KL SENTRAL

Kuala Lumpur Sentral (also known as KL Sentral) is the leading transit hub in Malaysia (9.3 acres of land in total, and 10.5 acres are dedicated to the depot) and a largest integrated railway terminal in Southeast Asia. It opened in April 2001 at the heart of KL Sentral CBD to replace the old Kuala Lumpur Railway Station. KL Sentral is integrated with major roads (such as Jalan Damansara and Jalan Syed Putra) in Kuala Lumpur and with other modes of transportation, including Light Rail Transit (LRT), Mass Rapid Transit (MRT), Keretapi Tanah Melayu Komuter (KTM Komuter), monorail, intercity trains (electric train system - ETS), interstate buses and taxis. KL Sentral also connects the hub to Subang Airport by KTMB, Kuala Lumpur International Airport (KLIA), and Kuala Lumpur International Airport 2 (KLIA2) by KLIA Express and KLIA Transit, operated by the express rail link (ERL). The point that connects almost all major lines manifests what KL Sentral truly is. In 2022, the annual average daily number of passengers at KL Sentral entry and exit recorded 220,354 passengers, a spike during the post-pandemic period (www.mot.gov.my).

To understand the physical characteristics of KL Sentral from a broad perspective, Table 1 illustrates five (5) different typologies: terminal building, station, space, function, and settlement hierarchy. Furthermore, Singh et al. (2017) and Kim and Shin (2021) suggest these typologies. As an interchange transfer station, KL Sentral produces a complex space typology connecting many modes of transportation with many lines and routes. As a multiple-function station space for economic and commercial activities, service areas, and social and cultural activities as in-transfer areas, KL Sentral strives to optimise its functions in the city centre of Kuala Lumpur and affect the urban fabric.

Table 1. Different Typologies for KL Sentral

Typology	Terminal Building	Station	Space	Function	Settlement Hierarchy
	On-Ground	Transfer/Interchange	Complex	Multi-Function	City Centre

ANALYSIS AND DISCUSSION

Measuring TOD Performance

Ewing and Cervero (2010) have recommended the land use proportion of urban TOD. To fit in the Malaysian context, this study also reviews the recommendations by (Niu et al., 2019), who studied Singapore TOD stations' land use characteristics. In this study, the area within 800 metres of the KL Sentral is analysed, and spatial statistics are used using a Geographic Information System (GIS) technique (see Figure 3).

Table 2 below shows the land use distribution according to housing, commercial, public facilities, parks and green space, and roads. The total buffer area of KL Sentral is approximately 2.011 km2. Giving to the TOD performance for KL Sentral based on land use

characteristics, KL Sentral received an 'A' grade for housing, commercial, parks, green space, and roads, which is feasible for the land use proportion recommended by Calthorpe (1993). The public facilities received an 'H' grade as they calculated 19.70%, exceeding 11%. As for the hierarchy of KL Sentral as an urban TOD station, the study found that development years, urban economic growth, and urban regeneration programs result in higher land use mix degrees. This is undoubtedly true in that the functions of a transit station are elusive because they can be constrained by various other factors such as planning policies, the political environment, passenger socio-demographics, train operating characteristics, financial mechanisms, development plans, and others.

Table 2. The Distribution of Land Uses of KL Sentral Within an 800-Metre Radius and Its TOD Performance Score

Land Uses Category	Area (Hectare)	Percentage (%)	TOD Performance
Housing	40.34	20.00	A
Commercial	31.81	15.76	A
Public Facilities	39.73	19.70	H
Parks and Green Space	21.43	10.62	A
Road	59.76	29.61	A

L	Lower than The Standard TOD	A	Applicable Within Standard TOD	H	Higher than The Standard TOD

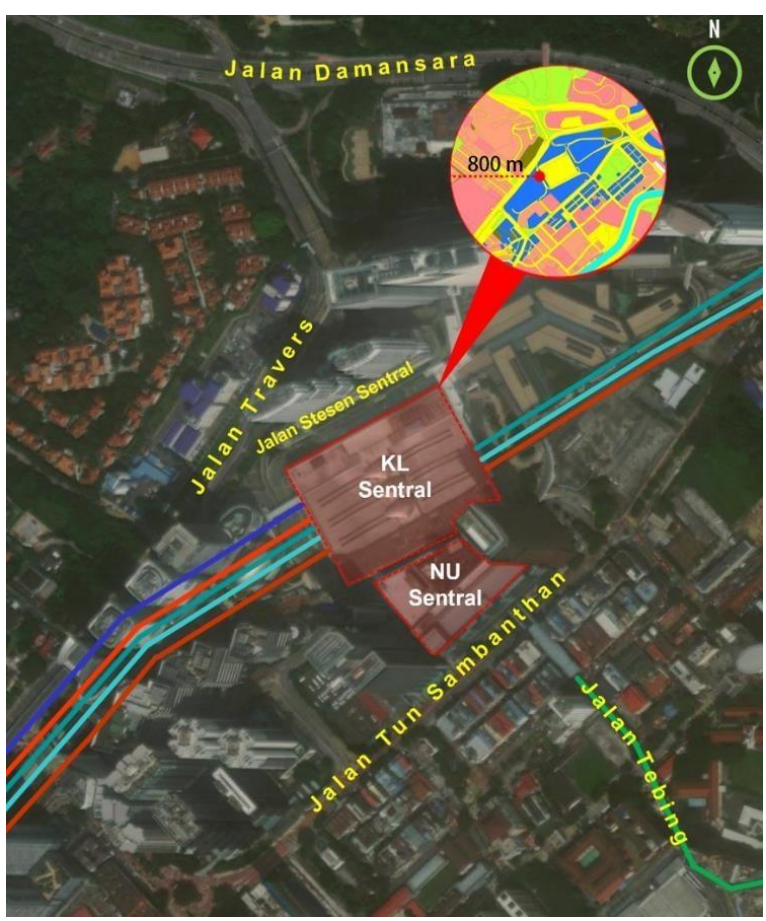


Figure 3. The Sation's Buffer of KL Sentral Within 800 Metres

This paper also comprehensively analysed the TOD level for KL Sentral based on five (5) sets of indicators: diversity, design, distance to transit, and destination accessibility, as suggested by Cervero & Kockelman (1997); Ewing & Cervero (2010). The indicators were calculated and aggregated using ArcGIS, as presented in Table 3. All indicators have been standardised using the maximum standardisation technique, which applied a 0–1 gradient to all values and aggregated them into the TOD index with an equal-weighted technique. The indicators help to determine how effective and successful the TOD concept is regarding supporting the function of the rail station and its network and accommodating a liveable environment. Overall, KL Sentral received a score of 1.24, with the design elements of open space (1.00) and parking (0.82) scoring higher than the diversity of land use (0.92) and distance to transit (pedestrian density) (0.90). The result of the land use score is proven by the earlier analysis on land use distribution within the 800-metre buffer of KL Sentral and scores as applicable within the standard of TOD with the diversity of land uses. For pedestrian density, the semi-grid iron street pattern with minimal conflicts over the street and the interconnectedness around KL Sentral areas offer many available alternatives for pedestrian routes that are accessible and convenient to walk, especially with the high degree of land use mixedness.

Table 3. Calculation of TOD Index Indicators

Indicators	Measurement	Formula
Density	Population Density (People Per km^2)	*PD* = *NP/A* Where *PD* = Population Density, *NP* = District Population, *A* = District Area *PA* = *PD/SA* Where *PA* = Buffer Area Population, *SA* = Buffer Area Coverage (2.01km^2) *PD* = *PR/SA* Where *Pd* = Population Density of The Buffer Area, *PR* = Population Residence Area
	Commercial Density (Number of Commercial Activities Per km^2)	*CD* = *NC/SA* Where *CD* = Commercial Density, *NC* = Number of Commercial Activities, *SA* = Buffer Area Coverage
Diversity	Land Use Diversity (Mix Percentage)	1 - $\sum$ (a/A)^2 Where *a* is the total area of specific land use (e.g. residential, commercial, industry, facilities) within the buffer area, *A* = total area of all land use categories within the buffer.
Design	Open Spaces	Total Area in Acre
	Parking Space	Total Area in Acre
Distance to Transit	Pedestrian Path	Total Length of Pedestrian Within The Buffer Area Using ArcGIS
	Intersection Density	Number of Road Crossings Per km^2 Within The Buffer Area
Destination Accessibility	Land Use Mixedness (Mixedness of Residential Land Use with Other Land Use Categories)	MI (i) = $\frac{\sum_j L_o}{\sum_j L_r + L_o}$ L_o = Non-Residential Land Uses for Each L_r = Residential Land Uses

To view each of the TOD indicators' results for KL Sentral, Figure 4 visualises the TOD performance based on five main TOD indicators. The diagram shows almost proportionality within each hexagon, whereas the strongest concentration is on land use, open space, parking, population, and pedestrian density indicators. While the smallest proportion of the hexagon axis shows a land use mixedness indicator.

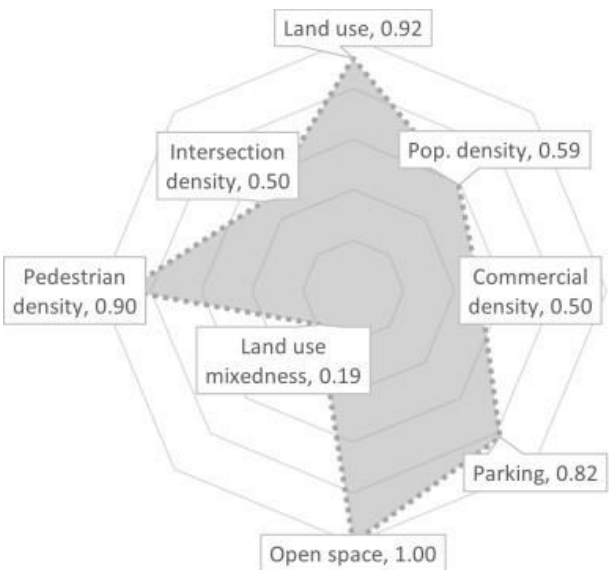


Figure 4. Hexagonal Diagram for TOD Index Level for KL Sentral Based on Five Indicators

Overview of Node-Place of KL Sentral

KL Sentral is progressively understood as an urban district with more than a transportation and infrastructure project, especially after it is integrated with the mixed development of NU Sentral. The brief assessment of node-place characteristics for KL Sentral is shown in Table 4 to examine the characteristics of the node and place of KL Sentral.

The 2-days observation was conducted in KL Sentral building, including Jalan Stesen Sentral, Jalan Stesen Sentral 3, Jalan Tun Sambanthan, Jalan Tun Sambanthan 4, Little India Brickfields, and Jalan Tebing. The observation started from 8.30 am until 8.00 pm on 3 January 2023, Tuesday. The purpose of observing on weekdays is to observe and analyse the daily movement, activities, and type of passengers (especially the workers who contribute more to the movement).

From the direct observation that has been carried out, two (2) types of passengers can be classified in KL Sentral: (i) transit passengers and (ii) office workers. The passengers only transit in the KL Sentral to transfer or to their destination, without stopping at any shops or stores in KL Sentral or NU Sentral. At the same time, the office workers working in KL Sentral, NU Sentral, or around the station areas are either departing (employment moving to the node area from the outside node) or leaving places (employment from KL Sentral building to outside the node area). These types of employment are related to the offices and residential functions provided close to KL Sentral.

The KL Sentral building, connected to the NU Sentral Mall, is relatively small to accommodate the current and future passenger capacity. Both buildings produce an excellent transition between the interchange and non-transport activities, evident in the efficient use of space. As the observation has been conducted at specific hours, the people's movement will be classified as heavy, moderate, or low based on the number of people passing the gate. The first observation in the morning found that the concourse creates heavy and fast movement and crowdedness during the peak hour between 8.00-9.00 am. The crowdedness is significant when the passenger density increases. A lower movement level is observed at 10.00 am and during office hours after the peak hour. The passengers are mainly in transit, either as retail workers or for leisure purposes, to the NU Sentral. The central concourse level observed less passenger movement, and the same was accurate at the commuter entrance hall and train gates. The movement level gradually increases between 12.00 noon to 2.00 pm as the period is reflected in the flux of space use patterns, whereby office workers mainly occupy the area during peak and lunchtime periods. The shops, restaurants, stores, and services in the KL Sentral become the movement attractors that attract passengers to stop by. This area becomes congested during peak hours, which are 12.00 noon to 2.00 pm and 4.00 to 8.00 pm. The movement rate at the LRT, KTM, and MRT gates and platforms increases from 4.00 to 7.00 pm. The movement rate increases at the NU Sentral entrance and rear entrance (southeast side) through the bridge and a series of escalators where passersby walk towards the LRT, KTM, and MRT platforms and gates. As Yuh Yao et al. (2018) claimed, the movement and circulation of the KL Sentral are based on the architectural design idea of the "Coral", which represents the city were urban life flows efficiently without boundaries. The other issue with internal layout is the unclear sense of orientation, instantly providing a sense of place and direction (Yuh Yao et al., 2018). Poor orientation may leave visitors wondering if they are walking in the right direction.

The main entrance of the KL Sentral in Jalan Travers is associated with clusters of urban mixed office towers, hotels (such as Hilton KL, St Regis, and Le Meridien), and commercial uses with a high level of pedestrian and vehicle movement. The building blocks linear arrangement gave visual consistency and reduced distance. In the planning concept of KL Sentral, the furthest buildings from each other are at most 400m to and from the station to encourage more movement by foot and create a convenient environment. In addition, KL Sentral has designed a horizontal façade facing the adjacent buildings with the lowest height to avoid the direct sunlight that the adjacent building has blocked from the station building. Most buildings and towers paint a picture of aggressive modernisation, only leaving behind only the KTMB Building and National Museum in Jalan Damansara. The front area (departure hall of KL City Air Terminal) is filled with mixed types of people and typical activities shared by office workers, commuters, and travellers, as well as local people.

KL Sentral has two completely different urban patterns between its front and rear, reflecting two distinct urban environments (Khalid et al., 2019). Both areas have a bustling front side contrasting with decrepit surroundings to their rear. Their urban patterns unmistakably imply that a significant amount of movement by vehicles and pedestrians are generated in the mixed-use front area, which is cohesive and densely built but needs to be better utilised with its surrounding block patterns (Khalid et al., 2019). For the rear area in Jalan Tun Sambanthan, Jalan Thambipillay, and Jalan Sultan Abdul Samad, the cluster of three-story old shophouses, located to the southeast of the KL Sentral and NU Sentral, is well defined by the urban grid. The rear entrance (southeast part) from the NU Sentral at ground

floor level needs passengers to pass by the shops and crowdedness to go to the monorail station and to get out of the building. The area also includes churches, a mosque, government offices, schools, retailers, hotels, and a morning market in Jalan Tebing, a section fronting the Klang River.

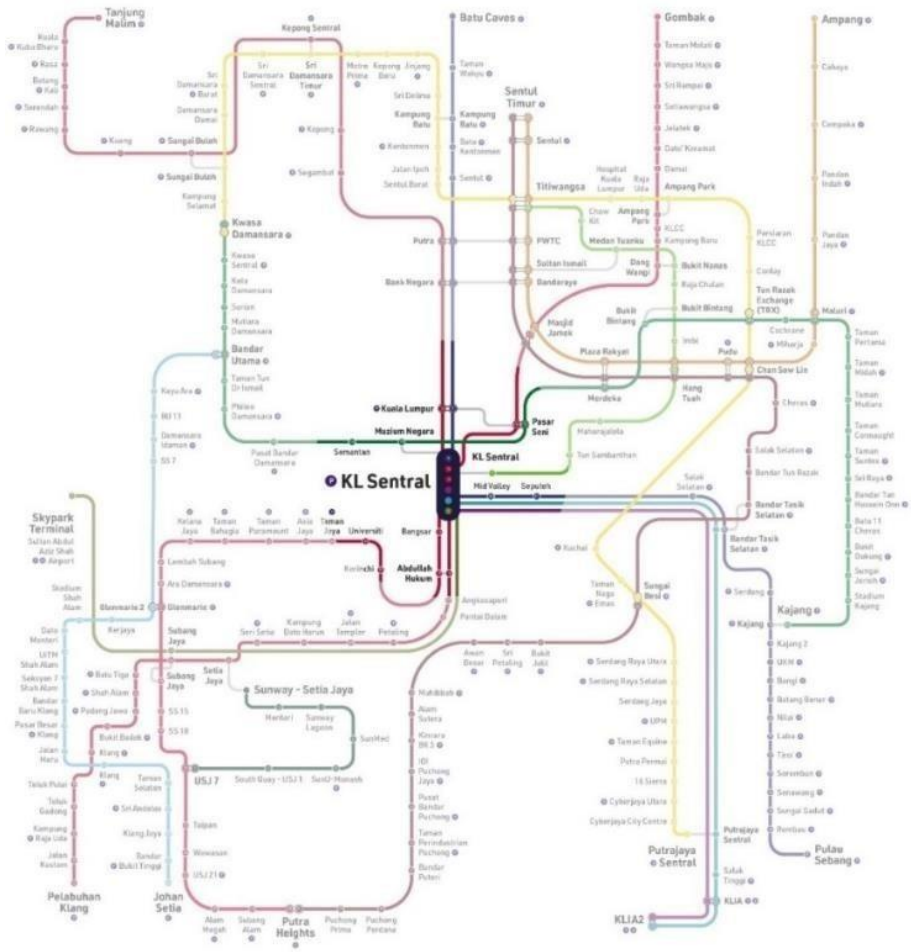
Table 4. Assessment of Node-Place Characteristics of KL Sentral

Elements	Characteristics
Node	
Spatial reach from node	Local – (inter) national
Transport pattern	Monocentric
Accent on	Domestic passengers
Transport unit cost	Lower middle
Management of node	No separation between infrastructure and services Monopolistic, subsidized
Target market	Commuters (for work, school/college), city users (shopping), long-distance business, local traveller, tourist
Spatial constraint on transport development at node	High
Place	
Typology location	Urban
Land consumption per unit transported	Moderate
Land use density	High
Variety of uses	Moderate
Dominant of uses	Transport related
Dominant place-connected activities	Commercial (shop lots), condominiums, shopping malls, hotels, corporate offices tower, institutions
Variety of place users	High
Access	Public
Type of property development	Regeneration of existing fabric
Node-place	
Node-place relationship	Local interaction, and intra-regional dependence
Economic impact of node	High
Environmental impact of node	Moderate and spatially limited
Density of actors	High and fragmented
Policy context: thematic focus	Environment (positive indirect effects)
Specific issue	Development of public transport, privatization of railway companies

The Node Value

Nodes are the points at which goods and passengers are transported from one node to the following (Bertolini, 2008). Reusser et al. (2008) argued that a transportation node like a rail station had more than just accessibility (how many destinations, how quickly, and how accessible it could be from the origin). Nevertheless, the station also serves as an activity hub (how many diverse activities can be performed in a station area) (Reusser et al., 2008). Node values measure the intensity and connectivity in the transit network and the vicinity of the transit stop, and based on this model, when transportation and land use-driven demand in the station area are balanced, the ideal state of a node has been attained Bertolini & Spit, 1998). In this case, KL Sentral has a significant function as a railway station that provides transportation facilities to people, as the interchange is the central concept. Because of its central position in the national railway network, KL Sentral is the largest railway station in the country and the biggest connecting station where passengers can transfer between

monorail, LRT, and intra-city trains like commuter by KTM and Express Rail Link (ERL a high-speed rail service in Malaysia that operates between KL Sentral - Kuala Lumpur International Airport, KLIA and KLIA2) and including intercity buses (see Figure 5). It connects transit networks, offers transport services to the catchment areas, and comprises a transportation demand.



(Source: www.mymrt.com.my)

Figure 5. KL Sentral in the Networks of Urban and Regional Public Transportation

From a node perspective, KL Sentral is accompanied by other public transport and services. These modes of transportation services as multi-modal transport hubs where various types of passengers can switch between them. KL Sentral was integrated with four lines as an interchange station. There are the LRT Kelana Jaya Line, monorail line, KTM Komuter Batu Cave - Pulau Sebang Line, and Tanjung Malim - Pelabuhan Klang Line.

The Klang Valley's rail-based transit system generally consists of three (3) LRT lines: the LRT Ampang Line, the LRT Sri Petaling Line, and the LRT Kelana Jaya Line. The Klang Valley Mass Rapid Transit (KVMRT) was designed to support continuous connectivity and integrate with the existing LRT, KL Monorail, KTM Komuter, KLIA Express, and KLIA Transit systems in the Greater Kuala Lumpur/Klang Valley. Two MRT Lines have been

implemented: the MRT1 Sungai Buloh-Kajang (SBK) Line, which has been fully operating since August 2017, and the MRT2 Sungai Buloh-Serdang-Putrajaya (SSP) Phase 1, which began early construction in 2016 and was fully operational in March 2023. Two (2) commuter lines operate: KTM Komuter, a monorail line known as KL Monorail, and an airport rail link to Kuala Lumpur International Airport (KLIA Terminal 1 and Terminal 2).

Drawing on the integrated rail networks of Klang Valley, it can be analysed that the spatial pattern is monocentric. However, despite its continued expansion, the conventional central business district (CBD) remained the predominant area as cities typically have a core business district, like KL Sentral, where the main operations are concentrated because of economies of scale (employment, property, and services).

In addition to being a monocentric city, the spatial system of Klang Valley is a radial structure which connects the central attractant area directly with transfers with the rest of the city. The new lines, such as MRT Putrajaya Line Phase 2 and LRT3, are created to serve new attractant spaces along the lines resulting from the CBDs scattering. Due to the slow progress of new CBDs growth along these lines and station location, the aim appears challenging, given the slow expansion of new CBDs along the lines and the station's location.

It can be summarised that the transportation networks of KL Sentral consist of three (3) phases. The first is a highly centralised one where the major activities occur in a CBD such as KL Sentral. The second is an intermediary phase, when some of these activities start scattering over adjacent CBD areas, such as Bangsar, Cheras, Bandar Sri Permaisuri, and Sentul. The final phase is a scattered urban form, where many activities are relocated to the new peripheral areas far away from the KL CBD, such as Putrajaya Central, Subang Jaya, and Kwasa Damansara. The decentralisation of the cities in Klang Valley, especially a few decades ago, was brought on by changes in land use, transportation, and the sprawling of the CBDs. Even with this, the public transport system in Klang Valley is still mainly oriented toward the core cities. At the same time, suburban communities such as Puncak Alam, Kuala Selangor, and Bangi are less connected by public transport, especially rails and buses. Therefore, the somewhat high level of car use in cross-commuting Klang Valley makes intuitive sense because many commuters from the suburban areas also live in the suburban.

The Place Value

As marked by Tuan (1979), space and place define geography's nature. Space may have been created out of nothing, but how it is organised, used, and understood results from social translation, transformation, and experience. Also, as functional nodes in space, place is much more than just location and extends beyond the spatial dimension of socio-economic phenomena (Banerjee & Saha, 2022). The terms individuals employ to give any area a sensation having a stronger emotional charge than location or practical space hold the key to place meaning. The place value of railway stations may vary depending on where they are located within the city (Alexander & Hamilton, 2015). If the station is in the urban core, it urges a different plan for developing the space in and around it than a peripheral area. Rail stations in urban core locations have more comprehensive of being well-connected intra- and inter-urban network linkages. In contrast to the stations of peripheral locations, which have the discomfort of comparatively poor linkages with public transportation or active mobility such as walking and cycling (Cao, 2022).

KL Sentral was initially designed to provide transport services to inter and intra-passengers. However, as time goes on, it transforms into a multifunctional urban fabric, providing a wide variety of public transport services to people with different social needs. Besides, it has been designed as a place with multifarious roles and has been foreseen as an urban place that performs various social and economic functions to serve locals, tourists, and travellers. The rear areas of the KL Sentral, in Jalan Tun Sambanthan, connected to the Little India Brickfields (approximately 400m from KL Sentral by foot), can be seen as public spaces that created and encouraged a sense of community. The station renders visitors and tourists a unique experience without even going far from the station- become a social and cultural hub with diversified services and facilities. Besides Little India Brickfields, it can be recognised that pedestrians enjoy walking along Jalan Tun Sambanthan because of the built environment elements such as the small blocks of shophouses, the colourful street furniture, shading, historical façade, pop-up booths, informal stalls, and the connected pathways, among others, which make walking along Jalan Tun Sambanthan enjoyable for pedestrians and significantly contribute to the vibrant public life. On the one hand, neighbourhood walkability is stimulated by mixed land use and high density, and public transport for travelling outside the neighbourhood is promoted by efficient transit infrastructure such as bus stops, pedestrian pathways, and crossings. High densities correspond to comfortable and walkable environments and easily reach the destination. However, KL Sentral is only walkable within it. It is an island compared to the surrounding neighbourhood and parcels connected only by private bridges. It may reflect the concept of "City within a City", where the linkages are only designed within the building purposely. It is only walkable from the next door of KL Sentral, such as CIMB Tower, Q Sentral, or St Regis. Another example is the poor connection from Botanical Garden to KL Sentral unless access via MRT Muzium Negara for air conditioner and covered bridge. KL Sentral should be a perfectly walkable city within a city where nobody should be driving to KL Sentral with so many public transport options converging there.

DISCUSSION AND CONCLUSION

Quantifying a balance between the KL Sentral's node and place functions is challenging in terms of its network, accessibility, and activity as well. This system's node and place functions must be strongly balanced to achieve a high impact on the station. It becomes clear that in planning, designing, and developing activities (social and economic growth) around the railway station areas, the spatial configuration is a crucial procedure.

The study highlights the significance of the node-place model in evaluating transit-oriented development (TOD) stations, emphasizing the relationship between transportation infrastructure and the potential for surrounding area development. The motivation for the study came from the demand for more attention to the spatial configuration in the TOD research topic using the node-place model. In considering any typology of railway stations, planners are challenged with node and place tasks that may be similar or different. Planners must consider two crucial needs: first, a node and a place function must be distinguished, and second, node-place interactions must be dealt with together. the challenge of the development of node-place is the need to deal at the same time with both transport infrastructure and urban development issues. This implies, among other things, two distinct and often conflicting sorts of policies, demands, management, operational, and technical realms.

The study confirms that entire movement networks connect space and society, and that movement significantly impacts urban form and function in the station area. This suggests that a more detailed study of the spatial configurations of KL Sentral and their impact on movement patterns is required. To objectively transform railway station areas into a place in the city, it is necessary to clarify the station's spatial impact on their urban settings and people. The relationship between the internal and external spaces of the station buildings and between the station area and the city is vital in planning and designing programmes for the most apposite spatial intervention.

Figure 6. The 'Place' of KL Sentral Evolved into Thriving Social and Economic Spaces, Designated Within the Existing Urban Fabric in Which It Offers as Places of Great Experience Value for Passengers, Urban Dwellers, and Tourists

ACKNOWLEDGEMENT

This work is supported by the Malaysian Ministry of Higher Education (MOHE) and Universiti Teknologi MARA under the Skim Latihan Akademik Bumiputera (SLAB) as part of a PhD study.

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DOMINANT ISSUES IN LOSS AND EXPENSE CLAIM APPLICATIONS FROM QUANTITY SURVEYORS' PERSPECTIVES

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Abstract
The construction industry has been plagued with numerous disputes from construction claims due to delays. The concern of delay may lead to further distress particularly relating to claims for loss and expense. Despite the high number of claims for loss and expense, rejections for their approval often occurred. Hence, this paper aims to identify the main issues pertaining to the claims for loss and expense from the perspectives of quantity surveyors within the Malaysian construction industry. This is to delve deeper into the causes leading to the failure in submissions of compensation claims for loss and expense. The study is viewed from a contract administration, legal perspective. The research adopted a cross-sectional survey analysis among quantity surveyors who represent quantity surveying firms registered under the Board of Quantity Surveyors Malaysia (BQSM). The findings found that the two leading causes resulting in claim rejection are poor documentation and unclear contractual issues. Hence, it is imperative to identify measures to secure successful claim applications for loss and expense.

Keywords: *Claim; Quantity Surveyors; Loss and Expense; Applications*

INTRODUCTION

The construction industry is well-known for the conundrums that regularly surfaced due to its unique traits and diverse stakeholders involved within the field which has been further classified as complex and risky (Abdel-Khalek, Aziz & Abdellatif, 2019). While construction contracts often try to harmonise conflicting issues, it remains prevalent notably for those relating to construction claims. Construction claims become more evident in unexpected events or crises such as those relating to the COVID-19 pandemic. The suspension of projects, labour shortages, job losses, time overrun, cost overrun, and financial ramifications are the COVID-19 pandemic's most noticeable effects on the continued survival of firms in the construction industry (Gamil and Alhagar, 2020). According to Mishmish and El-Sayegh (2018), an application for reimbursement for losses suffered by any contracting party is known as a claim. Construction claims are meant to rectify the imbalance brought on by incidents that result in cost or schedule overruns (Rai, Jagannathan & Delhi, 2020).

The claim may also be understood as a valid request for compensation for amended contractual terms, whether in the form of money, time, or both (Stojadinovic, 2018). Based on the study by Abdel-Khalek et al. (2019), the most frequent form of claims is those relating to delays, which occurred in many different projects. It was found that the primary reason for most construction projects is delays in the construction field and the associated claims originating from these delays (Assaf, Hassanain & Abdallah, 2017). According to Ssegawa and Keakila (2023), regardless of whether a claim is successful or becomes a subject of dispute by a project stakeholder, it has the potential to cause disruption. Claim for loss and

expense is one of the claims associated with delays but can be for any event where the contractor incurs loss due to the client's failure or omission. A study by Rai et al. (2020) mentioned that claims are made in response to change orders issued by clients. Hence, it is necessary to first review the main causes of claims which can contribute to the claim for loss and expense.

AN OVERVIEW OF CLAIMS FOR LOSS AND EXPENSE

Claims are the means at the discretion of contracting parties to be able to modify their contractual and financial relationships to consider changing events (Parikh, Joshi & Patel, 2019). According to Ssegawa & Keakila (2023), claims can be categorised based on the three rights contractors may bring to their clients. Firstly, this may involve requests for an extension of time (EOT) for unintentionally prolonging the project's contract duration. Secondly, this may involve requests allowing contractors to seek compensation for any losses or expenses caused by delays, disruptions, or changes in the project's scope or circumstances. And, thirdly, this may involve the right to recover additional costs resulting from variations in the project's specifications or requirements. This research focuses on the latter which is related to the compensation for any losses and expenses. A previous study by Cunningham (2014) deduced that claims for loss and expense typically occurred due to administrators' instructions, receipt of late information, postponement, employer interference, and/or other employers' default. Other than these, the issues also come from the client as highlighted in the study by Zhang, Fenn and Yongcheng (2019), where contractors may perceive unfairness caused by the clients' unreasonable disapproval, and delayed responses. Based on the study by Shaikh et al. (2020), clients should try to resolve contractor claims quickly and amicably before these turn into disputes, as it can be time-consuming, expensive, and damaging to the relationships between the parties. Further, the occurrence of construction disputes has a negative impact on client organisations (Mashwama, Aigbavboa & Thwala, 2016). According to Hai (2019), contract administration, cause recognition, claim solutions, documentation systems, and a thorough understanding of the contract are vital and essential factors in the claims process that can greatly contribute to disputes and the development of an adversarial working relationship.

Causes Leading to Issues of The Claim of Loss and Expenses

From the previous literature related to loss and expense, four (4) main issues contributed to the issues in the process of having a successful claim of loss and expenses. The issues are lack of documented evidence, lack of contract understanding, weaknesses in current practices for loss and expense claims, and no uniform guideline on loss and expense claims. For the first issue is related to the lack of documented evidence. Claims for loss and expense may also be part of a claim that usually results from the delay or disruption caused by the client in construction projects. However, it is crucial to emphasise that a delay, loss, or incurring costs does not automatically grant a contractor the right to be compensated (Ssegawa & Keakila, 2023). Hence, a contractor must provide proper evidence to demonstrate that the costs they have incurred are a result of the client's fault or other causes that, according to contractual or legal provisions, entitle them to compensation (Yusuwan & Adnan, 2013). In addition, the claim analysis should consist of thorough evidence and calculations that clearly demonstrate the loss of productivity, which forms the foundation for determining the extent of damages (Gibson, 2015; Amucheazi and Nwandem, 2020). Based on the study by Ali et al. (2020), an

inefficient document management system may cause data loss, inadequate documentation, poor presentations, a lack of proof, and a lack of communication, all of which are crucial for winning the case. Meanwhile, the client's claim system should also respond professionally and objectively to facilitate the prompt processing of the claim when a contractor raises a claim (Ssegawa & Keakila, 2023). This is to make sure both parties conduct themselves professionally in handling claims to reduce future disputes.

Meanwhile, for the second issue, contract claims appear to be inevitable in the construction industry due to the wide range of contract forms and conditions that may be adopted (Abdel-Khalek et al., 2019). Furthermore, poorly understood contract documents have been cited to be one of the sources of construction disputes (Bakhary, Adnan & Ibrahim, 2015). According to Yussof et al. (2020), poor contract management, incomplete contract, and unsupported claims were the leading causes of payment disputes. The contract term is considered to be one that accepts risk, opportunity, and unpredictability; yet at the same time, inadequate knowledge about upcoming events is bound to lead to uncertainty (Mukilan, Rameshbabu & Velumani, 2021). In recent years, the volume and complexity of contracts have significantly grown, leading to unprecedented risk exposure for many companies (Assaad and El-adaway, 2020). Therefore, in response, consultants are required to be well-versed in construction contracts.

Based on the study by Hai (2019), a lack of thorough understanding of the contract among on-site personnel could also lead to a significant risk of non-compliance with the contractual procedures when unforeseen circumstances arise. The evaluation and resolution of disruption claims have identified "unclear and lack of legal basis under the contract" as a factor with the highest probability of occurrence (Cevikbas, Okudan & Isik, 2022). According to Hai (2019), some contracts may explicitly require claimants to submit notices of their intention to file claims within a specific number of days after the occurrence of relevant events, while others may not distinctly specify such requirements. This is crucial when handling claims for loss and expense because the claimants need to submit notices of their intentions to claim within a specific number of days as stated in the Standard Forms of Contract. Failing to do so will lead to an unsuccessful claim. If a claim is not properly managed, it can potentially lead to a lengthy and unresolved dispute, posing a risk to the successful completion of a project (Ssegawa and Keakila, 2023) and souring relations in the process.

On the other hand, the third issue is related to weaknesses in current practices for loss and expense claims. It is difficult to demonstrate the cause and effect if general contractors do not properly organize the real data acquired in the field, which leads to poor claim performance (Seo & Kang, 2020). According to Assaf et al. (2019), a claim can be time-consuming even though it is not arising the dispute. Arranging data promptly is just as essential as collecting data when preparing a claim. As a result, a tool that automatically organizes field data and provides vital information such as the impact of productivity loss and claim cost from a claimable event should be useful for general contractors when substantiating the cause and effect in a timely manner, thus improving two performance measures for claim management, such as lack of substantiation and time-bar miss (Seo & Kang, 2020). Based on Charehzehi et al. (2017), existing claim management procedures experiencing flaws. Lack of claim management leads to disagreement situations, which typically deteriorate the quality of the parties' relationship (Asadi et al., 2022). Furthermore, Jalal et al. (2020) mentioned that the lack of an efficient document management system and qualified people to monitor the entire

process, as well as the selection of important personnel, particularly those with the greatest expertise about the claims, complicates the claim management processes. Besides that, the growing number of conflicts in construction projects demonstrates the inadequacy of the procedures used to manage construction claims (Ibraheem & Mahjoob, 2022).

The fourth issue is no uniform guideline on loss and expense claims. Bakhary et al. (2018) mentioned that one of the biggest issues experienced by the contractors in the claim process is the lack of awareness of site staff to detect a claim. For claims related to loss and expense, it is important to detect the issues earlier to submit a notice for an intention to claim within the stipulated time stated in the contract. According to Zhang et al. (2018), contractors may risk financial losses if the procedure takes too long. Despite that, the most major issues encountered during claim notification is the inaccessibility of documents to be submitted together with the notice and poor communication/instructions to continue with notice submission (Bakhary et al., 2018; Hayati et al., 2019). Besides that, Bakhary et al. (2018) added that in many circumstances, contractors lose their claims due to a lack of documentation evidence, which negatively impacts the contractor's position during claim negotiations. Hayati et al. (2019) also carried out a 4 survey which reveals that (i) some information/instructions are not recorded in writing; (ii) recorded information is imprecise; and (iii) poor record-keeping system. However, according to Seo & Kang (2020), in the case of a claim, it is critical to provide all relevant details consistently as soon as possible once the problem occurs.

Based on Abdel Khalek et al. (2019), having a system for document management is a must since without the system project failure is certain. As projects progress, clients will insist on changing the orders, which causes contractors to make claims related to discrepancies (Mukilan et al., 2021). If past events are accurately recorded, they may be utilized to anticipate current problems and potential conflicts in the future (Jalal et al., 2020). Although the CIDB in Malaysia organizes a yearly program to promote BIM among construction practitioners in order to improve construction practices, the Malaysian construction industry is still dominated by traditional processes (Rahim et al., 2015), which result in delays, cost overruns, less quality, poor performance, and poor productivity, all of which have consequences for development and delay its international competitiveness. Mohamed et al. (2014) mentioned that a modest conflict can turn into a big dispute affecting other areas of other projects if there is no framework in place to handle disputes.

Outcome of Issues: Legal Disputes

From the mentioned issues above, the issues leading to claims for loss and expense may also lead to legal disputes despite the inclusion of clauses stipulated in Standard Forms of Contract available as guidelines recommended by regulatory bodies in the construction industry. This is evident from the case law relating to the claim for loss and expense in the case of *SKS Pavillion Sdn Bhd v Tasoon Injection Pile Sdn Bhd* [2019] 1 LNS 1512 where the claim has been rejected by the courts because of unavailable proof of loss incurred due to the late delivery of the project. Another notable example can be found in the case of *Pembinaan Emaskami Sdn Bhd v Hakikat Engineering Sdn Bhd* [2019] 1 LNS 695 where the defendant's claim was not submitted within the stipulated timeframe up to the filing of the lawsuit. These cases highlighted that issues relating to the claim for loss and expense could lead to disputes which can affect many parties if proper management is absent. According to

Fawzy et al. (2018), the parties are, nevertheless, responsible for their respective obligations resulting from the legal provisions, even if they plead ignorance. The increasing complexity of and uncertainty in construction projects are accompanied by corresponding growth in the number of disputes (Haugen and Singh, 2015) which can further deteriorate if construction claims are not settled in an effective, economical, and timely manner (Mashwama et al., 2016). In this context, quantity surveyors are expected to provide all stakeholders with advice relating to financial integrity, procurement, and upholding the stakeholders' value systems throughout a project (Olanrewaju and Anahve, 2015). Hence, this research is carried out to identify the perspectives of quantity surveying firms on issues relating to the claims for loss and expense.

METHODOLOGY

The research involves a cross-sectional survey among the targeted group of professional quantity surveyors who are working in and who represent quantity surveying firms registered under the Board of Quantity Surveyor Malaysia (BQSM) (N= 398). The purpose of the survey is to identify the issues relating to claims for loss and expense among construction stakeholders. A cross-sectional survey is a survey where the data is collected at one particular point in time (Creswell and Creswell, 2018). The quantity surveying firms were selected based on their expertise in the assessment of construction claims. Based on Cochran's (1977) formula for sampling with a population size of N=398 as recorded in the BQSM website taking a 95% confidence level with ±5% precision, the sample size should be 196 respondents. The survey form was therefore distributed to 196 respondents. The data was collected through electronic survey methods using official company email addresses and Google Forms. A total number of 38 responses were received with completed questionnaires with a response rate of 19.5%. According to Fosnacht et al. (2017), with a sample size of at least 500, the estimations based on the data would remain accurate even with a 5% - 10% response rate for a sample size of at least 500. A survey with a lower sample size of less than 500 requires a response rate of 20% to 25% in order to yield estimates that are reasonably significant. Hence the 19.5% response rate achieved for a sample of 398 is acceptable.

These 38 respondents comprised 19 Quantity Surveyors, 8 Contract Executives, and 11 Directors working with quantity surveying firms registered with BQSM. It is noteworthy that survey research offers a quantitative or numerical representation of the trends, behaviours, or viewpoints of that population by analysing a sample of that population (Creswell and Creswell, 2018). The results of the questionnaire survey were then processed and analysed using descriptive statistics with the Statistical Package for the Social Sciences (SPSS) software.

Table 1 illustrates the profile of the respondents, their years of experience in the industry, and their involvement in loss and expense claims. Based on Table 1, 30 out of 38 respondents have been involved in assessing claims for loss and expense. This indicates that the majority of the respondents have experience with claims for loss and expense. In addition, 20 respondents have more than ten years of experience in the construction industry. Based on the experience and involvement of respondents, this can be concluded the respondents is suited to provide comments and answers on any issues dealt within this survey and their opinions are expected to reflect the real industry's situation as in (Bakhary et al., 2015). The data from

the survey was then analysed with a detailed breakdown of the data shown in the following section.

Table 1. Respondent's Profile and Involvement in Loss and Expense Claims

Position	Total (Number)	Involvement In Loss and Expense Claims (Number)	Years of Experience in The Industry	
			Less Than 10 Years	More Than 10 Years
Quantity Surveyor	19	13	11	8
Contract Executive	8	6	5	3
Director	11	11	2	9

FINDINGS

Based on the questionnaire survey, findings from the quantity surveyor's perspectives on claims for loss and expense are shown in Table 2. A five-point Likert scale was used to measure the indicators. This ranged from "1 – totally disagree", "2 – disagree", "3 – neutral", "4 – agree", and "5 – totally agree", for each item. However, for expediency, the results shown in Table 2 are presented in three categories which correspond to disagree, neutral, and agree to get a clearer view of their perspectives. Totally disagree and disagree are grouped as one category. The same applies to agree and totally agree.

Table 2. Quantity Surveyors' Perspectives on A Claim for Loss and Expense

No.	Quantity Surveying Firms' Perspectives	Results (%)		
		Disagree/ No	Neutral	Agree/ Yes
1.	Claim for loss and expense is a result from extension of time (EOT)	5%	11%	84%
2.	Entitlement for time extension means entitled to claim for loss and expense	29%	47%	24%
3.	Experience with rejecting claims for loss and expense (for the period 2018 – 2021)	39%	-	61%
4.	Disputes in claims for loss and expense tend to drag into litigation cases	3%	26%	71%
5.	Construction industry needs a guideline in the claim for loss and expense application	11.9%	25%	60.5%

Table 2 shows that 84% of the respondents agreed that the claims for loss and expense resulted from an EOT. This finding is in line with (Cunningham, 2014; Jusoh & Sarman, 2021) where this appears to be a primary concern when they comprehend the relationship between a claim for loss and expense and an EOT. It suggests that a claim for loss and expense is associated with the delay. The respondents were then asked if they agreed that if the contractor is entitled to a time extension, he is also entitled to a claim for loss and expense. 47% of the respondents provided a neutral response, which suggests they neither agree nor disagree when asked about the claim entitlement.

Another 24% of the respondents, however, agreed with the statement. This seems to suggest that most of the respondents appear unclear about the relationship between an EOT and a claim for loss and expense. An EOT does not always justify a claim for loss and expense although these are often paired together. Based on the Standard Forms of Contract used in the Malaysian construction industry, only a few relevant events that allow for EOT claims, also allow for a claim for loss and expense. Furthermore, the claim for loss and expense can only be submitted if it is due to the client's fault. Hence, when the contractor has received an EOT, this may not necessarily identify with an entitlement for an additional payment.

Further, 61% of the respondents have experience in rejecting a claim that has been submitted to them in the three (3) years between 2018 and 2021. This suggests that the rejection of claim submissions for loss and expense is relatively high. This also seems to suggest that the failure rate in claim submissions for loss and expense may be due to many reasons. Among all the respondents, 60.5% are agreed that there is a need to have a proper guideling in the process of claim loss and expense. In addition, 71% of the respondents agreed that the disputes relating to claims for loss and expense tend to also drag into litigation cases.

Table 3. Ranking Based on Issues Relating to Loss and Expense Claim Rejection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Documentation	15	39.5	39.5	39.5
	Contractual	13	34.2	34.2	73.7
	Procedures	7	18.4	18.4	92.1
	Resource	1	2.6	2.6	94.7
	Others	2	5.3	5.3	100.0
	Total	38	100.0	100.0	

The data from the survey relating to claim rejection was analysed and shown in Table 3 and Figure 1 respectively. 39.5% of the respondents agreed that the most common cause among the issues resulting in claims for loss and expense rejection is related to poor documentation. This is followed by 34.2% of the respondents who agreed that the claim rejection was due to unclear contractual issues and another 18.4% because of the procedures. Hence, it appears plausible to conclude that the main reasons for the rejection of claim submissions for loss and expense within the three years (2018 to 2021) arose because of documentation and contractual issues.

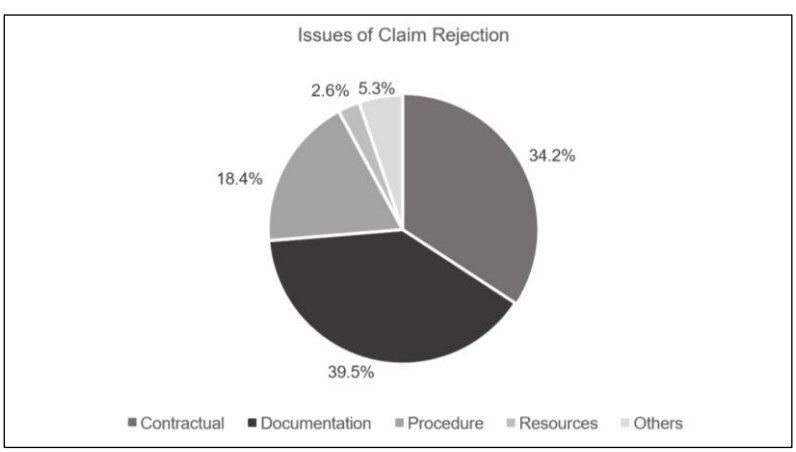

Figure 1. Issues Relating to Loss and Expense Claim Rejection

Next, the survey elaborates on the guidelines respondents wish to adopt when they encounter issues in claim for loss and expense applications. These are highlighted in Table 4. The respondents were asked about the need to have guidelines in loss and expense claim applications in order to minimize the disruptive issues they might otherwise face. 58% of the respondents agreed that such guidelines are needed and these are as elaborated in Table 4.

The survey suggests that more than half of the respondents agreed that a claim for loss and expense could be better managed by having clearer guidelines on loss and expense claim applications.

Table 4. Selected Respondents' Feedback on The Need for Guidelines in Loss and Expense Claim Applications

Need for Guidelines in Loss and Expense Claim Applications	Respondents	Feedback
	R1	For better preparation on the documents and to ease respondents' time to assess
58% Agreed	R4	Contractor is clearer of the procedures to claim before submit documentation
	R6	To prevent unnecessary payment or overpayment to the contractor
	R7	Minimise the disputes between contractual
	R10	To ease the application process for claims in loss and expense
	R12	Understand the item to be claimed and provide proper documentation
	R15	Minimise disputes
	R16	Contract stipulates conditions entitling the contractual parties to claim for loss and/or damages due to default by the other party
	R22	Avoid disputes and interference from employers
	R25	A proper way to differentiate or to identify the actual amount of loss
	R26	To have clear information regarding loss and expense
	R27	Make it clear
	R28	Set the rules and guidelines to be more specified
	R29	To have clear understanding in submitting loss and expense claims
	R31	Most claims were made without a proper procedure especially when it involves contractual matters
	R32	To get a better picture for the next strategy when faced with this matter
	R33	Yes, for clearer flow and application
	R34	What constitutes losses need to be identified and listed by the governing bodies
	R35	It should be straightforward, not necessary to use claims expert which might be costly for small contractors
	R36	Most small and medium-sized contractor are unaware of the procedures and rights to claim
	R37	To help contractors how to deal with or prepare for loss and expense applications
	R38	Need to create base line for loss and expense claims

DISCUSSIONS

This study focuses on the perspectives of professional quantity surveyors practicing in quantity surveying firms and is premised on the understanding they possessed expertise in claims evaluation. Common problems faced by claimants when submitting their claims are further identified. The importance of feedback from quantity surveyors cannot be understated as they are the dominant professionals involved with the evaluation of claims and their approval. Hence, they are the appropriate respondents for this study as they have experience relating firstly to the lack of information in claim submissions and secondly to identify the procedures in making successful claim submissions for loss and expense based on the requirements needed by the evaluator. According to Parchami Jalal et al. (2020), the submission of claims requires procedures that must be followed, including the provision of

specific facts, substantiation of the claim with proof, and filing the claim within the stipulated time limit. Nonetheless, a misunderstanding appears to remain among the claim evaluators when the respondents seemed unclear about the correlation between the EOT claim and loss and expense claim. It is acknowledged that only a few events or risks entitled the contractor to claim for loss and expense, which come from relevant events or risks permitted for the EOT claim. Besides the claim for loss and expense that occurs due to the client's fault, the contractor needs to prove the said events or risks have occurred that entitled him to claim. People with "claims consciousness," familiarity with prospective claim circumstances, and awareness are necessary for a successful claim procedure to take place (Bakhary et al., 2017).

Due to the high percentage of rejection for claims of loss and expense, the survey identifies the causes leading to issues that lead to the claim rejection. From the above findings, it can be concluded that the two main causes leading to issues that resulted in claim rejection are poor documentation and unclear contractual issues. Poor documentation and lack of complete evidence are part of the reasons that fall under documentation. The claimants are required to submit all the evidence starting from the causes of events to prove that they are entitled to that claim. Incomplete evidence would render it harder for the claimants to succeed with the claim. Documenting details about the claimable occurrences is essential for proving the cause and impact of claims (Seo & Kang, 2020). Similarly, failure to submit a letter of intent to claim for loss and expense and failure to comply with the contractual timeline is part of the reasons that fall under contractual issues. This is because the Standard Forms of Contract used in current practices require the claimant to submit the notice of intention for the claim within the deadline and to submit the full details of the claims within a certain stipulated period. These are the common mistakes that have been made by claimants when submitting their claims for loss and expense, which led to claim rejection. The findings from this present research address the same issues as highlighted earlier in previous studies where complete documentation and contractual understanding were identified as crucial when submitting a claim for loss and expense.

The respondents from the survey appear to concur that there should be straightforward guidelines to help the claimant to better prepare the claim documents and to ease the respondents' time to assess the claims. The rules of the guidelines are to be set and specific with clear procedures to claim and stage before the process of submitting the documentation for the claims. In addition, the baseline of a claim for loss and expense and its guidelines needs to be clear. Consequently, the claimant and the assessor would have a clearer picture of the actions to be taken while engaging with the claim for loss and expense. Besides that, it can help the claimant from having to pay for extra by engaging a claim expert which might be costly for small contractors while at the same time, facing claims for loss and expense. Furthermore, a set of comprehensive guidelines would be useful for everyone to make sure that the claim submission and evaluation could be run smoothly to comply with the contract requirements. It can also be concluded that issues about claims for loss and expense might be due to the negligence of the party itself in carrying out the works and preparing the claims. Every party should play their roles properly in handling the whole project successfully because disputes that affect project completion are costly compared to managing existential problems during a project. Therefore, it is imperative for the claim for loss and expense to be understood by all parties in the construction industry to ensure no further dispute or issue arises.

CONCLUSION

It is acknowledged that issues related to claims for loss and expense are inevitable due to the dynamic nature and complexity of the construction industry. Hence, it is necessary to identify these issues thoroughly and to resolve them properly to minimise disputes arising from the claims for loss and expense. The survey findings from this present study show that the two main causes of issues that lead to claim rejection are improper documentation and misplaced contractual issues arising from the part of the contractor. It is important to make sure that every party understand the requirements stated in the contract documents and to fulfil all these requirements once the problem arises in the future. The contractor should keep proper documents related to a project starting from the kick-off until the project is completed. Similarly, clients should be aware that unexpected changes implemented at the start of a project may affect the project in the long run-in terms of project costs and delivery. Further studies are recommended to investigate and identify the measures that lead to successful claim applications for loss and expense.

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CHALLENGES OF ESTATE AGENCY PERFORMANCE DURING PANDEMIC COVID-19: PRELIMINARY REVIEW

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Abstract
The unprecedented COVID-19 pandemic outbreak has affected the world's population and disrupted the global way of life. The new normal is taking over the way of doing things including in real estate business dealings. The pandemic challenges have required new strategy and opportunity to be implemented to sustain the estate agency performance in real estate industry. Therefore, the research objectives are identifying the challenges face by estate agents and to assess the challenging challenges during pandemic COVID-19. The methodology includes literature review and synthesis to explore the current situation of pandemic challenges. The challenges found through the exploration of literature search formed the evidence of the pandemic disruptions in estate agency practice. Another perspective of the content analysis focused on assessing the challenging challenges of the estate agency in accordance with the second research objective. As a conclusion, content analysis on the related literature provides insight for the arousal of new strategies and opportunities to sustain the estate agency performance in real estate industry during COVID-19 pandemic.

Keyword: *Challenges; Estate Agency; Estate Agent; Realtors; Estate Broker; Performance; Pandemic COVID-19; Pandemic Disruption*

INTRODUCTION

The spread of COVID-19 not only affecting human health, it also has affecting country's economy, world's population and disrupted the global way of life (Cucinotta and Vanelli, 2020). Real estate industry is in services sector and like most capital-intensive industry, has been badly affected by it COVID-19 pandemic (Tuah, 2021). Due to the implementation of lockdown, almost all countries experienced economic recession, causing disrupted or stunted on many economy sectors, as well as changing employee workflows and increasing reliance on technology and collaboration of virtual (Nah and Siau, 2020). The implications of the new challenges the pandemic has presented to society and need to face by real estate professionals worldwide are the economic, social, psychological (Maison, Jaworska, Adamczyk and Affeltowicz, 2021), shifting climatic circumstances, shifting political climates, erratic markets, rising purchase rates, and shifting technical advancements (PropertyPro, 2022). According to Woodruff (2019), economic growth factors such as human resources, physical capital and technology may have an impact on the property industry. The decline in demand is one of the COVID-19 crisis's effects (Tanrivermis, 2020) especially in sale and purchase transaction of properties. This affects the estate agents' performances in conducting property on behalf of property owners.

In Malaysia, EA profession is governed by Ministry of Finance and regulated by Valuers, Appraisers, Estate Agents and Property Managers Act 1981 (Act 242) and Malaysian Estate Agency Standards (MEAS) third edition 2020. According to MIEA president Chan Ai Chen (2022), it is a profession that have been recognised by government, and public is encouraged to engage their services to stay protected. The term of estate agent might be different in

different countries, for example in United States the term use is broker or realtor (National Associates of Realtors, 2020), however, in Singapore the term use is estate agent which it is similar with Malaysia term. Therefore, EA play an important role in the real estate industry and need to be knowledgeable in various areas such as business development, law, technology usage, sales, negotiation and social media to support real estate industry in growing the business (Montgomery, 2021).

According to Samsonowa (2012), there is one (1) common characteristic, the two (2) term that related are effectiveness and efficiency. Effectiveness as a measure of goal achievement and efficiency as indicators of resource that used to attain level of achievement. The performance of EA during the buying, selling, and renting processes contribute to his aptitude and attitude to accomplish contracts. These capabilities give clients interesting insights into the agent's performance in the present and able to be strengthening their confidence when appointing an agent. In order to maximise performance effectively and efficiency; and to achieve the mission in business operations with strategy planning, it is important for EA to grab the opportunities in enhancing the work routine as EA.

Problem Statement

The pandemic COVID-19 continues to have an impact on our society, affecting the entire global economy (Hoekstra and Leeflang, 2020), government policy, health, educational system, individual routine, social life and employees at work physically and psychologically (Seo et al., 2023; Xiang et al., 2020). According to NAPIC (2020), property market activity and transaction value in Q2 2020 has sharply contracted due to pandemic COVID-19. Besides, during pandemic estate agent's performance has worsened and the agent cannot act in the best interest of principal (Eckey and Memmel, 2022). Hence, during total lockdown declaration, it makes the real estate sector and others observed nervously (Mohmad Lehan et al., 2020). All industries were to focus on change business method and enhance business performance (Abu Bakar and Yaacob, 2020; Kristinae et al., 2020). Thus, pandemic COVID-19 was limiting agents from attending meetings with customers for business transaction and property viewing which causing a decline in their working performance (Kathy, 2020). According to Dang (2019), EA faced more challenges than before due to COVID-19. Therefore, this paper will assess the challenging challenges of EA during pandemic COVID-19.

Objective

The research objectives are to identify the challenges faced by estate agents and to assess the challenging challenges during pandemic COVID-19.

LITERATURE REVIEW

The Challenges During Pandemic COVID-19

The pandemic COVID-19 has various implications on human life which involved the world community. Until now, the impact of the pandemic on changing the work routine as an EA is still affected, from physical to remotely. EA needs to take steps to get an effective way of working with a new norm, which is by using modern technology.

Dependence on Technology

Real estate has traditionally been a high-touch business, but the pandemic has changed everything. While property showings and open houses were once commonplace, health regulations now prohibit them (Agent Image, 2021). With a property being such a large investment, clients understandably want to view it in person before deciding if it's suitable for them. This has been one of the biggest challenges real estate professionals faces, as countless paperwork and property listings must be placed online in digital form for people to browse from the comfort of their own homes (Lindahl, 2021). According to Armstrong (2021), the customer experience on EA website has never been more important, and companies that invest in innovative technology will be the ones that attract, engage and retain consumers where EA can do live using teleconferencing app or virtual reality (VR) platform. Hence, the implementation of VR technology during pandemic will increase the chances that client to purchase or rent the said property after knowing how it is works (Adegoke et al., 2021; Juan et al., 2018). According to Adegoke et al. (2021) property buyers preferred to have a VR tour instead of a physical inspection during a pandemic. The importance of digital marketing for EA has increased, making it even more crucial to have a website that offers a top-notch online experience and is adaptable to all kinds of screens and devices. Additionally, if EA do not keep pace with this technology trends and updates technology on a frequent basis (PropertyPro, 2022), they risk falling behind and losing business to their competitors. This means that, it is now crucial for EA to embrace technology during pandemic COVID-19 (Tew, 2021) and current technologies have made it feasible for EA to prevent a complete economic shutdown (Marona & Tomal, 2020).

Fear of a Housing Bubble

On the other hand, many buyers are wary of buying a home amid a pandemic. After all, some experts are less optimistic about the real estate market as they predict a real estate bubble will happen. Such talk can certainly deter buyers, who fear they will buy property at peak prices only to see the value plummet once the bubble bursts. Coupled with lingering concerns about job security, agents may find it difficult to close deals with finicky buyers. According to Li and Zhang (2021), they found that the COVID-19 pandemic has a significant impact on real estate agents' workflow and their clients' perceptions. Hence, due to pandemic that has causing uncertainties economy, lack of buyer's traffic and weak market sentiment may affect in the housing market (Hamzah, Yazid and Shamsudin, 2020). A manager from MKH Berhad, Dr. Foo Chee Hung stated that he is optimistic that the housing market will contraction caused by COVID-19. Additionally, President Lim Boon Ping from Malaysian Institute of Estate Agent (MIEA), reported in The Edge Market, during pandemic COVID-19, the property market would shift into a buyer's market where the housing price could decline by 10% until 20%. However, in order to ease the fears of potential buyers during pandemic, EA need to provide facts about real estate market prices with authentic data. These data can be referenced from the property market report issued by National Property Information Centre (NAPIC). It is to make sure that the EA are aware and able to gain knowledge on current property trends.

Lack of Inventory

According to Bian, Turnbull, Waller and Wentland (2015), lesser sales effort can happen when EA have larger listing in their inventories. According to Thakkar (2022), EA with low

inventory will negatively impact the performance of individual and company and of course, less inventory with high demand leads to spike home prices (Lambert, 2022). The Malaysia central bank said that while the home-buying stimulus continued, the disruption caused by the pandemic had partly contributed to a slowdown in the clearance of unsold housing stock (Khalid, 2022). "More broadly, the increase in the number of unsold homes reflects pre-existing housing affordability issues that have worsened since the start of the pandemic as consumers income have been impacted. In this regard, supply adjustments are continuing, with more new construction shifting to the low-to-medium price segment," BNM said. In order to add a listing to the inventory, EA needs to do a metric where the metric can help the EA in identifying properties that have been sold in a specific area. With the existent of metric, EA can see the number of properties clearly and be ready to find new listings to add to the inventory, then, EA can do marketing through the appropriate online media to sell new properties.

Online Competitors on Listing Portals

Social media is now the most powerful in real estate marketing and it has become a challenge to real estate industry where EA need to compete with their rivals through online listing platforms. According to McLachlan (2023), 96% of home buyer search for their dream home online while 47% home buyers start to hunt with an online search. Pandemic COVID-19 has growing online competition between EA where they share home listing, generate leads, get clients engagement and exhibit their skills during hot and cold market. According to George Brown College (2023); best options to cultivate, create and maintain networking goals during pandemic COVID-19 are building a general digital presence by being active on social media (LinkedIn, Facebook, Instagram, Twitter, TikTok and etc.) and the goal of digital marketing is to maintain a communication process with customers via which customers can obtain information about items, characteristics, pricing, and terms of sale (Pandiangan and Martini, 2021). Hence, the achievement of EA also related to an effectiveness of work management. This is visible in how estate agent's work is done to achieve satisfaction results. According to Brooks (2021), numerous studies have shown that EA can improve and maximise their performance by utilising social media more efficiently and strengthening connections with both buyers and sellers. This indicates that online competition gives the opportunities to make EA more enthusiastic on knowledge development to the latest technology where these technologies have become a company survival strategy during pandemic (Akpan, Soopramanien & Kwak, 2020).

Developing and Cultivating a Database

Next challenge is developing and cultivating a database. Utilising it successfully is tough. Most agents are not aware of how crucial consistent touch with contacts is. Business opportunity to estate agent surfaced when strong referral network takes place and expand to new business in the future. This emphasises a significant issue affecting EA. Inexperienced agents frequently place a higher priority on closing deals quickly than maintaining contact with their clients after the sale (Titan, 2023). When selling a property, the relationship between agent, property owner and potential purchaser is very important to build a network and can building relevant customer database (Hoxha and Zeqiraj, 2022). Based on research provided by Buffini and company, 50% of their annual business is through referrals and 25% of agent achieve, 88% of buyers claim that will use the same agent or introduce them to others

potential customer. Therefore, EA need to implement marketing automation to keep in touch with hundreds of contacts and this marketing automation would automating email delivery which will save EA valuable hours and help EA more successfully target the appropriate market niche with messages.

The Rise in Cyber Crime

Due to the COVID-19 pandemic breakout and the mandatory stay-at-home order, the threat of cybercrime has abruptly increased and the rate of cybercrime victimisation during the stay-at-home order has increased as a result of advancements in the electronic medium (Tarshini, Mas'ud and Hassan, 2022). In general, cybercrime refers to illegal activities that use a computer or smartphone as its primary means of commission to intentionally cause harm against individuals or groups of individuals. Online identity theft, which uses sophisticated digital techniques like "pharming" and "phishing" to deceive its intended victims, is the fastest-growing type of consumer crime (Quade, 2020). According to Pranggono and Arabo (2021) claimed that the COVID-19 pandemic's widespread stay-at-home orders and remote working conditions, which contributed to a great reliance on digital technology across all industries, have increased the frequency of cyberattacks globally. According to a data provided by the Malaysian Computer Emergency Response Team (MyCERT), from January 2020 to September 2020, there were approximately 8,366 cybercrime cases recorded in Malaysia (The Star, 2020). This demonstrates the need of EA presenting the REN number registered with The Board of Valuers, Appraisers, Estate Agents and Property Managers (BOVAEA) to make it easier for potential purchasers to review information about EA and avoid doubts. This is to prevent cybercrime from happening to potential purchasers who rely on digital technologies to purchase real estate during pandemic.

To conclude the above reviews, it shows that there are several parameters that significant which are social, economic and technology. Analysis and forecast conducted by Oriental Real Estate Sdn Bhd (ORESB) stated that the COVID-19 had a significant impact all aspects of people's lives across the world where they are living under some form of lockdown, movement control order (MCO) or quarantine resulting effects on the economy which profound impact on tourism, services, manufacturing and property industry. Besides, it is more challenging when EA need to execute transactions with short operation hours and stringent social distance rules as result, this would effect on the EA work performance. Previous studies stated that, most industries' performance suffered as a result of the abrupt shift in work environment from being physically present in the office to a remote working environment (Zuhairi, Fateh and Hong, 2022; Aon, 2020; Bartsch et al., 2021; Mohd Rahim et al., 2018; Orsini & Rodrigues, 2020; Raišiene et al., 2020). Lastly, to survive in real estate business, EA will have to adapt to the new normal and implement business digitalization in capturing interest of potential buyers to purchase properties. Attractive digital marketing by EA coupled with government, bank and developers' attractive incentives will act as key element to potential buyer doing property transaction amid a pandemic (ORESB, 2020).

RESEARCH METHODOLOGY

According to Jansen and Warren (2020), to ensure validity and reliability of the results is all about how the author systematically design the research methodology. The below is Figure 1 shows the content analysis flowchart:

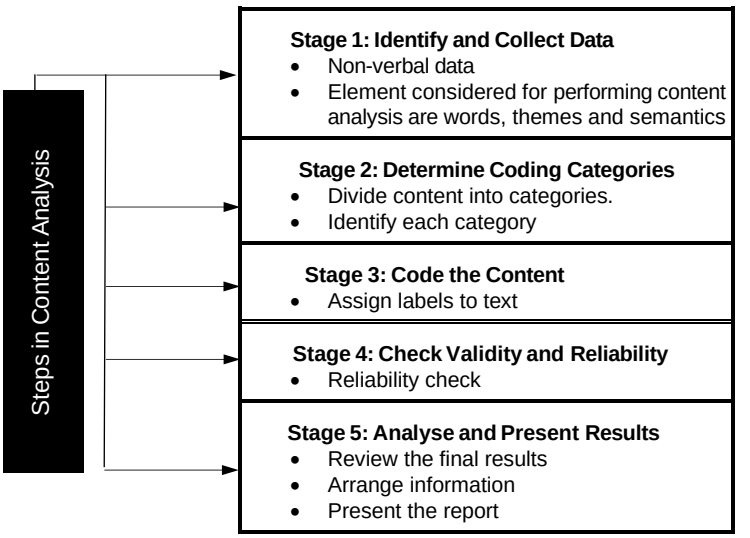

Figure 1. Content Analysis Flow Chart

Stage 1 - Identify and Collect Data

The literature review has been extensively conducted in achieving research objectives. The research methodology is using non-verbal method which is taken from secondary data sources such as articles and journals, other research publications, webpages, magazines, news, etc. The authors concluded preliminary study by using the content analysis to understand issues, research problems, research questions and research objectives. The elements that are considered in performing content analysis are words, themes and semantics that are related to the challenges of EA during pandemic COVID-19. The right keyword is important to capture the relevant information in search engine. The example of keywords that authors used are Challenges, Estate Agency, Estate Agent, Realtors, Estate Broker, Performance, Pandemic COVID-19 and Pandemic Disruption. There are various types of journals that has been retrieved and reviewed which are academic or scholarly journals, current affairs or opinion magazines and newspapers.

Stage 2 - Determine Coding Categories

In this research, the categories are the list of challenges known as dependence on technology, fear of housing bubble, lack of inventory, online competitors on listing portals, developing and cultivating a database and the rise in cyber crime. These variables are gathered from seven (7) different journals. Therefore, authors can be more focused to conduct the research for each category for specific words that answer the research objectives and in order to have a better management on the data collection, it is important to divide collected content into categories.

Stage 3 - Code the Content

The content observation is important to explain the coding rules. In this research, the relevant information for each category was assign label to text. The frequency and direction were use as code of content where frequency of word during extensive exploration described

consistency of code and direction was refer to challenges appears in the literature review. Therefore, this code is taken into consideration to achieve the research objectives.

Stage 4 - Check Validity and Reliability

The reliability of data is important to know whether the data is reliable where it should be consistent throughout the process. In this research, the stability code can be seen on the literature review which all the coding is consistent with objective number one is to identify the challenges faced by estate agents and to assess during pandemic COVID-19. The validity and reliability for second objective which to assess the challenging challenges during pandemic COVID-19 has been validated via in-depth literature review and synthesis.

Stage 5 - Analyse and Present Results

After collecting the data from literature review and attaining reliability of the data, authors had organised the information based on the received results and finally, this research can be presented.

FINDINGS

The findings of this study found that there have 6 challenges of EA which dependence on technology, fear of a housing bubble, lack of inventory, online competitors on listing portals, developing and cultivating a database and the rise in cyber crime. Table 1 below shows the challenges of EA and the first objective of the study has been achieved with consistent content. The frequency of challenges can be seen on Table 1.

Table 1 shows the result for second objective which is to assess the challenging challenges during pandemic COVID-19. Based on the in-depth literature review and synthesis, it shows that, there are four (4) challenges were challenging during pandemic and the item are dependence on technology, lack of inventory, online competitors on listing portals and the rise in cyber crime and the less challenging are fear of a housing bubble and developing and cultivating a database. The most and less challenging were analysed by using coding on direction.

Besides, based on the above analysis, EA can identify elements that shows the most impact to EA performance. Therefore, EA should conduct strengths, weaknesses, opportunities and threats (SWOT) analysis for the purpose on determining and analysing internal and external opportunities and threats, as well as strengths and weaknesses, that influence present and future operations and aid in the development of strategic goals. After analysing the strength; increase innovation and adapting to circumstances, and opportunities; to faced challenges or threats, EA can move to the next steps which are making a decision and take an action on sustainability of EA for long-term performance.

Next, EA able to do strategy formulation and application for long-term business continuity plan (BCP), which includes both external and internal environmental scanning, also evaluation and control. These strategies need to be implemented because unpredictable life behaviour has shifted to the era of new normal. According to Pandiangan and Martini (2020), a well-craft strategy is the goal that not just temporary competitive success and gain

profit in a short-term, but it is long-term goal that can support economy growth and secure the company future operations.

Table 1. Results In-Depth Literature Review and Synthesis on The Challenges on Estate Agent

The Challenges During Pandemic COVID-19	The Most Challenging	The Less Challenging	Frequency	Authors	Year	Location
Dependence on Technology	/		5	Kris Lindahl	2021	Real Estate Website, Emerald Insight & ResearchGate
				Mark Armstrong	2021	
				Ayodele Samuel Adegoke, Timothy Tunde Oladokun, Timothy Oluwafemi Ayodele, Samson Efuwape Agbato, Ahmed Demola Jinadu and Sulaimon Olawale Olaleye	2022	
				Mark Tew	2021	
				Bartłomiej Marona & Mateusz Tomal	2020	
Fear of a Housing Bubble		/	2	Xinba Li & Chuanrong Zhang	2021	MDPI Journal & Semantic Scholar
				Amir Azlan Hamzah, Mohd Faizun Mohamad Yazid and Mohd Farid Shamsudin	2020	
Lack of Inventory	/		4	Dhara Thakkar	2023	ResearchGate & Real Estate News (TheEdge Malaysia & Fortune)
				Lance Lambert	2022	
				Sulhi Khalid	2022	
				Xun Bian, Geoffrey Turnbull, Bennie D. Waller and Scott Wentland	2015	
Online Competitors on Listing Portals	/		3	Stacey McLachlan	2023	Real Estate News & Academic Website
				George Brown College	2023	
				Becky Brooks	2021	
Developing and Cultivating a Database	/	/	2	Maria Titan	2023	Emerald Insight ResearchGate & Google Scholar
				Visar Hoxha and Emblema Zeqiraj	2022	
The Rise in Cyber Crime			4	N.K. Tarshini, Faizah Haji Mas'ud and Zamri Hassan	2022	
				Phil Quade	2020	
				Bernardi Pranggono and Abdullahi Arabo	2020	
				The Star	2020	

In addition, EA need to depend on technology in order to be creative and innovative to compete with their rivals in real estate industry, especially in digital marketing where EA will sell home per available inventory to online audience by utilizing online listings portal. This challenge would be able to give an opportunity to EA in managing and making strategic plans to enable operations in the real estate business to run smoothly and orderly. According to Putra and Darma (2019), to build company brand image or product during pandemic COVID-

19, the medium that can be used as a platform is digital marketing, because it is an effective way to support the sale function of target market which is referring to potential buyer and can improve purchasing decisions.

Other than that, the achievement on successful organization and employee is depending on ethical leadership which able to gives a motivation and clear structure to the EA, especially to new EA who just venture into real estate industry which they are potentially exposed to be cyber crime victims. At the same time, leader should share new knowledge to EA on how to be gathered properties for sell into their listing inventory. According to Zuhairi, Fateh and Hong (2022), in order to improve efficiency and productivity of employee, motivation is the most substantial factors to be drive. Hence, employee that lack with motivation, unable to performing task successfully, make a decision, adapt to changes and handle a problem, conversely it turns out to give a negative impact on work performance through uncertain times. Therefore, ethical and appropriate leadership behaviour is a key factor in sustaining employee motivation.

To conclude, the pandemic disruption has caused people to work remotely and need to face many challenges on individual nor organizational where the reliance on technology has become priority during pandemic. Thus, many employees were overwhelmed because the abrupt and such a significant change towards digital-based working environment coupled with home environment which exposed to feelings of stress. Therefore, EA should get a motivation from upper line, able to be exposed to new knowledge and can implement the modern technology knowledge into real estate business which able to give a good performance on EA work operation.

CONCLUSIONS

As a conclusion, this paper has provided the most fundamental information on real estate agent and the real estate market. However, due to time limits, the study can only focus on gathering information sources from website, newspapers, journals, articles and publications that are relevant to the topic rather than covering all business challenges faced by real estate agents in the COVID-19 era. Pandemic COVID-19 has given challenges to EA to frequently keep a pace on the technology trends in order to maximise the performances. Although we are now in the post-COVID-19 era, it is clear that businesses continue to encounter obstacles related to the COVID-19 translation, corporate finance drops totally, changes in human resources, or changes in client buying preferences. When the disruption happened, it gives an opportunity in finding new potential which enable EA to adapt in technology advancement and push themself to do knowledge management. Businesses may use websites and social media platforms online. It is possible to record product introduction videos so that clients can observe real-world examples of the project from the comfort of their homes rather than meeting them in person. In order to keep running real estate business to generate income, achieve working satisfaction and also accomplish mission and strategy in work process, EA must think creatively and effectively. Thus, EA needs to grab the opportunity for better performance in real estate industry in the era of COVID-19. Lastly, unprecedented COVID-19 makes EA advance in technology and can transform for better.

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IDENTIFYING THE ARCHITECTURAL LANGUAGE FOR TRADITIONAL MALAY AND CLASSICAL MALAY ARCHITECTURE

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Abstract
Identifying Malay architecture within the Malay region is necessary due to the diversity of its forms, elements, and expressions, regionally and geographically. This broad diversity gives challenges for documentation, identification, and characterization. Traditional building forms and constructional systems of the past became 'fossilized' quickly. Until now, due to unestablished variables, there has been no proper documentation of the Malay architectural language and characteristics as a guideline to all parties. All well-known architecture styles are Traditional Malay and Modern Malay architecture, whereby Classical Malay architecture is yet to be defined. The architectural language is crucial for The National Heritage Department, Malaysia, to select and classify significant heritage buildings to be chosen for national heritage buildings preservation and conservation under the National Heritage Act. The rich variation of Malay architectural values and style needs to be observed, where some appear diverse, and some share the same prevalent qualities. Almost all the polity in the Malay regions share traits of the same character of Malay architectural principles. Narrative reviews were conducted to sort findings from previous scholars to justify the authentic principles and stylistic characteristics of Malay Architecture. The building facade and its form were the focus of the architectural physical attributes. Two building typologies were selected for cultural mapping analysis: The Traditional Malay and Aristocratic Malay buildings. These case studies were observed and mapped out for comparative analysis. Case studies' measured drawings helped to picture the façade elements and stylistic characters. The attributes were tabulated further into a list which defined the architectural language of Classical Malay Architecture. From the comparative analysis of these two typologies, the strong façade identity and principles were identified, which can fashion a new era of urban language. This study contributes to the local rules of architecture that carry identities of the climatic and cultural character beyond the variations and visual appearances.

Keywords: *Language and Grammar; Architectural Styles; Malay Classical Architecture*

INTRODUCTION

Malaysian architecture is influenced by various cultures, from the indigenous Malay to the European colonizers. Due to these factors, Malay architecture has evolved and lost the authenticity and values of its own. New generations hardly justify which buildings is Malay architecture. Buildings in the northern part of Malaysia, such as Kedah, and the eastern part of Malaysia, such as Kelantan and Terengganu, are reminiscent of Thai architecture. In contrast, southern buildings are reminiscent of Javanese architecture. The introduction of European glass and nails altered the built environment when the country started to be colonized. The hybridization of building materials and construction methods evolved Malaysian architecture tremendously. The traditional buildings in the tropics were designed to take advantage of the weather by being elevated on stilts, having high roofs, and having huge windows. However, these characteristics are no longer being implemented in modern

buildings. Timber was the primary construction material before it evolved into bricks and steel. Like its neighbouring countries, Malaysia has a rich and diverse culture and heritage treasures.

What makes Malaysia unique is its diversity as a multi-racial and multicultural country. Due to modernization, assimilation, and globalization, these cultural heritages might become lost and extinct without any efforts to preserve and safeguard them. The current situation in Malaysia worries us. These cultural heritage tangible aspects were not being taken care of much. These historic structures represented the country's character and served as a source of pride for the local populace. Most of the heritage buildings were left unpreserved and not conserved; they collapsed, fell apart, burned in a fire, left deteriorating and caused a visual nuisance. The lack of validation on the criteria of values of the buildings had made us ignore the importance of these heritage buildings and omit them from our list of national heritage buildings. One of the main criteria that measure the values is the architectural language of the building.

In Act 645 - NATIONAL HERITAGE ACT 2005, there are nine criteria for declaring National Heritage buildings. Establishing variables of these Malay buildings based on the architectural language will help to justify and classify which ones should fall under 67.2 (a): the historical importance, association with or relationship to Malaysian history. Besides National Heritage Department, the build environments sectors, such as architects, designers and policymakers, would also need some guidelines on defining the architectural language of Malay architecture. The Board of Architects Malaysia (LAM) published an ungazetted policy on Architecture National Policy 2017 (DASIK), but yet to be implemented. The modern and modernizing world needs meaningful nomenclatures and discourses in local architecture. Policymakers, urbanists, administrators, and professionals were trying to develop proper guidelines on the variables or attributes that defined Malay Architecture as a whole. Such 'urban' principles and codes must align with authority and sustainability requirements.

Two main typologies that represent Malay architecture are traditional houses and aristocratic buildings. There are many Malays architectural variations until one cannot distinguish them. How can we determine the elements or principles relevant to be restricted as Malay Architecture? Which one is Traditional Malay, and which one is Classical Malay? A clear outline of Malay architectural identity should be established where no one would argue for its originality and purity (Mohamad et al., 2001). Aristocratic or Palatial architecture, in traditional times, is often the most distinctive expression of its genius loci, as it is inextricably linked to the social structure and cultural advancement of its times (Abidin et al., 2017). Deupi's arguments can be observed in the Malay palaces' separate elements of grammar, which represent an aesthetic of hybrid aspects of architecture. The formal and spatial expression, including frontage elevations, is seen as the evolution and refinement of an essential character.

The Difference Between the Language and Grammar of Architecture

Architectural languages are developmental stages that categorize architecture according to historical eras, geographic locations, and cultural influences (Jahnkassim et al., 2018). The architectural language specifies forms, design features, and building materials. While columns, pitched roofs, naturally ventilated porticos, louvres, tall windows, roof finial

decoration, and ornamental panels are frequently recognized as identical elements, variances are generated from the 'generic' features. The descriptions of common architectural styles and building forms help recognize, identify, and appreciate the character of the building during the context period (Bentley, Ian. Alcock, Alan. Murrain, Paul. McGlynn, Sue. Graham, 1985). Styles and building forms are usually reorganized and portrayed by their primary uses comprising features and components that create a language and character for a building.

Figure 1 below depicts a large picture to comprehend the concept of architectural grammar and language. The architectural language is a more extensive scope of understanding specific designs, including overall building massing such as the roof forms, façade elements, shape, form, and layering. Architectural grammar, which focuses more on specifics, is a component of the architectural language. The grammar of a structure is made up of its structural elements, such as its columns, pedestal, brackets, architrave, windows, recesses, intercolumniation, and ratios. This study thus begins with distilling the generic qualities of the Malay vernacular house form to identify fundamental elementary principles. Then palaces and houses case studies link to the generic codes. The terms architectural grammar, morphology, and language are defined in Table 1.

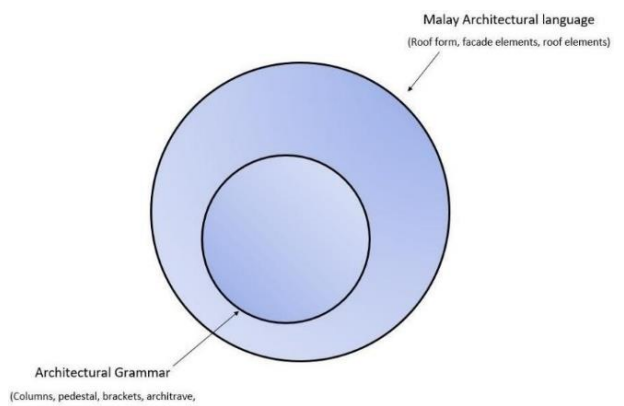


Figure 1. The Interrelationship Between Architectural Language and Grammar

Table 1. Definition of Architectural Grammar, Morphology and Language

Architectural grammar is a complex of rules of a language (style, age), which governs (defines) the accuracy of the formation of architectural signs into certain combinations (words, texts). For example, the combination of elements of the Corinthian order into the shape of the portal allows the facade of the building the effect of solemnity, respectability, and pomposity. The main fields of grammar are morphology and syntax, like in natural languages.
Architectural morphology is a set of rules for forming primary semantic units from small units and controls of shape formation into meaningful combinations (such as portals, arcades, and entrances), and architectural syntax is a set of rules and techniques for the construction of integral combinations of façade, ensemble, and others. Morphological description fixes the objective side of the piece of art; includes its dimensions, geometry of its shape, ruggedness, texture, colour, and other empirical data. Such words as archetype, rhythm, meter, tectonics etc., are often used.
The architectural language embodies a system of sign architectural shapes, which can convey various senses and contents by applying compositional techniques and patterns of arrangement and combination of these shapes, i.e., architectural language possesses its own semantic, morphological, and syntax structures.

Source by Remizova O. (2015)

Identify the Language and Grammar of Malay Architecture

Identification of the Language and Grammar of Malay Architecture is necessary to develop a standard description, semantics or terminologies that can be associated with the identities of the buildings, whether in decorative forms or ornamental non-structural aspects. This grouping relies on the principle of separation between structural and non-structural elements of Malay architecture, primarily the outcome of a study and analysis undertaken by Sabrizaa (2008). According to Sabrizaa (2008), as per Table 2, the first category is the structural members, which represent the essential elements that form the foundation of the design to be built. The second category is the non-structural members of the forms. He usefully observed that at least 16 decorative elements could be identified in the Malay Traditional language (Abd Rashid et al., 2007). Sabrizaa (2008) reported that the elements could be classified into three categories as per the table above; structural members, non-structural members, and decorative elements.

Table 2. Classification of Malay Architectural Elements

Structural Members	Non-Structural Members	Decorative Elements
Tiang Seri	Dinding	Tunjuk Langit
Tiang Tongkat	Tingkap	Sisik Naga
Rasuk	Pintu	Sulur Bayung
Kasau Lintang	Bumbung	Kepala Cicak
	Tangga	Kekisi
Kasau Jantan	Tebar Layar	Ande-Ande
Kasau Betina		Peles
Bendul		Tiang Gantung
Jenang		Dinding Bertindih Kasih
Belebas		Dinding Kelarai
Tetupai		Dinding Janda Berhias
Alang Panjang		Sesiku Keluang
Alang Pendek		Pagar Musang
		Gerbang Tingkap
Gelegar		Pintu Gerbang
Tunjuk Langit		Kepala Pintu Gerbang
		Kepala Tingkap
Gegulung		Gerbang Pintu
		Kepala Pintu
		Kepala Tingkap

Source by Sabrizaa (2008)

Esmawee Endut (1993) mapped Malay vernacular studies to include modern descriptive interpretations and observed traditional design principles due to ignorance about its essence and a widespread preference for Western styles and images. What is more critical, Esmawee (1993) identified characteristics of Malay architecture and discussed the essential design formal character of its local architectural language and traits. He mentioned:

"Although there are many types and variations in the design of traditional Malay buildings, they still follow a basic pattern and share several standard features. The similarities that can be found in these buildings are: -

1. All are raised above the ground.
2. All have pitched roofs and deep overhangs.
3. All have open-plan concepts.
4. Construction modules regulate all.
5. All have several levels for the interiors.
6. All use similar building materials.
7. All have large window openings.

Another valuable collection of palatial individual case studies (Tajuddin, 2005, 2012) aims to define elements of language that can constitute generic forms, while variants are derivations from the consistency of generic form and their vocabulary. Sabrizaa (2014) usefully divided the Malay language into 'structure' and 'ornamentation'. Gaps of the research that had never been investigated were the differences between traditional and classical Malay architecture. The building forms, elements, structural detailing and ornamentations mostly have some hierarchy. The architectural styles can be differentiated accordingly through the intricate design of the building elements, the orders, the evolutions and the façade treatment.

Malaysia underwent modernization throughout the 1800s and 1900s and absorbed the changes wrought by events elsewhere – the Industrial Revolution in Europe. There were gradual infusions of modern construction and technology – masonry, cast iron and wrought iron - as opposed to the local timber vernacular elements. This increasing use of masonry and iron-based elements was combined with its accompanying foreign styles and vocabularies. These styles first permeated the public buildings built by the British and the Malay palaces of Perak, Selangor, Kedah, Kelantan and Johor in Malaysia, and Langkat Riau, Medan, and Palembang in Sumatera. External sources' stylizations include Neo-classical and Georgian English architectural elements consisting of Classical columns, arches, windows, and façade compositions that were rapidly brought in to 'modernize' public buildings.

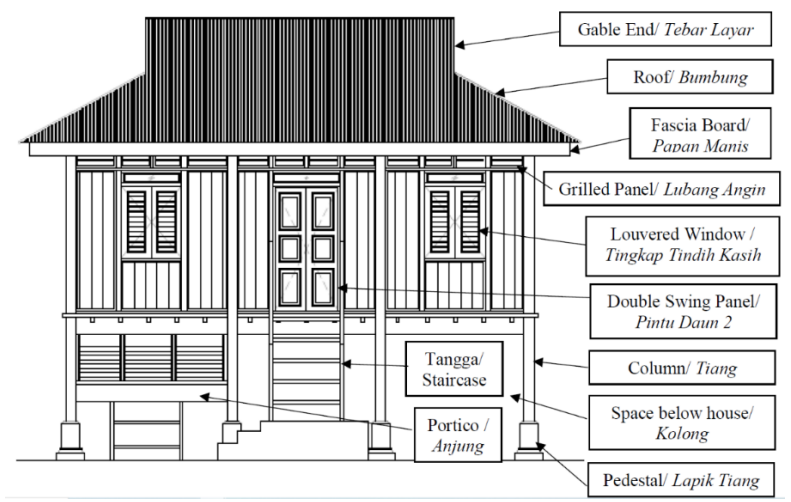
The characteristics of these elements create a style and impression that enable us to define the structure by a semantic name readily, including the building materials and even the construction process. The history of architectural style shows that design patterns alter depending on the viewpoints, ideologies, and technology accessible at the time. Some old architectural types and styles are still evident and notable today as architecture evolves and changes. Hybridities in architectural form arise from both modernizing intentions. Hybridity is a term commonly connected with post-colonial cultural ideas and describes cultural or creative fusion. Ambiguity, multivalence, fusion, and interbreeding are all analogous to hybridity.

Traditional Malay Architecture

The traditional Malay house is one of the wealthiest facets of Malaysia's cultural history. Locally sourced materials and methods were used to construct the buildings. Architecturally (Aziz Shuaib et al., 2011; Hosseini et al., 2014; Ibrahim, 2013; Rashid, 2015; Wan Ismail, 2005) have discussed the diversity of vernacular houses focusing on traditional houses and mosques in this region. The Malay vernacular house form, which appears to have perennial and persistent elements of language, is a basis of the consistent characteristics of mosques and palaces. The ordinary language is a pitched roof with a specific pitch, the overall columnar

style, the elevated form with an open, permeable ground floor, tall windows, and a linear hierarchy of spaces.

However, these generic elements of language vary from state to state and region by region, each spewing and evolving distinctive styles. The structure of the building is predominantly post and lintel, with thatched gabled roofs and timber or bamboo walls. The building's sides always have sizable apertures to provide adequate cross ventilation for the interior house (Khairudin et al., 2018). The Malay carpenters invented the technique of '*tanggam*'. One of its distinctive features where the absence of nails or metal supports in traditional Malay architecture. Carpenters have perfected the technique of sawing wood such that joints are smooth and robust, whereas wedge fasteners snug up the joints between the wood planks.



(Source: ASLI @Vorteza UiTM, Annotations by Author)

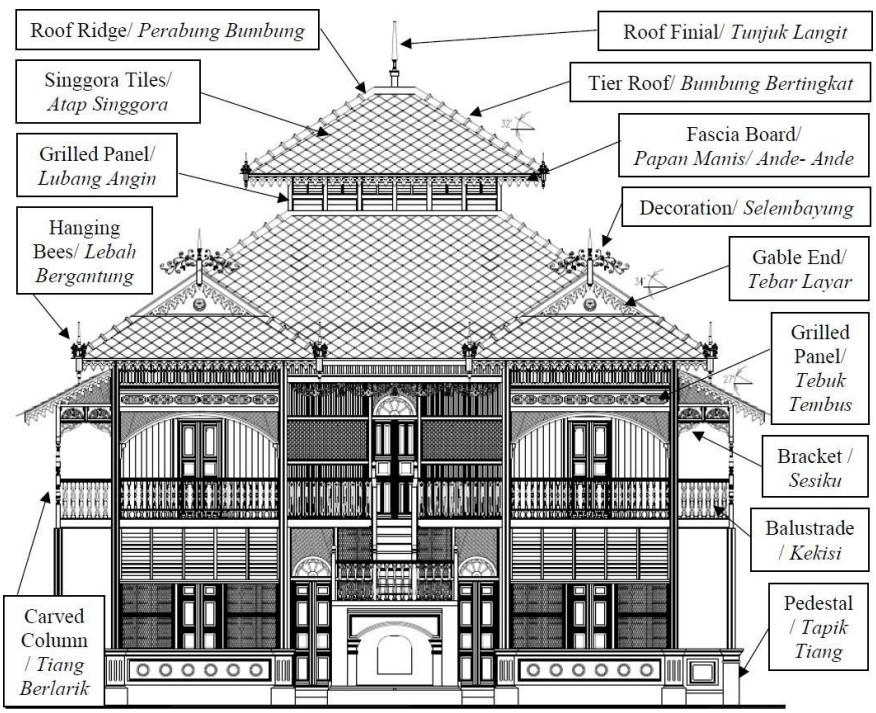
Figure 2. Traditional Malay House

Traditional Malay architecture incorporates a unique style of geomancy. The central portion of the home is supported by the '*tiang seri*,' a freestanding pillar without any joints. '*Tiang Seri*' is the first structure to be installed for building a Malay house. Commoners usually built a house with a typical square or rectangular layout elongated to the back for '*selang*' and kitchen space. The house employs a modular design, adding additional rooms as the family grows. No ornamentations, detailings, or embellishments are found in ordinary commoners' houses. Due to their hierarchy kast in society, regular houses were not allowed to be more prominent and notable than palaces and aristocrats' houses.

The typical Malay house appears to blend in with the surroundings and context. The massive gabled roofs obscure the low walls, which have an intriguing visual aspect due to their varying sizes and orientations. The Traditional Malay house is constructed with low thermal capacity local materials and various ventilation systems to accommodate the region's unique climatic conditions. In addition to having good environmental adaptation, the traditional Malay dwellings' design is adaptable to meet the occupants' needs and has developed into a prefabricated building system (Utaberta et al., 2015). The structure has created a complex expansion system that enables the building to be readily expanded to meet the needs of the tenants.

Aristocratic Architecture

The Malay palaces and other aristocratic types represent the strong position of the Malay aristocracy. The palace is a monumental expression of the larger houses of wealthier owners. The palaces are essential institutions that protect the vernacular as the monarch. In many cases, there are extended and refined versions of the Malay vernacular house, reflecting the highest form of technology and craftsmanship available in the locality. The distinctive aesthetic addition and stylization were expressed through ornamentations, and the value increased with refinements of the decorative motifs in eaves, fascia boards and finials (Mohd et al., 2008). They were drawn and inspired by the surrounding flora and fauna patterns.



(Sources: Heritage Lab, IIUM, Annotations by Author)

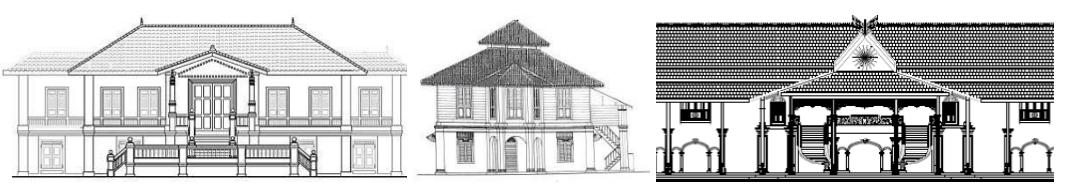
Figure 3. Aristocratic Malay House – Baitul Rahmah, Kuala Kangsar, Perak

Palaces, however, reveal the infusion of masonry features, particularly stylized elements of columns, capitals, and arches with mouldings or cornices, during the 18th century, introducing colonial influences on the region. The natural result or outgrowth of the time's technological expressions is related to the Malay culture's natural evolution within the same socio-political system and civilization. As these centres grew, the stylistic forms of their public architecture and urban design were reflected by colonial expression and hybridity, with more masonry elements in their building traditions (Seok-Joon, 2016). Their structures are still infused with a high level of refinement and skills of traditional artisans regarding timber artisanship. The palace has increasingly complicated domains and varieties because of regional neighbouring influences. The aristocratic residences and palaces displayed the same spatial divisions but were intensified hierarchically.

DEFINING CLASSICAL LANGUAGE

The evolution in styles and materials became an expression of hybridity. It is also a form of 'Classicality' because it is derived from the ingenuity of the Malay social structure, imbued with local craftsmanship and local motifs. In Malay regions, palaces are larger and more complex structures with multiple functions. 'Aristocratic' architecture refers to all forms of palaces, including those conventionally referred to as mansions and houses of community leaders. For example, the Panglima Ghani House, Melaka and Dato Bji Sura Houses are also included in the aristocratic definition as they were designed for illustrative purposes. Many of these palaces are classical in style.

'Classicality' has been characterized as a collection of conventions and crucial rules of an aesthetic style tied to an ancient past and buildings created with a particular 'facade'. Classicality is associated with what is enduring and ageless (Summerson, 1980). 'A classical building is one whose decorative components are derived directly or indirectly from the architectural vocabulary of the ancient world,' he writes. According to Murray (1986), a 'Classical language' is a 'composition of elements' in which the classical architect sought symmetry and harmony "along with the interrelation of all parts." The principles of symmetry and balance guide the composition of a succession of combined parts in a humble approach, reflecting the 'public' face of Malay vernacular architecture and the effect of the Malay courts' more significant resources, capabilities, and affluence. In the 1800s, these became infused with additional masonry elements. Figure 4 shows a series of Malay Classical Architecture infused with masonry elements.



(Source: Heritage Lab, KAED, IIUM, Annotations by Author)

Figure 4. From Left: Istana Jugra Selangor, Istana Raja Bilah Perak & Istana Balai Besar, Kedah

METHODOLOGIES

Past studies have particularly mapped vernacular architecture, also known as Traditional Malay architecture, mainly houses. In traditional societies, buildings and typologies are primarily divided between houses, palaces, and religious structures. Palaces have been less discussed than residential houses and mosques, as it is a typology and heritage marked by extreme and considerable external (colonial-linked) influence. While (Hassan & Ramli, 2010; Mohd Rasdi, 2001; Utaberta & Spalie, 2011) have documented and discussed the collection of critical Malay buildings and their construction expression in timber, this fundamental archetype of the Malay world consists of the total timber-based vernacular. This study covers an in-depth understanding of the building language and the character-defining elements of Traditional Malay and Aristocratic Malay buildings as the background information of case studies. Case studies of Traditional Malay Houses and Aristocratic buildings were selected, ranging from the years the building was built between 1800 to 1930. The compilation, mapping, and identifying clustering of the language and grammar of the buildings were conducted through elevational studies. The features classify not only the similarities but also

the differences in terms of spaces, massing, functions, materials, and other relevant elements which define the language of a building.

The ‘mapping of hybridity' approach is required to derive classifications that can classify the buildings into architectural styles and languages (refer to Figure 5). A series of elevational analyses were conducted based on the measured drawings and digital information acquired by studying the character of the façade and associated attributes. Fifty case studies were chosen from Traditional and Aristocratic structures in Malaysia. Each case study contains specific aesthetic enhancements and stylizations, such as ornamentation and the refined use of intricate ornamental motifs, which are the architectural styles' hallmarks. The case studies were chosen based on the availability of historical data, architectural data, and measurement drawings from various sources. The following tasks have been completed for data collection: (1) Field studies including observation, interviews, photographs, and sketching, (2) analysing measured drawings and data extraction and (3) from comparative analysis from data collected and archive papers and documents, both published and unpublished.

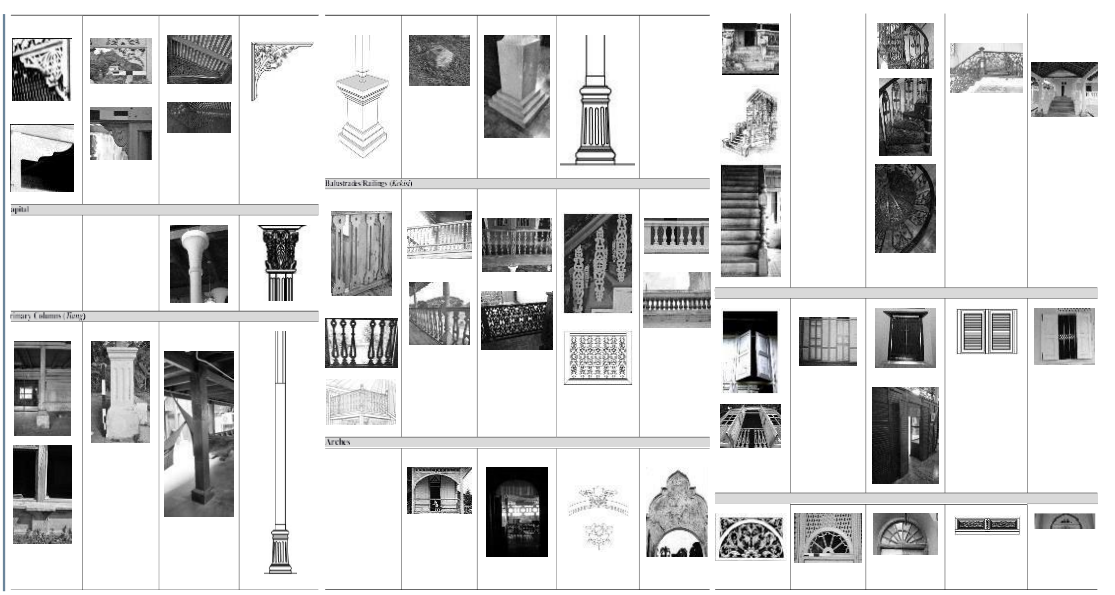


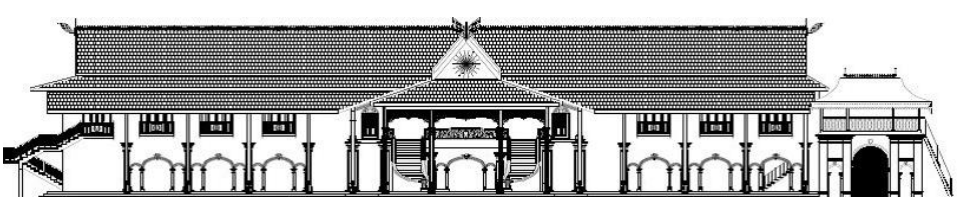
Figure 5. Mapping of 'Hybridity' Elements of Classical Malay Architecture Found in Case Studies

COMPARATIVE ANALYSIS BETWEEN 'TRADITIONAL MALAY HOUSES' WITH 'ARISTOCRATS MALAY BUILDINGS'

Based on measured drawings and past useful collection of palatial individual case studies (Tajuddin, 2005, 2012), the aim is to define elements of language that can constitute generic forms, while variants are derivations from the consistency of generic forms and their vocabulary. Sabriza (2014) usefully divided the Malay language into ‘structure’ and ‘ornamentation’. At the same time, Shuaib (2014) usefully outlined the Kelantan style through specific architecture, construction, and ornamentation elements. Wong (2013) observed how palaces mainly reflect the Malay vernacular ‘archetypical’ houses, which evolve and become ‘enlarged’ into public buildings that are essentially state-based styles. The histories of any vernacular society, including the Malays, therefore, constitute an evolutionary style of its own. It demonstrates its institution's core and emerges from its spiritual and cultural role.

Styles can be genealogically traced to an overall rooted typical style, which had changed as external forces but remained in their essential principles. A shared language must again be proposed in terms of nomenclature and terminology. It can potentially be set as a standardized set of rules and guidelines that can be developed further into 'prototypical façade design styles, including hybrid design approaches, public frontage, or façade design options. The royal courts populate much more significant and wealthier settings and structures, and their palaces are encapsulated in their rich range of artisanal works (Shireen et al., 2019). They also reflect the Malay decorative arts and regalia's efflorescence and are resonated in its local court practices, palaces, dance and drama, weapons, martial arts, and metalwork. Symmetry and balance can be summarised as assembling a succession of combined materials in a basic yet visually appealing manner, and these portray the 'public' face of Malay vernacular palaces. Aristocratic complexes were eventually identified as the source of the form of the Malay vernacular structure.

On the other hand, traditional Malay houses are much smaller in scale, simplified in a single form, one or two levels and less decorative. Table 2 indicates the 14 main attributes collected from literature reviews and the author's observation of case studies between the Traditional Malay and Classical Malay features. Figures 6, 7, 8 and 9 show another strand of Classical Malay Architecture with 'Hybridation'. Classical Malay Architecture has three variants of strands which are 'Early Classical', 'The Classical' and 'Late Classical'. The representations of the 'Early Classical' built by full timber may have been destroyed and mostly were left as case studies were the Classical and Late Classical Malay language. These frontages exemplified the strands which evolved from timber to hybrid to essentially masonry yet still retain vital essences of the Malay regional language.



(Source: Heritage Lab, KAED, IIUM)

Figure 6. One of The Case Studies, Istana Balai Besar, Kedah (1896) Showed the Elements of A Malay Classical Style: A Hybrid Column, A Hybrid Window-Wall, A Roof and Weaved Geometrized Patterns

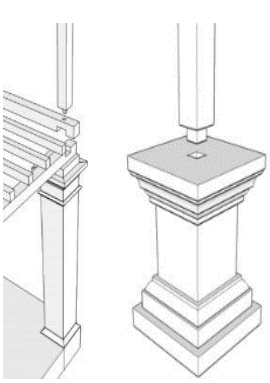


Figure 7. The hybridity of columns

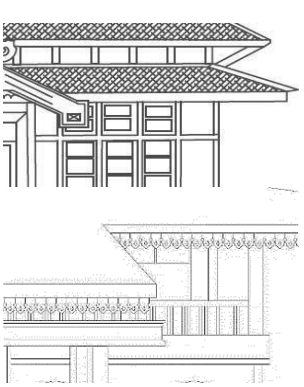


Figure 8. The presence of layered roofs with/ without ornamented Architraves

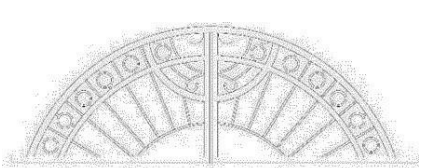
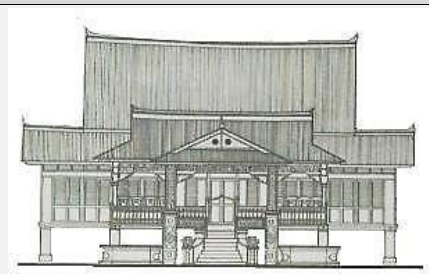


Figure 9. The intricate ornamental elements of geometric and curved in walls, doors, balustrades, fanlight and transoms

These Classical Malay elements were found to be relevant in modern days for featuring the historical urban façade. (Ramli et al., 2012) pointed out that conservation and facade play a crucial role in the evolution of cities and their identities, necessitating a re-assertion and re-examination of a historical facade-focused approach. Table 3 indicates the 14 main attributes collected from literature reviews and the author's observation of case studies between the Traditional Malay and Classical Malay features. Most of the architectural elements in these regions are unique and defined by cosmological beliefs. This region's palaces and aristocratic buildings uphold the richness of wood carvings.

However, the detailed motifs are distinct. The 'modernized' vernacular, found in Southeast Asia's aristocratic structures, has a standard set of rules and language, including a range of vocabulary or elements. As modernization proceeded at different rates in different states, the language underwent globalization or 'modernization'; i.e., it evolved into a hybrid style, with some cases able to retain the essence of the vernacular of place. The stylistic progression of the frontages can be seen in the case studies, which range from those built entirely of wood to hybrids with a brick or masonry ground floor, staircase base, or bottom pillar. In general, the amount of wood as a component building material declined throughout time, demonstrating the pressure of modernization and how the barometer of modernity is represented in the materials.

Table 3. Variations Between Traditional Malay and Classical Malay Buildings

Attributes	Traditional Malay Houses	Aristocrats Malay Buildings
Façade Image	 Rumah Warisan Perlis	 Rumah Penghulu Ghani
Owned by	Commoners (ordinary people in a community)	Royalties, Nobleman, Leaders of the community,
Scale & Form	More minor in Scale and Form (asymmetrical)	More significant than typical Malay Traditional houses
Spaces	Open planning with segregation of spaces: '*rumah ibu*', '*rumah dapur*', and '*Selang.'*	Spaces are subdivided into rooms with dedicated functions—many transitional areas, such as corridors.
Function	For the nucleus family, the father, mother, and children.	Palaces have a unique space for administration and public areas such as '*Balai Rong'* and Hall.
Size/ Massing	Only one-storey height and one unit with or without extended structure/space.	Usually, more than one storey, with multiple spaces or attached buildings, had different hierarchies of areas and a fence or compound surrounding it.
Typological Form/Shape	Most were asymmetrical form. It has a veranda attached to the right or left wing of the building.	Have specific orders, symmetrical, balance, axis, and hierarchy. Types of the Classical Building Forms; - Axis, Binuclear, Peristyle, Perabung & Asymmetrical)
Height from Ground	Mostly raised on stilt, some are built on the ground or water.	Mostly raised on stilt with staircases. The height of the raised floor depends on the size of the elephant when it sits (*Elephant-mode of transportation)

Attributes	Traditional Malay Houses	Aristocrats Malay Buildings
Material	It is mainly built from timber for the whole of the building structures. Some have bricks or stones on pedestals or staircases.	Various materials are mostly made of timber; however, due to the evolution of construction technology, brick and steel were used for specific building components, such as columns, railings, staircases, and brackets.
Compound/ Gateway	Open compound surrounded with the landscape, trees, well and outdoor toilet.	Some palaces have a gated, guarded compound with inner and outer perimeter fencing. However, the compound no longer exists, but the open space of the public area in front of the palace's building remained known as '*Alun- Alun'*.
Wall	Normal timber wall such as '*dinding tindih kasih*' or *woven wall*/ '*dinding tepas*'/'*kelerai*'.	Wall-decorated panels with or without engraved patterns. Some of the walls are grilled walls ('*tebuk tembus'*) and woven walls made of bamboo with beautiful designs. The materials may vary, but the Classicality and embellishment are richer.
Door/Window	Standard doors and windows are usually designed on a full-height scale from floor to human height. The design allows cross ventilation with additional '*kekisi*' or balustrades.	The door and window in palaces differ from the commoners, *'pintu/jendela labuh'*, but additional carving on the panels and top-head panels above the door and window panels differentiate the owner's status. Panels placed on top of window and door panels have meanings to reflect the owner's rank.
Columns	Typical timber columns, slender and placed on stones known as *'pelapik tiang*'.	The columns were primarily built from timber. Slender in size, high and attached with brackets or arches on top. Pedestals were placed at the bottom of the cement or carved stone columns.
Roof	Pitch roof and gable roof. Most roofs have high volume, and some roof spaces are used as attics for girls' sleeping areas /hiding areas or storage areas.	A few types of roofs are commonly used in aristocrat buildings, such as 'bumbung panjang', '*bumbung panjang berlapis/bertingkat*', '*bumbung limas*, '*bumbung perabung lima*', and '*bumbung limas bertingkat*'. The height and volume of the aristocrat's building, not only depend on the tiered roof, layered roof but also to the wall ratio.
Decoration	Ordinary commoners' houses can have decorations but are very minimal. The carvings or embellishments were not allowed to be more enhanced than the ruler or leader.	Palaces were designed full of flourished patterns, decorations and even painted. The decorations were vibrant and intricate. Some were crafted on structural elements such as columns, beams, and roofs. Some were additive elements attached to the building's features; *'tunjuk langit*', *'ekor itik'* and *'sisik naga*'.

These fourteen attributes were all important for identifying Malay architectural styles. No matter if it is Traditional, Classical or even Modern architecture. Without any of those attributes, the features of Malay architectural styles were not robust. The elements may no longer exist in modern buildings where colonized elements become the domain parts of the buildings. Each Malay building may carry different detailed characteristics based on the influences, such as in the Eastern, Northern and Southern parts of Malaysia. For example, the geometric and floral panels decorate the created pillars' capitals, shafts, and bases that were carved differently based on each region. Similar carved panels adorn the walls to the right and left of doorways, further emphasizing the importance of classical Malay architecture façade found clearly in Classical Malay buildings in Kelantan and Terengganu Regions. Kelantan's buildings stand at a minimum height of raised floor compared to the buildings in Southern Thai, where all the structures are put on a pedestal more than two feet tall. Terengganu and Kelantan have a pemeleh with two- and three-tiered panels and curvy ornaments at the end of the fascia board, which resembles the one found in the building in Southern Thai.

Figure 10. Ekor Itik and Papan Cantik/ Ande-Ande (Istana Jahar, Kelantan)

Figure 11. Sisik Naga/Filigree (Istana Jahar, Kelantan)

This '*pemeleh*' can be placed only on aristocrats' buildings and palaces during the old times. These have Dragon scales/filigree or sisik naga ornamentation attached along a roof ridge. Most Malay royal palaces use dragon scales as roof decoration, symbolizing a person's status and prestige. However, the detail motifs are distinct. For example, the design of *ékor itik* in Southern Thai seems to have many curvy elements (also known as *ékor naga*) compared to Kelantan's style, which exhibits a much simpler form. Certain evolutions and hybridizations are unavoidable in Malay architecture. Although Colonial or "global" influences can be integrated into a Malay design, a case is considered classical if it contains more than 50% detailed Malay features. The following table represents a range between the poles of 'Malay to Globalization' and 'Globalization to Malay', meaning the external influences as global elements. If more than half of these aspects satisfy the degree of Malayness, the dominating style defines the architecture's overall language.

Regardless of place, these formal archetypes can be identified and classified. Malay architecture has been conventionally discussed by historians and heritage researchers such as Mohd Rasdi et al. (2005); Shuaib et al. (2014); Halim and Hashim (1997); Hasan and Nawawi (2014), as timber craft, artisanal traditions and carpentry rather than masonry construction and language throughout the modernizing period of the early 1800s to 1900s in Malay, colonial forces and influences catalysed change in public architecture. Still, in many cases, Malay builders and patrons of architecture attempted to appropriate masonry into new 'hybrid' forms of a 'modern' vernacular.

A range of stylistic forms and elements arose from an evolution of localized grammar, which can be argued as essentially Malay and Malay inventions. Modernity was reflected in the infusion of masonry elements of the region's architecture to different degrees, whether in whole or half columns, in moulded staircases and balustrades. However, this infused modern local (Malay) elements was done without compromising the local language. The local population was naturally a cultural custodian. Their attempt reflects the will to evolve the local language, representing and reflecting status and 'progress' in their societies. In some cases, the combination of the lightness and delicate forms of timber-based traditions encountering the masonry and cast-iron technology, yet the vernacular condition persists. Their masonry columns were kept at the ground floor level and the curving staircase. Such new materials and technological transmutations were included, yet these hybridized, fused, or grafted upon local forms but still reflected the essential local (Malay) formal stylistic rules.

CONCLUSION

Nomenclatures or Semantic description is crucial to define or categorize the whole corpus of architectural strands, styles, and specific elements. The fourteen attributes and variables of architectural styles were essential in identifying Malay architectural styles. Without semantics, the tangible and intangible content and any aspects of grammar cannot be universally agreed upon and shared. The process of deconstructing and rethinking the architectural stylistic 'tree' of the vernacular is crucial. The new strand characterized as the 'classical' is part of the semantic to bridge the continuum and position the cosmopolitan vernacular. Classicality can thus be argued as a temporal attribute relating to the histories of the Malay world and reflected the critical characteristics of an era of the advanced level and epitome of local yet civilizational practices. Thus, Classicality can be linked to a specific visual trait and connotation in all evolving societies, which appears to be universally represented by a controlled aesthetic approach, including the predominance of "clean" lines and the rule of proportion in form elements spaces and building compositions. The rising modernization of cities no longer evokes tradition and turns back on traditional patterns, forms, and memories. This issue has resulted in an escalating loss of urban identity in all aspects and dimensions. Seeing how urban developments have resulted in a lack of local aesthetics and complete, contextual plans and actions triggered the industry to volte-face to emphasize national identity. This study hopes to clarify stylistic parameters that can be developed and documented as a shared 'Classically based vocabulary' of a forgotten Malay region arising from a common root. This comparative analysis clearly showed which traditional and classical morphology suits the urban façade. Classical Malay Architectural language and grammar are more promising to be transmuted into the modern building and blend with different hierarchies and extensive forms of buildings. The intricate detailing and decoration emphasize the beauty and established visual impact on the appearance as an identity-making character. Hopefully, these findings justify the basis of a set of local forms of classicized language, including generic rules, forms, and various elements from Malay architecture.

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CAUSES OF CONFLICTS AND THEIR EFFECTS ON THE RELATIONSHIP QUALITY OF PUBLIC FINANCE INITIATIVES (PFIs): A CASE STUDY OF MALAYSIAN PUBLIC-PRIVATE PARTNERSHIPS (PPPs)

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Abstract
Public-private partnerships (PPPs) have been introduced in Malaysia with the aim of creating a dynamic, prosperous, robust, competitive, and resilient nation. This research focuses on the conflict that arises in public finance initiatives (PFIs) within the PPP framework. The study examines previous research and literature through a qualitative approach to develop a conceptual framework. Various databases were reviewed, leading to the identification of 17 causes of conflict in PFIs, which were categorised into three main causes: behaviour-related, contract agreement-related, and technical-related conflicts. The study highlights three types of conflict: opportunistic and adversarial behaviour and resource unavailability. Conflict management strategies and relationship quality attributes emerged as crucial aspects of PFIs. The long-term nature of PFI contracts, spanning 15 to 25 years, poses challenges in maintaining relationships between the private and public sectors. Post-construction stages become critical as operations and maintenance services are implemented, giving rise to conflicts. Addressing conflicts promptly is crucial to avoid wasting time and energy and ensuring that project goals are not compromised. Identifying the causes of conflict improves the long-term relationship between clients and concessionaire companies in PFIs, ultimately enhancing relationship quality.

Keywords: *Private Finance Initiative; Causes of Conflict; Types of Conflict; Conflict Management Strategies; Relationship Quality; Maintenance and Operational Stage*

INTRODUCTION

The Malaysian government has decided to stimulate the construction industry; therefore, public-private partnership (PPP) has been introduced to reduce one-off commitment for projects. It concerns Malaysia's 2020 vision, introduced in 1990, to help the Malaysian construction sector become dynamic, prosperous, robust, competitive, and resilient. World Bank (2011) defined PPP as an 'arrangement between public and private sectors whereby maintenance and operational stages fall under the responsibilities of the private sector known as concessionaire company'.

Furthermore, elaborating on the PPP concept, a concessionaire company is involved from the initial stages, like design, construction, and facility operations, during the maintenance and operations stage. The concessionaire company finances expenses from the beginning. In return, the public sector or client makes regular payments for availability, maintenance, asset replacement, and other charges to the concessionaire company over the contract period. PPP is being used in Malaysia for construction industry activities. It is common to find private sector involvement. Private sector involvement in PPP project delivery was introduced in 1983 and has been used since then.

The PPP was formally defined under the Ninth Malaysia Plan report (2006) as *'the transfer to the private sector, the responsibility to finance and manage a package of capital*

investment and services including the construction, management, maintenance, refurbishment and replacement of the public sector assets which creates a standalone business. The private sector will create the asset and deliver a service to the public sector client. In return, the private sector will receive payment commensurate with the levels, quality and timeliness of the service provision throughout the concession period ' (Ninth Malaysia Plan, 2006).

Malaysia's Public-Private Partnership Unit (UKAAS) operates under the Prime Minister's Department of Malaysia. PPP has two subsets: private finance initiatives (PFIs) and privatisation. PPP involves funding from the private sector using private financial resources to construct public projects. There is reciprocity, where a contract is awarded to the private sector entity, known as the concessionaire company. Award duration is a long-term contract period, usually up to 25 years for PFIs and at least seven years for privatisation and depends on signing terms in the contract. Table 1 shows the difference between PFIs and privatisation as a sub-set of PPPs (UKAAS, 2022, Conventional, PFI & Privatisation Differences). One major difference between PFIs and privatisation is the involved parties. Public finance initiatives (PFIs) involve the public sector; meanwhile, in privatisation, the government acts as a regulator to emphasise rules and regulations. Therefore, PFIs are the main focus of this research due to the relationship between the public and private sectors.

Table 1. Differences Between Public Finance Initiatives (PFIs) and Privatisation

Public-Private Partnership (PPP)	
PFIs	**Privatisation**
Privately funded without Government guarantees	Privately funded without Government guarantees
Development expenses and operational expenses (OE) affect the government's budget throughout the duration of the concession contract	Development expenses and operational expenses (OE) do not affect the government's budget throughout the duration of the concession contract
Public and private sector bear their own risks	Private sector solely bears the risks
Public sector engages with the private sector by enforcing KPIs	Regulated by the government
Long-term contract between public and private sectors	Long-term contract between public and private sectors
Suitable for projects with commercial elements	Suitable for projects with commercial elements

Based on UKAAS (2022), there were 116 PPP procurement projects in Malaysia from the ninth to the twelfth Malaysia Plan. Several projects in Malaysia use the PPP model.

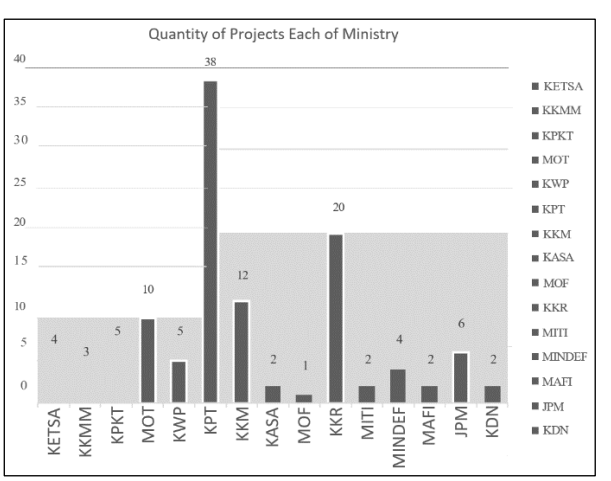

Figure 1. Number of Private Sector Projects in Each Malaysian Ministry

Figure 1 shows the number of PPP projects under the Ministry in Malaysia. During the Tenth Malaysian Plan (Malay: *Rancangan Malaysia ke-10*), the government spent about RM20 billion on PPP projects (Unit Perancang Eknomi, 2011). Figure 1 shows that KPT (Malay: Kementerian Pendidikan Tinggi) has a higher number of projects, which is 38.

The nature of PFIs in the context of PPP often leads to conflicts that significantly impact the overall relationship quality. Public finance initiatives (PFIs) involve the transfer of responsibilities for financing and managing capital investments and services to the private sector, including construction, maintenance, refurbishment, and asset replacement. The private sector, referred to as the concessionaire company, is involved from the initial stages of design and construction and continues to operate and maintain the facilities throughout the concession period. In return, the public sector or client makes regular payments to the concessionaire company over the contract period, covering various charges such as availability, maintenance, and asset replacement.

The duration of PFI contracts is typically long-term, extending up to 25 years, with a significant portion of the contract period dedicated to the post-construction stage, known as the implementation, maintenance and operational stage (UKAAS, 2022, Conventional, PFI & Privatisation Differences). During this extended phase, conflicts can arise due to the complexities and uncertainties involved in maintaining and operating the infrastructure over an extended period. The long-term nature of PFI contracts inherently introduces uncertainty and risk, which can contribute to conflicts between the private and public sectors. If these conflicts are left unresolved, they can consume substantial time and energy.

Understanding the causes of conflicts that emerge in PFIs is crucial for enhancing the overall relationship quality between the client and the concessionaire company. By identifying these causes, project teams can proactively address conflicts and mitigate their potential negative impact on the project goals (Van Oerle, 2022). This research aims to determine the specific causes of conflict in PFIs to improve relationship quality and ensure the efficient and effective implementation of PFIs within the broader PPP framework.

METHODOLOGY

This research uses a qualitative approach by reviewing precedent research and literature review to develop an initial conceptual framework. The main survey is yet to be conducted based on literature evaluation and the elements in the proposed framework. The topic was searched based on the preliminary literature searches in different databases such as Scopus, Google Scholar, Science Direct and Web of Science. Themes include 'private finance initiative', 'causes of conflict', 'relationship quality' and 'maintenance and operational stage. A conceptual framework comprising relationship quality during maintenance and operation in PFIs consists of four elements. The elements are i) causes of conflict, ii) types of conflict, iii) conflict management strategies and iv) attributes of relationship quality.

CONFLICT AS THE ANTECEDENT OF THE RELATIONSHIP QUALITY OF PUBLIC FINANCE INITIATIVES (PFIs)

Conflicts in PFIs substantially influence the dynamics of the client-concessionaire relationship. The efficacy of PPP initiatives hinges upon the interplay between public and

private sector entities, and a deficient rapport between these organisations can often engender misinterpretations and discord. The success of PFIs has been attributed to critical factors such as enhanced communication and increased relationships among project participants (Chan et al., 2003). Nevertheless, diverse stakeholder expectations, contractual agreements, and divergent philosophical perspectives may give rise to tensions and strain in the relationships between the relevant parties, ultimately resulting in suboptimal relational dynamics (Consoli, 2006). Scholars have underscored the significance of promptly addressing disagreements, as they can rapidly escalate and strain the interpersonal dynamics of the involved parties (Smyth & Edkins, 2007).

Public finance initiatives' (PFIs) operation and maintenance stage is particularly vulnerable to conflicts and challenges (Van Oerle, 2022). Conflicts related to the relationship directly impact the workgroup performance during this stage. Unresolved conflicts consume time and energy and can have detrimental effects over time. The uncertainty and risks associated with the long-term nature of PFI contracts contribute to conflicts during the operation and maintenance stage. Successful service delivery in this stage requires attention and a collaborative working relationship between the concessionaire and the client. Building understanding, sharing a common vision, knowledge transfer, and trust are crucial for the success of a PFI.

In the construction industry, relationship quality is seen as a key factor for project success and performance (Akintoye & Main, 2007). It involves factors such as trust, commitment, teamwork, and performance satisfaction (Jelodar et al., 2016). Relationship quality has been linked to customer satisfaction and the anticipation of future commitment. The long-term nature of PFI contracts presents challenges, such as difficulties in specifying service quality and different interpretations of contract clauses, which can lead to conflicts between the public and private sectors. To address these challenges, a collaborative working or partnering relationship is essential, along with systems and communications that support and enhance relationship quality throughout the duration of the PFI.

While some frameworks for relationship quality exist, they are not universally applicable to all types of projects. The type of project, the contracting arrangement, and the cultural setting determine the particular framework for relationship quality. Given the limited research on relationship issues in the context of PFIs in Malaysia, further studies are needed to explore and understand relationship quality in this specific context.

Causes of Conflicts

Identifying and exploring the nature of common causes and triggers of conflict is of utmost importance. It can help build a comprehensive understanding and the ability to recognise conflicts during the later stages of the project when significant resources and financial investments have already been made.

The detection and categorisation of causes will also facilitate the identification of preventable causes of claims, hence aiding in mitigating conflict. Numerous researchers have evaluated the causes of conflict, each offering distinct classifications. However, a closer examination of their classifications reveals patterns of commonalities and shared notions.

Table 2. Common Causes of Conflicts in Public Finance Initiatives (PFIs)

Causes of Conflict in PFIs	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Unfair Risk Allocation	x	x											x	x
Improper Communication			x											
Discrepancies In Document Agreement				x										
Undefined Roles and Responsibilities of Parties			x		x									
Unpredicted Tariff Changes						x								
Excessive Contract Variations							x							
Political Involvement			x							x				
Uncertain Goals and Objectives								x					x	
Imperfect Transfer of Risks	x								x					
Incomplete Document Contracts												x		
Unrealistic Deadlines									x					
Delays In Decision Making				x										x
Delays In Make-Good Defects During Maintenance & Operational Stages										x				x
Lack of Enthusiasm to Seek Clarification											x			
Incompetent Individuals										x				
Unreliable Service Delivery										x				
Unclear Payment Adjustments in The Event of Non-Compliance													x	

([2]Ibrahim et al. (2006); [3]A.P.C et al. (2011); [4]UNDP; [5]Acharya et al. (2006); [6]L. Tang et al. (2012); [7]S.O. Babatunde et al. (2015); [8]Cheung & Chan (2011); [9]Ng et al. (2012); [10]Kumaraswamy (1997b); [11]Osei-Kyei et al. (2017); [12]D.G. Carmicheal (2002); [13]Mansor & Rashid (2016); [14]Lam & Javed (2012); [15]Sugimura & Kato (2022))

Based on Tariq and Shujaa Safdar Gardezi (2023), there are 35 causes of conflicts in the construction industry; however, there are seven common causes of conflicts which are related to communication, poor relationship, contract document problems, financial problems or delayed payment, cultural differences, unforeseen site conditions and external interference. Research by Acharya et al. (2006) on the Korean construction industry reveals that conflicts are caused by public interruption, differences or changes in order valuation, different site conditions, design errors, excessive contract quantities variation and double meanings of specification.

The construction industry in New Zealand has identified 13 primary factors contributing to conflict. These factors encompass environmental concerns and weather conditions, limitations and restrictions related to site conditions and access, technical challenges arising from the complexity of design and construction, resource unavailability, time constraints, design errors, ambiguities and change orders, ambiguities within contract documents, inadequate risk allocation, quality issues, opportunistic and adversarial behaviour, poor communication and misunderstanding, lack of experience with the specific type of work being performed, and a deficiency in fostering a collaborative spirit.

In this research, a questionnaire is distributed to participants with five years of experience in the construction industry (Jelodar & Wilkinson, 2016). Further, the research by Diekman and Nelson (1995) indicates that conflicts are caused due to incomplete contract documentation, differing site conditions, differing weather conditions, strikes, and riots.

Similarly, Love et al. (2010) indicate that incorrect design and incomplete documentation create conflicts in the construction industry. Conflicts concerning traditional bid-build contracts and PFI contracts are slightly different due to the situation and duration of the contract. Table 2 shows common causes of conflict in PFIs.

The review indicates 17 causes of conflicts in PFIs. The main cause of conflicts in PFIs is unfair risk allocation, followed by undefined roles and responsibilities of involved parties, political involvement, uncertain goals and objectives, imperfect transfer of risks, delay in making decisions, and inadequate defect handling during the maintenance and operational stage. The causes of conflict listed in Table 2 appear unfocused and are difficult to understand. Hence, these causes are categorised (Osei-Kyei et al., 2017; Williamson, 1979). Conflicts are summarised into three categories based on: behaviour, contract, and technical causes. Table 3 shows categories for each cause of conflict in PFIs.

Table 3. Categories of Each Cause of Conflicts in Public Finance Initiatives (PFIs)

Behaviour	Contract Agreement	Technical
Improper communication	Discrepancies in document agreement	Unfair risk allocation
Undefined roles and responsibilities of parties	Unpredicted tariff changes	Political involvement
Uncertain goals and objectives	Excessive contract variations	Imperfect transfer or risks
Lack of enthusiasm to seek clarification	Incomplete document contracts	Unrealistic deadlines
	Unclear payment adjustments in the event of non-compliance	Delays in decision making
		Delays in make-good defects during maintenance and operational stages
		Incompetent individuals
		Unreliable service delivery

Types of Conflicts in the Construction Industry

Conflicts within contractual agreements might have both advantageous and detrimental consequences for the parties involved. Conflicts can be broadly categorised into two main types: functional conflict and dysfunctional conflict. Conflict types are categorised similarly throughout the construction industry (Chen et al., 2014; Kumaraswamy, 1997b). According to Nunkoo and Sungkur (2021), functional conflict is healthy, leading to constructive disagreement between groups or individuals. On the other hand, dysfunctional conflict is an unhealthy disagreement that occurs between groups or individuals. Different conflict types have different consequences for the parties involved in the contract.

Functional conflicts comprise consultative interactions and productive exchange of information. Functional conflicts are believed to have beneficial effects on peer relationships. Where a functional conflict exists, parties feel free to express their opinions and challenge others' ideas, beliefs and assumptions (Baron, 1991). Functional conflict can be considered the opposite of 'groupthink', where feelings of solidarity and loyalty to a decision-making group override the imperative to logically and realistically evaluate all options. Therefore, functional conflict is a constructive challenge of ideas, beliefs, assumptions, and respect for others' viewpoints, even when parties disagree.

In contrast, dysfunctional conflict is believed to reduce team performance. Parties involved in contract fulfilment might be affected by tension and antagonism, distracting people from their tasks (De Dreu & Weingart, 2003). Therefore, dysfunctional conflict is unhealthy and is associated with dysfunctional behaviours, dissatisfaction, and poor individual and group performance.

There has been a suggestion to investigate conflict categorisation, specifically examining the potential for classifying conflicts as functional or dysfunctional. According to Gardiner and Simmons (1992), a potential alteration in the incidence of harm caused by conflicts in projects can be achieved by an enhanced comprehension of conflict types. Gardiner and Simmons (1992) and Kumaraswamy (1997b) indicate a need to differentiate dysfunctional conflict from functional conflict to imply prolonged disagreement as an effect of dysfunctional conflict, leading to time, cost, and relationship issues.

Conflict Management Strategies

Conflict is a dynamic phenomenon that does not appear suddenly but holds and passes through several phases (Kenan Spaho, 2013). Based on the approach of Louis R Pondy, there are five phases in the conflict process (Gonan Božac et al., 2008). The phases are latent conflict, conflict perception, conflict personalisation, conflict manifestation, and consequences.

Parties can use a wide variety of approaches to manage and resolve conflicts, many of which have been researched over the years. Most current studies recognise and employ five primary conflict management styles (Li et al., 2021). There are conflict management styles, as seen in Figure 2. When neither party is prepared to make any concessions, cooperation results. The strongest side prevails. Conflict avoidance happens when both parties decide to stay out, preventing them from pursuing their interests. One aspect of an accommodation style is placing the other party's interests above their own. Compromise is the fifth management technique; both parties make sacrifices so that neither can fully advance their interests, but the outcome is acceptable to both.

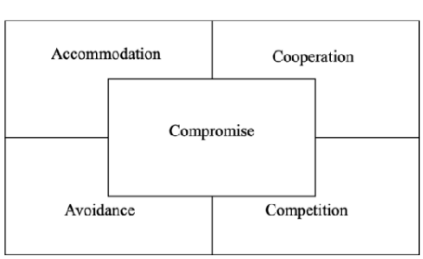

Figure 2. Conflict Management Styles

While management styles offer a broad framework for individuals or groups to select their course of action in achieving their intended objectives, they do not offer specific techniques for de-escalation (Van Oerle, 2022). There are three distinct classifications of de- escalation measures: preventative, alternative, and traditional. Preventive measures are implemented in advance of the occurrence of a dispute. The primary objective of these initial efforts frequently revolves around mitigating the impact of conflict. In contrast to preventive measures, alternative and traditional measures are implemented in response to the emergence of a

conflict. According to the study by Marzoouk et al. (2011), alternative measurements emphasise collaborative problem-solving. In contrast, conventional metrics are distinguished by the parties functioning as separate entities. Consequently, conventional involvement frequently leads to direct opposition between parties, resulting in a zero-sum outcome where only one side can emerge victorious (Menessa et al., 2010).

Preventive measures are implemented to proactively mitigate and reduce the impact of disputes if they arise. These measures aim to influence the customer and concessionaire's behaviour and attitude before, during, and after a disagreement. Preventive measures can be implemented to establish outcomes that are either mutually beneficial (win-win), advantageous for one party at the expense of the other (win-lose), or detrimental to all parties involved (lose-lose). One primary strategy to achieve a mutually beneficial outcome is promoting collaboration among the involved parties. This approach is effective in facilitating collective problem-solving efforts, as evidenced by the studies conducted by McNary (2003a), Chan et al. (2004), and Femi (2004). It consequently enhances the likelihood of achieving mutually beneficial outcomes in conflict situations. A crucial aspect of collaboration entails the establishment of shared norms and values that permeate all hierarchical levels (Chan et al., 2004). The coordination and cooperation between many entities is predominantly regulated through procurement methods.

In contrast to task-oriented traditional procurement strategies, partnership emphasises establishing long-term relationships between stakeholders (McNarry, 2003). Additional strategies for attaining a mutually beneficial conclusion include establishing shared objectives, a sustained emphasis on long-term outcomes, and exchanging pertinent information (Thompson, 1998). According to Loosemore et al. (2000), the likelihood of achieving a mutually beneficial conclusion can be enhanced by implementing regular, transparent, and efficient communication among all involved parties.

Alternatives Measures revolve around conflict resolution strategies that prioritise the welfare of bilateral relationships. The two most prevalent methods are mediation and arbitration.

- Mediation has emerged as a widely utilised method of dispute resolution in the construction sector, as evidenced by its popularity and preference among industry professionals (Alaloul et al., 2018). Mediation involves the process of negotiation between parties in conflict, facilitated by an impartial third party (Alaloul et al., 2018). The mediator actively engages in the process of attentively listening to the perspectives of both parties and facilitates dialogue sessions. By actively engaging with both parties involved in the conflict, the mediator is able to discern and highlight disparities in their respective views. Through reflection, the mediator endeavours to mitigate the disparities between the parties involved in the conflict (Harmon, 2003a; Moore, 2014). According to Senan et al. (2018), mediation has the potential to foster increased trust among parties involved in a disagreement. By facilitating the identification of the fundamental issue at hand, the parties involved are more inclined to discover a satisfactory resolution. One of the primary benefits of mediation is the ongoing communication between parties while resolving a dispute. Moreover, the mediation process necessitates that conflicting parties collaboratively reach a mutually agreeable conclusion, placing the onus on the parties involved to actively

address and resolve the disagreement. One drawback associated with the mediation process is that the outcome lacks legal enforceability. Consequently, the resolution process highly relies on both parties' intentions (Alaloul et al., 2018).

- Arbitration is a dispute resolution mechanism in which opposing parties explain their conflict to an impartial third party. According to the provided information, a neutral third party is responsible for issuing a binding statement regarding the resolution of conflicts (Alaloul et al., 2018). The appointment of the third party must be achieved through a unanimous agreement among the parties involved in the disagreement. The arbitration system bears similarities to the litigation procedure, albeit with several notable distinctions. The arbitration process is often performed confidentially. Moreover, there are no restrictions on the admissibility of evidence before the arbiter. The parties involved in the conflict often exhibit a preference for arbitration as opposed to litigation. The conflicting parties influence the selection of an arbiter (Alaloul et al., 2018). Moreover, arbitration is a very expeditious procedure, characterised by restricted expenses, particularly when contrasted with its more conventional equivalent, namely litigation. One drawback of arbitration is the observed trend of escalating costs in recent years (Alaloul et al., 2018). The rising demand and formalisation of the arbitration procedure have contributed to this phenomenon.

Traditional Measures are predicated on the concept that conflicting parties operate as discrete entities. Therefore, their primary focus is on attaining their own interests. There are two primary traditional measures: negotiation and litigation.

- Negotiation is frequently employed by parties in conflict to mitigate and reduce the intensity of the conflict. During a negotiation, it is customary for the parties involved to exchange their respective concerns and interests, with the ultimate goal of reaching asettlement that is agreeable to all parties (Alalout et al., 2018). Negotiation aims to facilitate the expeditious resolution of conflicts between parties. These conversations frequently occur across many hierarchical organisational levels (Alalout et al., 2018). When conversations at the operational level fail to yield an instant resolution, the negotiations go to the tactical and strategic levels.

- Litigation refers to the initiation of legal proceedings, such as the commencement of a court process, with the objective of resolving a dispute (Alalout et al., 2018). The measure in question is frequently perceived by opposing parties as a final option. The extended duration and uncertain nature of the judgement contribute to this outcome. Moreover, the judgement possesses legal enforceability and frequently exhibits a restricted consideration for the project's interests. One drawback associated with litigation is the limited consideration given to the interpersonal dynamics and relationships between the parties.

The intricate and fragmented characteristics of PFIs give rise to conflicts that are bound to occur. If these conflicts are not resolved within a reasonable timeframe, both parties may incur non-compensable damages, such as inefficiencies throughout a PFI's maintenance and operation stages. Hence, selecting an appropriate and efficient approach holds significant

importance in resolving disputes within the context of PPP projects. This is essential for fostering a positive and enduring relationship between the customer and the concessionaire.

Underpinning Theories

The conflict theory in sociology emerged in the late 1950s and is considered an important component of the discipline. It draws heavily from the ideas of classical sociologists such as Karl Marx, Max Weber, and Georg Simmel (Jia, Yang, Wang et al., 2011). The conflict theory focuses on social conflicts and utilises them to explain social change. The abovementioned perspective rose to popularity as a contrasting viewpoint to the prevailing structural functionalism paradigm, ultimately establishing itself as a highly significant field within sociology. A number of prominent sociologists represent the conflict theory school. The perspective in question is closely related to notable figures such as J. Raikes, a sociologist from Britain; Ralf Dahrendorf, a sociologist from Germany (2007); and Lewis A. Coser and L. Collins, both sociologists from the United States. Dahrendorf's conflict theory emphasises social organisations' unequal distribution of authority and power. According to Dahrendorf, these organisations consist of quasi-groups, where one group holds power and authority while the other is subordinate. These quasi-groups engage in conflicts as collective actors, seeking to redistribute power and authority within the social organisation. Consequently, society is depicted as being in constant conflict (Dahrendorf, 2007).

Meanwhile, Raikes' conflict theory highlights the dominant role of the distribution of material resources in constructing social models. Hierarchical structures utilise coercive power to enforce integration within the social structure, often following a path from currency to power to value to ritual, all serving the ruling class's interests. Nevertheless, this particular social arrangement has the potential to result in a very disproportionate allocation of resources, hence motivating those belonging to the inferior class to unite and act collectively. Ultimately, this phenomenon has the potential to precipitate the decline of the dominant social group.

Collins' conflict theory posits that social conflict is a fundamental process in human life, and the structure of society results from individuals constantly creating and recreating it through their interactions. The social structure is formed and sustained through ongoing interactions among individuals. Similarly, Coser's conflict theory suggests that conflict, despite its negative aspects, can also have positive consequences for society. It can ensure social continuity, prevent the emergence of extreme opposing classes, foster social adaptability, and enhance social integration. In summary, the conflict theory in sociology provides a conceptual framework for comprehending the role of social conflicts and power dynamics in shaping society and facilitating social change. Given the multitude of perspectives and theories within conflict theory, it is not feasible to incorporate all of them in the study of PFIs. Therefore, this research primarily draws upon Coser's conflict theory as a reference.

In order to gain a comprehensive understanding of PFIs within the framework of conflict theory, it is imperative to examine the impact of conflict and delve into the intricate relationship between PFIs and conflict theory. Conflict refers to a state of opposition and lack of cooperation, and individuals aspire to minimise social conflicts. Nevertheless, life is inconceivable without confrontations. The presence of conflicts within projects can contribute

to their advancement. As Dahrendorft (2007) asserts, conflict is an inherent aspect of society, stemming from power dynamics and resulting in inequality. However, it is through this inequality and subsequent conflict that social progress is achieved. In fact, conflict serves as a catalyst for transformative change, particularly benefiting the majority of individuals. However, it is evident that not all conflicts are advantageous to society, such as war, which represents the most explicit and brutal form of human conflict and can result in devastating and negative consequences for society. According to Coser (1964), disputes may only have a constructive impact in a society if the fundamental components, such as aims, values, interests, and relationships, do not contradict one another.

As previously indicated, disagreements can be perceived as a catalyst for fostering constructive reactions to change. However, it is imperative not to overlook the adverse effects of conflicts on PFIs and disregard the associated dysfunctions. The prevailing perception of conflicts is to focus on their negative aspects. However, employing these theories can provide a broader understanding of functional conflicts. Hence, in the context of PFIs, disagreements, particularly severe or intricate, are perceived as crucial by the stakeholders involved. Rather than allowing these conflicts to escalate, individuals strive to identify and implement strategies to effectively address the issues at hand, aiming to foster a harmonious and productive working relationship.

Conceptual Framework

In this research, it is important to acknowledge the causes of conflict that trigger inevitable long-term contract duration problems. The next step comprises categorising the causes and types of conflicts.

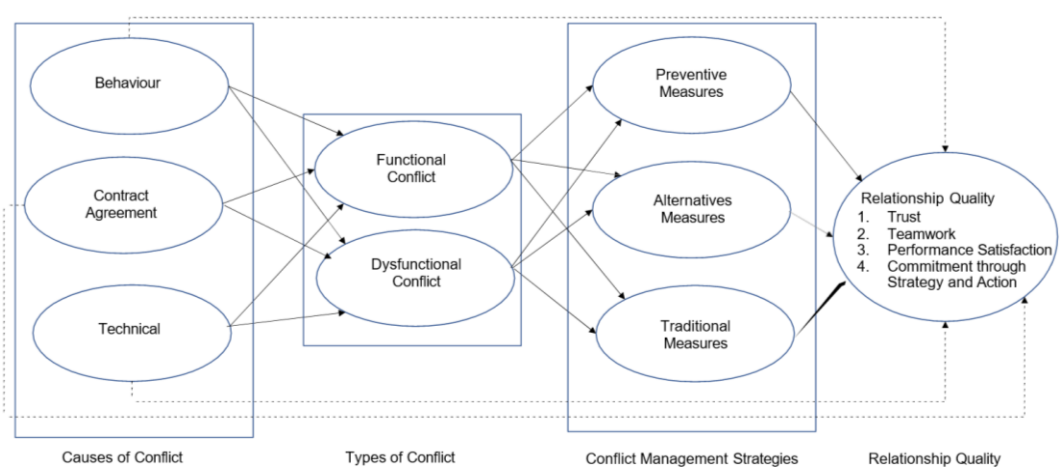

Figure 3. Conceptual Framework of the Correlation between Relationship Quality During the Maintenance and Operational Stages of Public Finance Initiatives (PFIs)

This process could indicate if the causes of conflict lead to functional or dysfunctional conflicts. Understanding the underlying reasons for conflict can provide valuable insights to the people involved, enabling them to adopt more suitable strategies in order to restore and strengthen their relationships. If causes of conflict fall into the functional category, it has a positive impact, enhancing quality, strategy, and implementation. In such functional conflicts, the related public and private sector parties hold consultations, interactions, and exchanges

based on mutual respect (Massey et al., 2019). Dysfunctional conflict is the opposite of functional conflict.

Conflicts are inevitable in PFIs; consequently, both parties may cause non-compensable damages such as inefficiency during a PFI's maintenance and operation stages. Ignoring or delaying the resolution of conflicts in PFIs can have serious implications for the present and future relationships of the parties involved in a PFI. These aspects help identify the relationship quality attributes of Malaysian PFIs' maintenance and operational stages. Knowing and addressing attributes in relationship quality can manage the causes of conflicts and indirectly assist relationship development.

While it is crucial to consider the causes of conflict, it is said that how conflict shows itself in various forms and how it is effectively managed holds more significant value in determining the quality of relationships within the construction industry (Jelodar & Wilkinson, 2016). Therefore, this research will investigate the associated causes, types of conflict and the positive attribute: relationship quality.

CONCLUSION

The interaction between the private and public sectors is widely recognised as a critical factor in the success of PPP projects, particularly those utilising the PFI model. A deficient relationship between these sectors can easily give rise to misunderstandings and conflicts, jeopardising the overall effectiveness and outcomes of such initiatives. Overcoming conflicts in the early stages is crucial due to the potential influence on workgroup performance in PFIs' operation and maintenance stage, as these conflicts are often associated with relationship issues. In conclusion, there are several causes of conflict in PFIs at the operation and maintenance phase which have been classified into three leading causes: behaviour, contract agreement, and technical aspects.

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AN EXPLORATORY STUDY ON WIND SPEED PROFILING OF HIGH-RISE BUILDING/MONUMENT USING ENVIMET

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Abstract

Envi-MET is a useful tool for simulating wind speed at building heights and modelling microclimatic conditions around buildings, including wind speed around buildings and other structures. Envi-MET is used in this study to simulate wind speed toward building heights. When R2 = 0.8186, relative bias is -0.0775, and RMSE is 0.2578, the agreement between Envi-MET simulation and ground observation indicates acceptable agreement. With this establishment, it was discovered that the building's height and wind speed are not the only factors causing destruction; the less friction of wind with surface features will also increase the wind speed, as shown by the results of the vertical profile wind speed in relation to the toll way building's height. At a height of 13 metres, the wind speed is 3.5 m/s. Wind circulation affects the building at this elevation, causing damage to the roof and ceiling. Buildings and structures can sustain significant damage as a result of high wind speeds. When wind speeds are high, the wind's force increases, causing pressure differences on different sides of a building or structure. The findings of this study inform relevant parties of the impact of wind on building construction and how it may influence variations in wind speed.

Keywords: *Windstorm; Envi-MET; Coriolis force; turbulent drag; Wind disaster*

INTRODUCTION

Wind is the flow of air relative to the Earth's atmosphere. It is caused by a force acting on it, as is the case with all moving things. According to Wang et al. (2020), a force is a pull or push that modifies the resting state, motion, or direction of an object. Wind speed can cause building destruction in several ways. Strong winds can create high-pressure zones on one side of a building and low-pressure zones on the opposite side, resulting in unbalanced forces that can cause the building to sway or vibrate. This might cause structural damage, possibly even causing a building component to crack or break or even to collapse (Taranath, 2021). Strong winds can blow objects into buildings, such as tree branches, signboards, or loose building parts, in addition to the direct wind pressure. This can cause physical damage to the building's exterior and windows, and potentially cause injury to people inside the building.

Furthermore, wind-induced vibrations can cause fatigue damage to building components over time, especially in tall buildings or those with slender components like beams or columns (Lago, Trabucco, & Wood, 2019). Tall or slender buildings are more susceptible to wind-induced damage or destruction due to their increased height and flexibility. Wind tunnel

testing and other wind engineering studies can help identify potential wind-induced damage and provide recommendations for building design, materials, and construction methods to reduce the risk of failure. This can lead to cumulative damage and eventual failure if not addressed. To prevent wind-induced building destruction, building codes and standards typically require buildings to be designed and constructed to withstand specific wind loads based on the local wind speed and other factors (Mendis et al., 2007). Engineers use wind speed data to calculate wind loads and design building components that can resist those loads. In addition, regular inspections and maintenance of building components can aid in identifying and addressing potential damage caused by wind or other elements. There are several areas around the world that are prone to high wind speeds, including:

1. Coastal regions: Coastal regions are often subject to strong winds due to their proximity to the ocean. Regions situated along the Gulf Coast of the United States are subject to regular occurrences of hurricanes and tropical storms, characterised by elevated wind velocities and storm surges.
2. Mountainous regions: Mountainous regions can also experience high wind speeds due to the funnelling effect of the terrain. Wind speeds can increase as the wind is channelled through mountain passes or over ridges. The Rocky Mountains in the western United States are one example of a region prone to high wind speeds.
3. Polar regions: Polar regions can experience strong winds due to the temperature differential between the cold air at the poles and the warmer air at lower latitudes. The polar jet stream can bring high winds to areas near the poles as well as to areas further south.
4. Tornado Alley: Tornado Alley is a region in the central United States that is prone to tornadoes, which can bring high wind speeds and cause significant damage. Tornado Alley includes parts of Texas, Oklahoma, Kansas, and Nebraska.
5. Cyclone-prone regions: Cyclones, also known as typhoons or hurricanes, can bring high wind speeds to coastal regions in many parts of the world, including Southeast Asia, the Caribbean, and the Gulf of Mexico.

In areas prone to high wind speeds, building codes and regulations may require specific wind-resistant construction. A decrease in albedo leads to an increase in mean wind speeds and the frequency of high wind speeds along with increased turbulent energy in the planetary boundary layer n techniques and materials to ensure building safety and prevent destruction (FEMA, 2018). Previous study has investigated the dynamics of land surface albedo and temperature (Salleh et al., 2022). A reduction in albedo results in elevated mean wind velocities and heightened occurrence of strong wind speeds, accompanied by amplified turbulent energy inside the planetary boundary layer.

Apart from that, there is no denying the benefits of wind for urban cooling purposes. Study by Isa et al. (2020) concerns the effect of urbanisation at Greater Kuala Lumpur that leads to Urban Heat Island (UHI). The use of wind to ventilate and cool the city was needed. Even if the wind is less than 10 m/s, it has led to destruction of monuments and buildings in Malaysia especially in urban areas and residential areas (Zakaria et al., 2019). The process of wind deflation caused the land surface to become armoured, leading to a subsequent rise in both average wind speeds and gustiness. This statement highlights that the albedo, ascertained by analysing the surface geology in this context, may exert positive feedback on wind

velocities. The perturbation in albedo as a result of wind erosion activates the feedback mechanism.

Winds are a natural disaster that almost every country on Earth has to deal with. Because of this, there has been a lot of study and analysis. The complicated wind activity that causes windstorms has caused damage to both public and private property. Numerous websites assert that urban areas are frequently impacted by windstorms. More and more often, windstorms kill people and damage or destroy both public and private property. In the Emergency Incidents Database (EM-DAT), the Centre for Research on the Epidemiology of Disasters (CRED) revealed that storm damage was worse in 2017 than in 2016 (Kishore et al., 2018). As an example, Hurricane Katrina in 2005 caused overall financial losses of around 108 billion USD, making it the most expensive natural disaster in the United States. The direct and indirect damage caused by the storm halted the progress of Gulf Coast states. People claim that Sandy and Ike were the second and third costliest storms in history. In 2012, Hurricane Sandy cost $71.4 billion, and Hurricane Ike cost $29.5 billion (Blake et al., 2007). About 13 billion Euros worth of economic damage was done. (Ulbrich et al., 2001).

Typhoon Haiyan, also called Super Typhoon Yolanda, hit the Philippines in 2013. It was called the most powerful tropical storm to ever hit land. The typhoon's strong winds and storm waves caused a lot of damage in southern Asian countries. The total cost of the damage was expected to be about $2.86 billion. Damage from windstorms depends a lot on the physical factors of an urban area (Střelcová et al., 2009). Small hazard events like local windstorms are becoming more important to human security. They have the ability to cause even bigger problems by destroying people's possessions and key infrastructure, which lowers the threshold of resilience in local communities (Kasperson et al., 1996). Windstorms have significant consequences in metropolitan areas. High winds may cause deaths, uproot trees, and cause significant structural harm to homes, power and telecommunications lines, radio masts, and other urban infrastructure. Small variations in temperature and climate extremes have the ability to wreak havoc on structures designed to survive previous climate extremes (Adelekan, 2012). In Australia, building damage increased by 650% for every 25% increase in high wind gust speed (Coleman, 2003). The International Group for Wind-Related Disaster Risk Reduction (IG–WRDRR) was started in June 2009 by the United Nations International Strategy for Disaster Reduction Secretariat (UN–ISDR) in response to a growing understanding of the social and economic effects of severe wind events at the international level. One of the main goals of IG–WRDRR is to use the Hyogo Framework for Action to reduce the risk of disasters caused by wind.

The wind is generally light and variable throughout Asia, Africa, North America, South America, Antarctica, Europe, and Australia. Throughout the observation time, an easterly wind blew at lower latitudes. As North-eastern winds blew in the Northern Hemisphere and southeast winds blew in the Southern Hemisphere, air converged along the equator, creating the Intertropical Convergence Zone just north of the equator (ICTZ) (Wu, 1997). However, there are several seasonal variations in flow patterns, and four seasons may be differentiated from these wind flow patterns, including the Southwest Monsoon, the Northeast Monsoon, and two shorter Inter-Monsoon seasons (Rasyidah & Othman, 2010). During the Southwest Monsoon, the predominant wind is light, averaging less than 15 knots (7.7 m/s) (Gasing, 2015). During the Northeast Monsoon, sustained winds of 10 to 20 knots (5.2 to 10.3 m/s) prevail, with gusts of up to 30 knots (15.4 m/s) over Peninsular Malaysia's east coast states.

The winds are usually light and unpredictable throughout the two Inter-Monsoon seasons (Rasyidah & Othman, 2010). The Malaysia Meteorological Department states that on September 15, 1992, the highest average daily wind speed was 3.8 m/s in Mersing, Johor, and the highest maximum wind speed was 41.7 m/s in Kuching, Sarawak. (MetMalaysia) (Nizamani et al., 2018). In 2018 total damages in Malaysia due to windstorm hazards were 53, and some of the cases resulted in fatalities.

The Malaysian Meteorological Department (MMD) is the government agency in charge of informing Malaysians about impending weather conditions, such as windstorms, through television, social media, and websites. Malaysia currently lacks a comprehensive database of windstorm incidence and injury (Wan Chik et al., 2014). The full extent of the windstorm's impact will be beneficial to society, both in terms of emergency response plans and future planning and growth. The urban metropolitan population has been significantly impacted by the windstorm outbreak. According to a study by Zakaria et al. (2019), the seasonal monsoon has some relationship with windstorms in Malaysia. The study looks at the effects of the Southeast Monsoon, the Northeast Monsoon, and the time between the two. The strongest windstorm was during the Southeast Monsoon. The Northeast Monsoon had the fastest wind speed, which was between 5.96 and 6.23 m/s. Southeast Monsoon winds blow the fastest and have the most effect on the land north of the peninsula. Their speeds range from 9.20 to 10.96 m/s. Windstorms in Peninsular Malaysia were to blame for 80% of roof damage. The reason was that big towns were getting more and more people, which meant that high-impact facilities and services were getting closer together (Tao, 2013). A study done in Pulau Pinang between 2010 and 2013 found that steel sheet roofing caused 47% of the damage, the truss system caused 30%, roof tiles caused 13%, and other parts caused 20% (Majid et al., 2016).

Envi-MET proposes a method for designing the metropolitan landscape to have the best available microclimate environments for inhabitants, which is critical for human safety. It is possible to determine the impact of wind gusts caused by jet impacts at building corners (Huttner et al., 2008). Environmental planning and developers will get a decent standard in urban environments and be mindful of the urban microclimate through the Envi-MET initiative (Langer et al., 2012). The microclimate model in three dimensions Envi-MET is a model for simulating microscale atmospheres in urban environments with a standard spatial resolution of 0.5 to 10 m and a time resolution of 10 seconds. Envi-MET is a predictive model focused on fluid and thermodynamic fundamental laws. Heat and water vapour exchange processes at the ground surface and at walls, vibration, exchange at the soil, and vegetation parameters are all simulated in this software. Under various mesoscale settings, Envi-MET investigates the impact of small-scale improvements in urban architecture (e.g., trees, backyard greening, modern building constellations) on microclimate.

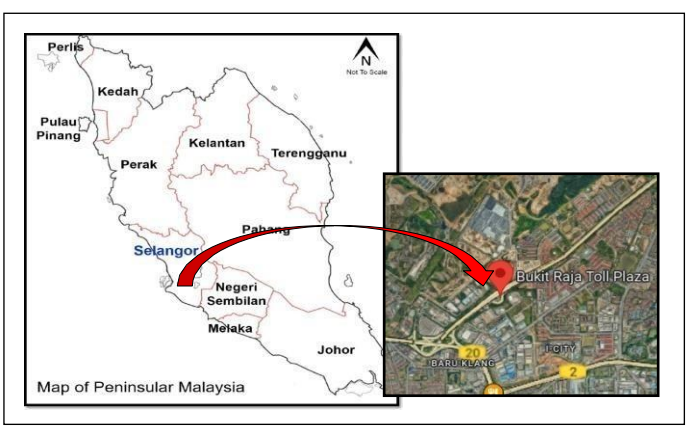
Temperature, wind direction and intensity, evaporation, relative humidity, and sunlight period are all important meteorological measures (Yan et al., 2019). Sealed surfaces, for example, have a detrimental impact on the local atmosphere because they heat up quickly during the day and cool off steadily at night. Furthermore, the ability of such areas to filter air contaminants and attach dust particles is very limited. The removal of open/green areas, emissions, and barriers to air exchange systems (such as building structures) all have an adverse effect on the microclimate (Liu & Shen, 2014). Thus, this analysis looks at wind speed on a microscale. Since there was no ground station to determine wind speed, the alternate method of using Envi-MET to model the actual event was selected. The total number

of Meteorology Department stations that can record wind speed in Selangor, Malaysia, is fewer than 20. Currently, only a few stations have complete wind speed records. Every station's coverage area is much too broad to be useful in certain regions. In this analysis, the effect of wind on man-made features was established.

METHODOLOGY

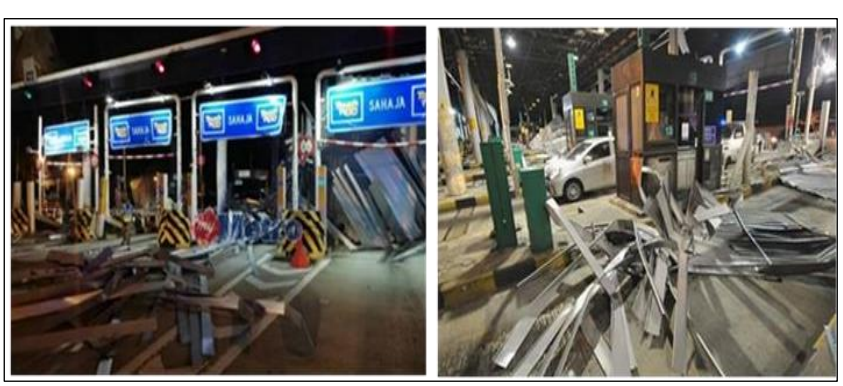
Study Area

Due to a storm event reported on August 24, 2018, which took place during the Southeast Monsoon season, the Bukit Raja Toll Plaza was chosen as a study area (Harian, 2018). Bukit Raja is located in the Klang district with latitude and longitude: 3.0734° N, 101.4752° E and part of Klang, Selangor, as shown in Figure 1, with an average wind speed of 1.6 m/s to 2.7 m/s (METMalaysia, 2018). The studied area is surrounded by industrial zones and toll roads. The total study area encompasses roughly 17,38 hectares. Bukit Raja Tol measured approximately 80 metres in length and 13 metres in height.



(Google, 2020)

Figure 1. Study Area at Bukit Raja Toll



(Harian, 2018)

Figure 2. Damage at Bukit Raja Toll Plaza on 24 August 2018 Reported by Berita Harian Newspaper

Around 9 p.m. on August 24, 2018, a storm destroyed Bukit Raja Toll, causing damage to the roof and structure of the building. During the event, a public witness reported that the wind was blowing significantly harder than usual (Astro Awani, 2018). Figure 2 shows the damages caused by the event. The report shows the top siling falling and a few monuments damaged. Thus, the microscale simulation of wind speed in Bukit Raja Toll was carried out on the same date of event to study the approximate wind speed during the event using Envi-MET simulation. 24-hour data was analysed for 24 August 2018 with different heights from 0 metres to 13 metres.

Envi-MET Simulation

Envi-MET version 4.1 was used to simulate the wind speed for this study. Due to the software's capability to simulate microclimate, Envi-MET's is used to simulate the microclimate study. Envi-MET is a computer program designed to simulate the urban microclimate. Envi-MET is a helpful program to simulate the urban climate in cities and can assist with environmental planning (Chatzinikolaou, Chalkias, & Dimopoulou, 2018). The 24-hour data was simulated on 24 August 2018. The simulation size was a 50 x 50 x 40 grid with 1 grid equivalent of 10 metres. Therefore, the total size of the simulation was 500m x 500m x 400m. This is the maximum size that can be conducted due to licensing restrictions while using the Envi-MET. Figure 3 shows the Envi-MET simulation workflow. 3D modelling of study area was created using Envi-MET tool, as shown in Figure 4. A Google map image was used as a reference while designing the study area model.

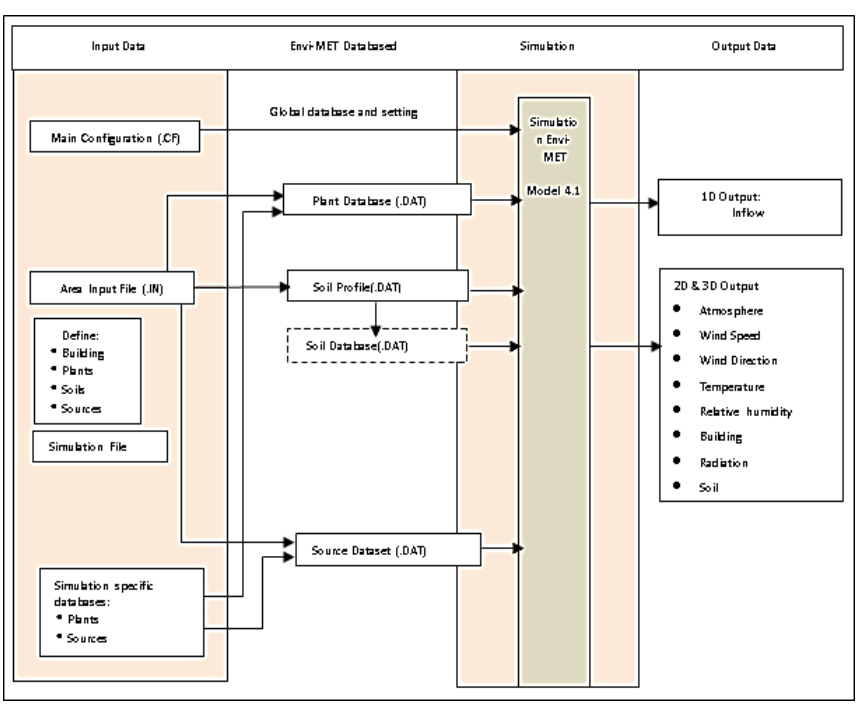


Figure 3. Envi-MET Simulation Workflow

Figure 4. Bukit Raja Toll from Google Earth Image was Modelled Into the SPACE Tool in Envi-MET Software

The model was simulated using the real environment representation criteria, such as the model geometry, model location, material of building, the height of building, type of vegetation and type of soil, as well as the real meteorology data ENVI-met databases provide a variety of materials and 3D plants, allowing the detailed reconstruction and accurate modelling of the urban environment. The climatic data input for the simulation were the minimum and maximum wind speeds on the day between 1 m/s and 2 m/s, the temperature between 28˚C to 35˚C, and the direction of wind at 345° as shown in Table 1. For the height of the building, it follows the real height in ground data, such as toll monument height of 13 metres, then, inside the model, 13-metres. The element type uses of the built environment are illustrated in Table 2. For the building element, the concrete wall (cast dense) was selected. For the type of soil and surface, this model uses asphalt road and soil and vegetation using grass, vegetation with a height less than 0.5 metres and a few above 2-metre height trees.

Table 1. Data Input to Envi-MET Model

Data Input	Value
Simulation Date	24 August 2018
Start & Duration of Simulation	00:00, 24h
Minimum Wind Speed	1 m/s
Maximum Wind Speed	3 m/s
Minimum Temperature	28˚C
Maximum Temperature	35˚C
Direction of the Wind	345°
Minimum Humidity	60%
Maximum Humidity	90%

Table 2. Element Type of Build Environment

Element	Type
Building Wall	• Concrete wall (cast dense)
Soil and Surface	• Asphalt Road • Soil
Vegetation	• LAD lower 0.5 meter • LAD above 2.5 meter • Grass

Ground Station and Envi-MET Data Validation

The compatibility between ground station data and Envi-MET simulation has been determined. This comparison to test the accuracy of Envi-MET software to conduct the microscale simulation for wind speed. The available ground data on 24 August 2018 was used to validate with Envi-MET simulation. This validation purposely checks the accuracy of Envi-MET simulation compared to ground station data. Using domain 20 x 20 x 20 grids which is 1 grid equal to 2 metres, the ground station was modelled in 3D into Envi-MET software at height 4 metres, following the real data. Figure 6 shows the study area ground station in SPACES tool was modelled from google earth image in format .BMP.

The criteria approximated the real environment, such as the model geometry, model location, material of building, the height of building, type of vegetation and type of soil. To simulate the model, the real meteorology data was used. Then, the model was imported to ENVI-Guides and given the real meteorology data configurations. The minimum and maximum wind speed on the day between 1 m/s to 2 m/s, the temperature between 28˚C to 35˚C, and the direction of wind at 310° were used for the simulation. The simulation was carried out using the Envi-MET tool. The map of wind speed by each height was generated, and the analysis of data was carried out in the LEONARDO tool. The variations in the accuracies of wind speed and energy efficiency between ground measurement and Envi-MET simulation were quantified using statistical methods. Equations (1) and (2) were used to quantify the bias and root mean square defect, respectively:

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(f_i - o_i)^2} \qquad \text{Equation 1}$$

Where:

- n: number of samples
- f: forecasts
- o: observed values

$$RE = \frac{\sum_{i=1}^{n}(P_i - O_i)}{\sum_{i=1}^{n} O_i} \qquad \text{Equation 2}$$

Where:

- O_i is the observation value
- P_i is the forecast value.

METHODOLOGY

Validation of Ground Station vs Envi-MET Simulation

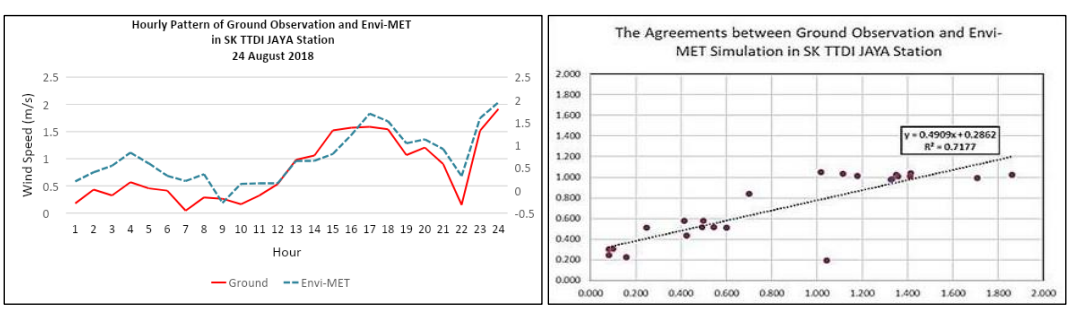
The calibration between ground data and the Envi-MET simulation was established. The purpose of this calibration is to prove the efficiency of Envi-MET simulation to substituting ground data due to the absence of data for certain areas. Generally, Malaysia lacks ground

stations, and some of them are unable to give continuous readings. Hence, the nearest ground station at SK TTDI Jaya station on 24 August 2018 was used to validate the Envi-MET simulation, and the results were compared.

Table 3. Statistical Calculation for Validation Data of Ground Observation and Envi-MET Simulation for SK TTDI Jaya Station on 15 April 2017

Residual	Square	RMSE	Relative Bias
0.0210	0.000441	**0.2578**	**-0.0775**

Table 3 shows the statistical result comparison between wind speed reading (m/s) from ground observation and Envi-MET simulation. Since the height of ground station equipment was 4 metres, the simulation at Envi-MET also used the same vertical height at 4 metres during the simulation. The pattern of wind speed from both ground observation and Envi-MET was shown in Figure 5. As a result, from the statistical calculation, the highest residual was 0.266 at 4.00 a.m. and the lowest residual was -0.715 at 3.00 p.m. From the result, the positive value shows the observation value is higher than Envi-MET and vice versa. Figure 5 shows the agreement between Ground Observation and Envi-MET simulation on 15 April 2017 (SK TTDI Jaya station). The graph indicates that the R2 value is 0.8186, which is closest to 1. A similar study by (Bande et al., 2019), where the R2 value is more than 0.5, therefore the reading of wind speed from Envi-MET simulation can be accepted for this study. The Root Mean Square Error (RMSE) and Bias value were 0.2578 m/s and -0.0775m/s. RMSE is between 0.2 to 0.5 shows that the model fits this study (Chatzinikolaou et al., 2018). The lower the RMSE, the better the model and its predictions. A lower RMSE indicates that there is a small deviation from the residual to the ground truth (Hien, Ignatius, Eliza, Jusuf, & Samsudin, 2012).



(a) (b)

Figure 5. (a) 24-Hour Wind Speed Pattern Between Ground Observation and Envi-MET Simulation on 24 August 2018 (SK TTDI Jaya Station) (b)The Agreement Between Ground Observation and Envi-MET Simulation on 24 August 2018 (SK TTDI Jaya Station)

Based on the RMSE and Bias tolerance, this analysis determined the exceptional agreement between the simulation and the ground observation. Therefore, the Envi-MET simulation model can be used in this study to simulate the wind speed in a microclimate area. The model was implemented for the study area, the Bukit Raja Toll Plaza on 24 August 2018. There were windstorms reported by the media that caused destruction (Astro Awani, 2018). Therefore, the model was used to see the vertical profiling of wind speed impacts towards the building.

Wind Speed of Bukit Raja Toll from Different Height

The simulation was conducted for twenty-four hours on August 24, 2018. To determine changes in wind speed, the model was simulated at various heights. As shown in Table 4, the k value in Envi-MET was modified from 0 to 1, 2, 3, 4, 5, 6, 7, 8, and 10 to represent the height of the model. Height was used to generate graph analysis. Since the destruction was recorded at 9 p.m., the analysis focuses on that time (Harian, 2018). The minimum wind speed at 9.00pm during the event was 0.095 m/s and the maximum wind speed was 2.149 m/s. Generally, with the speed below 10 m/s of wind speed is considered as a light breeze following world Beaufort scale and should not cause any destruction. Unfortunately, for this study area and date, there was destruction recorded. Therefore, the profiling of each height was investigated to define the factors that caused the damages to the Bukit Raja Toll Plaza on 24 August 2018 at 9.00pm.

Table 4. *K* Values and The Height in Metre with Wind Speed at 9.00 PM During the Event

K (Value of Height Use in Envi-MET)	**Height (0-Metres from Ground in Real World)**	**Wind Speed (m/s) at 9.00 PM**	
		Minimum	**Maximum**
0	0.2	0.095	1.303
1	0.6	0.096	1.323
2	1	0.097	1.346
3	1.4	0.099	1.365
4	1.8	0.101	1.309
5	3	0.114	1.426
6	5	0.135	1.476
7	7	0.186	1.557
8	9	0.294	1.676
9	11	0.491	1.869
10	13	0.814	2.149

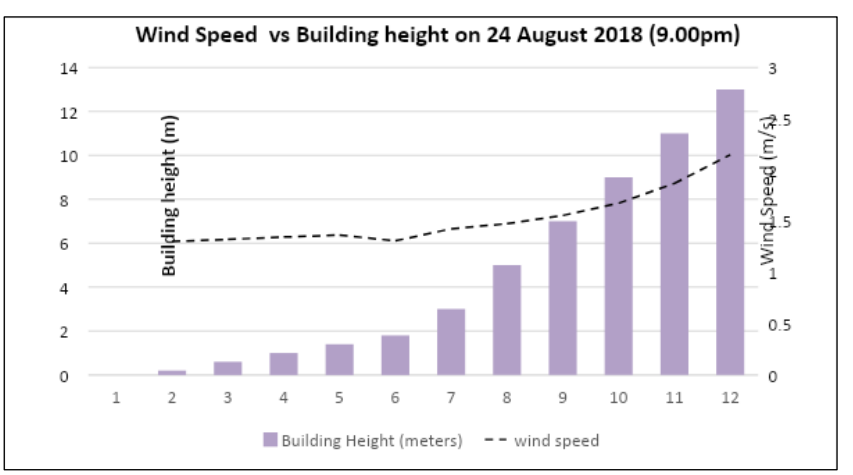


Figure 6. Wind Speed Profile Versus Building Height on 24 August 2018 (9.00 PM) During Windstorm Event

Figure 6 shows the maximum and minimum wind speeds versus building height on August 24, 2018, at 9.00 p.m. during the windstorm event. From the graph, it can be seen that the wind speed increases as the height of buildings increases. The minimum and maximum

wind speeds show an increment as the height of the building increases. The higher the building is, the more susceptible it is to wind loads. The wind is a complex phenomenon consisting of an infinite range of flow situations, especially with regard to the relationship between structures and wind flows. Wind loads exerted on a building are not stable but extremely fluctuating and dynamic.

Figure 7 (a) shows the hourly profiles of wind speed using the simulation at height 0.2 metres. The highest wind speed was 2.5 m/s and the lowest value was 0.35 m/s. From the Figure 7 (a), the wind speed in front of the toll plaza shows most wind speed readings less than 1 m/s even though the surrounding area of the simulated model shows the reading is above 2 m/s. Wind speed that is below 1 metre usually does not affect the building or monument that is made up of concrete and cement (Atkinson et al., 2009). Similarly, as height 0.6 metres, 1.0 metres, 1.4 metres and 1.8 metres as shown in Figure 7 (b), Figure 7 (c) and Figure 7 (d) there is no significant difference in wind speed reading since there is small increment of wind speed. Wind speed at 2 metres (6.5 feet) height and below can cause minor damage to buildings, especially if the wind speeds are sustained for an extended period of time (Wen, Palanichamy, & Ramasamy, 2019). Wind speeds at these heights are typically lower than wind speeds at higher elevations but can still cause objects such as loose roofing material, siding, or debris to become dislodged and pose a hazard to people and property.

Building codes and regulations typically require buildings to be designed and constructed to withstand certain wind speeds, depending on the location and wind conditions (FEMA, 2018). Wind speed studies are often conducted to assess the potential wind load on a building and to ensure that the building is designed and constructed to withstand the expected wind forces. It's important to note that wind speed alone may not cause significant building damage, as other factors such as building design, materials, and construction quality also play important roles. Additionally, wind direction and duration can also have significant impacts on building stability and safety. The wind speed is dynamic and uncontrolled. It depends on various situations including the high wind load. As a result, it will impact the wind speed to become low or high (K. Kumar, Krishna, & Bhandari, 2012).

Figure 7 (f) shows the map of wind speed when simulation is at 3.0-meter height. The lowest wind speed is about 0.40 m/s, and the highest wind speed was 2.87 m/s. In general, wind speeds at this height are higher than wind speeds at lower elevations, as they are less affected by friction from the ground (Wang, Liu, Li, & Zhao, 2010). In urban areas, wind speeds can be affected by the surrounding buildings, which can cause wind to be funnelled or accelerated through narrow streets and alleyways. However, the effect of ground friction can still have an impact on wind speed and wind direction in urban areas or areas with complex terrain. This can result in higher wind speeds and gusts than would be expected in open areas. The surface roughness of the ground can cause friction and slow down the wind speed near the ground (Zhang, Wang, Chen, Li, & Dickinson, 2019). Therefore, wind speeds at lower elevations are generally lower than at higher elevations, where there is less friction. Wind speed studies are often conducted to assess the potential wind load on a building and to ensure that the building is designed and constructed to withstand the expected wind forces, considering the ground friction and other factors that can affect wind speed and direction.

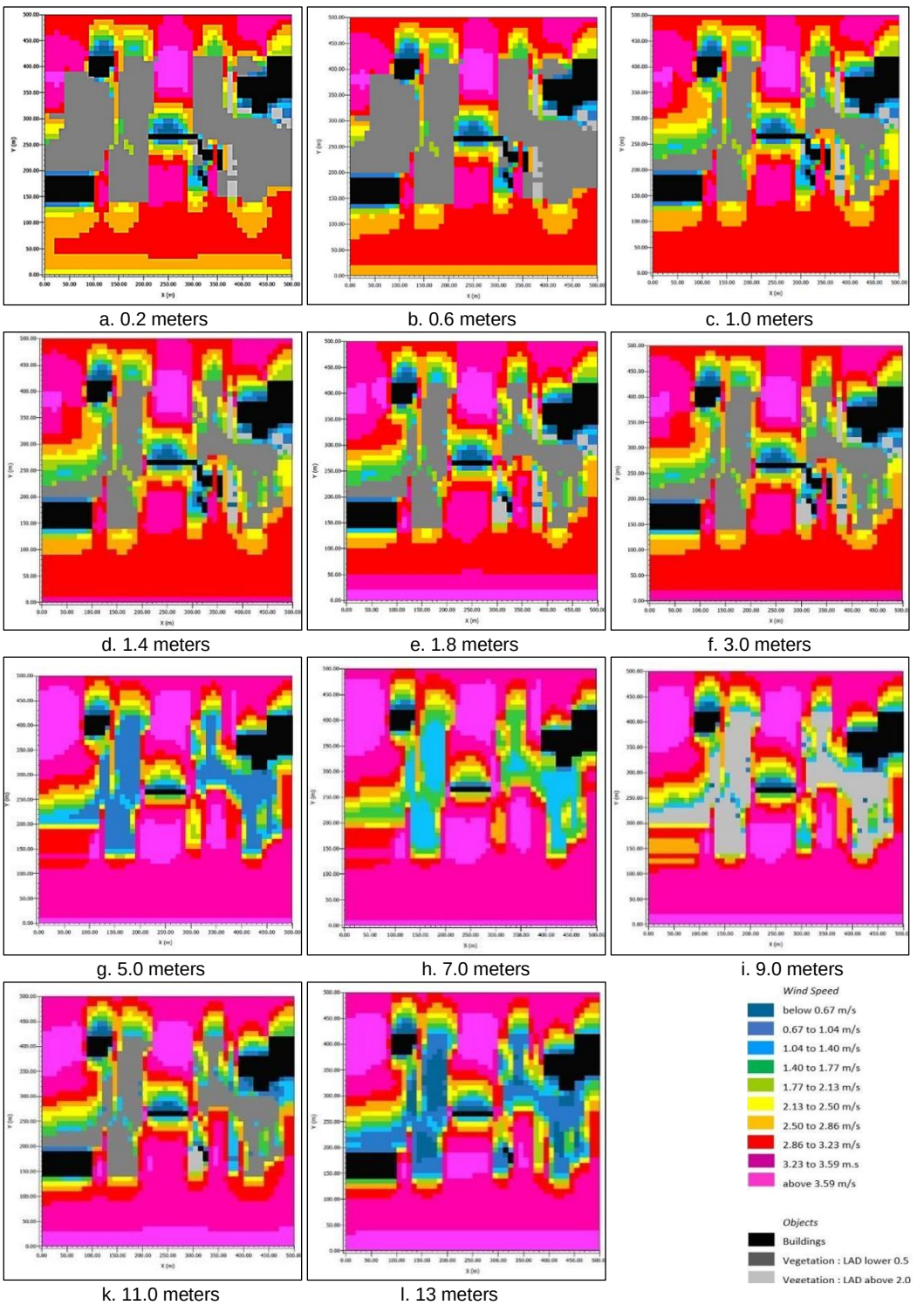


Figure 7. Profile of Wind Speed from 0.2 Metre to 13 Metres Height at 9.00 P.M. During The Event

CONCLUSION

A study on the effects of the height of buildings on wind speed was carried out. It can be concluded that low wind speeds can also cause wind disaster damage and loss. High wind speeds can cause significant damage to buildings and structures, and it is important to design and construct buildings with wind-resistant features to ensure building safety and prevent damage. When wind speeds are high, the force of the wind increases, which can create pressure differences on different sides of a building or structure. This can lead to structural damage, such as bending, twisting, or buckling of walls, roofs, or supports. If the wind speeds are strong enough, entire sections of a building or structure can be ripped off or destroyed. In addition to structural damage, high wind speeds can also cause non-structural damage, such as broken windows, damaged siding, or debris impacts. These types of damage can be dangerous for the occupants of the building or for people in the surrounding area. In areas prone to high wind speeds, building codes and regulations may require specific wind-resistant construction techniques and materials, as well as designs that take into account the wind direction and duration. The aim is to ensure building safety and prevent damage by designing and constructing buildings that are resistant to the wind loads they are likely to experience.

Aside from wind speed, there are a few other factors to consider in windstorm hazard events, such as environmental factors, other meteorological factors, the way monuments are built, and many others. Hence, this study focuses on vertical profiles that cause the wind speed to be high and lead to destruction. In general, wind speed increases with height above the ground, and this effect is more pronounced in urban areas with tall buildings. This is due to the creation of wind tunnels and other wind patterns that are unique to urban environments. The shape and orientation of the building can also affect the wind flow around it. Tall buildings with flat sides can create large zones of low-pressure areas on the windward side, which can lead to strong and unpredictable wind gusts. These wind gusts can cause damage to the building or objects in its vicinity. The proximity of other buildings can also have an impact on the wind speed near buildings. The interaction between buildings can generate wind vortices or eddies, which can have significant effects on the stability and safety of neighbouring structures. Additionally, computer simulations and wind tunnel tests can be used to model the wind flow around buildings and assess their wind resistance.

Wind speed increases with height above the ground. The wind loads are higher for bigger office buildings because the wind speed is higher. The speed and direction of surface winds are significantly influenced by surface friction. Because the air slows as it moves over the ground, wind speeds are lower than predicted by the pressure difference, and the wind direction changes so that it blows across the isobars into a centre of low pressure and out of a centre of high pressure. Since wind in Malaysia is classified as ‘light air’ and ‘light breeze’ based on the Beaufort Scale, it should not cause harm to the environment and destruction. However, there were several wind destruction incidents reported between 2010-2018. This study investigated the factors that contributed to such contradictory wind behaviours. It was identified that the buildings’ height has contributed to the severe condition of ‘light air’. When the wind is blowing towards the house, its force increases from moderate to strong. Anything on Earth's surface, such as grass, trees, and buildings, can cause drag by stopping and slowing the wind. The atmospheric boundary layer (ABL) is the thin layer at the bottom of the atmosphere. It varies in depth from 0.3 km to 3 km. Turbulence in the ABL mixes the very

slow movement of air near the top with the faster movement of air in the ABL and slows the wind speed in the full ABL (Nugent & Russell, 2020).

According to the findings, the highest wind speed ranged from 1.303 m/s to 1.476 m/s from 0.2 meters to 5 meters in height. It is brought on by rubbing against structures like buildings, lorries, or anything else that is on the earth's surface. As can be seen from the report, there is less damage at this height. At a height between 7 to 11 metres, the highest wind speed during the event is between 1.557 m/s to 1.869 m/s. The less friction of wind with any monument on the surface, has caused wind speed to increase and there is building damage reported at this height. At the top of the building, 13 metres high, the wind speed during the event was 2.149 m/s. The building is completely affected by the wind circulation at this height. The ceiling and roof were falling and being uprooted from the building. In conclusion, low wind speeds should not be ignored, especially in densely populated urban areas. Low wind speeds can result in air stagnation, poor air quality, and ventilation problems, all of which can be harmful to building occupants' health. Additionally, low wind speeds can also contribute to the build-up of pollutants and heat in urban areas, creating an urban heat island effect. Even though the wind speed was not very high, damage might have still occurred. In the future, it will be necessary to conduct research on a variety of factors to determine what causes wind damage, including environmental factors, meteorological factors, construction methods, material types, and many others. It is crucial to reduce future damage and the loss endured by relevant stakeholders and the public.

ACKNOWLEDGEMENT

The research described in this paper was financially supported by the Universiti Teknologi MARA and the Ministry of Higher Education under the Fundamental Research Grant Scheme FRGS/1/2019/WAB03/UITM/02/1.

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SITE ESSENCE AND SENSING (S.E.S) METHOD FRAMEWORK AS AN ADVANCEMENT APPROACH FOR SITE STUDY IN INTERIOR DESIGN WORK

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Abstract
Site Essence and Sensing (SES) method is a new approach that support students to perform a systematic process of site study in interior design work. Initially, site study practices were performed based on architectural and urban planning work method. However, it was noticed that the current approach used has less impact on site appreciation and lacking of understanding towards the integration of site findings and the design process. Therefore, the objective of this research is to produce a framework of SES method, which is believed to be applicable approach for site study in interior design work. A site observation study was carried out by 60 students from Semester 5 of the Bachelor Degree in Interior Architecture, using a systematic design approach by applying both current site study method and the actual needs of interior design works. This method found that in order to conduct a quality site study for interior design projects, it is necessary to have a comprehensive grasp of the site's essence via both tangible and intangible site values. Findings from this site experiment, suggested for a new SES method framework as the advancement approach for site study in interior design work. This study projected to contribute a better insight of site study not just for academic purposes but may also be applicable to the interior design practices.

Keywords: *Site Essence; Site Sensing; SES Method; Interior Design Work; Site Study; Design Process*

INTRODUCTION

Site study practices in the built environment are essential for understanding and analyzing the physical, social, and environmental aspects of a site before commencing any construction or development project (Ouf Abou, Tarek; Makram, 2019). The process of site analysis holds a pivotal role within the broader design process in the construction industry. Onay (2015) suggested that site analysis for interior design work encompasses the systematic examination process and comprehension of a site's physical, environmental, and contextual attributes, serving as the bedrock upon which successful design concepts are built. Site analysis ensures that design solutions harmonize with the site's unique characteristics, facilitating a symbiotic relationship between the built environment and its surroundings. However, within the realm of interior design, a discernible issue arises in the form of insufficient appreciation for the site analysis process. This deficiency can be attributed to a variety of factors, including a prevailing misconception that site analysis is ancillary to the creative design phase (Ouf Abou, Tarek; Makram, 2019).

As a consequence of this underappreciation, interior designers might overlook the critical nuances that the site presents, ultimately leading to inefficiencies in their design work. Ignoring contextual elements such as cultural significance, historical context, and sensory experiences may result in interior designs that lack resonance with the site's identity and fail to optimize the potential of the space (Rafsanjani & Rezaei, 2021). The outcome could manifest as environments that feel disjointed, fail to meet user needs, and miss opportunities for meaningful integration with the site's surroundings. As such, a comprehensive

understanding in sensorial design elements and valuing of the site analysis process are paramount to facilitating efficient, contextually relevant, and purpose-driven interior design works within the construction industry (Mohan & Yogapriya, 2022). Thus, this research aims to establish a framework of Site Essence and Sensing (SES) method for the development of site study process, particularly for the interior design work. It is believed that by having a systematic sensory approach, interior design work will be much efficient towards construction industry.

LITERATURE REVIEW

Site Investigation Practices in Interior Design Work Process

In current practice of interior design work, site study is one of a crucial element in design process. It is called as site analysis, which draws inspiration from architectural and engineering site analysis methodologies. Since interior design work is the partial of architectural work, this method was adapted to focus specifically on interior spaces (Noorhani et al., 2021; Mustapha, 2019).

Site analysis is a systematic process of evaluating and understanding the physical, environmental, cultural and regulatory characteristics of a specific location or site before commencing any architectural or urban planning project (Kaprielian, 2020). It is a crucial step in the design process as it provides architects and planners with essential information to make informed decisions and develop contextually appropriate and sustainable solutions. The key components commonly used are as shown in Table 1.

Table 1. Site Analysis and Its Components in Architectural Works

Components in Site Analysis	Methodologies	Design Opportunities
1. Physical Features	Examining site topography, landforms, soil conditions, vegetation and water bodies	Determine the integration between building design and the environment
2. Climate and Microclimate	Evaluating the climate at site, including its temperature ranges, winds and seasonal variations.	Optimize design strategies for heating, cooling and its ventilation
3. Sun Path and Solar Access	Understanding the path of the sun and the amount of solar access available	Design strategies to optimize the maximum natural light and energy consumption for building lighting and heating
4. Wind Analysis	Study on wind patterns	Identification areas of discomfort and strategy to maximize natural ventilation
5. Views and Visual Connections	Analysing views from and towards the site	Giving the influence on building placement and giving the opportunity to design open spaces to optimize scenic vistas and visual connections with the surroundings
6. Contextual Analysis	Understanding the immediate context of the site, neighbouring buildings, and urban forms.	Complement and enhance the existing fabric of the area
7. Cultural and Historical Significance	Investigation on the cultural heritage and historical significance of the site	Incorporating the preserve elements and celebrate local traditions, fostering a sense of identity and community

Components in Site Analysis	Methodologies	Design Opportunities
8. Infrastructure and Services	Evaluating the availability and capacity of infrastructure and services such as water supply, sewerage, electricity and transportation	Ensuring project is feasible and well-functioning
9. Legal and Regulatory Analysis	Understanding zoning regulations, building codes and other legal requirements	Designing a project that complies with the relevant laws and permits
10. Socioeconomic Factors	Assessing the demographics, socio-economic conditions and needs of the community	Producing design that addresses specific requirements and aspirations of the users.

(Source: Razali et al. (2019); Hanso (2016); Taylor (2013))

From the table above, it is clearly seen that components of site analysis are lacking of elements that related to interior design work. Thus, some amendments towards the existing method of site analysis were being made in order to suits with the interior design work process and project needs.

On the hand, interior design work also applies the 'placemaking' method as part of site investigation, which inspired by the urban planning work. This 'placemaking' method is a dynamic process (Pillai, J. 2013) that creates meaningful and vibrant spaces that resonate with the community and reflect community's identity, culture and aspirations. Placemaking has significantly impact to interior design work process in a way of:

Table 2. Placemaking and Its Components in Urban Planning Work

Components in Placemaking	Methodologies	Design Opportunities
1. User-Centric Design	Understanding the needs, preferences and desires of the future space users	Produce design that not just visually appealing, but also functional and meaningful to the space users
2. Contextual Relevance	Understanding the uniqueness characteristics of the site	Aligning the design work with the context of the place that may create a harmonious relationship between interior spaces and its surrounding
3. Sense of Place	Creating a strong sense of place by making a special connection to the space and give a sense of ownership	Incorporating local culture elements and tradition into interior spaces
4. Inclusivity and Accessibility	Emphasizing space design that are accessible to all individuals, regardless of age, ability and background	Integrating universal design principles to ensure that the space accommodates a diverse need of its users
5. Views and Visual Connections	Activate public spaces by maximizing its usage and appeal	Turning a space into a vibrant and lively environment by producing design that encourage social interaction, community engagement, and various activities
6. Sustainability and Environment	Stimulates sustainable design practices to minimize the environmental impact and create healthier, more resilient spaces	Designing spaces by selecting eco-friendly materials, incorporating energy-efficient systems, and maximizing natural lighting and ventilation
7. Collaborative Process	Collaborating works between various stakeholders, including local communities, authorities, and designers	Ensuring every design made is cohesively approach that addresses every aspect of the space
8. Long-term impact	Creating lasting and meaningful spaces	Ensuring designing interior spaces that are relevant, functional and visually appealing for years.

(Source: Ellery & Ellery (2019); Smart city mission (2017); Sepe (2017); Bawa-cavia (2009))

Table 2 projected that the components of placemaking do affects the interior design work process by reorienting it towards user-centered, contextually relevant, inclusive, and sustainable design. Interior designers can create interior spaces that not only appear beautiful but also significantly improve the community's quality of life and social fabric by embracing placemaking ideas. The integration of both site analysis and placemaking is seen to be a value-added towards interior design work process that would also contributes values for both client and space users. Therefore, in order to make this integration works effectively, a suitable systematic site investigation approach for the interior design work need to be formed.

Interior Design Works

Interior design work is referring to art and science that plays an important role to enhance interior spaces of buildings by creating functional, aesthetically pleasing and harmonious environments. The design process entails a rigorous and imaginative process that includes the choice of colors, materials, furniture, lighting, and other décor components to maximize the space's utility and aesthetic appeal. Having said to that, the design works shall be produced with consideration of client's preferences in order to shape the right ambiance and character of living and working spaces, enriching the daily lives of those who inhabit them.

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The uniqueness of interior design works, according to Gurel & Potthoff (2006), cited in Anderson et al. (2007), is "to provide well-being and quality of life through responsiveness to the physiological and psychological needs of humans in interior environments", which establishes the key distinctions from that of a typical building works. He continued by outlining the process' requirements for designers to take into account the significance of actions that promote customers' and end users' health, safety, welfare, and environmental responsibility. These are to be accomplished through a thorough design process that includes 1) understanding the project background and project brief; 2) understanding the space (through an understanding of spatial relationships); 3) understanding the building structure (an extensive site/building analysis); and 4) organizing the space (through a conceptual design approach, understanding and articulating space circulations, ergonomics, and implementing the appropriate uses of finishes, materials, and finishes). Based on its significance and distinctiveness, interior design can be considered as one of the key sub-sectors in the construction industry, contributing to the development of people, society, and a healthy environment. The important elements of site study purposely for an interior design work, are as table below:

Table 3. Important Elements in Interior Design Work via Site Study

Elements of Site Study	Methodologies	Design Assessment
1. Visual Inspection	Conducting observation of the interior space (the layout, architectural elements, existing materials and finishes)	• Analysis of the existing layout plan via 2D plan production • Analysis of architectural elements (structure and non-structure) • Analysis of materials and finishes
2. Measuring and Documentation	Accurate measurements of the interior space are taken to develop scaled floor plans and elevations	• These measurements form the basis for creating detailed design drawings and building models
3. Building Services Analysis	Evaluating the existing of building services, such as electrical outlets, plumbing, HVAC and lighting features	• Analysis of the existing layout plan (M&E, Plumbing) • Analysis of potential design out of existing services
4. Environmental Factors	Studying environmental factors such as natural light, natural ventilation, thermal comfort and acoustic	• Projecting placement and sizes of doors and windows for the passive cooling or heating strategies.
5. Site Culture and Historical Context	Understanding the historical context of the interior space and the building's overall design can influence design decisions	• Site mapping • Analysis of important historical elements on site
6. Code and Regulation Compliance	Research on building codes, safety regulations, and accessibility standards applicable to interior spaces.	• Analysis of safety existing elements
7. Client Needs and Values (Abd Rahaman et al., 2020)	Interviewing the client and understanding their needs, preferences, and design aspirations is a fundamental aspect of site investigation in interior design.	• Table of Client needs and requirements • Analysis of Client Values (individual or corporate clients) • Analysis the need of the space users (public or private users)

METHODOLOGY

In this specific study, qualitative research emerged as the chosen methodology, engaging a cohort of 60 students enrolled in Semester 5 of the Bachelor's Degree program in Interior Architecture. The research was centered around the prominent Jonker Walk in Malacca, serving as the designated site study area. The primary objective was to delve into the intricate interplay between site culture, architecture, and interior design project development. Through an amalgamation of observational techniques and semi-structured interviews with the local community, the research endeavor aspired to unearth the distinctive cultural facets, heritage significance, and spatial dynamics inherent to this iconic thoroughfare. A meticulous documentation process was employed, systematically capturing the entirety of the site study journey within the realm of interior design. These recorded observations were seamlessly interwoven with critical interior design elements, subsequently culminating in the transformation of comprehensive data into tangible design concepts.

Preliminary Stage – Site Observation

The methodology of this research starts right after project brief presentation during the studio session. The initial stage performed by identifying areas that contain all the requirements needed in fulfilling the project objective. Ten (10) prominent streets within 5km radius from the Jonker Walk were identified to be the best area for this study. Each street has its own characteristics that essentially helped to provide students with an overview of the Jonker Walk's historical background. A preliminary mapping of the street will be produced

according to every task required. This technique helps to create the physical setting that set human activities or place experience in order to gain the bonding to a sense of place (Pillai, 2020). On the other hand, it also allows student to form a strategic workplan framework that shall integrate future results and design works.

Figure 1. Site Identification

Secondary Stage – Site and Building Analysis

During this stage, students will start to observe their site study comprehensively towards the street and site of their choice. Site appreciation is the beginning of the process, whereby students required to identify and recognize the historical background of the building, which consists of acknowledging the building era, design inspiration and the concept behind it (Figure 2). From this understanding, it is belief that it would be a good start to create awareness of appreciation before performing the building analysis process.

Figure 2. Site Appreciation

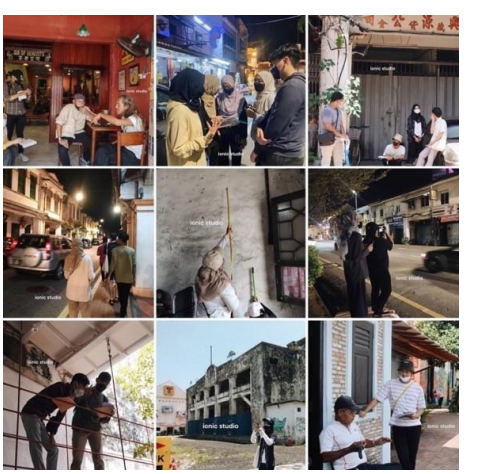

Figure 3. Building Analysis

Building analysis process is a method that would assist these future young designers to have a better understanding of the building context. They will start this process by mapping out the current conditions of the building in a format of an existing layout plan. Building analysis is the exploration of both exterior and interior, and it needs to be conducted to allow students to understand the building context in the manner of (i) building structures; (ii) building envelope; (iii) building elements; (iv) building materials; (v) building services/ maintenance; (vi) building mechanical and electrical; (vii) interior finishes; and (viii) interior ornaments (special details). All of the aforementioned qualities are technical parts of building

analysis, which appears to be comparable to architecture, but in interior design works, this analysis is much more detailed and focuses on how the site building will have a significant impact on the student's design project. It entails observation, measurement, exploration, and identification. All findings must be presented in reports, graphic interpretations, 3D modelling, and live sketching (Figure 3).

Along the way of this process, students were required to scrutinize the essence from the output. This process needs an analytical conversion from tangible into intangible meaning. By imagining imaginatively how the existing site building and design proposal would have a positive impact on society or the community, this technique helps students to explore the design potential from the results of building analysis. This can be started by using a SWOT analysis, in which students must identify the building's strengths and opportunities that can benefit the community and designers. Intangible meaning can be provided by the items gathered at the surrounding sites that would help students to establish the site essence better. To assist this procedure and with the aid of the initial cultural mapping, students required to record all the physical phenomena and significant events that would lead to a significant understanding between site context and the community. According to Harley and Woodward (1987), a practical mapping incorporates graphic representations that help to enhance a spatial comprehension of concepts, circumstances, processes, or occurrences in the human environment. Taylor, K (2013) expanded on his ideas, arguing that cultural mapping may make the hidden visible. Thus, students shall be able to capture the concepts of how their design proposal would be beneficial or contributes back to the community.

Tertiary Stage – Presenting Data

Once all the data were collected and analyzed, students required to present their findings during studio crit session in an informative graphical presentation and with the aid of site model. The outcome from this stage will then assist students throughout the design process, which includes the conceptual and spatial development. Students need to be critically imaginative and effectively describe an interior design project in how they offer their site results in narrative form. During this stage, they would produce their initial project brief for the proposed project and this process will take 3 to 6 weeks before proceed to schematic design stage.

Figure 4. Site Study Presentation

Figure 5. Conceptual and Spatial Development

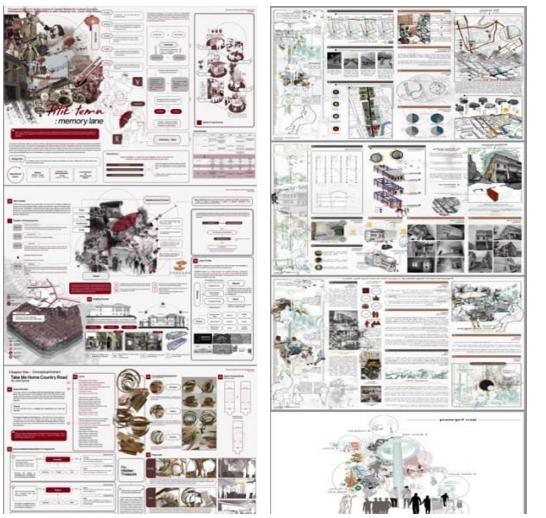

Figure 6. Final Schematic Design Presentation

In schematic design stage, student will produce an actual design work based on their project brief and concept that they have developed earlier. This is the most crucial stage that will test student's ability to comprehend their site study knowledge and cultural understanding into their design proposal. Nonetheless, the design would be suggested in creating a positive impact to the society and community. In previous practiced, this process was not being concerned and highlighted and the design outcome were partially more towards visually aesthetic, whereas it would be more than that. Therefore, to avoid this issue, frequent tutorial sessions among lecturers and students were suggested in order to ensure all design progress on track.

RESULTS AND DISCUSSION

The objective of this research is to establish a novel site study framework tailored specifically for interior design projects. During the course of this site study, it became evident that there is a scope for improvement within the existing site study practices by including value elements and sensory experiences just as per highlighted by both (da Silva et al., 2019; Mohan & Yogapriya, 2022). As previously mentioned, site study procedures were primarily derived from architectural works, with some aspects being adaptable to interior design. Similarly, placemaking, with its focus on human-environment interactions, has demonstrated a significant impact on interior design, promoting user-centered, contextually relevant, inclusive, and sustainable approaches. Embracing placemaking principles enables interior designers to create spaces that not only boast aesthetic appeal but also foster community well-being and social cohesion. Drawing from a comprehensive site study, the findings indicate that the interior design process can be structured around three fundamental components: site identification, site essence, and site sensing. This framework is believed to represent an advanced and well-organized methodology in comparison to current practices of interior design work that shall improve between human needs and environment (Rafsanjani & Rezaei, 2021).

Stage 1: Site Setting

The initial stage of site study is regarding site identification, where it is believed to be an important process in the early stage of a site study. Choosing the right site is crucial for the success of any project and it must be part of designers' expertise in site selection to ensure that the proposed development project aligns with the client's vision, needs and demands. The process involves thorough evaluation and consideration of various factors. The factors are (i) have a clear define of project objectives, scope and requirements; (ii) identify target location based on the requirements with the consideration of the neighbourhoods; (iii) comparative study of the shortlisted sites based on their suitability and potential; and (iv) get approval for the site selection.

After identified the right site, will be the process of site understanding. This process involves, (i) recognize current trend and culture of the location; (ii) apprehend for opportunities development; (iii) identify for any potential risks associated with site such as legal constraints or environmental hazards; and (iv) identify the stakeholders that may involve during the site development (local authority, investors, building owner) to gather insights of the location. Once all this has taken into consideration, designers will need to perform site observation and marking process. This procedure allows designers to perform suitable assessments that include environmental conditions, accessibility and infrastructure as well as building codes and financial feasibility. Taleb et al. (2017) stated in their research that the work process will be easier and smooth when designers are able to manage a good communication with clients from the early phase of project process, along with site study process. This shall benefit both parties in obtaining best value outcome from the design that designer produced.

Stage 2: Site Essence

Site Essence is a concept derived from the existing process of site analysis, whereby the process actually demonstrates a linkage of how the physical context can be also seen and converted into an abstract context. However, the method of capturing this important element has yet to be discovered. Thus, to perceive this process designers need to apprehend the existing process accordingly. The first step in site essence is by creating building appreciation. It involves analysing the various elements that contribute to the building's character and value. To perform this task, it requires for a comprehensive exploration of the building that includes, (i) documentation for both exterior and interior features (special design elements, ornaments, materials, construction techniques and unique characteristics); (ii) analysing the architectural style and era; (iii) materiality assessment; (iv) spatial function; (v) historical context; (vi) conservative and preservation needs; and (v) cultural and social significance. All of the above elements are required to be documented and analysed systematically (Ouf & Makram, 2019; Rafsanjani & Rezaei, 2021).

The following action of site essence is by conducting building analysis. The methodology follows as current established practices, with the exception that this specific step places a distinct emphasis on analysing the aspects relevant to interior design work. Meanwhile, building essence is referring to the fundamental of intrinsic qualities of the building uniqueness through a sensory experience that will enhance the design output quality in built environment (Mohan & Yogapriya, 2022). This could be captured by the multi-sensory

experiences that observed how the physical attributes such as visual, hearing, taste and touch Ranne (2019), historical context and cultural significance define characteristics that contribute to the building identity.

Stage 3: Site Sensing

Site Sensing involves the perception of human senses, where students are tasked with identifying both tangible and intangible elements. The tangible elements, manifested in objects and artifacts, can be experienced through sensory observations, while the intangible aspects reside within the community's collective consciousness. Tangible aspects are observable in locally crafted buildings, objects, and products, whereas the intangible aspects encompass the intangible cultural heritage cherished by the community. Both tangible and intangible outcome shall be recorded and presented it in a form of cultural mapping. This technique suggested to provide designers with a holistic understanding of a community's heritage, identity and social practices.

Site Essence and Sensing (SES) Method Framework

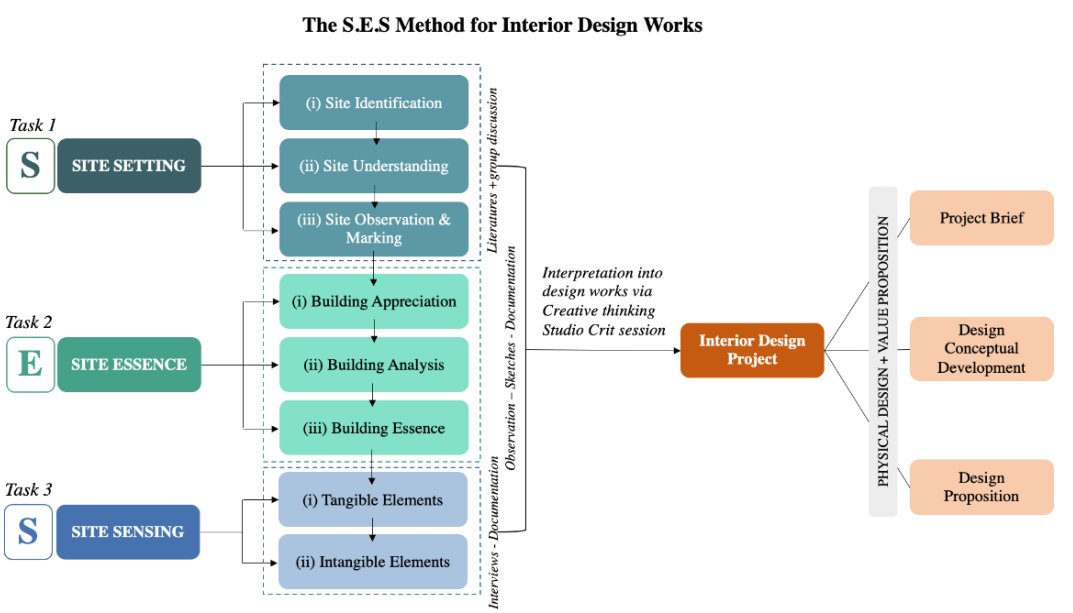

Figure 7. Site Essence and Sensing (SES) Method Framework

The above elements represent an enhanced and highly systematic approach compared to current practices, offering a structured framework for design exploration and analysis. The Site Essence and Sensing (SES) method framework is designed to provide interior designers with a structured and comprehensive approach to site study, ensuring that their design decisions are well-informed, contextually relevant, and deeply connected to the site's unique attributes. By integrating these three keys elements; site identification, site essence, and site sensing, the SES method framework encourages designers to delve into every aspect of the site, unlocking its full potential for inspiring and meaningful interior design solutions.

By integrating site identification, site essence, and site sensing into the SES framework, interior designers are equipped with a comprehensive and structured approach to site study. This holistic understanding of the site empowers designers to create interior spaces that harmoniously blend with their surroundings, celebrate the site's cultural and architectural significance, and, most importantly, cater to the needs and aspirations of the people who will inhabit those spaces. Through the SES method framework, interior design projects become not just aesthetically pleasing but also deeply meaningful and relevant to the communities they serve.

CONCLUSION

In conclusion, the SES Method Framework showcases remarkable potential not only in enriching students' understanding of sites and cultural environments but also in significantly contributing to the advancement of interior design education and the broader construction industry. Departing from conventional studio teaching approaches, the SES method offers a progressive pedagogical avenue for instilling a deeper comprehension of site dynamics and cultural contexts in aspiring interior designers. This method empowers students to cultivate innovative concepts and designs by fostering a profound connection with the site. Moreover, its alignment with the intrinsic nature of interior design work fosters a culture of critical thinking, particularly evident in the application of the SES Method to design transformations. The adaptable nature of the SES Method underscores its versatility, ensuring seamless integration into diverse academic settings, project contexts, and site-specific criteria. By harnessing the potential of the SES Method Framework, interior design education contributes not only to the holistic development of students but also elevates the quality value and relevance of design solutions within the construction industry.

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ENHANCING COMPETENCE IN PROJECT MANAGEMENT: STRATEGIES FOR INTERIOR DESIGNERS TO ENHANCE THEIR KNOWLEDGE AND SKILLS

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Abstract

The proficiency of interior designers in managing construction projects, specifically in the realm of project management, has been subject to frequent inquiry. The main claim of this argument suggests that the abilities of interior designers, acquired through educational pursuits and practical experience, exhibit a strong emphasis on design-related abilities and knowledge, often neglecting project management aspects. This research was undertaken with the aim of examining the means by which interior designers can acquire project management expertise, in order to effectively address the previous argument. During the phase of data collection, a total of fourteen key respondents were interviewed in order to identify any existing gaps. The activities of professional groups in the field of interior design were also examined. There exists a notable disparity in project management knowledge and skills between interior design higher education and the practical application of interior design. The most effective approach to bridging the gap in project management skills among interior designers has been identified as a combination of education and practical experience. The skills and knowledge necessary for the practise of interior design, which should be encouraged by professional associations in the field, were also identified. However, it is advisable to undertake additional research in order to develop and enhance the curriculum for interior design in higher education.

Keyword: *Competency; Project Management; Interior Design; Knowledge and Skill*

INTRODUCTION

Although interior designers are typically employed for their creativity and expertise in developing designs, images, and project concepts, their abilities to effectively execute and oversee the project beyond the design phase are as significant. The interior designer must possess the capacity to effectively balance the imaginative aspects of the design with its pragmatic implementation. This requires them to possess proficiency in project management as well. According to Rogers (2001) in the Interior Design Handbook of Professional Practise (1st edition), it is asserted that individuals in the field of design must possess proficient managerial skills in addition to their creative expertise. Individuals are obligated to utilise leadership abilities, managerial competencies, professional expertise, and practical experience. The Malaysian Architect Act of 1967 acknowledges the significance of the Interior Designer on par with that of the architect. They have the right to receive remuneration at an equivalent rate of compensation as that of the architect.

The significance of project management competence for interior designers was also acknowledged by CIDA (2009). The Council of Interior Design Association (CIDA) in the United States emphasised the significance of including project management into interior design education programmes, as outlined in their Professional Standards of 2009. The

International Federation of Interior Designers (IFI), an organisation representing interior design in Commonwealth countries, outlines in their publication "IFI Professional Practise" (2005) the requirements for interior design education in higher education. According to the IFI, essential components of interior design education include proficiency in verbal communication techniques, office organisation and practise, legislation, and site visits to ongoing or completed projects.

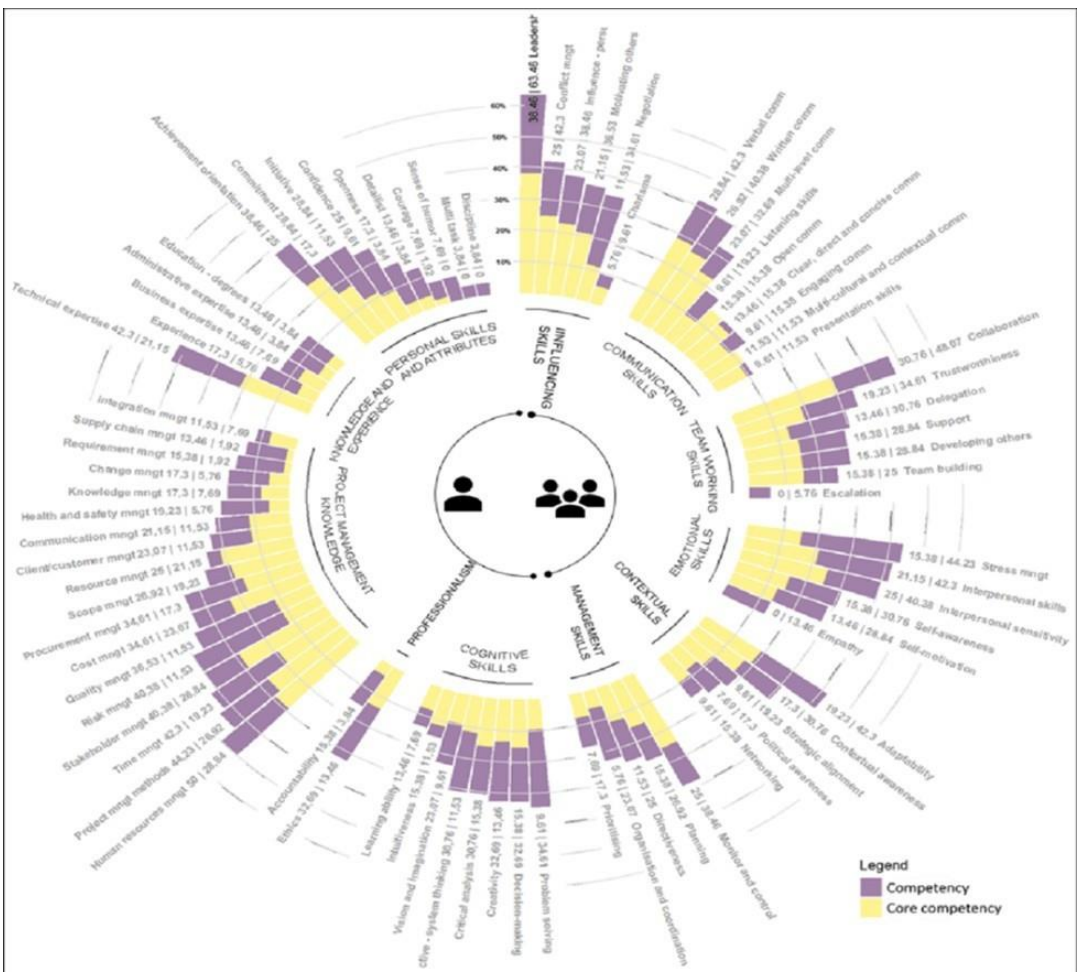
The demand for individuals with the requisite skills to effectively manage projects is currently high in the fast-paced and competitive industry of today. The global market demonstrates a growing inclination for paying project managers at higher rates, which is indicative of the rising demand for their services. In the realm of project management, it is customary for a project manager to assume the role of overseeing the entirety of the undertaking, while also fulfilling essential obligations that are necessary to ensure the successful completion and delivery of the project.

Nevertheless, it is important to note that project managers do not bear sole responsibility for the outcomes of a project, as there are other individuals who also contribute to its success or failure. In order to maintain competitiveness in today's market, project managers must consistently attempt to enhance their level of expertise and broaden their skill set. Project managers are required to possess not only the aforementioned technical and interpersonal skills, but also various additional essential abilities and proficiencies pertaining to project management. According to reports published by the Project Management Institute (PMI), project managers who possess a suitable combination of managerial and technical skills have the potential to enhance the success rate of their projects by up to 40%.

Leandro and Blackwell (2019) conducted a comprehensive examination of research on project management competency, encompassing various perspectives. This analysis resulted in the identification of several key areas of discussion, including leadership, emotional intelligence, general and project management competencies, and numerous other related subjects. The categorization of certain subjects resulted in a separated representation.

Consequently, Figure 1 depicts the Project Management Competency Framework (PMCF) encompassing all the competencies examined by authors utilising the PMI PMC Framework throughout the years. Furthermore, this study demonstrates the fundamental competencies in project management by organising them based on the frequency with which respondents ranked them as more significant than other capabilities. The inner bar represents the core competencies. Given the multitude of classifications provided by various authors regarding project management capabilities, this study aims to organise these competencies into eleven fundamental groupings based on their shared characteristics and this research paper centres on Skill 10 (Table 1).

In the field of project management, the act of providing value to individuals is achieved by employing a combination of knowledge, skills, tools, and strategies. Hwang and Ng (2013) assert that effective project management necessitates the possession of requisite background knowledge and relevant competencies by the project manager. The possession of a diverse range of abilities and knowledge across all three domains of competency is considered crucial for project managers.



(Leandro & Blackwell, 2019)

Figure 1. Project Management Competency Framework

Table 1. Core Competencies According to The Eleven Basic Grouping

Skill 1 INFLUENCING	Skill 2 COMMUNICATION	Skill 3 TEAM WORKING	Skill 4 EMOTIONAL
Skill 5 CONTEXTUAL	Skill 6 MANAGEMENT	Skill 7 COGNITIVE	Skill 8 PROFESSIONALISM
Skill 9 KNOWLEDGE & EXPERIENCE	Skill 10 PROJECT MANAGEMENT KNOWLEDGE	Skill 11 PERSONAL SKILLS & AATRIBUTES	

PROJECT MANAGEMENT SKILLS AND KNOWLEDGE

A project manager requires a very demanding range of skills in order to fulfil its roles and carry out its functions. The Construction Industry Council (CIC) has identified skills required by a project manager, which was well expressed in their publication, Construction Project Management Skills (2001). The skills have grouped into five areas which are follows:

i. Strategic – Strategic planning, Value management, Risk management, Quality management, Safety, health and environment.
ii. Project Control – Project control cycle, developing a schedule, Monitoring, Managing change, Action planning, Client/project interface, Information management.
iii. Technical – Design management, Estimating, Value engineering, Modelling and testing, Configuration management.
iv. Commercial – Business Case, Marketing and Sales, Financial Management, Procurement, Legal issues.
v. Organisation & People – Organisation structure, Selection of project team, People issues.

The demand for proficient project management skills is significant in the contemporary business landscape. The increasing wages of project managers globally serves as a positive indicator of the market's demand for their professional expertise. The responsibility of overseeing and executing essential tasks to ensure the successful completion and delivery of a project is typically assigned to a project manager. Nevertheless, it is important to note that project managers are not the sole individuals accountable for the outcome of a project, whether it is deemed successful or unsuccessful. In the current highly competitive market, it is imperative for project managers to consistently enhance their competence and skillset. Project managers must possess a range of talents, competencies, and soft skills in order to meet the additional requirements of project management. According to reports published by the Project Management Institute (PMI), project managers who possess a balanced combination of managerial and technical skills have the potential to enhance the success rate of their projects by up to 40%.

The ten categories of Project Management Knowledge Areas, as outlined in the Guide to the PMBOK Sixth Edition (2017), are shown in Figure 2. These categories form the basis for both the knowledge and performance competencies. In contrast, personal competencies encompass a total of eleven distinct components. When commencing a novel undertaking, it is imperative to take into account the cognitive acumen and proficiency of the individual assuming the role of project manager. The acquisition of knowledge pertaining to project management-specific concepts, processes, procedures, and terminology can be regarded as a fundamental competency.

According to Udo and Koppensteiner's (2004) study cited in Mohale and Loggia's (2018) research, two fundamental pillars were identified within the realm of personality. These pillars were considered to be of the highest significance. The first pillar encompasses a range of personality traits, including an individuals can perform attitude, self-belief, ebullience, and willingness to learn and adapt. Human resource management encompasses various competencies, including effective communication, the capacity to motivate and influence individuals, and political awareness. Moreover, it is imperative for project managers to

possess a heightened degree of political knowledge. The influence of politics on projects is significant due to the complex structure of their execution. The two colleagues emphasise the importance of maintaining political awareness and engaging in collaboration with them, while maintaining a distinct identity separate from their group.

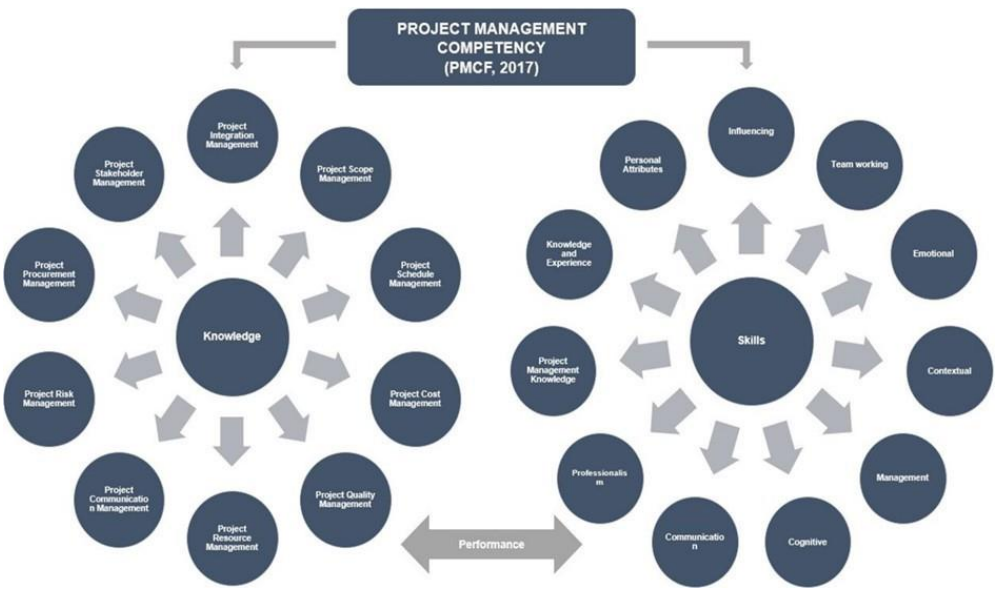


Figure 2. Overview of Knowledge and Skills in Project Management Competency

In the field of project management, the delivery of value to individuals is facilitated through the utilisation of knowledge, skills, tools, and strategies. It is essential for project managers to possess a comprehensive blend of skills and knowledge across the three key domains of competency. There are several factors that should be taken into consideration.

i) Taking action at various levels is a crucial requirement for project managers. Project managers can establish trust among stakeholders and team members by effectively illustrating the correlation between the organization's business objectives and the specific project at hand. As a team leader, it is imperative to establish a strong alignment between one's personal identification with the team's objectives and the alignment of these objectives with the overall objectives of the organisation.
ii) Diverse corporate cultures require different emphases within each of the three competency categories.

Having the ability to adjust within a project setting, whether through the utilisation of simulations, evaluation of leadership skills, or assessment of management abilities, is essential for a project manager, conversely. Consequently, it is vital for a project manager to possess the requisite skills and competencies in order to effectively manage projects and achieve successful outcomes. This necessitates a demonstrated track record of performance, as well as the ability to handle projects and bring them to a successful conclusion. The successful fulfilment of a project manager's responsibilities necessitates a broad range of skills and abilities. However, it is important to note that project management is subject to the influence of its environment, leading to an increase in responsibilities, knowledge, and competence.

In order to achieve competency in project management for the purpose of achieving success in the field of construction, it is crucial for a project manager to engage in the practical application and development of the necessary project management competencies specific to construction projects (Khamaksorn, 2018). The observed phenomenon can be attributed to the inclination of project managers in the construction industry to prioritise the acquisition and application of knowledge and skills, with the aim of enhancing and fulfilling their professional competencies in project initiation and execution. The correlation between the success of a construction project and the competence of its project managers is evident in the construction industry.

Project managers have a tendency to enhance their competency in knowledge management, thereby facilitating the advancement and application of their project management skills and knowledge throughout the project's execution. Khamaksorn (2018) emphasised the importance of the project manager's proficiency and competencies in guaranteeing the achievement of the project. Throughout every phase of their professional journey, an experienced project manager is expected to develop a diverse range of technical and managerial competencies. In order to further develop and effectively apply project management abilities, it is important for project managers to build on their knowledge and skill proficiencies.

METHODOLOGY

This study proposes the utilisation of a qualitative research methodology to enhance understanding of the potential for developing an enhanced framework. This will be achieved by gathering comprehensive data on expert perspectives, opinions, and perceptions. The objective of this study is to assess the concept that pertains to the potential enhancement of project management knowledge and skills in the field of interior design, within the existing framework of education and professional practise.

The implementation of new knowledge and skill training initiatives would enhance the existing educational and professional practise frameworks, thereby facilitating a deeper comprehension of project management within professional contexts. The establishment of this entity is of utmost importance. Consequently, the primary inquiries for this inquiry pertained to the concerns that were brought up during the initial interview session conducted in January 2021. The following points summarise the key findings from the initial interview, focusing on the identification of deficiencies and concerns related to project management skills among interior designers in the context of interior design education and professional practise. The answers to these inquiries hold significance in ascertaining the suitability of different methodologies.

For the purposes of this study, a total of fourteen participants were carefully chosen and subsequently categorised into four distinct groups based on their respective backgrounds. Within the initial cohort, three participants were identified, specifically an Interior Design Project Manager, two of whom were affiliated with Project Management Consultants (Respondents 1 and 2), and one who belonged to an Interior Design firm (Respondent 3). The selection of these individuals was predicated upon their extensive experience of over 15 years in successfully overseeing interior projects. The second group consisted of individuals who held the position of Senior Interior Designers. Three of the respondents possess over two

decades of experience in the interior design industry and have held esteemed positions, including that of ex-president, within interior design professional organisations such as MIID. Additionally, one of the respondents has accumulated 10 years of experience working in an interior design company. The third group consisted of three Architects who possessed over 15 years of experience in the construction industry and collaborated closely with interior designers. Respondents 8, 9, and 10 held the position of principal within their respective firms. The fourth group consisted of individuals who represented the perspective of the client. According to Respondent 14, the client representative possesses a professional background in architecture and has accumulated over 15 years of experience in the field of construction projects.

RESULTS

The objective of this research inquiry is to explain and gain a comprehensive understanding of the phenomenon under investigation, encompassing the individuals who were subjected to observation. Throughout the duration of the procedure, data is gathered from a sample of participants who have been carefully chosen based on their competence in their respective contexts and work environments, as well as their knowledge of the research subject. Throughout the duration of the research study, the themes were carefully categorised based on the analysis of the data, with the aim of maintaining the original structure intact. Qualitative research refers to the systematic collection of data with the aim of constructing concepts, hypotheses, or even theories through an inductive process commonly referred to as "data gathering." Consequently, qualitative research requires employing a comprehensive descriptive reporting approach to effectively convey information to the researcher, with the aim of enhancing their understanding of the phenomena under investigation.

The interviews' findings clearly demonstrate that interior designers encountered challenges during the project management process. Additionally, these issues are evident in both the field of professional interior design and the realm of educational provision. The primary causes of the problems can be attributed to a deficient comprehension of the duties and obligations associated with the role of a project manager in the context of an interior design project, specifically pertaining to the scope of work within the field of interior design. Furthermore, it is undeniable that there exist challenges pertaining to integration, collaboration, and communication among clients, consultants, and contractors. However, with regard to the scope of this research paper, it will not be addressing the challenges encountered by interior designers in project management.

The result also discussed the approach that can be considered to improve the understanding and to develop the knowledge and skills of project management among interior design practitioners. It can be viewed as:

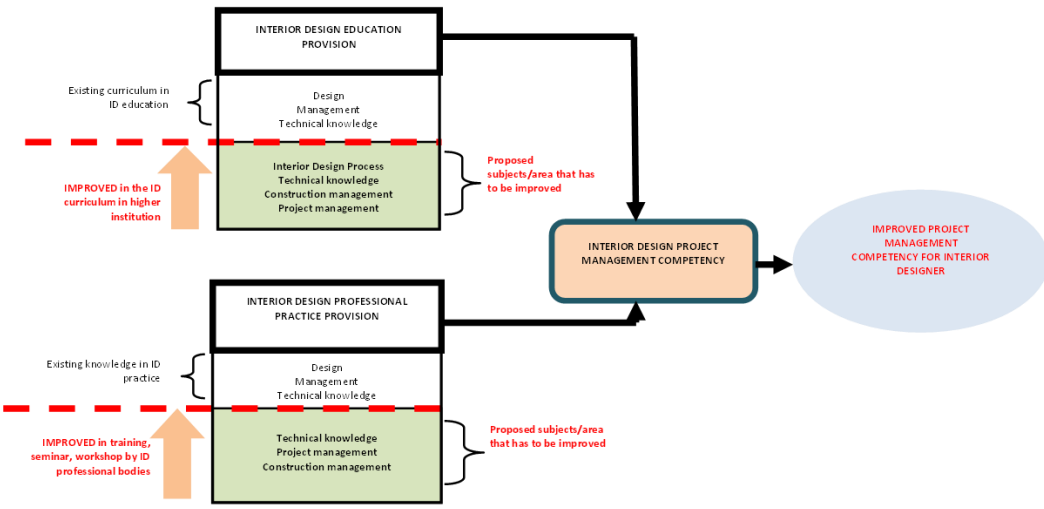


Figure 3. Research Model

A. Increase the perspective in learning of project management throughout the education provision.

   i. <u>Project Management Knowledge</u>
   Ensuring an understanding of project management knowledge within the curriculum of interior design education is of the greatest significance. There is a need for the enhancement and refinement of educational programmes pertaining to the core principles of project management. The significance of acquiring knowledge and understanding project management within the context of interior design education is evident in ensuring successful project outcomes.

   ii. <u>Technical Knowledge</u>
   In addition to project management, a comprehensive grasp of technical knowledge should be regarded as a crucial aspect for interior designers. A comprehensive understanding of the technical aspects will facilitate the effective management of projects during each phase of their construction.

B. Expand the knowledge and skills of project management during practice through a training, seminar and workshop organise by the professional bodies.

   i. <u>Project Management Knowledge</u>
   The majority of participants have clearly indicated that the application of project management knowledge is crucial and significant. The development of project management knowledge can greatly benefit interior designers by enhancing their ability to effectively manage projects and reduce potential challenges that may arise during project execution. The field of interior design encompasses more than just the conceptualization of designs; successful execution and implementation are crucial components for achieving desired outcomes. Furthermore, it is crucial for every interior designer to possess a comprehensive understanding of project management, as it is not merely an option but a necessity in effectively managing projects.

ii. Technical Knowledge
It is important for interior design professionals to acquire a comprehensive understanding of the technical aspects of construction.

DISCUSSION

The lack of comprehension in project management among interior designers can be enhanced through the integration of relevant knowledge within the university curriculum. In fact, these results provide support for the proposition that the lack of project management skills among interior designers can be enhanced.

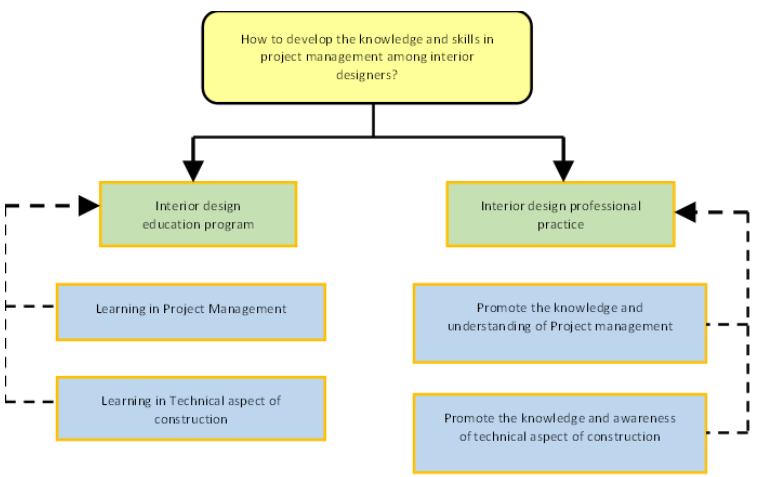


Figure 4. The Approach to Improve the Skills and Knowledge Among Interior Designers

The approaches proposition is by establish the curriculum within the interior design education program on the important issues as follow:

A. Learning in Project management
1) Develop the awareness of importance of Project management
2) Enlighten the roles and responsibility of interior designer
3) Expand the knowledge of new product and material
4) Establish the project work progress for interior project
5) Introduce the collaboration system in the interior design scope of work
6) Setting up the Interior design handbook
7) Introduce the communication skill within stakeholder
8) Increase the Law of contract awareness
9) Expand the Contract management knowledge

B. Learning in Technical aspect of construction
1) Develop the understanding of BOMBA and safety requirement and local authority approval.
2) Introduce the concept of Green Building and awareness of the material suits to the GBI concept.
3) Increase and expand the understanding and knowledge of M&E and C&S

The poor of project management understanding among interior designer can be supported by expanding the knowledge within the professional practice and professional bodies. In conception of the difficulty in getting the awareness and understanding among interior design practitioners, the data analysed validates that interior designer's career development needs for knowledge and training that can be improved. This was supported by the following propositions:

A. Promote the knowledge and understanding of Project management through training, seminar or workshop by interior design professional bodies
   1) The appropriate of Interior design practice.
   2) Increase the knowledge for effective Project management within coordination and integration system, tender document process, contract document process, work schedule and project documentation.
   3) Reboost the knowledge for the efficiency of Project manager including leadership skill, communication skill, motivation skill and teamwork skill.
   4) Expand the knowledge and understanding of roles and responsible on construction site.
   5) Increase the understanding of Project objectives.
   6) Increase the responsibility in Project implementation.
   7) Increase the knowledge of understanding in Project execution.

B. Promote the knowledge and awareness of technical aspect of construction through training, seminar or workshop by interior design professional bodies
   1) Increase the understanding and knowledge of M&E and C&S.
   2) Expand the understanding and knowledge structural works, engineering structural works, architectural works, piling system, soil and investigation and project suitability and constructability.
   3) Increase the understanding of BOMBA and safety requirement.
   4) Reboost the knowledge and awareness of Law and Arbitration, Local authority approval requirements, Malaysia building by-law and Malaysia Act regarding OKU.
   5) Expand the knowledge of Green Building concept including the material that suits to the GBI concept.

CONCLUSION

This research study has made a significant contribution to enhancing and broadening the knowledge and training that can potentially foster the advancement and refinement of interior design project implementation. This perspective advocates for the application of design and conceptual principles to the execution of projects of greater significance, requiring heightened focus and emphasis. Conversely, this could potentially yield advantages in terms of the professional growth of interior designers, the quality of their work, the overall project, and the organisation. Furthermore, it highlights the significance of implementing strategies aimed at enhancing and expanding the knowledge and training process within the field of interior design. This is crucial in order to meet the demands of the industry and cultivate interior design project managers who receive enhanced training.

In summary, the research study provides evidence that the field of interior design necessitates immediate recognition of the importance of project management, which should be accompanied by appropriate training. Given these circumstances, it is vital for interior designers to shift the prevailing mindset within their field. This entails placing less emphasis on design concepts and ideas, and instead prioritising the execution process, as it holds greater significance in determining the overall success of a project. Hence, any provision and proposal aimed at fostering the growth of individuals' knowledge and skills should primarily prioritise the establishment and promotion of an environment beneficial to cultivating an appreciation for the importance of project management application. This is due to the fact that the environment facilitates the development of an appreciation for the significance of implementing project management. In order to enhance interior designers' comprehension of project management and effectively navigate the challenges associated with managing interior design projects, a substantial attempt to expand one's knowledge becomes imperative. Furthermore, it is evident that there are additional relevant topics that require investigation in order to proceed with this study.

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INDICATORS OF LABOUR PRODUCTIVITY IN THE CONSTRUCTION FIRMS: THE CONCEPTUAL MODELLING OF CAPITAL INTENSITY AND MARKET REGULATION

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Abstract
The construction industry is a crucial sector in the economy, but the industry has been facing stagnant productivity levels over the years. Various studies have attempted to understand the reasons behind the slow productivity growth, which can have significant implications for the industry's sustainable profits and wages. Both internal and external factors may contribute to the decline in productivity. To facilitate a comprehensive investigation, the research strategy focuses specifically on labour productivity levels within construction firms. This concentration allows for a more direct exploration of the dynamics at play. Addressing these concerns, this study aims to develop a conceptual model that explores the connections between capital intensity, market regulation, and their interactions with labour productivity. The research proposes the utilization of financial and economic data of construction firms that listed on the case study country's Stock Exchange, covering the period from 2009 to 2020 to assess capital intensity, labour productivity, and market regulation measures. Additionally, this paper meticulously assesses the methods of measuring variables by considering economic and financial theories and selects appropriate modelling techniques guided by robust theoretical and statistical principles. By testing theoretical propositions between these constructs, the study seeks to offer insights for policymakers on enhancing long-term construction labour productivity at the firm level while considering sustainable economic incentives. Ultimately, this research strives to bridge the gap between theory and practice, using empirical evidence contributing to a better understanding of productivity dynamics in the construction industry and facilitating informed policy decisions.

Keywords: *Capital Intensity; Market Regulation; Construction Labour Productivity; Labour Productivity*

INTRODUCTION

In the economy, the construction industry holds significant importance. However, globally, the industry has been grappling with sluggish productivity growth over time. A report from McKinsey highlights the construction sector's lack of substantial improvement in terms of productivity, despite contributing 13% to the worldwide Gross Domestic Product (GDP). In fact, compared to other industries, construction has only achieved a skimpy 1 percent annual productivity growth over the past two decades (Maria João Ribeirinho et al., 2020).

Productivity generally refers to the measurement of efficiency that relates input to output. The United States Bureau of Labour Statistics (USBLS) defines productivity as a measure of economic performance, comparing the output of goods and services to the inputs used for production (USBLS, 2022). Different researchers view productivity as achieving maximum

output while optimizing input utilization (Durdyev et al., 2018; Naoum, 2016). In economics, productivity is described as the ratio of output volume to input volume (Lacka et al., 2021).

The productivity equation remains the same at the total factor productivity (TFP) level, representing the ratio of total outputs to total inputs (Ayele & Fayek, 2019). On the other hand, labour productivity refers to the output produced per unit of labour input. Its performance can be assessed using various indicator variables that have evolved over time, including capital usage, workforce skills, knowledge, inflation, financial growth, quality of governing institutions, and openness to the economy (Pami Dua, 2019). In most cases, improving labour productivity improves wages and profitability (OECD, 2022).

In the construction industry, productivity measurement is the most essential method of evaluating overall project performance (Momade, 2020). Generally, high productivity plays a key role in enhancing individuals' economic prosperity, as it enables better allocation of assets and advancements in technology, resulting in greater life comforts and overall prosperity for a nation's population (Weil, 2013). Moreover, greater productivity enhances the battle for market share and the ability to withstand economic uncertainties (İmrohoroğlu & Tüzel, 2014). In the construction industry context, Construction Labour Productivity (CLP) directly impacts a company's performance, fosters competitiveness, and positively influences the national economy (Momade, 2020). The significance of productivity is underscored by the detrimental consequences of productivity decline on an economy, leading to inflationary pressure and social conflicts due to stagnant income (Banaitis, 2019; Saurav Dixit, 2019).

In response to the sluggish productivity growth in the construction sector, which is observed in various developing economies, including Malaysia, achieving high productivity growth has become a pivotal focus of government policies. This can be exemplified by initiatives like the Construction Industry Development Board (CIDB)'s Construction Industry Transformation Plan (CITP) 2015-2020 and the recent Construction 4.0 Strategic Plan (2021-2025) (CIDB, 2020). Governments are seeking to reduce reliance on labour by promoting automation, thereby increasing capital intensity in the industry. As a crucial indicator of long-term growth in labour productivity, capital intensity is significant because investing in assets often replaces labour utilization (Dawson, 2014). Determining labour productivity involves calculating a company's capital intensity as the ratio of fixed capital per headcount, per labour cost, to total assets. Alternatively, capital intensity can be defined as the capital intensity ratio or capital stock (Jorgenson & Yun, 2013).

Market regulations encompass the regulations, laws, and policies initiated by the government to regulate financial markets, impose regulation, and manage market-centric strategy (Holmes et al., 2013). These regulations directly impact industry outputs as they influence decision-makers actions. Moreover, market regulations play a crucial role in a country's business environment, affecting economic emergence. Government policies or regulations that control the actions of market participants within the market economy can potentially shape and impact economic outcomes for firms, industries, and countries (Amin et al., 2023; North, 2005).

In both domestic and international markets within the construction industry, labour productivity has become a critical factor for competitiveness due to increasing globalization and intensified market competition. High labour productivity positions companies favourably

in global markets, leading to lower unit costs (Ismail, 2018). Researchers, such as Novotná et al. (2020), have emphasized the close relationship between labour productivity and capital intensity. Labor productivity measures labour efficiency relative to a company's available capital. Thus, capital intensity and labour productivity are vital in determining long-run economic growth. Capital-intensive methods enable increased output and higher living standards. However, existing literature provides limited evidence on the impact of capital intensity and market regulation on changes in labour productivity, particularly in the construction industry and other sectors (Lannelongue et al., 2017). The argument concerning whether high capital intensity benefits construction firms remain unclear due to the construction industry's heavy fragmentation caused by subcontracting and its cyclical nature, which may not always support high capital intensity argument related to the industrial organisation (Frein, 2012; Myers, 2016). Achieving high capital intensity requires consistent investment and commitment, which may also explain the prevalent labour intensity in the construction industry.

Nevertheless, there are several measurement issues when considering sector and project levels, including occurrences like offsite prefabrication, typically categorized within the manufacturing sector. As a result, labour productivity might provide a more precise representation at the industry level, yet its applicability at the project level is limited to onsite tasks, failing to encompass innovations taking place during offsite activities. (Nasir et al., 2014). Therefore, using firm-level is more balance when considering between those two levels because some construction firms might be vertically integrated by having off-site manufacturing subsidiaries.

To attain the aim of the study, the research objectives are (1) to identify the level of capital intensity, market regulation, and labour productivity in construction firms, (2) to determine the impact of capital intensity, and market regulation on labour productivity in construction firms and (3) to produce the model of the interaction effect of capital intensity and market regulation on labour productivity in construction firms. This study is anticipated to help policymakers plan policies to improve the construction firm’s labour productivity.

LITERATURE REVIEW

Labour productivity refers to the measurement of unit output in relation to labour input. Its growth is a critical aspect of economic performance and plays a vital role in improving living standards. The increase in Gross Domestic Product (GDP) per capita is often influenced by the growth of labour productivity, measured as GDP per hour worked and changes in labour utilization. Enhanced labour productivity can result from reducing low-productivity workers and/or increasing the use of capital and efficiency improvements through innovation (OECD, 2022).

In a nation's economy, construction productivity holds significant importance and occupies a central position in the industry (Naoum, 2016). Furthermore, construction productivity is closely linked to labour and is regarded as the most vital and adaptable resource utilized in construction projects (Muqeem et al., 2012). In such projects, labour costs constitute approximately 30 to 50% of the overall project expenses, particularly in labour-intensive projects that involve basic hand tools and equipment (Alaghbari et al., 2019). As a

result, labour productivity emerges as a key management factor for successfully completing projects (Rad, 2014).

Moreover, construction labour productivity significantly influences the profitability of construction companies. However, labour productivity is the most variable among project resources, making it a significant source of project risk (Tsehayae, 2015). Improving the efficiency of construction labour forces necessitates identifying the factors that affect labour productivity, enabling the development of strategies to reduce inefficiencies (Kazaz & Acıkara, 2015). This improves the project performance of construction companies, increase their competitiveness, and ultimately enhance their chances of survival in a highly competitive sector by effectively managing the labour force (Robles et al., 2014).

According to Zhou (2021) findings, based on Growth Theory, labour-intensive firms do not experience additional productivity growth, while capital-intensive firms do. Therefore, the capital intensity of firms is a critical factor influencing their productivity. Hussain (2017) study demonstrates a significantly positive effect of capital intensity on labour productivity in Pakistani firms, indicating that higher capital intensity enhances automation and leads to increased productivity. However, the specific impact of capital intensity on labour productivity remains unclear, as there is a lack of research on this aspect, particularly within the construction industry.

In New Institutional Economics, market regulation plays a crucial part in a nation's development by shaping the business environment. It is established through public regulations or administrative policies that control the actions of market players, which might either benefit or hinder economic growth (Acemoglu et al., 2005; North, 2005). Economists generally agree that positive changes in market regulation can enhance productivity growth by incentivizing efficient resource utilization in production (Acemoglu & Dell, 2010). Some studies have explored how market regulation impacts productivity, but previous research (Castelnovo et al., 2019; Lasagni et al., 2015; Ng & Yu, 2014) and Borghi et al. (2016) mainly focused on non-construction sectors, lacking in-depth analysis of various market regulations' effects on productivity. While some studies used aggregate measures of market regulation, they may not provide detailed insights into the specific impacts of different market regulations on productivity (Borghi et al., 2016; Castelnovo et al., 2019). In the construction industry, direct examinations of the influence of market regulation on performance, particularly productivity, have been limited, although there is increasing research on the indirect effects of market regulation on strategy-productivity performance (Azman et al., 2022). Consequently, policymakers face challenges in determining which market regulations specifically affect construction labour productivity without clear comparisons.

At the regional market, the involvement of international players following from globalisation and liberalisation can be the cause of competition. In developing economies, besides expert and profoundly technical projects, non-domestic companies are also acquiring a wider range of projects (Rani et al., 2021). Moreover, globalization presents an opportunity for local contractors to expand globally, as the construction market is becoming increasingly accessible, thereby improving competitiveness and fostering growth in the construction sector (Ismail et al., 2012). In addition to boosting the economies of both developing and developed nations, liberalization also facilitates the flow of resources and fosters connections across the world (Moodley et al., 2008). This type of market openness fosters competitiveness and

globalization among local contractors as they compete with both foreign and local players in the market (Debrah & Ofori, 2005). Despite, it can be difficult for home countries to implement or change new regulations as there may be restrictions in the terms and conditions previously agreed upon by the government and counterpart countries (Ling & Hoi, 2006). Globalization and liberalization provide local contractors with the chance to venture into overseas projects. Even so, liberalization also puts domestic contractors in a vulnerable status within the local market as it reduces barriers to market entry, making it easier for foreign firms to enter the developing economies' construction markets. Over the last few years, foreign investors' market share also has constantly risen (Rani et al., 2021). The primary reason for the government in developing economies awarding projects to foreign contractors is due to financial limitations and the insufficient expertise and capability of local contractors to carry out the project (Dhillon, 2009).

Local contractors are becoming increasingly concerned about their ability to sustain their businesses due to heightened competition from foreign firms resulting from liberalization policies. While these policies have the potential to enhance productivity and foster healthy competition in the construction industry, some developing nations have faced challenges in accessing the markets of developed economies. Moreover, there are apprehensions that liberalization policies, intended to attract more foreign investment and improve industry efficiency, may negatively impact the growth prospects of the local market (Hung et al., 2016).

Additionally, a study by Lannelongue et al. (2017) explored the impact of environmental management and capital intensity on labour productivity and found that high capital intensity weakens the relationship between environmental management and labour productivity. In other words, a higher level of capital intensity leads to a more significant negative effect of environmental management on labour productivity. However, there is a lack of research on the connection between market regulation, capital intensity, and labour productivity, particularly in the context of the construction industry. Therefore, the aim of this study is to investigate how market regulation and capital intensity influence labour productivity in construction firms in a country in developing economies as a case study.

Besides, based on research gaps and research questions, the following Figure 1 is the theoretical framework:

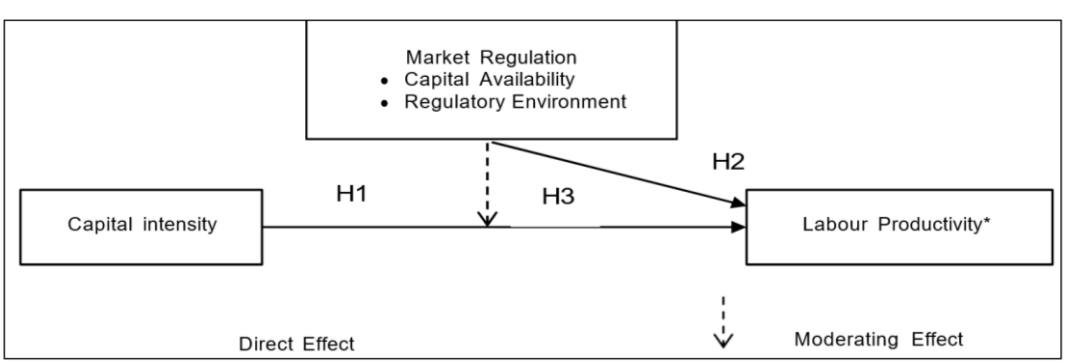

Figure 1. Theoretical Framework of Research

Based on the literature, the followings are the proposed hypotheses:
H1: There is a direct effect of capital intensity on labour productivity in construction firms.
H2: There is a direct effect of market regulation on labour productivity in construction firms.
H3: There is a moderating effect of interaction between capital intensity and market regulation on labour productivity in construction firms.

Based on the literature, the followings are the proposed research questions:
1. What is the level of capital intensity, market regulation, and labour productivity in construction firms?
2. How do capital intensity and market regulation affect labour productivity in construction firms?
3. How does the interaction of capital intensity and market regulation affect labour productivity in construction firms?

RESEARCH METHOD

This study employs a quantitative approach to effectively analyse and model the intricate interplay between capital intensity, market regulation, and their impact on construction firm labour productivity. By utilizing a quantitative methodology, the study can rigorously examine and validate theoretical propositions and assumptions through numerical data and graphical representations (Nardi, 2018). Quantitative methods offer a systematic means to assess relationships, providing a structured framework to analyse complex variables, measure their associations, and derive empirical insights. This approach ensures a robust and comprehensive exploration of the research problem, enhancing the validity and reliability of the study's findings.

Data Collection

Annual reports of Malaysian construction firms listed on the Malaysian Stock Exchange, covering the period from 2009 to 2020 can be the case study for the research. The data includes details from both major general contractors and specialized construction firms capable of handling projects worth more than MYR 10 million (approximately USD 2.4 million as of November 2021). The Construction Industry Development Board (CIDB) provided a list of G7 contractors, and out of the 8845 registered G7 contractors in 2021, only 55 large construction firms meet the eligibility criteria and have complete annual reports. This study focuses on analysing the productivity growth of these large construction firms from the G7 group, as they are known to grant more significantly to the overall enhancement of productivity compared to smaller firms (Ciani et al., 2020). Moreover, it is expected that these large firms have higher levels of mechanization and utilize more fixed capital, such as machinery and smart automation. The use of secondary data from publicly listed G7 construction firms is due to their accessibility for this research. The results of the study are expected to be generally applicable to other large contractors in the industry.

Explanatory Variable

The focus of the study is lies on investigating the impact of two key variables, namely capital intensity and market regulation, on the dependent variable of labour productivity.

These variables are of paramount importance in understanding the factors that influence labour productivity within the context of the research.

Measuring The Capital Intensity

Capital intensity is measured as the proportion of capital to labour inputs used in an economy, sector, or company (Takahashi et al., 2012). Firmansyah and Febriyanto (2018) explain that capital intensity is determined by dividing the book value of plant, equipment, and property (Nicoletti & Scarpetta, 2003) to total assets. Capital intensity can be calculated using the equation below:

$$Capital\ Intensity = \frac{Fixed\ Assets}{Total\ Revenue} \quad (1)$$

Measuring Market Regulation

This study adopts the interpretation of market regulation by Holmes and Miller Holmes et al. (2013) which can be represented by various indices and economic data, such as those provided by the International Country Risk Guide (ICRG) and the Index of Economic Freedom. In this case, little adjustments are made; Varieties of Democracy index (V-DEM) were replaced by the Freedom House and POLCON index due to its unavailability. This huge number of indices can serve as proxies but might be interrelated (Voigt, 2013). As a result, this study employed principal component analysis (PCA) to condense the numerous index measurements into a collection of uncorrelated representative components (Garrido et al., 2014). Furthermore, in this study, a varimax orthogonal rotation with Kaiser Normalization was applied. This technique reduces the required number of factors to elucidate a variable and enhances interpretability, making it particularly suitable for research within a specific country context (Holmes et al., 2013). Consequently, the variables associated with market regulation are represented as standardised projected values of PCA (as detailed in the estimated changes concerning market regulation).

Measuring Labour Productivity

Labour productivity is described as unit output of labour input (Pami Dua, 2019). It is used to compute the worker's efficiency. In this study, labour productivity can be computed using the formula below:

$$Labour\ Productivity = \frac{Total\ Output}{Cost\ of\ Labour} \quad (2)$$

Modelling

It is expected that the 2SLS can be used to model relationships between capital intensity, market regulation and its interaction effect on labour productivity. 2SLS can be used to mitigate the endogeneity problem associated with the endogenous variables in the model. Thus, inefficient test statistics and biased parameters can be mitigated (Esquivias & Harianto, 2020). Here are the level equations of the proposed relationships.

$$Y_{it} = a + B_n control(firm\ specifics)_{it} + B_n control(year\ dummies)_t + B_n(capital\ intensity)_{it} + B_n(market\ regulation)_t + e_{it} \quad (3)$$

$$Y_{it} = a + B_n control(firm\ specifics)_{it} + B_n control(year\ dummies)_t + B_n(capital\ intensity)_t + B_n(market\ regulation)_t + B_n(capital\ intensity_{it} \times market\ regulation_t) + e_{it} \quad (4)$$

Where:

- Y_{it} is labour productivity
- α is estimated alpha/ slope coefficient
- β_n is estimated beta/significant
- e_{it} is error

Two Stage Least Square Estimation

This study adopts two-stage least square estimation (2SLS) because ordinary least square (OLS) is not efficient in mitigating endogeneity. In this case, the relationship between the independent and dependent variables can be biased and inefficient because the explanatory variable correlated with error term. To mitigate endogeneity, 2SLS is adopted where the instrumental variable is being used in the first stage (Mustafa, 2018). This provides advantage in term of estimating accuracy - less biased and more consistent.

$$E(X|e) \neq 0 \quad (5)$$

In equation (3.5), X, which is capital intensity, is expected to be endogenous because the correlation between the variable and error is not equal to zero. Therefore, the estimation of β coefficients are biased and inefficient. To mitigate this problem, 2SLS must be used so that the estimation of β coefficients could accurately accept or reject hypotheses. In this case, predicted X^{J} computed in the first stage is not correlated with the error as in equation (6) so that,

$$E[X^{J}e] = 0 \quad (6)$$

In first stage regression, an endogenous variable capital intensity X is regressed against instrumental variables Z_n, then values from the estimation compute the predicted X^{J},

$$X = \alpha + \gamma Z_n + e \quad (7)$$

The selection of instrumental variables Z_n satisfies 1) in the first stage: Z_n affect X, 2) independence: Z_n s uncorrelated with the e and 3) Exclusion restriction: Z_n only affects Y (observed variables) through its effect on X. In the second stage regression, the computed value of X^{J} is regressed against observed variables as per equation (3.8),

$$Y = \alpha + \delta V_n + \beta X^{J} + e \quad (8)$$

Where Y is labour productivity, α is the slope coefficient on Y, V_n is the control variable, and X^{J} is capital intensity while e is error.

Robustness Test

Robustness tests are employed in this study to ensure that the results are reliable and not sensitive to violations of statistical assumptions in panel data analysis. The robustness tests consist of two main procedures: Maddala and Wu (1999)'s stationary and Pedroni (2004)'s cointegrated tests. Besides, the stationary test assesses whether the time series data exhibit a constant distribution over time, ensuring that the statistical properties of the parameters remain stable throughout the analysis. On the other hand, the cointegrated test examines whether the model's variables have a long-term relationship, avoiding spurious regression that might lead to misleading results. By conducting these robustness tests, the study aims to enhance the validity and accuracy of the findings.

RESULT AND DISCUSSION

While this paper is still in its conceptual phase and requires further empirical testing, its objective is to investigate whether capital intensity, market regulation, and their interaction can positively impact long-term labour productivity in construction firms. This study offers valuable insights for policymakers and industry stakeholders seeking to enhance labour productivity in construction firms. The study underscores the importance of considering both capital intensity and market regulation when formulating strategies and policies in this sector. In addition, predicting the precise effect of capital intensity is challenging as it depends on estimation modelling accuracy and consistency. Based on the deductive approach selected, the use of an appropriate estimator i.e., 2SLS and the estimator's test statistic for the Beta Coefficient can highlight whether such a relationship exists. Using other types of estimators may give type I error (false-positive) and type II error (false-negative). Growth Theory suggests that capital intensity can enhance firm performance through labour productivity. However, achieving higher levels of capital intensity might be difficult due to industry segmentation (sub-contracting) and the construction industry's cyclical nature, which might deter construction firms from being more capital-intensive based on the Industry Organisation point of view (Frein, 2012; Myers, 2016). Notably, there is currently a lack of research specifically focusing on the influence of capital intensity on labour productivity within the construction domain. In other industries, capital intensity has been closely linked to labour productivity (Novotná et al., 2020). Zhou (2021) supports the notion that capital-intensive firms experience greater productivity growth compared to labour-intensive ones. Thus, a firm's capital intensity is a pivotal factor affecting its overall productivity. However, its precise impact on labour productivity in the construction sector remains uncertain, given the limited number of studies on capital intensity levels in this industry, particularly in developing economies which also can be moderated by different types of market regulation according to New Institutional Economics. Further research and empirical analysis are necessary to understand the relationship between capital intensity and market regulation and its impact on labour productivity in the context of the construction industry.

CONCLUSION

This paper presents a conceptual model that explores the interplay between capital intensity, market regulation, and labour productivity in construction firms. Additionally, the study aims to investigate the moderating effect of market regulation on capital intensity. By addressing existing gaps in the literature and conducting a thorough review, the paper establishes the theoretical framework, formulates hypotheses, identifies research questions, and outlines the study's objectives. Moreover, the paper carefully evaluates and selects appropriate research methods based on both theoretical principles and statistical considerations. The anticipated outcome of this paper is to provide valuable guidance for the subsequent phases of the research and contribute significantly to the fields of capital intensity, market regulation, and the construction industry. By laying the groundwork for the forthcoming study, this paper aims to advance our understanding of how capital intensity and market regulation impact labour productivity in the context of construction firms especially in developing economies. Despite that, the study has some limitations: the results may vary on small construction firms due to a lack of data and may be accurate for construction firms in developing economies.

ACKNOWLEDGEMENT

This work was supported by the MyRA Research Grant [600-RMC/GPM ST 5/3 (045/2021)], Universiti Teknologi MARA, Malaysia.

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DESIGN FOR SPATIAL IDENTITY CREATION IN CULTURAL TOURISM: A CASE STUDY OF A SMALL HOTEL IN CHANTHABURI PROVINCE, THAILAND

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Abstract
The study explores how spatial identity creation for cultural tourism can be used as the primary guideline for designing spatial development strategies. This research focuses on understanding the identity of Chanthaburi Province with the aim of developing an interior design approach for small hotels. Additionally, it investigates tourists' perceptions of environmental design. This research employs a qualitative approach combined with quantitative analysis. The research tools include conducting in-depth interviews with two sample groups to identify the design factors that effectively convey spatial identity and to examine environments that represent spatial identities. Based on design theory, the findings indicate that integrated designs should possess functional characteristics that align with user behaviour and needs. Principles of interior layout facilitate ease of use by allocating space effectively. Moreover, designs should take human proportions into account. Distinctive colours can successfully convey a clear spatial identity, ensuring a customer-friendly environment. Materials utilized should prioritize safety and durability. Incorporating architectural motifs proves to be an effective way of conveying spatial meaning. Additionally, the result of tourists' perceptions of the physical environment design indicates the successful, effective communication of spatial identity in Chanthaburi Province, signifying an excellent level of communication and indicating that the design has effectively communicated Chanthaburi's spatial identity to a remarkable degree.

Keywords: *Spatial Identity; Cultural Tourism; Interior Design Guideline; Perception*

INTRODUCTION

Tourism plays a vital role in enhancing economic growth and holds considerable significance for developing nations. It constitutes an industry that yields substantial national revenue, attracting domestic and international visitors (Kariyapol & Agarwal, 2020). Furthermore, tourism is acknowledged as a fundamental cultural aspect, contributing to the present-day economy and offering prospects for the local community (Hanafiah et al., 2013). However, focusing on popular tourist attractions within major cities has led to unequal income distribution, neglecting nearby communities and provinces (secondary cities) (Lertkulprayad, 2007). Moreover, each province requires better public relations and promotion of its local culture, as visitors still need to discover some exquisite tourist spots with unique cultural heritage. The appreciation of culture and recognition of the cultural diversity in each region serves as the foundation for developing cultural tourist attractions and fostering community life. In this traditional settlement, the indigenous community plays a pivotal role in defining the exceptional universal values and the tangible elements that sustain skills, cultural activities, and living traditions (Jamaludin et al., 2022).

Chanthaburi Province holds immense historical and cultural significance, making it a treasure trove of valuable local traditions, art, and ways of life that deserve preservation and

development. Moreover, renowned as one of the country's top gem markets, Chanthaburi boasts numerous captivating attractions, leading to a surge in tourist numbers (Tourism Authority of Thailand, 2023). However, modern-day tourists seek more than just good service; they crave immersive cultural experiences that connect them with the region's essence (Anusorntharangkul & Rungwongwan, 2021). Therefore, it becomes crucial to incorporate designs that authentically convey the area's cultural story when designing physical environments catering to tourists, such as hotels. This approach uniquely attracts visitors and aligns with Thailand's secondary city tourism policy, aimed at promoting tourism growth in secondary provinces. By emphasizing the area's identity and narrating its story through thoughtful design, increasing tourist footfall will translate into enhanced income opportunities for local communities and further boost the tourism economy's expansion.

This study explores the significance of effectively conveying spatial identity (e.g., physical environment, aesthetics) during the design stage. The interior design concept integrates various aspects of cultural identity and the physical environment to enhance the quality and identity of tourist attractions (Qazimi, 2014). Design management efforts play a pivotal role, involving continuous work in the background and considering different attributes of the physical environment that contribute to the identity of tourist attractions. This becomes a crucial competitive priority, as it enhances promotional capabilities, cultivates a positive image, and supports the local organization's reputation. From a quality management perspective, the speed of new design and the thoughtful approach to physical environment design underscores the importance of incorporating quality into identity communication issues (Anusorntharangkul & Rungwongwan, 2021). By optimizing physical environment design, these efforts inherently influence consumer perception, making effective design an essential factor in shaping the overall experience.

The pay-off for businesses promoting place identity during the design of the physical environment is important and has a competitive advantage in the market. The physical environment evaluation can be made from an external perspective. Identity concept-related knowledge is also in the company’s internal business interest for guidance and methods to develop smarter, more effective system solutions. All of these relate to spatial identity creation and physical-environment attributes. Also, most research on the physical-environment attributes has concentrated on social or sign value that environments express (Giuliani & Bonnes, 1987), as Rapoport (1995) and Cooper (1974) have focused on the correlation between taste and social status. Most studies have conceptualized physical-environment attribute designs as symbols that convey meanings (Schneider, 1990) and express identity (Csikszentmihalyi & Rochberg-Halton, 1981; Rapoport, 1990; Qazimi, 2014). Additionally, numerous scholarly investigations have framed designs of physical environmental attributes as symbolic representations that convey meanings and manifest identity (Jackson, 2019).

Hence, the primary objective of this study is to focus on understanding the identity of Chanthaburi Province with the aim of developing an interior design approach for small hotels. Additionally, it investigates tourists' perceptions of environmental design. The design guidelines established through this research contribute significantly to creating a spatial identity for cultural tourism. These guidelines can serve as a valuable reference for designing other small hotels, enhancing customer awareness, and promoting the hotel's image in different regions.

METHODS AND MATERIALS

This part presents the researcher's information collection, including the research methods and materials.

Research Area

In this research, the focus was on studying the identity of Chanthaburi Province to establish interior design guidelines for small hotels that effectively convey spatial identity. The study followed three categories of research areas as guiding principles.

1. Explore the interior design guidelines and styles applicable to small hotels, encompassing design theory and applying interior design concepts and principles. The researcher outlines the study's framework as follows (Lin, 2007):
   i) Investigate the relationship between design and human behaviour.
   ii) Analyse the perception of floorplan layouts.
   iii) Examine the role of materials and colours in interior design.

2. The researcher outlines the framework for the study of identity character as follows:
   i) Examining the historical background of Chanthaburi Province.
   ii) Analysing the architectural features of residential buildings in the area.
   iii) Analysing the cultural heritage and local traditions prevalent in Chanthaburi Province.

3. By analysing data from various studies, the objective is to create a distinctive identity for small Chanthaburi Province hotels that make them unique and align perfectly with their intended purpose.

Furthermore, this study investigated tourists' perceptions of the designed physical environment to influence tourist behaviour (persuasion) to travel to secondary cities. The research employed multiple methodologies, including data gathering from documents, books, and relevant studies, conducting a field survey, employing quasi-experimental research techniques, and employing a questionnaire with accompanying pictures (Krukaset, 2011). The detailed operating procedures are presented in Figure 1.

Research Design

There were issues in the study:

1. This qualitative research focused on two main aspects: the identity issues of Chanthaburi Province and the design factors capable of expressing spatial identity. The researcher analysed the strengths of various characteristics that serve as indicators of the region's societal, communal, and local cultural traits. An in-depth discussion research tool was developed and utilized with a representative sample of experts, employing the EDFR method (Ethnographic Delphi Futures Research) to achieve this. Through this approach, the study aimed to identify the design factors capable of conveying spatial identity (Anusorntharangkul & Rungwongwan, 2021).

The Ethnographic Delphi Futures Research is a research technique that combines the Ethnographic Futures Research (EFR) and the Delphi Technique. It has strengths and advantages. The Ethnographic Delphi Futures Research processes are similar to the Ethnographic Futures Research, but the Ethnographic Delphi Futures Research interviews are more flexible. Open-ended questions are prepared in advance in order to get the appropriate answers that match the research goals (Anusorntharangkul & Rungwongwan, 2021).

2. This quantitative research addressed the issue of tourists' perception of the physical environment in relation to conveying spatial identity. The research tools used by the researcher encompass an Interview form and a 3D environment model, both utilized to convey spatial identity.

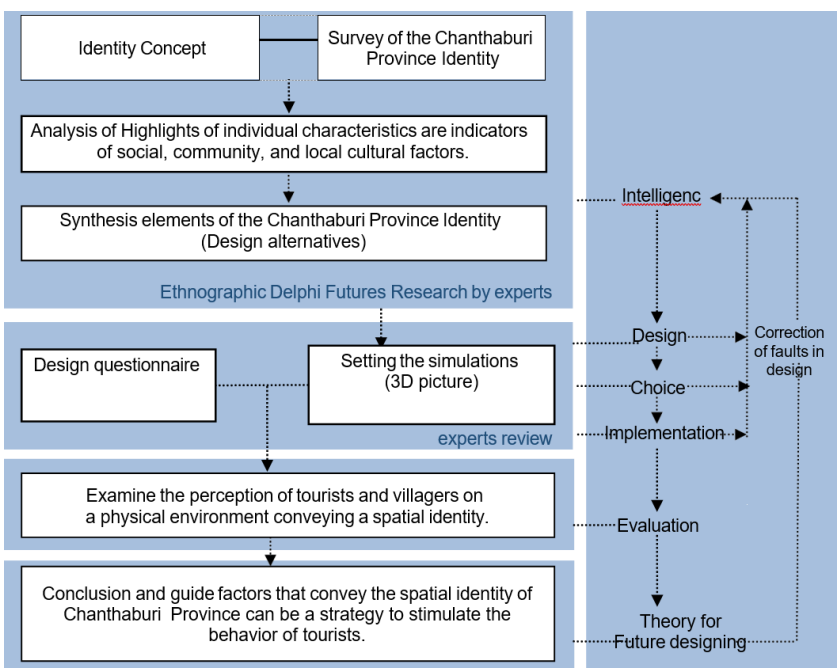

Figure 1. Research Procedure (Lang, 1974)

The Sample Groups

The sample group was divided into two groups in this research:

1. In qualitative research, we used purposive sampling. The researcher has defined specific characteristics, comprising nine experts. The sample group consisted of individuals with expertise in community stories, community villagers, and designers with experience in dealing with spatial identity in design. Three members are chosen from each group.

2. In the quantitative research, the researcher categorized the sample representatives into two groups: (1) 20 villagers and (2) 50 tourists, totalling 70 participants. Interview forms were gathered from communities and tourist attractions in Chanthaburi Province. Participants evaluated spatial identity perception through storytelling

within the designed interior environment. The researcher employed a Quota sampling method and utilized Accidental sampling to reach the desired number of samples during data collection in the designated areas.

Research Procedures

This section presents the research procedures according to critical issues in the study. The data collection included the interview form and a questionnaire divided into four parts:

1. The researcher employed an interview form with an expert group from each group (three experts in community stories, three community villagers, and three designers with experience in dealing with spatial identity in design), utilizing the EDFR Delphi method to uncover the identity representation of Chanthaburi province. The EFR (Ethnographic Futures Research) initially consisted of open and unguided interviews by recording sound. The first interview time was 30 minutes per person. Those topics are divided into two issues, viz., the way people live from the past until the present and the physical environment identity. Subsequently, the data collected were carefully analysed and synthesized to identify the representative identity of Chanthaburi Province, forming the basis for developing a Delphi tool for the subsequent phase.

2. The second Delphi round involved using the interview form with the expert group, based on the outcomes obtained from the 1st Delphi, to gather further input from the experts. This step aimed to determine the level of agreement among the experts regarding the analysis results and to rank the prominence of identity representatives. The reconsideration process focused on enhancing the accuracy and clarity of the previously identified identity of Chanthaburi.

3. During the third Delphi iteration, the researcher employed an interview form with the expert group, presenting them with the results obtained from the second Delphi. The experts re-evaluated the findings and provided explanations for their choices concerning each item. After analysing the information, the researcher applied the results to the interior design of a small hotel, considering design principles and identity creation. These designs were then presented to experts for their evaluation and feedback regarding the suitability of the design.

4. In the tourists' perception of the physical environment in relation to conveying spatial identity, the researcher utilized a perception interview form to investigate how the physical environment conveys spatial identity, addressing two main issues within the interview. Firstly, participants provided general information, and a questionnaire was designed to categorize the samples into two groups: villagers and tourists, with the aim of exploring the relationship between their perception levels. Secondly, the interview focused on participants' responses to spatial identity storytelling through design. To stimulate perception and elicit interview responses, the researcher employed simulations in the form of 3D pictures (Norman, 2004). The Rating Scale method with five levels on the perception scale was used alongside open-ended questions.

THE RESULTS OF THE STUDY

The researcher divided the results of the study into four parts as follows:

The Study of Chanthaburi Province Identity

Chanthaburi, known initially as "Chanthaboon," derives its name from the city of the moon, signifying peace and happiness. The provincial seal, a round blue emblem, portrays a rabbit amidst a radiant moon, symbolizing the region's serene and blissful beauty. The moonlight represents an extraordinary and gentle allure akin to the tranquillity and joy found in this area. The rabbit emblem represents a part of the moon. The local wisdom of Chanthaburi province encompasses various aspects:

1. Chanthaboon mats, distinguished by their black and red colors and made with jute as a warped line
2. Wickerwork from the Khla tree, resembling bamboo but being softer and more pliable.
3. Crab rings and fish rings
4. Gemstone cutting
5. Chan noodles, a delectable local dish

The traditions of Chanthaburi Province include 1) Khao Khitchakut Footprint Worship Tradition; 2) Chak Phra Tradition; 3) Taksin Remembrance Festival; 4) Boat Race Tradition. Among the remarkable architectural landmarks in Chanthaburi are:

1. The Cathedral of the Immaculate Conception (Catholic Church)
2. The Red Building
3. The Shrine of King Taksin the Great
4. The Characteristics of houses in the old community

Figure 2. Characteristics of An Old Community in The Riverside Area of Chanthaburi Province

The architectural building in Chanthaburi exhibits Doric-style stucco columns and Western-influenced arches. Above the doors, stucco plants add a touch of elegance, while decorative gingerbread-style wood carvings adorn the vents. The roof is adorned with perforated carved wooden battens, all distinct features pointing to the building's age. An illustration of this can be seen in Figure 2.

As prosperity flourished, the architectural landscape of Chanthaburi evolved, with modern houses reflecting a blend of commercial and high-rise elements influenced by industrial-style design. Notably, various shapes and forms of wrought iron are employed for decoration, featuring prominently in windows, balconies, corridors, and entrances. These wrought iron embellishments create patterns that align with the era's trends, resulting in intricate, beautiful, and diverse designs. Figure 3 provides an illustrative example of this architectural transformation.

Figure 3. Patterns of Wrought Iron in Modern Building Styles of Chanthaburi

To explore the identity representation of Chanthaburi province, the researcher conducted Delphi interviews, gathering insights from three distinct groups of experts. The first group consisted of experts well-versed in the community's history, while the second group comprised villagers providing their perspectives. The third group consisted of designers experienced in creating designs linked to spatial identity.

The Results of The Analysis of The Design Concept and Representation of The Identity of Chanthaburi Province

Based on the interviews conducted with three groups of experts, the design concepts and identity of Chanthaburi Province can be summarized as follows:

1. The design should comprehensively address functionality to cater to user behaviour and meet their needs effectively.
2. The principles of interior layout necessitate the allocation of space in relation to one another, ensuring ease of use. This involves dividing the interior space into precise proportions, considering human proportions, furniture size, and the specific activities to be carried out in each area.
3. Flashy colours emerged with the highest prominence among the various factors influencing colour choice. This is due to their association with pagodas, shrines, and decorative architectural tiles. Additionally, flashy colours effectively convey the vibrant hues of gemstones, representing the province's high-quality products. Furthermore, cream and white hues complement the overall design when used in building colour, providing an enhanced sense of prominence.

4. The material factor analysis highlights the importance of customer-friendly materials in interior design, particularly for the floor, walls, and furniture. Safety and durability are essential considerations when selecting materials. Furthermore, incorporating architectural motifs can effectively convey spatial meaning and enhance the overall design.

After gathering data and analysing information from all four parts, the researcher applied the results to the interior design of a small hotel, considering design principles and identity creation. These designs were then presented to experts for their evaluation and feedback regarding the suitability of the design.

The Evaluation Results of The Chanthaburi Identity Were Used to Formulate Comprehensive Interior Design Guidelines for Small Hotels, Focusing on Effectively Conveying Spatial Identity

Based on the design evaluation conducted by nine experts, the results were summarized into three key issues as follows:

1. The space allocation design divides the area into well-balanced proportions, ensuring practicality and convenience of use. This includes thoughtful allocation within rooms to create a sense of privacy.
2. Decorative materials, particularly synthetic wood, were chosen for production due to their exceptional qualities. These materials offer durability and resilience against all weather conditions in Thailand. Additionally, their solid nature makes them well-suited for long- term maintenance, ensuring easy upkeep and preserving their aesthetic appeal over time.
3. The careful selection of colours for each functional area effectively conveys the distinctive characteristics of the province. Architectural motifs are integrated to complement the design, creating a beautiful, modern, and robust environment that ensures safety. Moreover, these design elements play a vital role in conveying the appropriate spatial meaning for the concept, resulting in the establishment of a unique identity for the small hotel.

The Result of Tourists' Perceptions of The Physical Environment Design Indicates the Successful Communication of Spatial Identity in Chanthaburi Province

The interview focused on two main points. Firstly, it gathered general information from the informants, allowing the researcher to divide the samples into two distinct groups: 20 villagers from the community and 50 tourists, totalling 70 participants. The objective was to explore the correlation between the perception levels of these two informant groups. Secondly, the interview delved into the informants' responses to spatial identity storytelling through design. The researcher utilized simulations in 3D pictures to stimulate perception and gather responses, as depicted in Figure 4. The Rating Scale method was employed, featuring five levels on the perception scale, and the informants also answered open-ended questions to provide more detailed insights into establishing a unique identity for the small hotel.

Figure 4. The Simulations (3D Picture) Examples

Table 1. The Result of Perceptions of The Physical Environment Design Communicates Spatial Identity

The Design Issues	Villagers Group		Tourists Group		Total	
	$\bar{X}$	S.D.	$\bar{X}$	S.D.	$\bar{X}$	S.D.
Dividing the space into proportions makes it convenient for practical use	4.14	0.42	4.70	0.14	4.42	0.28
It was choosing furniture that meets the needs of the user	4.69	0.41	4.26	0.15	4.48	0.28
The selection of materials was solid and durable	4.17	0.42	4.68	0.57	4.43	0.50
Atmosphere (colours in space design)	4.54	0.48	4.45	0.14	4.50	0.31
The design was modern/distinctive	4.61	0.51	4.55	0.57	4.51	0.54
The design was unique	4.55	0.32	4.75	0.14	4.53	0.25
Communication of the spatial identity of Chanthaburi Province	4.97	0.51	4.69	0.57	4.82	0.54
Total	**4.53**	**0.44**	**4.59**	**0.33**	**4.53**	**0.39**

(Source: Researcher, 2022)

The data presented in Table 1 shows that the perceptions of the physical environment design effectively communicate spatial identity in Chanthaburi Province. The overall average of all issues yielded a mean perception score of 4.53, signifying an excellent level of communication. Among the specific communication issues, the one concerning the spatial identity of Chanthaburi Province received the highest average score of 4.82. This was followed closely by the uniqueness of the design, which scored 4.53. The design's modern and distinctive attributes attained a mean perception score of 4.51, while the overall atmosphere received a score of 4.50. These scores are rated at an excellent level, indicating that the design has effectively communicated Chanthaburi's spatial identity to a remarkable degree.

Table 2. The Level of Perceptions

Rank	Villagers	Tourists	Total
1	Communication of the spatial identity of Chanthaburi Province	The design was unique	Communication of the spatial identity of Chanthaburi Province
2	It was choosing furniture that meets the needs of the user.	Dividing the space into proportions makes it convenient for practical use.	The design was unique
3	The design was modern/distinctive.	Communication of the spatial identity of Chanthaburi Province	The design was modern/ distinctive.
4	The design was unique	The selection of materials was solid and durable.	Atmosphere (colours in space design)
5	Atmosphere (colours in space design)	The design was modern/distinctive.	It was choosing furniture that meets the needs of the user.
6	The selection of materials was solid and durable.	Atmosphere (colours in space design)	The selection of materials was solid and durable.
7	Dividing the space into proportions makes it convenient for practical use.	It was choosing furniture that meets the needs of the user.	Dividing the space into proportions makes it convenient for practical use.

(Source: Researcher, 2022)

After considering each sample group, it was observed that the villagers had an average perception score of 4.47, indicating a good level of perception. Among them, the communication issue regarding the spatial identity of Chanthaburi Province received the highest average score of 4.97. The perception scores for choosing furniture that meets the needs of the user, the design being modern/distinctive, the design being unique, and the atmosphere was also high, with average scores of 4.69, 4.61, 4.55, and 4.54, respectively – all at an excellent level of perception.

For tourists, the average perception score was 4.59, signifying an excellent level of perception. The uniqueness of the design received the highest average score of 4.75 while dividing the space into proportions for practical use received a score of 4.70. The communication of the spatial identity of Chanthaburi Province, the selection of solid and durable materials, and the design being modern/distinctive all obtained excellent perception scores with averages of 4.69, 4.68, and 4.55, respectively. Tables 1 and 2 provide a detailed summary of these results.

DISCUSSION AND CONCLUSIONS

This research aimed to study the identity of Chanthaburi Province and utilize the findings to develop an interior design approach for small hotels. Additionally, the research sought to explore tourists' perceptions of the physical environment design. The ultimate goal was to establish design guidelines that effectively create a distinct spatial identity for small hotels, using Chanthaburi province as a case study. To achieve this, the researcher made improvements and enhancements to the design by seeking expert opinions and suggestions. This included designing a comprehensive questionnaire to assess the needs of the sample group. In summary, the research successfully culminated in developing practical design guidelines that contribute to perfecting the spatial identity of small hotels, with the context of Chanthaburi province being a key reference. The summarized findings are as follows:

1. In the context of design and user behaviour, it is essential for the design to encompass complete functionality, effectively catering to the behaviours and needs of the users.
2. Interior layout principles are vital in creating a harmonious and functional space. Allocating space in consideration of how different elements relate to each other is essential for ensuring ease of use and seamless movement within the environment. Moreover, considering human proportions is crucial for designing spaces that feel comfortable and accommodating to the people using them. By adhering to these principles, interior designers can create spaces that look visually appealing and facilitate a smooth and pleasant user experience.
3. Using colours in interior design is vital in creating a distinctive and visually appealing environment that effectively conveys a clear spatial identity. Colours can evoke emotions, set the ambiance, and define the character of a space. Selecting materials, safety, and durability are paramount to ensure the design's longevity and integrity. Additionally, choosing customer-friendly materials enhances the user experience and ensures comfort and convenience. Integrating architectural motifs into the design can be a powerful way to communicate spatial meaning and tell a story about the space's identity. These motifs can add cultural, historical, or symbolic significance, enriching the overall design and creating a more engaging and meaningful user experience.

The results from the analysis, based on the data collected from the sample, reveal various opinions and suggestions. This is because the sample group, which includes both design experts and hotel users, possesses different backgrounds and experiences with hotel rooms, making it challenging to design a one-size-fits-all solution (Nasar, 1994). People's preferences vary, with some focusing on usability, while others prioritize the atmosphere of the place. These differences often correlate with factors like the age of the sample group and the expertise of the design experts (Winschiers-Theophilus et al., 2012). However, despite these variations, most participants have a consensus regarding the design's role in effectively communicating spatial identity.

The design guidelines established through this research contribute significantly to creating a spatial identity for cultural tourism, as exemplified in small hotels within Chanthaburi Province. These guidelines can serve as a valuable reference for designing other small hotels, enhancing customer awareness, and promoting the hotel's image in different regions (Allen & Ferrand, 1999). Customer satisfaction is greatly influenced by the physical environment surrounding them, such as furnishing, function setting, business equipment, and other tangible evidence like signs and symbols (Hoffman & Bateson, 2006). In other words, environments are more than physical (Rapoport, 1977). Meaning and identity are often expressed through various elements such as signs, materials, colours, forms, sizes, furnishings, lighting, and finishes. All contribute to the expression of meaning and style within the space. By understanding and leveraging these elements effectively, designers can create immersive and meaningful experiences for the users of the hotel spaces.

Notwithstanding, this research was conducted in accordance with the designed study and research procedures, which is considered a good part of the research, suggesting the design determinants of the physical environment convey the identity of Chanthaburi Province. Suppose the results of this research are to be used. In that case, similar contexts are needed, or more in-depth studies on other factors are required from this research or analysis of the physical environment that affects the perception of consumers with different tastes in each

group, such as the conservative group and groups like a luxury, etc., to attract and influence the perception of consumers in each group with more different tastes. That may extend the results in the broader area and analyse and show the relationship more rationally, leading to further knowledge development.

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SPATIAL EXPERIENCE PSYCHO-BEHAVIORAL INCLINATION MODEL AND PUBLIC SECTOR CONDUCIVE ECOSYSTEM DIMENSION TOWARDS ORGANIZATIONAL COMMITMENT IN NAVAL BASE

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Abstract
The psycho-behavioral impact of spatial experience has been extensively evaluated, but little is known about the impact of organizational commitment orientation towards the Public Sector Conducive Ecosystem context. The primary issue in this study is the lack of pro-psycho-behavioral orientation toward organizational commitment in the Royal Malaysian Navy (RMN). This study aims to achieve the following: To investigate the relationship between spatial experience and psycho-behavioral inclination; to formulate the contextual relationship between spatial experience and psycho-behavioral inclination; and to develop a Psycho- Behavioral Inclination Model (P-BIM) of Spatial Experience association with Public Sector Conducive Ecosystem (EKSA) Dimension Towards Organizational Commitment. This study will employ a mixed-method approach that combines qualitative and quantitative data in the following ways: Phase 1: Content Analysis and Literature Review; Phase 2: Assessment of the characteristics of EKSA dimension in practice; Phase 3: Assessment of general psycho- behavioral inclination; and Phase 4: Assessment of Spatial Context and Modelling of multi- directional associations between spatial experience and psycho-behavioral inclination. P- BIM of Spatial Experience will contribute accordingly to the following: Fulfill the RMN's mission to enhance and create Navy People's satisfaction, belonging, and commitment; Improve the spatial planning quality in the direction of a healthier spatial experience for the relevant stakeholders; Promote the psycho-behavioral disposition of Navy Officers and reduce RMN training and disciplinary costs. Pro psycho-behavioral officer can contribute to the lower dismissal/disciplinary among Navy Officers and the model will assist government policies and agendas to achieve a more balanced social, environmental, and health well-being.

Keywords: *Spatial experience; Psycho-behavioral; Public-sector; Organizational commitment; Naval Base*

INTRODUCTION

The Royal Malaysian Navy force (RMN) is the military constrain and has been given the duty to defend the country's sway and national security. In this manner, the command given to the RMN must be carried out with the most noteworthy sense of polished skill, which is vital to guarantee that the sway of the nation is protected (Rusland, Jaafar et al., 2020). The Malaysian Naval force (RMN) is the military constrain and has been given the duty to defend the country's sway and national security. In this manner, the command given to the RMN must be carried out with the most noteworthy sense of polished skill, which is vital to guarantee that the sway of the nation is protected.

The position of this obligation is advanced as it were when everybody receives a center esteem of personality from the starting of their business with the RMN. The position of this spatial experience in physical environment obligation is advanced as it were when everybody receives a center esteem of personality from the starting of their psycho-behavioral inclination

with the RMN (Aun and Aziz, 2021). As an organization, the RMN is similar to other organizations in a sense that it tries to see after its authoritative, coordination's, and properties as well as performing its work of protecting the nation (Inderjit, Mohamed et al., 2022).

Since of the peculiarity of Public Sector Conducive Ecosystem its benefit, the human capital is one of the fundamentals in creating human assets for future arranging organizational commitment other than the conventional work and holding its resources within the most noteworthy of status toward the world-class naval force (Inderjit, Mohamed et al., 2021). The RMN comprises of three central branches; official, supply, and building for the officer and men to develop Psycho-Behavioral Inclination.

The administrators are the RMN mariners who are mindful for the exercises of the RMN, counting security route of ships, gunnery operations, and communication in physical environment that affect psycho-behavioral inclination. The supply covers the monetary, calculated, and acquirement perspectives such as apportions whereas the psycho-behavioral inclination is dependable for overseeing the RMN resource upkeep arrange. The military benefit is unmistakable from that of other respectful workers in Malaysia. Whereas open hirelings are anticipated to serve until retirement age, military officers and others rank have the alternative of clearing out the benefit after 10 a long time of benefit (without a benefit and a short-term service) or some time recently the age of 60 (Prakash and Angamuthu, 2022).

LITERATURE REVIEWS

Psyco-Behavioral

The psycho-behavioral impact of spatial experience has been extensively evaluated, but little is known about the impact of organizational commitment orientation towards the context of the Public Sector Conducive Ecosystem. The primary concern of this research is the Royal Malaysian Navy's (RMN) lack of pro-psycho-behavioral orientation toward organizational commitment. This research seeks to accomplish the following: To investigate the relationship between spatial experience and psycho-behavioral inclination; to develop the contextual relationship between spatial experience and psycho-behavioral inclination; and to create a Psycho-Behavioral Inclination Model (P-BIM) of Spatial Experience association with Public Sector Conducive Ecosystem (EKSA) Dimension Towards Organizational Commitment. This investigation will employ a mixed-methods strategy that integrates qualitative and quantitative data in the following ways: Phase 1: Content Analysis and Literature Review; Phase 2: Assessment of EKSA dimension characteristics in practice; Phase 3: Assessment of general psycho-behavioral inclination; and Phase 4: Assessment of Spatial Context and Modelling of multi-directional associations between spatial experience and psycho-behavioral inclination. Accordingly, P-BIM of Spatial Experience will contribute to the following: Fulfill the RMN's mission to increase and foster Navy People's satisfaction, loyalty, and sense of belonging; Enhance the quality of spatial planning towards a healthier spatial experience for the relevant stakeholders; Reduce RMN training and disciplinary costs and improve the psychological disposition of Navy officers. Pro psycho- behavioral officer can contribute to a reduction in Navy Officer dismissal/discipline; The model will assist government policies and agendas in achieving a more balanced social, environmental, and health well-being.

Spatial Cognition and Environmental Perception

Ittelson (1978) noted that environmental psychologists emphasized the understanding of how individuals respond to daily complex contexts. Individual's awareness level, degree of adaptation, and essential selectiveness in attentiveness to environmental signals in complex actual settings indicate that a person may overlook important elements of a setting, resulting in detrimental effects on well-being or safety (Stamps, 2005). Humans frequently perceive and interpret comparable situations differently due to certain and cultural differences in perception of the environment. The theory of probabilistic functionalism (Brunswik, 1956), the theory of affordances (Gibson, 1976), the theory of correlative properties (Berlyne, 1974), and the phenomenologist's approach (Seamon, 1982) are significant approaches to understanding how people "read" their environment. Human intelligence processing differs from mechanical information processing, according to spatial cognition scholars (Lynch & Rivkin, 1959), but it is effective in general. However, according to Perissinotti and Portnoi (2016), spatial cognition heuristics that ordinarily function may occasionally result in errors. The distinct points of departure for theories of spatial cognition are the environment itself, cognitive development, and brain physiology. Certain of the most valuable applied research has resulted in improved circulation and way-finding in buildings and transitional spaces (Levine, 1982) and in assisting the disabled to navigate way-finding more easily (Passini et al., 2000). Humans utilize the physical spaces within their bodies in accordance with complex norms and compelling preferences. Despite the fact that these norms and preferences are sometimes unconscious, their significance becomes immediately apparent when they are compromised.

Pro Psycho-Behavioral Inclination

Numerous environmental setbacks are inherent in human behavior and can be mitigated by encouraging environmentally conscious behavior (Gardner & Stern, 2002). Efforts to improve spatial experience condition through behavioral changes will be more effective if the following factors are identified: behavior that significantly influences contextual property, which features cause these behaviors, and interventions that modify these antecedents and behavioral aspect (Geller, 2002; Steg & Vlek, 2009). Important to psycho-behavioral disposition are behavioral factors that influence contextual impact. In deciding which factors should be targeted to promote pro-psycho-behavioral, it is crucial to comprehend which factors promote or inhibit pro-psycho-behavioral. In contextual psycho-behavioral research, there are two categories of individual stimuli to employ: perceived costs and benefits, and normative concerns.

The theory of planned behavior (Ajzen, 1991) assumes that individuals prefer alternatives with the highest benefits and the lowest costs, be they monetary, effort-related, or socially sanctioned. The theory posits that an individual's behavior stems from their intentions. Intentions that are proportional to the degree to which behavioral engagement is positively appraised and are influenced by attitudes toward the behavior. The theory also addresses social norms, which represent the social pressure exerted by others to engage in a particular behavior, and the perceived control of one's behavior, which reflects the individual's beliefs regarding his or her ability to execute the behavior. (Harland et al., 1999; Heath & Gifford, 2002) The Theory of Planned Behavior was effective in explicating various categories of pro-psycho-behavioral such as job satisfaction, performance, commitment, and other general pro-

psycho-behavioral aspects. Typically, a pro-psycho-behavioral act- inclination is associated with increased efforts and expenses. Thus, it is believed that normative and moral concerns play a significant role in pro-psycho-behavior. In actuality, people are more likely to engage in pro-psycho-behavioral acts when they subscribe to organizational values that are self-transcendent, unselfish, and biosphere, whereas self- enhancement or egoistic values are negatively associated with non-committed psycho- behavior.

The Norm Activation model (Schwartz, 1977) and the theory of value-belief-norm (Stern, 2000) propose that individuals act pro-psycho-behavioral when they perceive a moral obligation to do so. It depends on the degree to which humans are concerned about the setbacks caused by negative behavior, feel culpable for these setbacks, and seek to find a remedy for them. Further, the value-belief-norm theory suggests that the problem of awareness is embedded within the values and concerns of an organization. Both theories are effective in explaining low-cost psycho-behavioral and positive intentions, such as behavioral change willingness, political behavior, self-belongingness, and policy acceptability (Garling, Fujii, Garling, and Jakobsson, 2003; Nordlund and Garvill, 2003; Steg, Dreijerink, and Abrahamse, 2005).

Cialdini, Kallgren, and Reno (1991) establish two categories of social norms: injunctive-norms and descriptive-norms. Injunctive-norms refer to the range of behavior presumed to be normally accepted or objected to, while descriptive-norms refer to the degree to which behavior is recognized as standard practice. The most prominent norm has the greatest effect on behavior. In actuality, humans are more likely to transgress a particular norm if others do so as well (Cialdini et al., 1991). Moreover, when norm violations spread, for example, when other humans perceive that a certain norm has been violated, they are more likely to violate other norms, indicating that norm perceptions violations reduce the probability of normative behavior in general (Keizer, Lindenberg, & Steg, 2008). Numerous researchers have combined concepts and variables from various theoretical models or frameworks, indicating that behavior is influenced by a variety of motives. The theory of goal-framing (Lindenberg & Steg, 2007) acknowledges unequivocally that multiple motivations contribute to behavioral outcomes. The goal-framing theory identifies three aims or goals that frame the manner in which humans manage information and act towards it: a hedonistic goal-frame "to feel better right now," a gain goal-frame "to safeguard and improve one's resources," and a normative goal-frame "to act appropriately." In a given situation, one of these goals is presumed to be the focal one (it is the goal-frame), while the other goals serve to strengthen or weaken the focal goal.

Psychologists in the environmental sector play a crucial role in the management of environmental setbacks by promoting behavioral change. Psycho-behavioral interventions are typically more effective and successful when they are meticulously designed, implemented, and evaluated. By adopting pro-environmental behavior models, each individual can substantially contribute to the achievement of ongoing environmental sustainability goals. In order to facilitate all-inclusive pro-environmental behavioral inclinations, environmental psychologists face the challenge of understanding the individuals and fundamental factors and causes that impede environmentally sustainable agendas.

Public Service Conducive Ecosystem (EKSA)

Public Service Conducive Ecosystem (EKSA) was introduced in January 2014 as an initiative to rebrand 5S Practice in the public sector to make it more applicable to public sector agencies in Malaysia. The re-branding effort was appropriate and parallel to the current requirements transformation in order to elevate and foster competition among public sector agencies. It is also to inculcate a culture of creativity and innovation within the agencies. EKSA for Malaysian public sector agencies consists of the following five dimensions:

Corporate Image

Corporate image refers to the identity or perception of an organization's end-users or constituents regarding its actions and achievements. Creating a positive corporate culture requires that public servants share the same moral standards and work norms. In addition to this characteristic, EKSA emphasizes workplace safety in every public sector agency in Malaysia.

Creativity and Innovation

In order to increase workplace productivity, EKSA encourages citizens of public sector agencies to incorporate creativity and innovation into the execution of their duties. Changes in the public sector environment necessitate the establishment of a dynamic organizational culture founded on inventiveness and originality. Citizens in the public sector are also encouraged to "think outside the box" in order to create a safe and conducive work environment.

Green Practice

Emphasis is also placed on the green practice aspect of the office by instituting sustainable campaigns, such as the recycle program, and increasing energy consumption efficiency in an effort to conserve resources. Green Practice activities are integrated into all public sector agencies in an effort to maximize resource consumption.

Conducive Environment

In the public sector, a conducive working environment is crucial for bolstering high prestige organization cultures and fostering innovation. EKSA practices encourage and emphasize public sector customer service systems. In addition, it emphasized customer comfort when interacting with public sector counter service. For customers with special requirements and disabilities, suitable accommodations must be made.

Diversity in Agencies

EKSA also introduces new evaluation and auditing models that incorporate both generic and specific criteria, taking into account the varying service offerings of government agency locations. The previous practice of "one size fits all" was deemed inadequate for measuring the needs and differences of contemporary public sector organizations.

Royal Malaysian Navy Core Values

The Royal Malaysian Navy (RMN) has been entrusted with the responsibility and authority to protect national sovereignty and security. To ensure that the country's sovereignty is maintained, the RMN's mission should be carried out to the fullest extent. In addition, this responsibility is only promoted if each citizen embraces a core value of identity at the outset of their service in the RMN in order to maintain the integrity of the RMN's core values within themselves.

The significance of a sense of belonging within the RMN's core values and job satisfaction as a significant predictor of significant outcomes in the RMN. Moreover, belonging offers a multifaceted, person-centered, and dynamic approach that avoids reifying social structures and instead depicts them as actively lived (Vanessa, 2011). Thus, a focus on belonging enables a dynamic examination of the mutual influence between self and society, as well as of the ways in which everyday practices are both regulated and creative, and therefore conducive to social transformation. A sense of belonging can be potent because it is associated with life value and the capacity to acquire coping skills such as job satisfaction. Therefore, officers who do not receive their required equipment may experience decreased job satisfaction. In the past, there has been no empirical evidence for this issue; therefore, it is recommended that this issue be investigated further.

A sense of affiliation has a positive effect on many other aspects of our lives throughout the remainder of our developmental years and life cycle. When we have a sense of belonging, many aspects of our lives improve, including our intelligence, social skills, mental health, physical health, and motivation. A person has a sense of affinity when they feel accepted and supported in a variety of social settings. Lack of belongingness requirements can lead to feelings of job, social, and loneliness isolation. Thus, a sense of belonging can precede social connectedness and the desire for positive and enjoyable social interactions. An interpersonal bond characterized by stability, affective concern, and continuation into the predictable future also satisfies the need for belonging (Henri, 2016).

This interaction with other individuals is necessary to satiate the need to belong. They also propose that people with strong social relationships should pursue and form fewer additional bonds than those with weak social relationships. Kelly (2010), some individuals with a low need to belong may be content. Mahmood (2011) defines job satisfaction as a pleasant or positive emotional state that results from the evaluation of one's job or workplace experiences. Newstrom (2011) defines it as a collection of positive or negative sentiments and emotions that employees associate with their work.

Job satisfaction is a crucial facet of an employee's well-being and consists of emotional, cognitive, and behavioral factors. Emotional aspect refers to one's sentiments regarding the job, cognitive aspect refers to one's thoughts and beliefs regarding the job, and behavioral component refers to one's actions regarding the job (Zaim et al., 2012). Thus, job satisfaction is directly related to the degree to which our personal expectations of work outcomes are met. And because job satisfaction is essentially an attitude toward the job, theories previously discussed regarding attitudes are applicable to job satisfaction.

The need for belonging can help explain a wide range of human behavior, cognitive, and motivational processes, as well as emotions. Individuals may, for instance, explain their behavior in terms of their need for belonging. The fulfillment of this need results in the experience of positive emotions such as happiness and joy, whereas a deficiency can result in the experience of negative emotions such as anxiety, jealousy, depression, elevated levels of stress, and loneliness. Lack of affiliation explains numerous negative behavioral, psychological, and social outcomes, including mental illness, criminal propensity, and social isolation. Maslow (1968) suggested that underneath the majority of emotional breakdowns is a need for belonging, affection, and respect.

Motivation is an internal force that inspires an individual to do or want to attain a goal. Motivation can also be described as a strategy or desire to achieve success and avoid disaster in life. In other words, motivation is the process of generating energy that is directed toward the accomplishment of an objective. A person who is motivated has the willpower to attain excellence and success in their lives. In one organization, motivation contributes to the group's success.

In organizational work administration, the motivational factor of employees is regarded as the most significant factor. Motivation is an incentive that generates interest and sustains a person's drive to accomplish a goal. Even if a person has superior talents and abilities compared to their peers, they are ineffective if they are not highly motivated by the work they are performing. Valid self-actualization requires interaction with another individual. If a person is accepted by another individual, he will embrace himself. Self-actualization can influence an individual's responses to life's obstacles. While self-esteem refers to the approval or rejection of oneself by an individual. High individual regard for him enables him to always overcome personal setbacks and deal with life's challenges.

In addition, the RMN core value is a source of moral fortitude that shapes the attitude, manner, and living culture in support of the organization's mission and vision. In fact, core values are also applied to daily existence at all times and in all situations. Consequently, this fundamental value is regarded as an essential RMN principle. The true purpose of this core value is to serve as a guide in shaping the self-image of Navy personnel, as well as to assist them in performing their duties with excellence and contributing to the enhanced performance and success of RMN. It is extremely difficult to produce quality officers if the RMN's fundamental values are not ingrained in the officers themselves.

PROBLEM STATEMENT

Little is known about the impact of organizational commitment inclination towards Public Sector Conducive Ecosystem dimension context, such as corporate image, creativity & innovation, green practice, conducive environment, and diversity in agency on the psycho-behavioral of navy people (Yaman et al., 2019; Lee et al., 2018; Caffaro et al., 2018). The psycho-behavioral impact based on spatial experience has been widely assessed. The theory that the spatial experience can offer inclination repercussions for people's psycho-behavioral (2018) is supported by the term "the spatial context and experience affects people's mental and behavioral inclination" written by Khazanchi. Douglas et al. (2017) state, concerning the built environment, that "urban policy has failed to provide specific design guidance for health & well-being." "The environment shapes our experience of space in constant interaction with

the body," writes Pasqualini (2018). "Architectonic interiors amplify the perception of space through the bodily senses; an effect that is also known as embodiment."

The absence of, or lack of a pro-psycho-behavioral predisposition toward, organizational commitment in the Royal Malaysian Navy, and more specifically among the Navy Officers, is the primary concern raised by this study. A stress score of 72.74% places working for the military as the most stressful occupation of 2017, as reported by Human Resource Online (2017). The empirical statistics demonstrate that the dismissal of the navy officer from 2014 to 2018, naval officers with ranks below that of Lieutenant Commander have opted to leave the service when their credentials for the short time have expired credential. The Royal Malaysian Navy is a branch of the Malaysian armed forces that has the slogan "ready to sacrifice" and requires a high level of spirit in all parts of its operations. As a result, it necessitates having a heroic attitude of complete appreciation and empowerment when carrying out a trusted task. These kinds of behaviors and attitudes have been shown to be on the decline in recent times. Even while it is under control at the moment, if it is not brought under control as soon as possible, it has the potential to destroy the identity of the military and the spirit of organizational dedication.

To understand the pro-psycho-behavioral challenges towards organizational commitment in military organizations, it is essential to have a joint call for interdisciplinary researchers' team by coordinating the multi-directional associations specialist between built environment, military organization, and social scientist. In particular, when analysing the characteristics of the spatial experience and the contextual environment (i.e., corporate image, creativity and innovation, green practice, conducive environment, and diversity in agency) and their potential relation to positive psycho-behavioral inclination towards organizational commitment.

HYPOTHESIS

The spatial experience as a predictor of psycho-behavioral predisposition towards organizational commitment (corresponds to specific Public Sector Conducive Ecosystem characteristics of corporate image, creativity & innovation, green practice, conducive environment, and variety of agency).

RESEARCH QUESTIONS

In light of the problem and the theory that have been presented thus far, the following research questions have been developed:

a) Why does spatial experience in physical environment effect psycho-behavioral inclination?
b) How the spatial experience of corporate image and creativity & innovation effect psycho-behavioral inclination (negative or positive towards organizational commitment)?
c) How the spatial experience of green practice, conducive environment and diversity of agency contribute to psycho-behavioral inclination (negative or positive towards organizational commitment)?

RESEARCH QUESTIONS

This study aims to address the following objectives:

a) To examine the correlation between spatial experience and psycho-behavioral direction.
b) To determine the contextual relationship between spatial experience (corporate image, creativity & innovation, ecological practice, a conducive environment, and diversity of agency) and psycho-behavioral (negative or positive organizational commitment) variables.
c) To develop a Psycho-Behavioral Inclination Model (P-BIM) of Public Sector Conducive Ecosystem dimension associations between spatial experience and psychological inclinations.

SCOPE AND LIMITATION OF STUDY

In this research, the question of what aspects of a person's spatial experience in their physical environment affect their behavioral inclination was investigated. This research only looked at one aspect of the problem, which was how spatial perception is affected by one's physical surroundings. This is the study's primary limitation. Therefore, it was recommended that further research be done in the future on the question of what the difficulties were that were experienced by all TLDM employees in Malaysia during the COVID-19 pandemic.

On the other hand, the purpose of this research was to collect data, and it chose only one group – health care staff – from which to do so. The population was relatively small, as there were only 168 people who participated in the survey. These occurrences are evidence of prejudice in data collection, as the researcher only collected information from a single group. (TLDM staff). Because of this, it will be necessary in the near future to carry out research across the entirety of Malaysia in order to delve deeper into the study and acquire more information regarding this topic.

SIGNIFICANCE OF STUDY

The findings of this study will provide a new awakening to Malaysian researchers as well as the Malaysian defence ministry, which will allow them to use the findings of this study as a basis for further investigation into the question of what the level of satisfaction of TLDM residents is with regard to the implementation of the Quality Environment System.

All researchers in Malaysia may use the findings of this study as a reference to restructure their strategy in considering how the impact of the implementation of the Quality Environment System (EKSA/5S) on productivity, quality, and the work delivery system.

This study will give an appropriate action as suggestions on enhancing TLDM citizens on the impact of the implementation of the Quality Environment System as a new approach. "— " This study will give a proper action as suggestions."

This research can be used by academics to continue their investigation into the question of "How to develop Psycho-Behavioral Inclination Model based on Public Sector Conducive Ecosystem dimension in associations with spatial experiences."

In addition to this, every researcher in Malaysia is able to engage in methodical activities that lead to improvements in their understanding of the physical environment and their spatial experiences.

RESEARCH METHODOLOGY

The purpose of this research is to create a psycho-behavioral inclination model (P-BIM) of spatial experience and an ecosystem conducive to organization commitment (EKSA). This study will use mixed methods to collect qualitative and quantitative data (Figure 1).

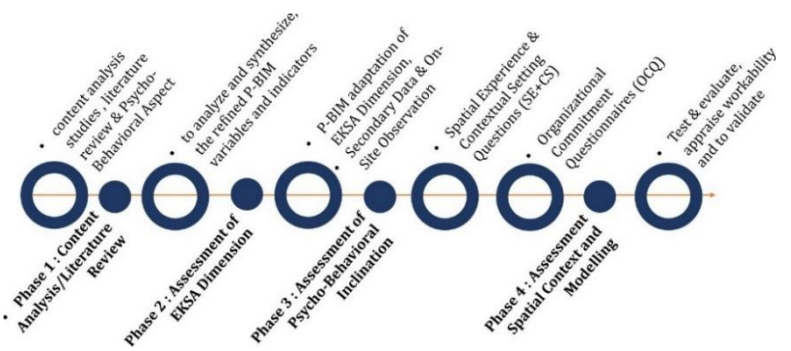

Figure 1. Research Method & Flowchart

Phase 1 – Content Analysis and Literature Review

Documents related to the study and background research are included in the content analysis. This analysis reveals the significance of the research as well as its limitations. As a result, comprehending all relevant information during content analysis will help to clarify the study. The literature review comes next in this study phase. Reading and citing written sources such as reference books, theses, magazines, journals, cuttings, clippings, and other materials. This project will investigate and learn from numerous existing examples in order to create a model for the Royal Malaysian Naval Base sector in Lumut.

Phase 2 – Assessment of the characteristics of Public Sector Conducive Ecosystem dimension in practice

a) Collection of secondary data Data on corporate image, creativity, and innovation (such as implemented policies and procedures at training and general data on green practises, conducive environments, and diversity in the case study agency will be collected from various departments and divisions in the Royal Malaysian Navy, specifically Wisma Suria, KD Sultan Idris 1.

b) Observation on-site According to Public Service Conducive Ecosystem (EKSA) aspects, the geographical context and physical environment of KD Sultan Idris 1 will be observed (corporate image, creativity and innovation, green practises, conducive environment, and diversity in agency). The scope of the study will serve as the

observation checklist. The site observation survey will use cameras and photos to assess the current condition and physical activity of the research areas. The use of a questionnaire survey and site observation is required to evaluate respondents' spatial context and physical settings (in relation to stage 3).

Phase 3 – Assessment of general psycho-behavioral inclination A new set of questionnaires survey will be used for the study to help inform further intervention in relations to the spatial context and physical environment by adaptation of questionnaires (a) and (b) below:

a) Adapted survey questionnaires based on Spatial Experience and Contextual Setting Questions (SE+CS) The Spatial Experience and Contextual Setting Questions (SE+CS-20) are used to quantify experiential learning based on Public Service Conducive Ecosystem dimensions. The SE+CS-20 is a brief, simple, and easy-to-complete set of five sets of questionnaires that consist of four questions for each dimension of the Public Service Conducive Ecosystem (EKSA). This instrument assesses inclination in navy personnel by focusing on two areas: the inability to perform normal duty and the appearance of non-commitment. Each item in SE+CS-20 is rated on four possible responses, which are typically "less than usual," "no more than usual," "rather more than usual," and "much more than usual. The binary method was used to score the SE+CS20: 0-0-1-1, where 0 represents the lesser two commitment severity options and 1 represents the greater two commitment severity options, yielding a score range of 0 to 12. Any score higher than 4 indicates a negative psycho-behavioural inclination or lack of commitment in the organization. A score of 4 or less indicates a pro- or positive psycho-behavioral inclination.

b) OCQ-based surveys. The Organizational Commitment Questionnaire (OCQ; Porter & Smith, 1970) is a widely used instrument for assessing affective commitment (Mathieu et al., 2000; Mathieu & Zajac, 1990). The OCQ item is a three-part construct that assesses employees' identification with and attachment to their organization (Meyer, Kam, Goldenberg & Bremner, 2013; van Dick, 2004). Three organization commitments are identified in this study: 1. Affective commitment demonstrates employees' emotions, 2. normative commitment demonstrates employees' moral obligation to the company, and 3. avoiding job changes motivates continuity commitment. OCQ contains 15 items. Each item is scored on a five-point Likert scale based on the frequency of the participants' experiences (1 = "completely disagree" to 5 = "completely agree"). Job satisfaction, performance, and commitment were all rated using self-description questionnaires. Job satisfaction will be measured on a five-point scale, with factors such as satisfaction with the direct superior and colleagues, opportunities for company development, workload, co-determination, the wage system, work contents, and company organization (e.g., breaks and holidays) all being taken into account. "How do you rank your performance in comparison to your colleagues'?" will be measured using a single- item scale. "Below average," "average," and "above average" are the seven response categories for navy officers. To determine commitment, flexibility, independence, innovation, teamwork, a desire for excellence, and quality, these attributes will be assessed. The Navy officer will be asked how much they actively realize each organization's value (on a five-point scale from 0 to 4 = "not at all").

c) Stratified random sampling is used. For KD Sultan Idris 1, Markas TLDM Lumut, a total of 167 samples (i.e., navy officers or end-users of the RMN Naval Base, which may include participants with or without psycho-behavioral inclination) will be collected with 95% confidence intervals (which will be confirmed after the pilot survey). Wisma Suria, KDSI 1, will be sampled because it represents the main aspects of the spatial experiences profile, namely the dimensions of the Public Sector Conducive Ecosystem dimension context, such as corporate image, creativity and innovation, green practices, a conducive environment, and diversity in agency. The questionnaire survey is stratified to represent the total population in the KD Sultan Idris 1 based on gender, age, education level, activity status (including recent life events), and dimension use location. SPSS software will be used to analyse the data.

d) Interviews and semi-structured face-to-face interviews will allow participants to openly express their thoughts on the urban physical environment and psycho-social behaviour (Vries & Aalvanger, 2015). Semi-structured interviewing is best for describing qualitative data from genuine events since it records "what people say (with words, gestures, and tone), observations of specific actions, studies of written documents, or inspections of visual images" (Newman & Robson, 2014). Thus, 20 interviewees will be randomly selected from 200 samples, depending on their psycho-behavioural tendency (OCQ and SE+CS 20).

Phase 4 – Assessment Spatial Context and Modelling of Multi-Directional Associations Between Spatial Experience and Psycho-Behavioral Inclination

Based on the results of stages 2 and 3, interaction variables will be established in order to investigate the potential psycho-behavioural benefits of spatial context. A multilevel growth curve model will then be used to assess cross-sectional, longitudinal, and directional links between spatial experience and psycho- behavioural tendency. This method models correlations between the starting point and two outcomes at the same time (Curran et al., 2010). Thus, using spatial and statistical methods, the effects of corporate image, creativity and innovation, green practises, a favourable atmosphere, and diversity in agency on the organisational commitment tendency of naval officers will be investigated. SEM, factor analysis, correlation/chi-square, and regression (SEM) KD Sultan Idris 1's demographics, commitment, perceived social support, and recent life events. The structural correlations between spatial experience factors/parameters, psycho-variables), tendency, and respondent commitment are evaluated using SEM, a multivariate statistical analytic method. This method incorporates factor analysis as well as multiple regressions. This method can estimate a number of interconnected dependencies in a single analysis, most notably the relationship between SE+CS 20 (outcome variable), psycho-behavioural inclination, and the spatial contextual environment (main explanatory variable).

ANALYSIS, DISCUSSION AND CONCLUSIONS

This study develops the best military psycho-behavioural inclination model. As mentioned in the introduction, the study's principal issue is early retirement or disciplinary dismissal. Due to the high expense of military officer training, taxpayer dollars have been wasted. Table 1 shows other rankings that quit early. This has drained public finances for military training.

Table 1. Statistics Dismissal of the Others Rank from 2015–2019

	Duration of Employment						
Years	**12**	**13**	**15**	**16**	**18**	**19**	**21**
2015	0	3	235	31	54	7	33
2016	204	200	116	43	3	7	522
2017	214	0	89	0	35	0	872
2018	168	0	82	0	18	0	281
2019	121	0	88	0	23	0	98
Total	707	203	610	74	133	14	1806

(Source: RMN Human Resource Department Report ,2019)

The research technique flow chart (Figure 1) addresses this issue by developing models rigorously. As a military theoretical framework, the Psycho-Behavioral Inclination Model (P-BIM) of Spatial Experience and the Public Sector Conducive Ecosystem (EKSA) Dimension towards Organizational Commitment will be explained. It is based on the cause- and-effect correlation of spatial settings and psychological fields. The Royal Malaysian Navy (RMN) will benefit from this research since it will assist in enhancing the level of happiness, belonging, and dedication felt by its sailors. In terms of the spatial experience and the physical surroundings, all agencies and stakeholders will stand to profit from the paradigm that has been offered. The realizations will, from a social point of view, lead to an improvement in the overall quality of stakeholders' spatial planning. It has an effect on the end-users' overall quality of life in the place. When determining the organizational influence of institutions that are publicly funded, it is essential to consider economic aspects. The RMN Human Resources report (2014–2018) states that there is reason for concern regarding the growing rate of Navy officers being discharged from their positions. This study enhances the psychological and behavioral tendencies of navy officers while simultaneously reducing the costs of RMN training and disciplinary actions. The pro-psycho-behavioral inclination paradigm minimizes the likelihood of early retirement or disciplinary dismissal by employees when end-users are devoted to the organization and have a sense that they belong there.

EXPECTED RESULTS AND BENEFITS

The purpose of this study is to present a theoretical framework for the military context, specifically focusing on the relationship between the Psycho-Behavioral Inclination Model (P-BIM) of Spatial Experience and the Public Sector Conducive Ecosystem (EKSA) Dimension in relation to Organizational Commitment. This framework is based on the cause-and-effect correlation between spatial settings and psychological fields. This research is expected to make contributions in the following areas:

a) The Royal Malaysian Navy (RMN) – is the naval branch of the Malaysian Armed Forces. The findings of this study will contribute to the fulfilment of the RMN's objective to enhance and foster contentment, sense of belonging, and commitment among Navy personnel. The proposed model will be presented to various Military Agencies and relevant stakeholders with the aim of enhancing the spatial experience and physical environment.

b) The social aspect - of a given phenomenon or topic is a crucial element to consider while analyzing or studying it. It refers to the interactions The results of this study

will enhance the quality of spatial planning, leading to a more beneficial spatial experience for the parties involved. The topic at hand pertains to the assessment of the stakeholders' quality of life.

c) The economic aspect - is a crucial component that warrants examination and analysis. According to the report published by the Human Resource department of RMN (2014- 2018), The Royal Malaysian Navy (RMN) has expressed worry on the increasing rate of dismissals among its officers. The findings of this study contribute to the promotion of psycho-behavioral inclinations among Navy Officers and the reduction of training and disciplinary expenses within the RMN.

d) Academia - Numerous publications are anticipated to be disseminated through academic journals and conference presentations, both at local and international levels. These platforms will facilitate the transmission of knowledge on a local and worldwide scale.

The purpose of this study is to create a psycho-behavioral inclination model for use in the armed forces, with a particular emphasis on the problem of early retirement or disciplinary dismissal. Incorporating the Public Sector Conducive Ecosystem (EKSA) dimension into the research with the intention of improving job satisfaction, a sense of belonging, and commitment among sailors in the Royal Malaysian Navy (RMN), the study will look at factors such as corporate image, creativity and innovation, green practices, a conducive environment, and diversity in agency.

The objective of this research is to develop a model of psycho-behavioral predisposition that can be implemented within the armed services. The subject of early retirement or disciplinary dismissal will be given particular attention as the focal point of this study. The research will incorporate the Public Sector Conducive Ecosystem (EKSA) dimension in order to improve job satisfaction, a sense of belonging, and commitment among sailors in the Royal Malaysian Navy (RMN). The study will look at factors such as corporate image, creativity and innovation, green practices, a conducive environment, and diversity in agency. The goal of the research is to improve job satisfaction, a sense of belonging, and commitment among sailors in the RMN.

The purpose of the proposed Psycho-Behavioral Inclination Model (P-BIM) of Spatial Experience is to study, from a cause-and-effect point of view, the link between psychological fields and spatial situations. This study proposes to improve the psycho- behavioral tendencies of navy officers, lower the expenses of training and disciplinary procedures, and boost organizational commitment in order to reduce the number of officers who retire prematurely or are fired for disciplinary reasons. This is of the utmost significance in view of the fact that the RMN Human Resources report (2014-2018) reveals that there has been a rise in the number of Navy officers who have been discharged. The report was conducted over the course of three years.

In addition to this, the research emphasizes the significance, from both an economic and an organizational point of view, of taking into account the impact that publicly financed institutions like the Royal Malaysian Navy have. Due to the high attrition rates of officers who leave their positions too soon, there is a load placed on the public money that are

allocated for military training. This burden comes in the form of a financial strain. Because of this, putting the findings of this research into practice could help strengthen the workforce of the navy and increase operational performance, hence decreasing the financial burden that is associated with attrition rates.

This study has the potential to improve the psycho-behavioral tendencies of Navy officers while simultaneously addressing the financial challenges associated with attrition rates because it focuses on the Public Sector Conducive Ecosystem dimension and incorporates elements such as corporate image, creativity and innovation, green practices, a conducive environment, and diversity in agency. In conclusion, this study has the potential to improve these psycho-behavioral tendencies because it focuses on the Public Sector Conducive Ecosystem dimension.

ACKNOWLEDGEMENTS

I am grateful to Kementerian Pengajian Tinggi, Universiti Teknologi MARA (UiTM) for funding this study under the FRGS Research Grant: FRGS/1/2019/SSI11/UITM/02/5, PS Universal Holding Sdn. Bhd. and International Islamic University Malaysia (IIUM).

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AN OUTDOOR TERRESTRIAL LASER SCANNER DATA QUALITY ASSURANCE: MINIMIZING POINT-BASED SELF-CALIBRATION NETWORK CONFIGURATION

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Abstract

Data quality assurance (QA) is a critical process to maximize the accuracy of terrestrial laser scanner (TLS) deliverables. Numerous errors augmented in TLS measurements have made that calibration procedure is crucial. Due to the atmospheric disturbances (e.g. temperature, pressure, and humidity), a priori calibration parameters have demonstrated less significant to the TLS QA. Hence, on-site calibration has become an option to resolve this limitation. However, reliance on features existence or surfaces for targets distribution has limited the existing on-site TLS calibration approaches for indoor implementation. Thus, this study has investigated a method that is applicable for outdoor on-site data quality assurance. Through point-based self-calibration, this research has systematically reduced the dimension of surfaces required to distribute all targets. The results obtained have demonstrated that with the surface dimension of 3.6m (width) x 1.2m (height) for targets distribution, derived calibration parameters can improve the accuracy of raw TLS data up to 57 percent. However, statistical analysis and synthetic errors experiment have indicated disagreement with calibration parameters derived for angular measurement. Through a significant effect experiment, the outcomes demonstrated that the minimum configuration for TLS self-calibration only applicable to derive errors in range measurement. The findings from multi-experiments concluded that the study has significantly quantified the sensitivity of minimum network configuration in deriving the TLS systematic errors through point-based self-calibration.

Keywords: *Data Quality Assurance; Network Design; On-Site Calibration; Quality Enhancement; Accuracy*

INTRODUCTION

Three-dimensional (3D) information has become an essential requirement for many purposes, especially on applications related to documentation, management, analysis and decision making. The ability to acquire dense 3D data with significant speed and accuracy have made terrestrial laser scanners (TLSs) become an option for numerous applications that demand sub-centimetre geometric quality. Among those applications are construction industry (Wu et al., 2022), structure health assessment (Korumaz et al., 2017), fracture detection (Cao et al., 2017), structural deformation measurements (Xu et al., 2018; Yang et al., 2018), stability analysis for hazardous natural features (Kromer et al., 2017), slope monitoring (Barbarella et al., 2017), and industrial measurements (González-Jorge et al., 2012; Popia, 2013).

Similar to any optical sensors, the acquired data can be augmented with errors contributed from numerous sources. The complexity of mechanism with swift movement borne by TLSs to acquire almost a million measurement points per second has made the data quality assurance procedure essential. Many researchers have presented their findings related to TLSs data quality assurance procedures which can be mapped as illustrated in Figure 1. In contrast

with the field-checking procedure that focuses on quantifying the accuracy of TLS measurement by disregard the element of errors, calibration attempts to enhance the quality of the TLS data by investigating the systematics errors (Staiger, 2007). In the abovementioned applications, improving the accuracy (by applying the calibration parameters) of TLS measurement is preferable, rather than checking the data quality.

According to Schulz (2007), component calibration is based on prior knowledge and understanding regarding the systematically errors that augmented in the instrument. The implementation is similar to tacheometry calibration, a specific experimental setup is required to investigate each systematic error. Böhler & Marbs (2005) have exploited components based on data quality assurance procedures to identify the best-suite application of the TLSs based on the capability to measure the edge and signal reflectivity. Meanwhile, Kersten and Mechelke (2008) have utilized this calibration approach to measure the accuracy of TLS using distributed fifty-three (53) reference points in the 3D test field at the Hafen City University, Hamburg with the dimension of 30m x 20m x 12m. As illustrated in Figure 1, it can be concluded that component calibration measures the calibration parameters separately based on the TLS measurement components. Due to the requirement of distinctive facilities and devices to carry out the procedures, component-based calibrations are only applicable at the specific calibration site or laboratory. In contrast, system calibrations are only employed to investigate systematic errors and able to be implemented at a laboratory or on-site. It can be performed based on two approaches which are either point-based or feature-based (as depicted in Figure 1). The first approach uses targets in which centroids can be determined and employed as input for self-calibration as applied by Lichti (2007), Abbas et al. (2015) and Medić et al. (2019). The latter approach has been developed by Chow (2014), Chan et al. (2015), Li et al. (2018) and Ge (2020) who have exploited the point cloud coordinates obtained from TLS on the surface of feature targets as input to the calibration.

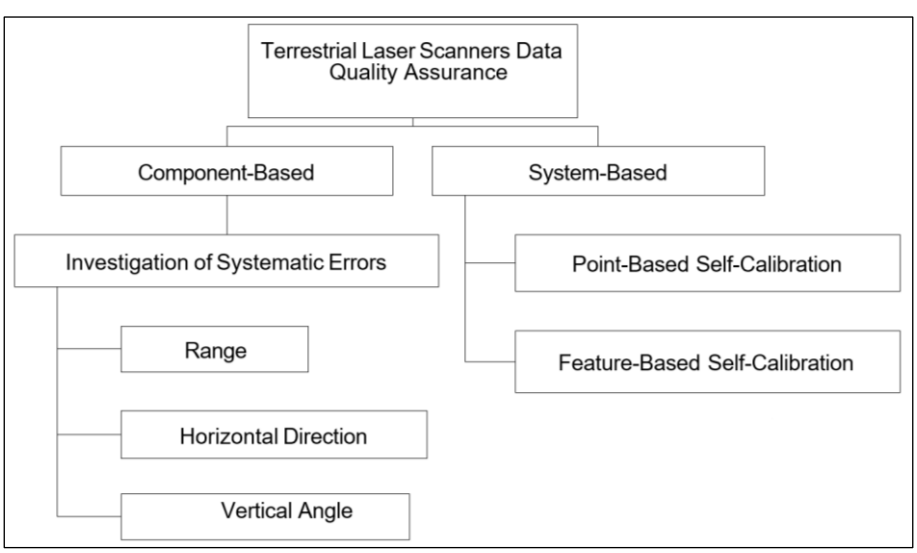
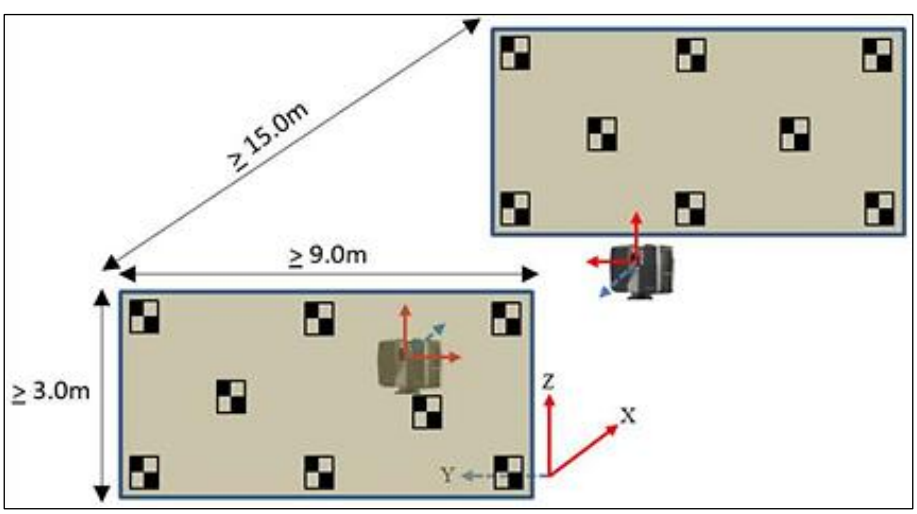


Figure 1. Calibration Procedures for Terrestrial Laser Scanner

Most of the researchers have carried out their calibration in the laboratory condition. This is due to the network configuration, facilities and devices required. Unlike the others, Schneider (2009) has performed calibration in both conditions, indoor and outdoor. His

findings have indicated that other than instruments, the systematic errors also can be influenced by the external measurement conditions (e.g., object distance, design of target, incidence angle, and the selected point density). This result supported the necessity of on-site data quality assurance. Furthermore, Medić et al. (2019) have clarified this argument through their findings, where the atmospheric factors (especially temperature) have exemplified significant uncertainties to the pre-derived calibration parameters. Due to the pre-requisite facilities and devices to implement component calibration, therefore, only system calibration is appropriate for on-site implementation. Feature-based calibration was developed to resolve the main limitation of point-based approach, which requires stringent configurations such as a massive number of well-distributed artificial targets and scanner stations (Lichti, 2007).

Bae and Lichti (2007) have stated that the feature-based calibration has demonstrated the ability to yield significant results as point-based and applicable for on-site implementation. However, the demand for well-distributed feature targets at the site has made the approach's suitability and reliability ambiguous. Abbas et al. (2014) have presented the minimum configuration to perform indoor on-site data quality assurance procedures. Even though the accuracy achieved is statistically similar to the ideal configuration but dependency on surfaces to distribute the targets and practicality to project the configuration into calibration frame (Figure 2) with a dimension of 3.0m (height) x 9.0m (width) have become the primary constraint of the enhanced method.



(Source: Abbas et al., 2017)

Figure 2. Minimum Configuration for Indoor On-Site Calibration

With the determination to improve the data quality assurance procedure developed by Abbas et al. (2014), this study has investigated any opportunity to reduce the configuration required. The experiments were designed by considering the stability and consistency of the accuracy obtained in each configuration. For benchmarking purposes, several verification points were positioned using close range photogrammetry (CRP) technique. With the aim to yield a configuration (smaller dimension than yielded in Abbas et al. (2014)) that is suitable to be projected into the calibration frame, experiments were performed by shrinking the dimension of the network dimension.

PREVIOUS STUDY

Intending to yield a TLSs calibration approach which capable of being implemented at the working site, previous research (Abbas et al., 2014) performed rigorous experiments. The reduction of configuration was systematically carried out to identify the least requirements for point-based calibration. Therefore, the final configuration will be more convenient that utilises less quantity of occupied scanners, real-world planes and targets. For that purpose, the previous study analysed three critical elements:

i. Determination of the least number of occupied scanner stations;
ii. Identification of the least number of real-world planes for the target's distribution; and
iii. Minimising the number of targets.

During the reduction of the abovementioned elements, the self-calibration bundle adjustment was performed in each configuration, and the raw TLS data were calibrated based on the modelled systematic errors. The accuracy of each configuration was assessed by measuring the discrepancies obtained from calibrated TLS data and reference values (acquire from CRP). The research findings found that with sixteen (16) number of targets, well-distributed at two opposite surfaces and scanned from two (2) scanner positions (as illustrated in Figure 2) are appropriate to obtained accuracy which is statistically similar to ideal configuration. According to Abbas et al. (2014), the proposed configuration was able to enhance the accuracy of calibrated TLS up to 50 percent and the accuracy discrepancy with ideal network configuration was very trivial (i.e., 0.3mm).

Similar to the feature-based self-calibration constraint, the existing on-site calibration approach was only applicable with the existence of real-world planes (e.g. surfaces or walls to distribute the targets) which constrained the approach for indoor on-site implementation (Abbas et al., 2017). Furthermore, projecting the proposed configuration by Abbas et al. (2014) (i.e., 3.0m x 9.0m) into calibration frame can be considered as not practical. Size of the frame will be very cumbersome and the mobility is impractical for TLS users. For that purpose, this study will scrutinize any possibility to reduce the indoor on-site point-based self-calibration configuration (Abbas et al., 2014) to enable it for outdoor on-site implementation. As a crucial priority in 3D data acquisition jargon, the experiment was carried out by ensuring that data quality is mathematically similar.

POINT-BASED SELF-CALIBRATION

Due to the similarity in measurement mechanism as well as observables yielded, thus, assumptions about the significant error model for terrestrial laser scanners have been made by most of the researchers based on errors augmented in reflectorless tacheometry (Lichti, 2007). Since the data measured by TLS are range (r), horizontal direction (φ) and vertical angle (θ), thus, the equations (1) and (2) are embedded with systematic error correction model, respectively as follows (Reshetyuk, 2010):

i. Based on coordinates system conversion from Cartesian to spherical.

$$r = \sqrt{x^2 + y^2 + z^2} + \Delta r$$
$$\varphi = tan^{-1}\left(\frac{x}{y}\right) + \Delta\varphi \quad (1)$$
$$\theta = tan^{-1}\left(\frac{z}{\sqrt{x^2 + y^2}}\right) + \Delta\theta$$

Where Δr, $\Delta\varphi$ and $\Delta\theta$ represent systematic error model for range, horizontal direction, and vertical angle, respectively (Lichti, 2007).

ii. Based on conversion from spherical to Cartesian coordinates system.

$$x = (r - \Delta r) \times \cos(\varphi - \Delta\varphi) \times \cos(\theta - \Delta\theta)$$
$$y = (r - \Delta r) \times \sin(\varphi - \Delta\varphi) \times \cos(\theta - \Delta\theta) \quad (2)$$
$$z = (r - \Delta r) \times \sin(\theta - \Delta\theta)$$

As employed in Reshetyuk (2010) and Abbas et al. (2014), this study focused on the four (4) most prominent systematic errors impaired in TLSs measurement: i) constant error (a_0); ii) collimation axis error (b_0); iii) trunnion axis error (b_1); and iv) vertical circle index error (c_0).

$$\Delta r = a_0$$
$$\Delta\varphi = b_0 sec\,\theta + b_1 tan\,\theta \quad (3)$$
$$\Delta\theta = c_0$$

Due to the use of a panoramic scanner (Faro Focus 3D) in this study, the mathematical model for horizontal direction and vertical angle in formula (1) should be modified as follows (Lichti, 2007):

$$\varphi = tan^{-1}\left(\frac{x}{y}\right) - 180° + \Delta\varphi \quad (4)$$

$$\theta = 180° - tan^{-1}\left(\frac{z}{\sqrt{x^2 + y^2}}\right) + \Delta\theta \quad (5)$$

METHODOLOGY

According to Abbas et al. (2014), the minimum requirement for TLS point-based self-calibration dimension is 3.0m (height) x 9.0m (width) x 15.0m (length). The dimension of walls required to distribute targets (as illustrated in Figure 2) is 3.0m x 9.0m, which is quite large to be projected into a calibration frame. With determination to resolve that issue, this experiment will manipulate the network configuration obtained in Abbas et al. (2014) by minimizing the dimension required to distribute targets, which eventually would be possible

to be projected into portable calibration frame. For that purpose, experiments have been designed into three phases, which are establishing verification points for benchmarking, investigation of minimum configuration for point-based self-calibration and statistical analysis to measure the reliability of the minimized configuration (refer Figure 3).

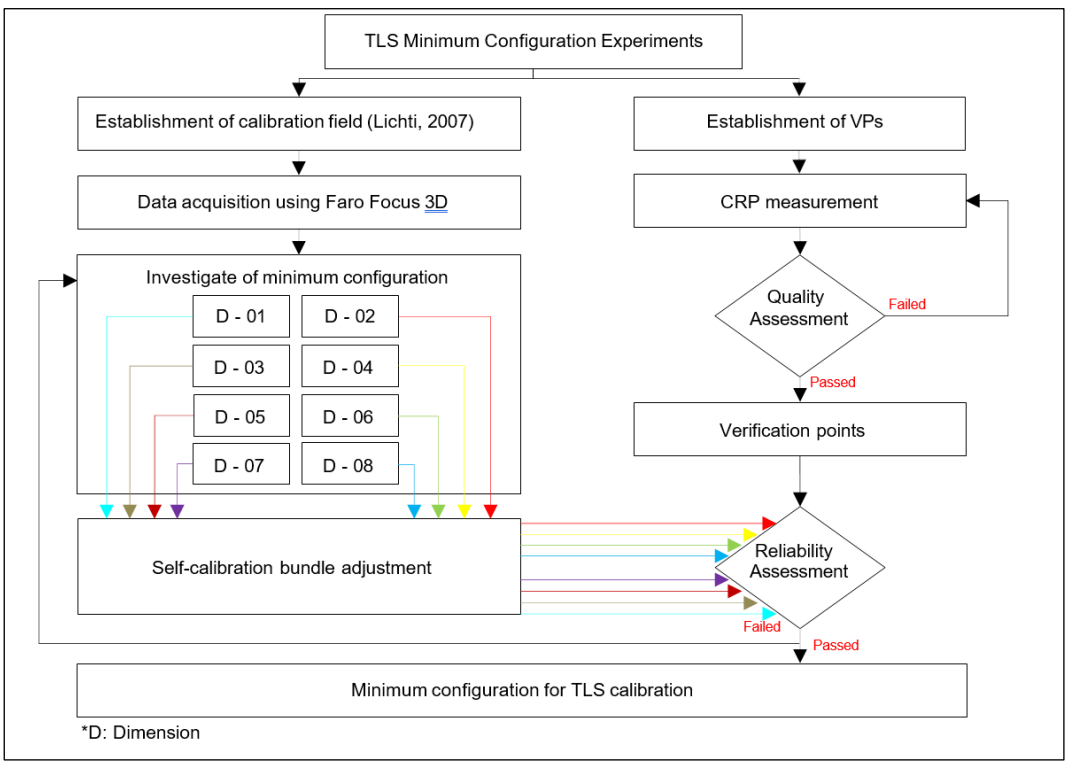


Figure 3. Procedure of The Research

Verification Points

At the first phase, seventeen (17) verification points (diamonds in Figure 4) were established at the experimental site using CRP technique. As stated in Luhmann et al. (2006), CRP measurement approach is capable of acquiring better than 0.1 mm accuracy which is applicable to be exploited as a benchmark for this research (that only expect for sub-centimetre accuracy). To concretely ensure on the quality obtained for the established verification points, two (2) scale bars were distributed at the opposite position (red and blue rectangle in Figure 5a). One was used as scale reference and another one acted as a quality measure. From seventeen (17) verification points, sixteen (16) independent vectors were generated to mathematically examine the quality of terrestrial laser scanner raw and calibrated data (yellow dashed line in Figure 4). The accuracies of both scanner data (i.e. raw and calibrated) can be computed based on discrepancies obtained from reference vectors (close range photogrammetry) and the 3D vectors yielded from TLS raw and calibrated data. Afterwards, those measured accuracies were exploited to examine the effectiveness of the proposed calibration procedure in enhancing the quality of TLS data.

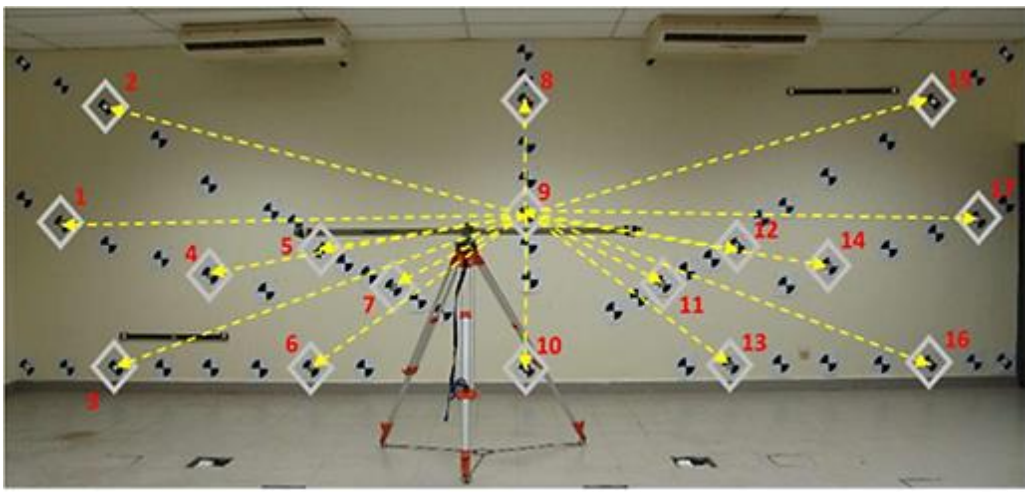
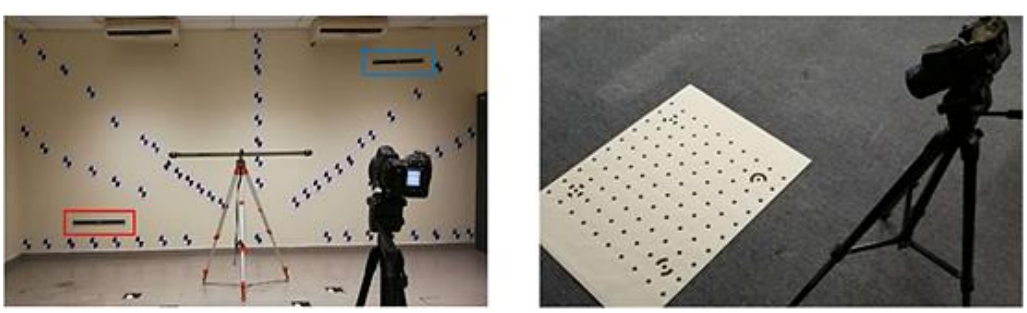


Figure 4. Distribution of Seventeen (17) Verification Points, Vectors and Scale Bars at Experiment Site

In order to establish the verification points, a digital camera (Sony DSC F828) with resolution of 8 megapixels and pixel size of 0.0027mm was utilised. For camera calibration and further image processing, Photomodeler Scanner 2013 software was employed. Figure 5 has illustrated the CRP process of data acquisition (Figure 5a) and camera calibration (Figure 5b) to establish reference values for verification points.



(a) (b)

Figure 5. Establishing Verification Points at Experiment Site (a) and Camera Calibration Using PhotoModeler Coded Targets (b)

Investigation of Minimum Configuration

Because the aim of this study was to determine the minimum network configuration for TLSs calibration, the first calibration had to include optimal design conditions as the benchmark for other network configurations. To do this, this study commences with the optimum dimension that was referred to Abbas et al. (2014) which is 9.0m (width) x 3.0m (height) and utilised two scanner positions (Figure 6). Each configuration requires sixteen (16) targets that were distributed at two opposite surfaces and this study utilised eight (8) dimensions making a total of hundred and twenty-eight (128) number of targets for investigating minimum configuration (refer Table 1). The positions and orientations of the scanner are as illustrated in Figure 2. To ensure that all targets were precisely scanned, resolution of Faro Focus 3D (panoramic scanner) was set as medium resolution (6.0mm points interval for 100m range).

Figure 7 shows the reduction of network configuration based on dimension that has been shrunk for every ten (10) percent until seventy (70) percent which will result in 2.7m (width) x 0.9m (height) dimension. To arithmetically verify the consistency and stability of the reduction process, pre-analysis has been performed for all dimensions. Computation of parameters precision can be obtained from the covariance matrix using formulation as shown below (Ghilani, 2010).

$$Q_{xx} = \sigma_0^2 (A^T W A)^{-1} \tag{6}$$

where:
Q_{xx} = Covariance matrix
σ_0^2 = Reference variance
A = Jacobian matrix
W = Weight matrix

Figure 6. Two (2) Scanner Position Used to Scan All 128 Targets at Experiment Site

Table 1. Multi-Configurations Utilized to Identify Minimum Dimension for TLS Self-Calibration

Configuration	Reduction Percentage	Dimensions		No. of Targets
		Width(m)	Height(m)	
Dimension 01	0%	9	3	16
Dimension 02	10%	8.1	2.7	16
Dimension 03	20%	7.2	2.4	16
Dimension 04	30%	6.3	2.1	16
Dimension 05	40%	5.4	1.8	16
Dimension 06	50%	4.5	1.5	16
Dimension 07	60%	3.6	1.2	16
Dimension 08	70%	2.7	0.9	16

A parametric least square adjustment and the data quality assessment as employed by Abbas et al. (2014) were carried out for each dimension reduction procedure. To acquire calibrated data, all calibration parameters derived from each configuration were augmented to the TLS raw data. The findings acquired from this study will determine the minimum configuration for outdoor on-site TLS calibration that able to model and reduce all significant systematic errors which eventually improve the accuracy of TLS measurement. As additional verification, synthetic errors (i.e. a_0, b_0, b_1 and c_0) will be introduced into TLS raw data (refer Table 2) to examine the sensitivity of the configuration to model the systematic uncertainties. Disregard the capability of the computed parameters to increase the quality of TLS measurement that may be due to fortunate circumstances, derived synthetic errors will concretely demonstrate the robustness of the configuration.

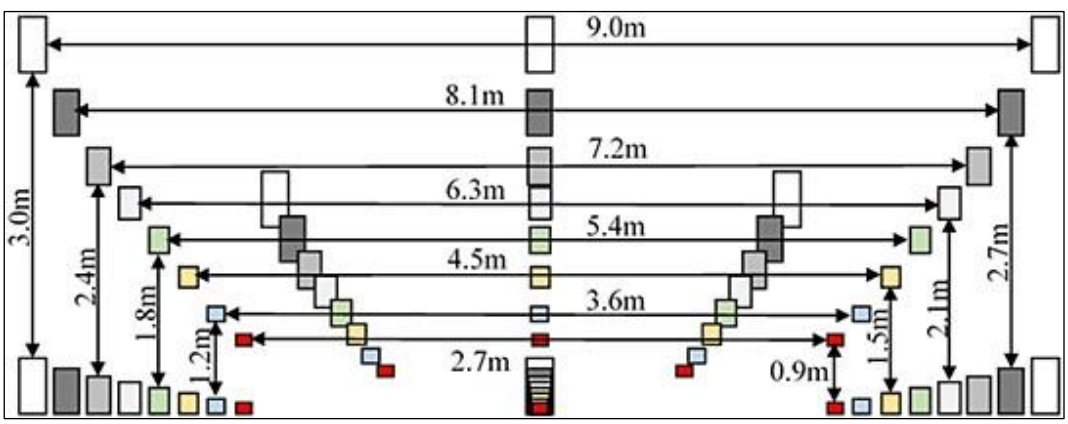


Figure 7. Reduction of Network Configuration Based on Dimensions

Table 2. Synthetic Errors Augmented into TLS Data

Calibration Parameters	Magnitude (mm/")
Constant error (a_0)	10
Collimation axis error (b_0)	30
Trunnion axis error (b_1)	30
Vertical circle index error (c_0)	30

Statistical Analysis

The crucial element of this research is to robustly validate the similarity of the derived systematic errors (i.e., a_0, b_0, b_1 and c_0) obtained from minimising configuration with respect to Abbas et al. (2014) configuration. Ghilani (2010) did mention that t distribution was utilised to equate the mean values obtained from population and sample set regarding the number of redundancies. In this case, this test was therefore appropriate to evaluate the computed calibration parameters from others configuration (sample mean) against the reference parameters (population mean) yielded from Abbas et al. (2014) configuration. The analysis of t-test can be performed using formula (Ghilani, 2010):

where:

$$t = \frac{\bar{y} - \mu}{S/\sqrt{n}} \quad (7)$$

$\bar{y}$ = Computed parameter from others configuration.
μ = Reference parameter.
S = Precision of sample.
n = Number of sample.

The hypothesis employed for this the test is:

H_0: The computed calibration parameter is equal to reference parameter.
H_A: The computed calibration parameter is not equal to reference parameter.

The alternative hypothesis (H_A) will be accepted if the calculated t value (formula (6)) is larger than the tabulated t value (obtained from the t-distribution table) with the selected confidence level. Rejection of H_0 indicates that the computed scale factor is statistically different with ideal value (acceptance of alternative hypothesis, H_A).

RESULTS AND DISCUSSION

With the aid of a CRP technique, accurate seventeen (17) number of verification points were successfully established. As depicted in Figure 8, the most significant root mean square (RMS) residual for all verification points is 0.690 pixel. As the pixel size is equal to 0.0027mm, the maximum residual obtained for the verification points is only 0.002mm. In Photomodeler Scanner 2013 software, residual represents the discrepancies of the targets manually marked by the user, on the images. As depicted in Figure 9, it is the difference between where the user marked it and where the program expects it to be.

To concretely ensure on the accuracy of the established verification points, the discrepancy of actual and measured values of scale bar (blue rectangle) has been exploited as depicted in Figure 5a. The result from scale bar assessment has demonstrated that verification points produced from close range photogrammetry technique have 0.10mm accuracy which is applicable to be regarded as reference values in this study.

To investigate the minimum configuration in TLSs calibration, the experiments have been performed by reducing the dimension of the target's distribution area (Figure 7). As presented in Table 1, from dimension 01 as employed by Abbas et al. (2014), the dimension was deducted for every ten (10) percent until seventy (70) percent (dimension 08). Acquired data for all dimensions have been processed using self-calibration bundle adjustment algorithm, however, for the last configuration which has the dimension of 2.7m (width) x 0.9m (height), the iteration did not converge. As expected, this may be due to the geometry of targets distribution is too narrow and weak. Hence, further discussion and investigation only focused on dimension 02 until dimension 07, while dimension 01 was exploited as a benchmark.

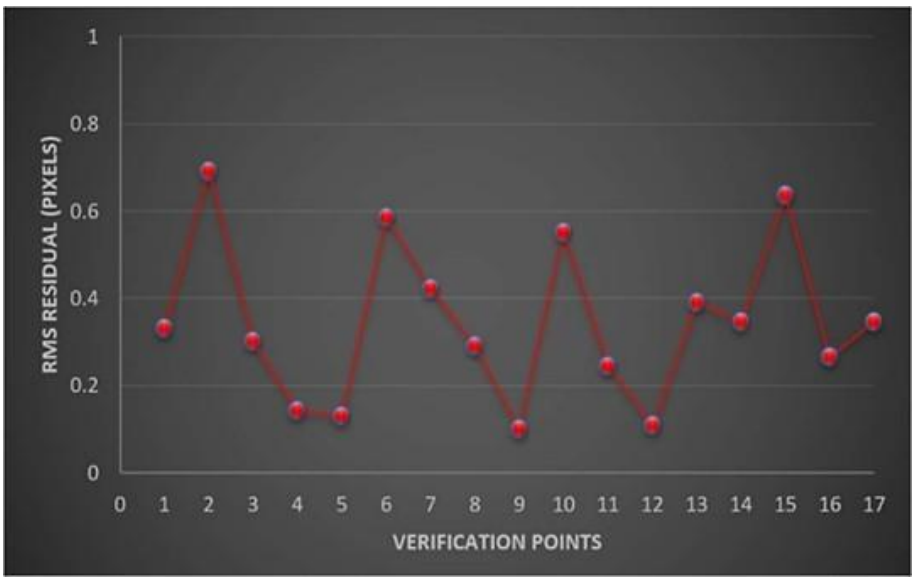


Figure 8. RMS Residual of Verification Points Obtained from Close Range Photogrammetry Measurement

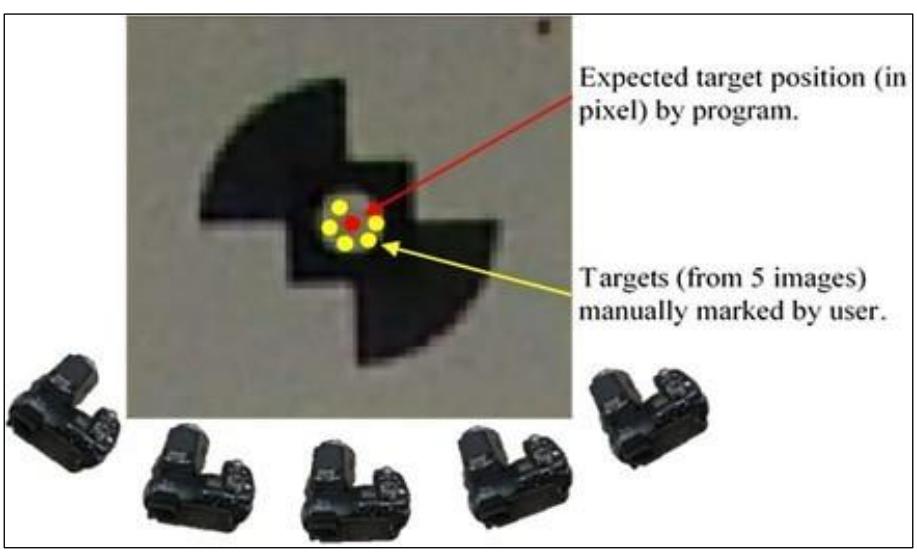


Figure 9. Target Centroid Residual Between Program Defined (Red Dot) And User Manually Marked (Yellow Dot)

Prior to the deriving calibration parameters phase, Figure 10 illustrated the pre-analysed standard deviations computed for all seven (7) dimensions, it can be concluded that those sixteen (16) calibrations points are having homogenous trend on every dimension reduction. Moreover, maximum standard deviation discrepancy was demonstrated by point number twelve (12) which is 0.0013m between dimension 02 and 06. With relatively small precision differences, through network analysis, the findings have positively stipulated towards the approval of the designed dimensions for TLS self-calibration.

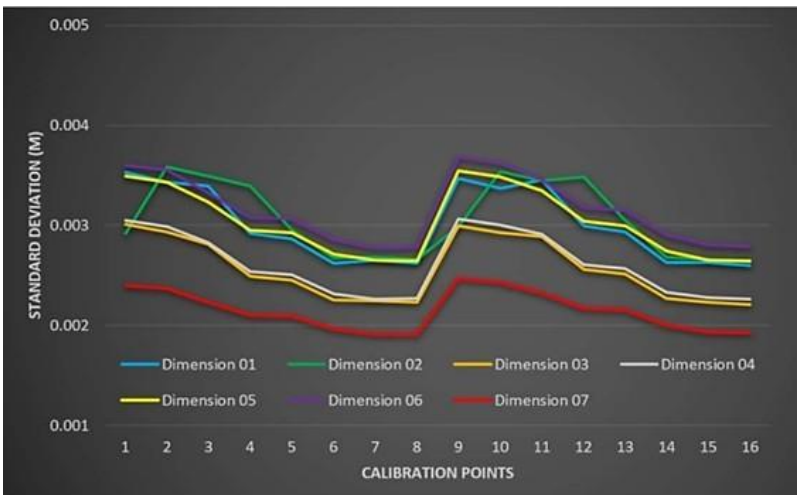


Figure 10. Standard Deviations of Sixteen (16) Calibration Points for All Dimensions

Further investigation was carried out by applying calculated calibration parameters obtained for each configuration to the raw data and those calibrated data then were compared to the actual values of verification points (established using CRP technique). This procedure was undertaken in order to examine the accuracy of the calibrated data, the results organised in Figure 11 have indicated the improvement in accuracy with the aid of calibration parameters. Surprisingly, RMS of others dimension configuration as tabulated in Table 3 manage to yield data quality that is mathematically similar to dimension 01 configuration (e.g., 3mm), except for the smallest configuration (i.e., 4mm). This shows the improvement in accuracy of up to 57 percent for all calibrated data, 4mm (refer Table 3) quality increment compared to raw data accuracy (i.e., 7mm). With these findings, minimum network configuration experiments (based on dimension reduction) have given a positive indication. Using the dimension of 3.6m (width) x 1.2m (height), similar results and accuracy as ideal configuration proposed by Abbas et al. (2014) are achievable.

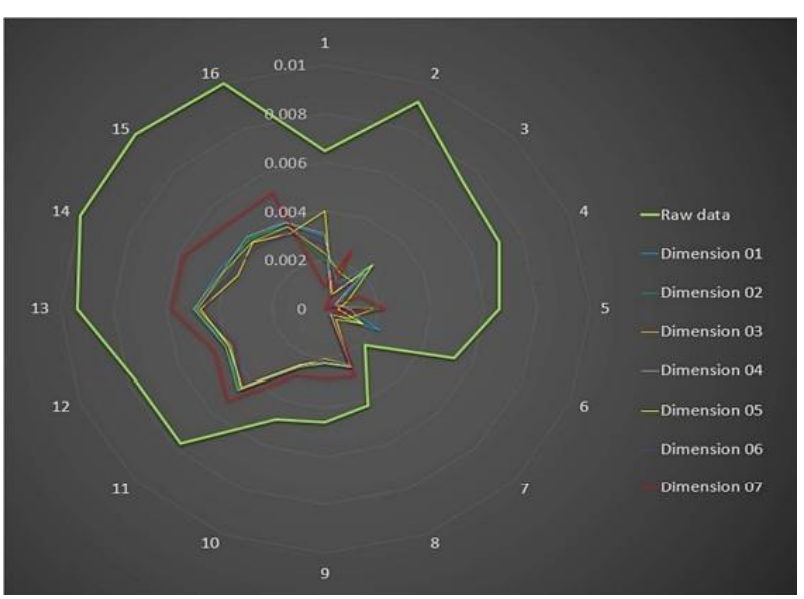


Figure 11. Plotted Accuracy of TLS Raw and Calibrated Data

Table 3. Accuracy Assessment of TLS Raw and Calibrated Data

Data	Root Mean Square (metre)
Raw (without calibration)	0.007
Calibrated (Dimension 01)	0.003
Calibrated (Dimension 02)	0.003
Calibrated (Dimension 03)	0.003
Calibrated (Dimension 04)	0.003
Calibrated (Dimension 05)	0.002
Calibrated (Dimension 06)	0.003
Calibrated (Dimension 07)	0.004

In contrast with the accuracy assessment outcomes, yielded calibration parameters from multi-configuration have demonstrated inconsistent trends. With the aid of thematic analysis, qualitative assessment has been performed based on the plotted calibration parameters. As illustrated in Figure 12, seven themes (dimension configurations) were utilized to plot the parameters (i.e., constant, collimation axis, trunnion axis and vertical circle index errors). It is quite interesting that the derived constant error from range measurement has a homogenous trend for all configurations, concluding the significance of the minimum configuration of TLS self-calibration. However, the computed parameters for horizontal direction (i.e., collimation axis and trunnion axis errors) indicated fluctuating trends for each configuration. As depicted in Figure 12, the significant differences of derived parameters in horizontal direction occur at the early stage, between dimensions 01 and 02. This circumstance might be happening due to the limitation of the panoramic scanner mechanism that exploited a two faces field of views (refer to Figure 13). The variation of angular measurement is divided into two faces, thus, the distributed targets of two real-world planes are separated. This condition has constrained the horizontal direction variation, resulting in a weak self-calibration bundle adjustment solution. Similar occurrence for the parameter (i.e., vertical circle index error) derived in vertical angle measurement, the uncertainties of system calibration results are directly proportionate with configuration's dimension. From dimension 01, when the configuration gradually minimized into dimension 01, the obtained parameters also became smaller. As the employed scanner utilized two faces mechanism, the only rational cause is limitation of vertical angle variation has limited the reliability of the calibration solution. From the thematic analysis, initial conclusion can be made that the two faces mechanism has constrained the reliability of minimum configuration for TLS self-calibration in deriving calibration parameters, which only applicable for range measurement.

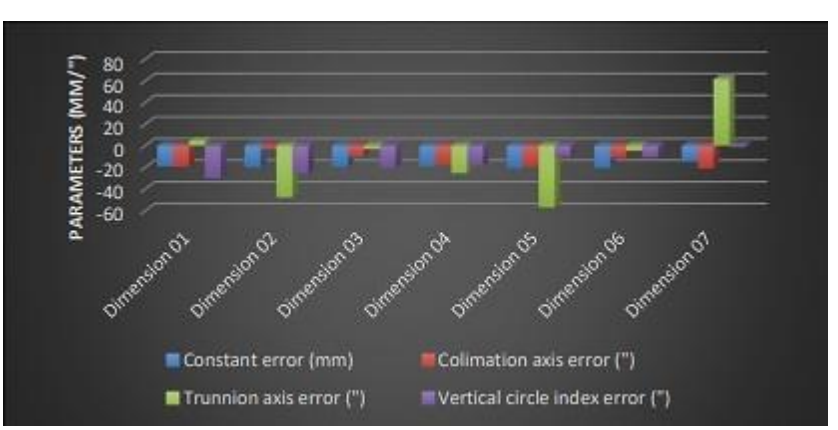


Figure 12. Calibration Parameters Yielded from Seven (7) Configurations

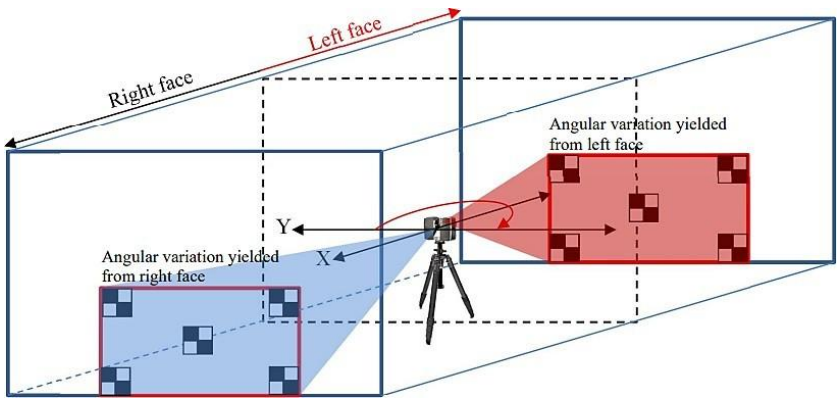


Figure 13. Two Faces Measurement Mechanism Has Limited the Variation of Both Horizontal and Vertical Angles

To strengthen the findings from qualitative assessment, this study has utilized the statistical analysis (i.e., t-test). As benchmark, all parameters computed from configuration 01 were set as reference values. With redundancies number of 28, the tabulated value of t for two-tailed test at 5 percent significant level is 2.04. As presented in Figure 14, test statistic for others examined parameters were computed using Equation (6). As expected, all derived parameters have demonstrated inconsistencies with benchmark configuration (i.e., dimension 01) except for constant error. Nonetheless, at the final configuration (dimension 07), the statistical test has disagreed with the solution of constant parameter. Disregard angular parameters computed from others configuration; conclusion was made according to configuration 02. Depicted in Figure 14, there are several occurrences where derived parameters for horizontal direction manage to pass the null hypothesis. For example, dimensions 04, 05 and 07 for collimation axis error, and dimensions 03 and 06 for trunnion axis error. As discussed in thematic analysis, these uncertainties might occur due to weak solution from self-calibration bundle adjustment.

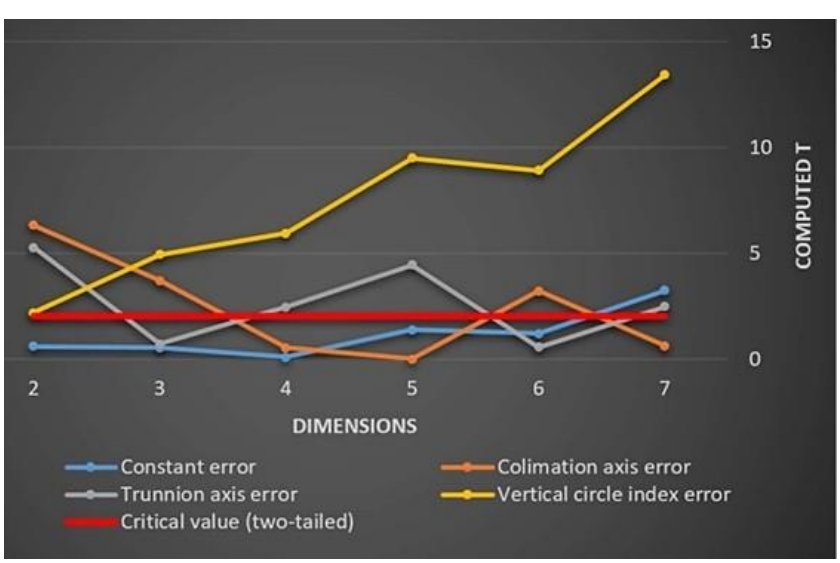


Figure 14. Similarity Analysis of Derived Calibration Parameters from Multi-Configurations

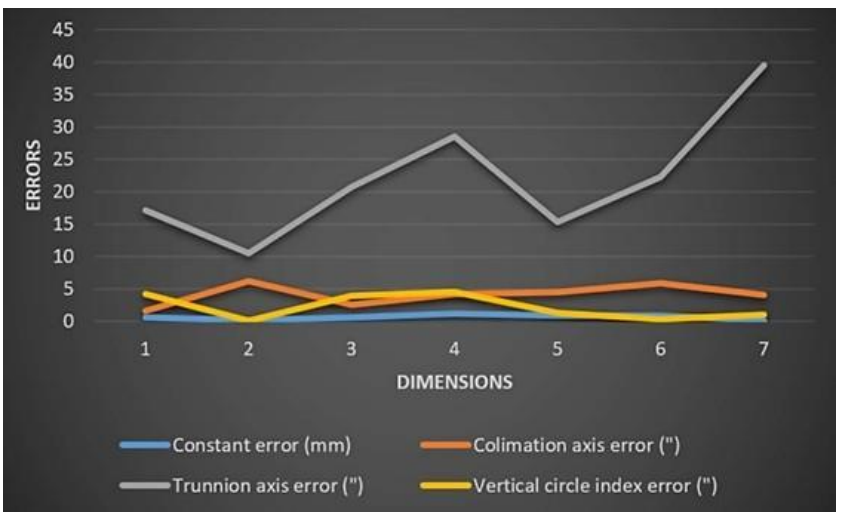


Figure 15. Multi-Configurations Sensitivity Analysis Towards Synthetic Errors

Due to disagreement findings of derived calibration parameters experiments (through the thematic and statistical analyses) and accuracy assessment (with the aid of verification points) to represent the enhanced point clouds data quality, another experiment was performed by augmenting synthetic errors to TLS raw data. As shown in Table 2, 10cm range error and 30" angular errors were introduced. The sensitivity of each configuration to isolate the augmented synthetic errors will indicate the reliability of the derived calibration parameters. As illustrated in Figure 15, computed parameters including Abbas et al. (2014) configuration have demonstrated less sensitivity towards trunnion axis error. With the maximum difference of 5" (from 30" synthetic errors), derived collimation axis and vertical circle index errors have exemplified promising solution. Without a doubt, all configurations manage to differentiate 10cm synthetic error in range measurement. Rather than excluding all derived calibration parameters in angular measurement as yielded in similarity analysis, sensitivity experiment just indicated disagreement with trunnion axis error.

With the complicated findings, further analysis has been made by considering the magnitude of computed calibration parameters. Having the average distance of TLS into observed targets, the significant effect of the parameter can be mapped. Maximum systematic errors from all configurations were organised in Table 4, trigonometry formula was employed to measure the effect of angular errors in determining the target position. With 10m distance from TLS to object, maximum uncertainty was contributed by constant error (i.e., -20.7mm), while maximum uncertainty for angular measurement was obtained from trunnion axis error (i.e., 3.0mm). Considering the magnitude effect embraced from constant error, the main reason of significant accuracy enhancement for calibrated point cloud has been answered. Additionally, in all experiments, the derived calibration parameters for range measurement for all configurations have mathematically and statistically demonstrated significant outcomes. Towards the end, a conclusion can be made that the minimising Abbas et al. (2014) configuration for TLS calibration is applicable for modelling range error (constant error). Based on the inconsistent findings of computed angular errors, it is not recommended to employ smaller dimension than utilised by Abbas et al. (2014) configuration.

Table 4. Significant Effect of Maximum Calibration Parameters to Define Target Position

Calibration Parameters	Dimension	Magnitude (mm/")	Distance to Target (m)	Effect (mm)
a_0	05	-20.7		-20.7
b_0	07	-21	10	-1.0
b_1	07	61.4		3.0
c_0	01	-30.3		-1.5

CONCLUSION

The focal limitation of point-based self-calibration which requires a rigid network configuration as stated by Lichti (2007) has been experimentally minimised by (Abbas et al., 2014). The proposed configuration has made this point-based approach applicable for on-site implementation. However, dependency on surfaces to distribute all sixteen (16) targets has limited the approach for indoor on-site calibration. With the aim to investigate any possibility to minimise the calibration approach for outdoor on-site employment, this study has performed rigorous experiments. Abbas et al. (2014) calibration configuration has been mathematically reduced (through network analysis) in terms of dimension until sixty (60) percent. The outcomes of the study have demonstrated that examined configurations (reduction of surfaces dimension) are unable to provide thematically and statistically similar calibration parameters as Abbas et al. (2014) configuration, except for constant error. In contrast, accuracy assessment of the calibrated data for all configurations have demonstrated significant and homogenous data quality enhancement. Through synthetic errors experiment, only trunnion axis errors exhibit insignificant trend. As for final assessment, maximum values of derived calibration parameters were extracted from all configurations and were examined towards the effect in determining target position (at 10m distance). The conclusion can be made that the minimum configuration of 3.6m (width) x 1.2m (height) for TLS point-based self-calibration only applicable for deriving constant error. With the aid of robust experiments, this study has yielded novel contribution regarding network design for TLS calibration. The findings have demonstrated the insensitivity of minimum configuration to derive the systematic errors in angular measurements. Nevertheless, it is applicable in formulating uncertainties in the range component. Considering the element of user-oriented in the calibration procedure, further research is crucial to identify a significant configuration that is reliable to derive angular errors in TLS measurement.

ACKNOWLEDGEMENT

We would like to thank the Ministry of Higher Education (MoHE) of Malaysia for the funding of this research under the Fundamental Research Grant Scheme (FRGS) 600-RMC/FRGS 5/3 (011/2021). Our special thanks also go to the Photogrammetry and Laser Scanning Research Group, Universiti Teknologi Malaysia, for providing instruments and the experimental site.

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SUSTAINABLE URBAN DEVELOPMENT SDG 11 INDICATORS AND FACTORS IMPLEMENTATION IN MALAYSIA, INDONESIA AND THAILAND

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Abstract
The planet is undergoing the biggest historical surge of urban outgrowth and this took place mainly in the domain of developing nations. Approximately, the current world population is reaching almost 8 billion inhabitants, above 50 percent of population inhabiting the urban area. Thus, both anthropoid conducts including the consumption of required energy are concerted in conurbation areas. Urbanization SDGs campaign has been initiated due to the urban dynamism which signifies the main sustainable developmental opportunity. The dedicated urban SDG and specific goal is crucial in mobilizing stakeholders, promoting integrated, city level strategies, and accelerate growth towards holistic sustainable urban development, including to almost eradicating extreme urban poverty. The article discusses all the UN-OWG indicators and factors of SDG 11 towards sustainable urban development in selected ASEAN nations of Malaysia, Indonesia and Thailand. The aims in this research are to evaluate the implementation level using indicators and factors of ways in making cities function differently today's economically challenged municipality administrations without expanding the additional costs.

INTRODUCTION

Sustainable urban development has become a pressing global issue in recent years due to the rapid growth of urban areas and the subsequent challenges they face. Cities in Malaysia, Indonesia, and Thailand have witnessed significant development and urbanization, leading to both positive and negative impacts on the environment and the well-being of their inhabitants. This article aims to explore the implementation of Sustainable Development Goal 11 (SDG 11) indicators and factors in these countries, examining the recent developments and their implications for sustainable urban planning and development. The municipality growth in Malaysia, Indonesia, and Thailand has been fuelled by various factors such as economic growth, population migration, and industrialization. The consequences of this growth, however, have been far-reaching, resulting in unsustainable urban development patterns. Ad hoc and instant urban planning and development have often prevailed, neglecting important considerations such as future projections of population density, infrastructure, and amenities, leading to uncontrolled urban sprawling and poor maintenance practices.

Urban developmental growth enacts a significant function in undertaking sustainability principle through socio-economic progression and innovation of technology (Shao, Qilong, et al., 2023; Wu, 2014). Urban sustainability development level implies a holistic, broader and balance specific condition of its inhabitants which incorporate incomes equity, work opportunities, housing, public infrastructure, basic facilities and amenities, connectivity accessibility as well as environmental and ecosystem protection (Reddy & Balachandra, 2023; Hiremath et al., 2013). Environmental sustainability could be attained at several phases and levels via urbanization development and it should be approached from the inside out, from the interior spaces, to the building forms, and to the neighbourhoods/townships and finally

the cities (Zen, 2023; Berg & Nycander, 1997). Townships are part of areas and systems in the cities, created through their built environment, economic and social dimensions. Townships are boundary to an allocated limit, and a collective public acquaintance subsists amongst their inhabitants (Wei et al., 2023; Mattarozzi & Antonini, 2011). In enhancing neighbourhood/township sustainable development, a comprehension of its build structures, communal shared spaces, public facilities and infrastructures (Konijnendijk, 2023; Luederitz, Lang & Von Wehrden, 2013), the promotion of a managing principles, and collaboration amid its components is essential.

Generally, in most of the developing nations, ad-hoc and instant urban planning and development has led to unsustainable developments. Inconsideration future projections of population density, infrastructure and amenities, uncontrolled urban sprawling and poor maintenance accumulate an amplified carbon footprint and growing negative impacts to the environments (Simkin et al., 2022). The shortage of land-plot in city areas of some developing regions has generated a more construction need for high-rise building structures in a progressively dense means, which at the same time simultaneously create problems and benefits to urban development sustainability within these constituencies (Wen, Ignatius & Wong, 2022; Ishak et al., 2018). Rapidly low-cost housing developments programs in remote locations resulting in poor standard accommodations, parking and traffic congestions, and less considerations to end user's lifestyle and livelihood strategies further adding the problems. In developing urban city settings, most of the populations still desire safe, decent and reliable housing as most of the state governments or developers view it as a social liability instead of sustainable responsibilities. A more profitable upper cost and medium cost development is favourable as it generates higher revenue margin instead of lower costing dwelling scheme for the mass which most of the time subsidized using states funds.

In recent years, Malaysia, Indonesia, and Thailand have recognized the need for sustainable urban development and have taken steps to address the challenges they face. Malaysia, for instance, has implemented the National Physical Plan (NPP) which emphasizes sustainable land use planning, conservation of natural resources, and the provision of quality infrastructure and amenities. The country has also introduced the Low Carbon Cities Framework to promote energy-efficient buildings, renewable energy adoption, and low-carbon transportation systems. Similarly, Indonesia has launched the National Urban Policy, which aims to improve urban governance and foster sustainable urban development. The policy focuses on enhancing urban resilience, improving access to basic services, and promoting inclusive urban planning. Indonesia has also made efforts to reduce carbon emissions by implementing the Green Building Council Indonesia and promoting sustainable transportation options. In Thailand, the government has recognized the importance of sustainable urban development and has integrated this concept into its national development plans. The country has initiated projects such as the Bangkok Mass Transit System and the Green Building Initiative to reduce greenhouse gas emissions (Yaman et al., 2015).

RESEARCH BACKGROUND

Urbanization is an ongoing phenomenon that has transformed the landscape of many countries, including Malaysia, Indonesia, and Thailand. Rapid urban growth in these nations has brought about various challenges, particularly in terms of sustainability. The principles of sustainable urban development have become crucial in ensuring the long-term well-being of

cities and their inhabitants. However, the ad hoc and instant approach to urban planning and development has led to unsustainable practices in these countries. The unsustainable urban development that has taken place in Malaysia, Indonesia, and Thailand has resulted in numerous problems. One key concern is the neglect of future projections related to population density, infrastructure, and amenities (Peterson, 2023). Consequently, uncontrolled urban sprawling and poor maintenance have accumulated an amplified carbon footprint, exacerbating negative impacts on the environment.

Recent developments in Malaysia have highlighted the need for sustainable urban planning and development. The country has witnessed a rapid increase in urban population, with estimates projecting that more than 80% of the population will reside in urban areas by 2050. The high population density has strained existing infrastructure, leading to issues such as traffic congestion, inadequate public transportation, and inadequate provision of essential services. In Indonesia, the situation is similar. The country has experienced a significant influx of people into urban areas, resulting in haphazard and unplanned urban growth. The lack of proper urban planning has led to the development of informal settlements, inadequate provision of basic services, and increased vulnerability to natural disasters. Additionally, the growing need for energy and resources in urban areas has further strained the environment, contributing to pollution and resource depletion. Similarly, Thailand has faced challenges related to sustainable urban development. The rapid urbanization in the country has resulted in the expansion of cities and the encroachment of natural areas. This has led to the loss of biodiversity, increased pollution, and strained infrastructure and services. The high demand for water and energy in urban areas has also placed a burden on natural resources, further exacerbating environmental degradation.

In response to these challenges, the governments of Malaysia, Indonesia, and Thailand have recognized the importance of sustainable urban development and have initiated efforts to address them. Malaysia, for example, has implemented various policies and programs aimed at promoting sustainable cities, including the Low Carbon Cities Framework and the Green Building Index. Indonesia has also taken steps to promote sustainable urban development through initiatives such as the National Urban Policy and the National Action Plan for Sustainable Development Goals. Thailand has implemented similar measures, including the National Sustainable Development Plan and the Green City Action Plan. Despite these efforts, much work remains to be done to fully implement sustainable urban development practices in Malaysia, Indonesia, and Thailand. Besides national's efforts, organizations, industrial players and corporate sectors effort in sustainability reporting are important in demonstrating their commitments to a sustainable economy, thus catalysing SDG 11 criteria towards sustainable development (Tarquinio & Xhindole, 2022). This article aims to explore the indicators and factors crucial for the successful implementation of Sustainable Development Goal 11 (SDG 11) in these countries. By examining the current state of urban development, identifying challenges, and analysing policy initiatives, this article seeks to provide insights and recommendations for achieving sustainable urbanization in the region.

In conclusion, the unsustainable urban development in Malaysia, Indonesia, and Thailand has highlighted the urgent need for sustainable practices. The rapid growth of urban areas, coupled with inadequate planning and infrastructure, has resulted in negative impacts on the environment and the quality of life for urban dwellers. However, the governments of these countries have recognized the importance of sustainable urban development and have taken

steps to address the challenges. By implementing the indicators and factors outlined in SDG 11, Malaysia, Indonesia, and Thailand can pave the way for a more sustainable and resilient urban future.

(Source: Loh et al., 2018)

Figure 1. Sustainable Development and Disclosure Initiatives Among Malaysia, Thailand and Indonesia

RESEARCH METHODOLOGY

The data were obtained from 31 experts' respondents in the field of urban planning from Malaysia, Thailand & Indonesia. The method employed in this study is the stakeholders' inclusion approach. The instrument used in this study is online questionnaire surveys and were distributed to professional stakeholders in these 3 ASEAN nations. The questionnaires were divided into 2 sections; Part A: Respondent's Background and Part B: UN-OWG: The Indicators & Factors. The survey questionnaires are multiple choice questions based on 5 points Likert Scale. Survey questions for Part A: Respondent's Background (5 questions) are as per Table 1 and questions for Part B: UN-OWG: The Indicators & Factors (UN-OWG, 2014) are as per Table 2 below:

Table 1. Part A: Respondent's Background

A.1	Country
A.2	Affiliation
A.3	Age Group
A.4	Designation Level
A.5	Annual Income (in USD)

Table 2. Part B: UN-OWG: The Indicators & Factors

Q. No.	Question
B.1	Indicator 11.1
	by 2030, ensure access for all to adequate, safe and affordable housing and basic services, and upgrade slums
	Factor
	To prevent existing urban mal-development and create equitable urban environments for all inhabitants.
B.2	Indicator 11.2
	by 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons
	Factor
	Reduce GHG emissions and affordable accessible mobility system in urban area for all inhabitants needs.
B.3	Indicator 11.3
	by 2030 enhance inclusive and sustainable urbanization and capacities for participatory, integrated and sustainable human settlement planning and management in all countries
	Factor
	Enhance and improve urbanization via efficient planning and management in urban development.
B.4	Indicator 11.4
	Strengthening attempts to defend and preserve world's natural heritage and culture
	Factor
	Conserve plus preserve natural heritage and culture due to rapid urban development
B.5	Indicator 11.5
	by 2030 significantly reduce the number of deaths and the number of affected people and decrease by y% the economic losses relative to GDP caused by disasters, including water related disasters, with the focus on protecting the poor and people in vulnerable situations
	Factor
	Decrease possible death, affected people and economic loss due to natural disasters especially vulnerable inhabitants due to improper and unbalanced urbanization
B.6	Indicator 11.6
	by 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management
	Factor
	Enhance urban environment quality per capita due to inhabitants' activity, operations and consumptions in the urban area
B.7	Indicator 11.7
	by 2030, provide universal access to safe, inclusive and accessible, green and public spaces, particularly for women and children, older persons and persons with disabilities
	Factor
	Provide and enhance equitable access to community spaces for all urban inhabitants.
B.7a	Indicator 11. a
	support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning
	Factor
	Extend sustainable pillar concerns not only in urban area but also vicinity / hinterland that form part of regional and national planning as it feed the urban operations, supplies and consumptions.
B.7b	Indicator 11.b
	by 2020, increase by x% the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, develop and implement in line with the forthcoming Hyogo Framework holistic disaster risk management at all levels
	Factor
	Enhance adaptation of sustainable policies/framework in urban areas due to climate change and disasters.
B.7c	Indicator 11.c
	sustenance of minimum developing nations, comprising via economic and technical support, towards sustainable and resilient urban built environment using regional supplies
	Factor
	Assist via financial & technical support least develop nations in developing sustainable urban settlement and developments.

The data were analysed statistically to yield the findings. The data were presented in the form pie-chart the demonstrated the frequency of Likert scale to rank the most and the least achievable indicators and factors of SDG 11 towards sustainable urban development in the ASEAN region particularly in Malaysia, Thailand and Indonesia.

ANALYSIS AND DISCUSSION

The findings for Respondent's Background are as the chart in Figure 2. Based on findings from respondent's background, more than half of the respondents is from Malaysia and followed by Thailand and Indonesia respectively. The affiliation is mainly from government sector, followed by private institutions and government-linked establishment. The age category was mainly from 31-40 years old, followed by 21-30 years old and 41-50 years old, and 51-60 years old. Most respondents are middle-executives and junior executives. The annual income is mixed of lowest and highest income. The gender is almost equal in respondents.

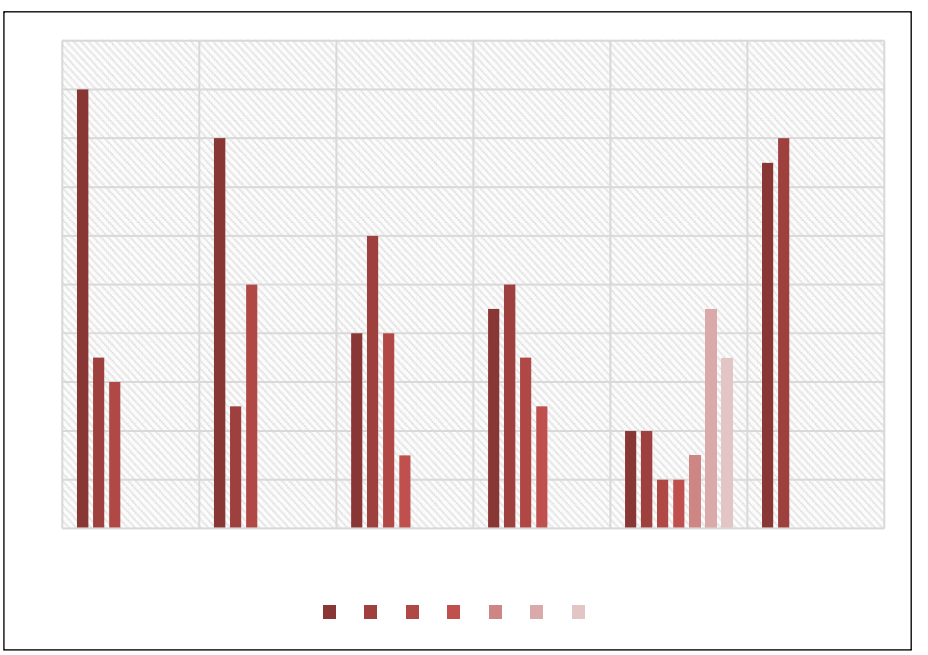

Figure 2. Part A: Respondent's Background

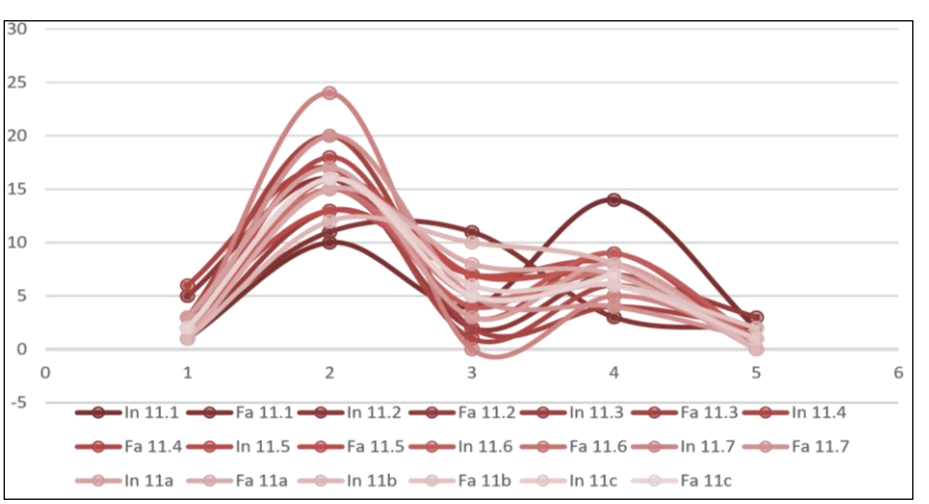

Figure 3. Part B: UN-OWG: The Indicators & Factors

Study outcomes suggested a hierarchical level of implementation with gaps for improvement. The highest scored indicator for SDG 11 is Indicator 11.4 with 19.4% and Indicator 11.2 with 16.1%. This suggested ASEAN nations prioritize consolidate efforts in protecting and safeguarding the world's socio culture and ecological heritage; and providing inclusivity to a safe, accessible, affordable and sustainable transportation systems to all, increasing road travel safety, particularly by developing public transportation, with a special consideration to the requirements of those in the vulnerable conditions, which includes persons with disabilities, elderly persons, women and children. The lowest score for SDG 11 indicators is Indicators 11.5, 11a and 11b with null percentages, hence, more efforts and emphasized should be given in strengthening these indicators.

Figure 3 also shows that the highest scored factors for SDG 11 in ASEAN nation are Factor 11.6, meanwhile the lowest factors are Factor 11.4, 11.5 and 11a. The chart above basically suggested all indicators basically achieve targeted SDG 11 indicators and factors but need improvement in implementing all SDG 11 factors and indicator to highly achieved towards 2030 SDG agendas.

The Hierarchical Levels of Implementation with Gaps for Improvement are (1) Policy and Planning Level, (2) Infrastructure and Transportation Level, (3) Environmental Sustainability Level, and (4) Social Inclusion and Community Engagement Level.

Policy and Planning Level

At the policy and planning level, all three countries have made significant progress in recognizing the importance of sustainable urban development. Malaysia has implemented the National Physical Plan, which provides a comprehensive framework for sustainable development, while Indonesia has launched the National Urban Policy to guide urban development in a sustainable manner. Thailand has integrated sustainable urban development into its national plans, with initiatives such as the Bangkok Mass Transit System and the Green Building Initiative.

Figure 4. Progress on Goal 11 Indicators Toward the 2030 targets

However, there are still gaps in the implementation of these policies. One key challenge is the lack of coordination between different government agencies and departments responsible for urban planning and development. This leads to fragmented and inconsistent approaches to sustainable urban development. This is evident particularly in managing and handling natural disasters such as flooding, landslides and other occurrences. Based on study by UN-ESCAP (Figure 4) on forward progress and regression of SDG 11 indicators towards ASEAN 2030, death and economic loss due to disasters is still regressing. To address this, it is crucial for these countries to establish inter-agency collaborations and enhance coordination mechanisms.

Infrastructure and Transportation Level

Infrastructure and transportation play a crucial role in sustainable urban development. Efficient and well-connected transportation systems reduce traffic congestion, air pollution, and carbon emissions. Malaysia, Indonesia, and Thailand have all made efforts to improve their transportation systems, with the implementation of mass transit systems and the promotion of sustainable modes of transportation such as cycling.

However, challenges remain in terms of the integration of different modes of transportation and the provision of accessible and affordable public transportation. Additionally, there is a need to prioritize non-motorized transport options and develop pedestrian-friendly infrastructure to create liveable and sustainable cities. Investments in sustainable transportation infrastructure should be increased, and public-private partnerships should be encouraged to ensure the successful implementation of sustainable transportation initiatives.

Environmental Sustainability Level

Environmental sustainability is a key aspect of sustainable urban development. It involves the conservation and protection of natural resources, the reduction of pollution and waste, and the promotion of green spaces. All three countries have taken steps to enhance environmental sustainability in urban areas, such as the implementation of green building initiatives and the promotion of renewable energy sources.

Table 3. Part B: UN-OWG: The Indicators & Factors

Green Bangkok 2030 Objectives	Green Bangkok 2030 Targets	Green Bangkok 2030 Initiatives
• Social: The design of green spaces is suitable for everyone (Universal Design). • Economic: The new green spaces must promote the community. • Environmental: The new green spaces must be able to enhance the balanced biodiversity of urban ecosystems. • Management: There must be a system for the maintenance of green spaces. • Community and Cooperation: There must be community and citizen participation.	• Increasing the ratio of green spaces to 10 square meters per person. • Increasing public green spaces that people can access within 400 meters or 5 minutes by walking at no less than 50% of Bangkok's total area. • Increasing urban tree canopy per urban area to 30% of Bangkok's total area.	There are 11 pilot projects in Phase 1 (2021-2022), including: ▪ 10 rais (approx. 4 acres) of Piyaphirom Park, Bang Kapi District, ▪ 2.5 rais (approx. 1 acre) of Santiporn Park, Phra Nakhon District, ▪ 29 rais (approx. 11.5 acres) of the park at Rom Klao Road and Chao Khun Thahan Road Interchange, Lat Krabang District, ▪ 37 rais (approx. 14.6 acres) of the park at Bangkok Land Development Station, Bang Khun Thian District, ▪ 0.5 rai (approx. 0.2 acre) of the park at Soi Na Wat Hua Lamphong, Bang Rak District, ▪ 2 rais (approx. 0.8 acre) of the park at Soi Vibhavadi 18, Lane 3, Chatuchak District, ▪ 66 rais (approx. 26 acres) of the area in On Nut Garbage Disposal Plant, Prawet District, and ▪ 5 km of green spaces in the Head Office of PTT Public Company Limited and along Phahon Yothin Road (Lad Phrao Intersection – Victory Monument), etc.

However, challenges persist in terms of waste management, pollution control, and the preservation of green spaces. There is a need for more comprehensive waste management systems, including recycling and waste-to-energy programs. Additionally, stricter regulations and enforcement are necessary to control pollution from industries and vehicles. Efforts should also be made to increase the availability of green spaces and enhance biodiversity within urban areas. Table 3 above indicates the initiatives taken by The Environment Department, Bangkok Metropolitan Administration (BMA) to increase urban green spaces by developing the unused spaces scattered throughout Bangkok. 11 pilot projects were initiated by BMA in the Phase 1 2021-2022.

Social Inclusion and Community Engagement Level

Social inclusion and community engagement are crucial for the success of sustainable urban development. It is important to ensure that the benefits of urban development are equitably distributed, and that marginalized communities are not disproportionately affected. All three countries have recognized the importance of social inclusion and community engagement in their policies and initiatives.

However, there is still a need to enhance the participation of communities in the decision-making processes related to urban development. This can be achieved through the establishment of community-based organizations and the promotion of public participation platforms. Additionally, efforts should be made to provide affordable housing options and improve access to basic amenities and services for all residents, regardless of their socio-economic status.

CONCLUSION

Urban development must be perceived as the vehicle and venue where the resolutions of world's climate and environmental problems could most effortlessly be put into practise due to it is the circumstances where highest inhabitants dwell densely together, it has a higher potential in making efficient consumption of diverse resources. Based on selected regional study, it is imperative to apply and highly encouraging to SDG 11 indicators and factors in sustainable urban development as it holds a significant sustainable awareness and marketable value (Yaman et al., 2015).

While Malaysia, Indonesia, and Thailand have made significant progress in implementing sustainable urban development initiatives, there are still gaps and challenges that need to be addressed. The findings of this study suggest that a hierarchical approach, focusing on policy and planning, infrastructure and transportation, environmental sustainability, and social inclusion and community engagement, is crucial for the successful implementation of SDG 11 in these countries.

To bridge the gaps and improve implementation, it is recommended to enhance inter-agency coordination, prioritize non-motorized transport options, invest in sustainable transportation infrastructure, strengthen waste management systems, enforce stricter pollution control measures, increase the availability of green spaces, promote community participation, and ensure social inclusion in urban development processes (Yaman et al., 2018). By

addressing these indicators and factors, Malaysia, Indonesia, and Thailand can achieve sustainable urbanization and contribute to the overall achievement of SDG 11.

ACKNOWLEDGEMENTS

This research was conducted with the provision by the Pusat Pengurusan Penyelidikan (RMC) in-house study grant scheme and with the expert teams and facilities of Kolej Alam Bina, Universiti Teknologi MARA. Research was accomplished via a co-operation with Environment Research Institute, Chulalongkorn University and School of Business Management, Institut Teknologi Bandung.

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ASSESSING BUILDING INFORMATION MODELLING (BIM) AWARENESS LEVEL AMONG THE ROYAL MALAYSIA AIR FORCE (RMAF) OFFICER: PUBLIC PROJECT

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Abstract
Building Information Modelling (BIM) is said as an evolving and transformative technology that has revolutionised innovation within the Architecture, Engineering, Construction, and Operation (AECO) industry. The fundamental premise of BIM revolves around facilitating collaboration across diverse project teams throughout the entirety of a project's lifecycle. Despite the Malaysian construction industry's ambitions to integrate BIM into public projects exceeding RM10 million in value, the utilisation of BIM remains vague in public projects financed by the Royal Malaysia Air Force (RMAF) and overseen by the Malaysian Public Works Department (PWD). As a result, the primary objective of this paper is to investigate the present awareness of BIM among project teams within the RMAF. A survey in the form of a questionnaire has been disseminated to project teams engaged in public building projects across Malaysia, funded by the RMAF. This research adopted descriptive data analysis using a combination of manual calculation of maturity level score and Statistical Package for the Social Sciences (SPSS). Findings indicate a significant majority of project teams within the RMAF exhibit limited awareness of BIM implementation. Consequently, further investigation is needed to examine the underlying factors contributing to this conspicuous lack of awareness within the teams, with corresponding suggestions for enhancement. From there, this could help public officers like RMAF to have a better awareness of how to adopt modern construction practices which enhance a country's standing on the global stage.

Keywords: *Building Information Modelling (BIM); Maturity Model; Awareness; Performance; Public Project*

INTRODUCTION

The inherent intricacies of the construction industry, coupled with its distinctive characteristics, have led to poor productivity levels in comparison to other sectors. To address this issue of low productivity, one avenue proposed for enhancement is the adoption of a more integrated approach within the industry (Opoku et al., 2021). The challenges stem from the complicated nature of the construction process, which involves multiple stakeholders within the sector. Communication of project information predominantly relies on paper-based documents and drawings (Mehrbod et al., 2019). Unfortunately, this approach often results in errors due to the sheer volume of paperwork and drawings, which are commonly managed in a less-than-optimal manner, subsequently leading to misunderstandings. As a response, endeavours have been directed toward leveraging emerging technologies and methodologies aimed at elevating productivity and delivering value to the construction domain over time (Saka et al., 2022). In light of these considerations, collaborative construction projects and advanced information modelling techniques have been put forth as strategies to confer a competitive edge upon the construction industry (Jones, 2020; Liao & Teo, 2019).

Building Information Modelling (BIM) is indicated as an evolving and transformative technology that has revolutionised the current landscape of innovation within the Architecture, Engineering, Construction, and Operation (AECO) industry. This transformation is represented by the cross-boundary collaboration facilitated by BIM technologies, processes, and policies, which exert a profound impact on industry deliverables, relationships, and roles. The implications of BIM extend to influencing various dimensions, as highlighted by (Succar and Kassem, 2016). BIM is not merely a technological advancement; it embodies an object-based, interdisciplinary approach that seeks to enhance collaboration among construction professionals and seamlessly integrate object-specific information throughout a building's project life cycle (Siebelink et al., 2018). Successful BIM integration hinges on educating BIM expertise and fostering a change in the mindsets of construction professionals, recognising BIM as more than a shift from 2-Dimensional (2D) to 3-Dimensional (3D) technologies. Additionally, current construction practices employed by professionals need to adopt to accommodate new technologies like BIM and foster harmonious collaboration among diverse construction stakeholders.

The exploration of BIM within the construction sector has produced extensive research spanning various industry tiers, organisational levels, and project scopes. The research has explored aspects such as BIM adoption, constraints, applications, and implementation strategies. The influence of BIM principles and practices fills through organisations, project teams, and the broader construction industry, accompanying a comprehensive paradigm shift from conventional construction delivery toward a more cohesive operational model (Succar and Kassem, 2016). Notably, in recent years, the spread of BIM has gained remarkable momentum, with numerous governmental and non-profit entities worldwide introducing BIM into their projects and furnishing pathways for BIM implementation. Among this dynamic landscape, numerous elements come into play, encompassing institutional, organisational, and technical sides. Researchers emphasise that the core pillars of BIM readiness rest upon individuals, processes, and technology (Olanrewaju et al., 2020; Raja Mohd Noor et al., 2023; Shojaei et al., 2022). Thus, it becomes important to evaluate organisational readiness through quantifiable terms, specifically assessing the alignment of people, processes, and IT infrastructure prior to embarking on any BIM investment (Harun et al., 2016).

However, the existing body of research concerning the specific actions and initiatives undertaken by the public sector to adopt BIM appears to be inadequate (Pinti et al., 2022). There is a notable shortage of comprehensive studies examining the readiness levels for BIM adoption, a critical factor in clarifying and supporting the large-scale integration of BIM. Evaluating the readiness of the public sector assumes significance to gauge the government's capacity to deliver certain services digitally and effectively utilise BIM for internal governmental operations (Britel & Cherkaoui, 2020; Harun et al., 2016). On a parallel note, the assessment of BIM implementation and proliferation, especially in terms of market reach, remains relatively limited (Chan et al., 2019).

Within the context of the Malaysian construction industry, the absence of widespread BIM implementation can be attributed to two key factors: a relatively low level of BIM maturity and a deficiency in comprehension and exposure to BIM concepts. The evolution from traditional construction methodologies to BIM-based design has been a long-standing and extensively discussed topic within the construction domain since the 1970s. Consequently, the industry has gradually embraced BIM. However, this transformation is

complicated, involving four distinct stages aligning with BIM's development: level 0, level 1, level 2, and level 3, corresponding respectively to conventional practices, design-focused approaches, collaborative strategies, and integrated methodologies (Manzoor et al., 2021). Each stage defines the techniques, tools, approaches, information depth, and cooperation levels to be employed.

Since the introduction of BIM in Malaysia in 2007, the government has initiated various measures and policies to integrate BIM. The Eleventh Malaysia Plan (RMK11) targets the adoption of BIM in 10% of public projects exceeding RM 50 million (Al-Ashmori et al., 2020). Furthermore, from the commencement of 2019, BIM was mandated for any public project with a budget of RM 100 million or more. Simultaneously, through the Public Works Department (PWD) Strategic Plan 2021-2025, the Ministry of Works has outlined the gradual adoption of BIM mechanisms, aiming for a 50% implementation rate in 2021 and an 80% rate by 2025 (Al-Ashmori et al., 2020; CIDB, 2020; Sinoh et al., 2020). Nonetheless, the quantification of an organization's performance and competency within specific stages is pivotal to evaluating their BIM maturity relative to the various BIM phases (Al-Ashmori et al., 2020).

Regrettably, in Malaysia, the level of BIM implementation still lags behind that of other industrialised nations and neighbouring countries like Singapore, the United States of America (USA), and the United Kingdom (UK) (Rogers et al., 2015). In 2013, Malaysia's BIM maturity ranged between Level 0 and Level 1; however, by 2014, it had advanced to a range between Level 1 and Level 2. The government aspired to attain Level 2 BIM Maturity by 2019, signifying network-based BIM integration throughout the construction sector. Yet, owing to inadequate comprehension and preparedness, achieving widespread implementation of BIM within the construction industry has proven to be a challenging endeavour.

Due to the lack of a literature review, a preliminary has been conducted to assess the existing comprehension of BIM among Complex Maintenance Officers (CMO) within the Royal Malaysian Air Force (RMAF). The findings underscore that despite their substantial involvement in various public projects across Malaysia, CMOs within the RMAF lack awareness of BIM concept. The RMAF is one of the Malaysian government agencies that aims to transform the development of the air force base. This includes the RMAF personnel who must be imparted with sustainable skills that are in line with the evolution of capacity development and, increasing the capabilities of technology-based airmen. In tandem, the Malaysian construction sector seeks to integrate BIM into projects exceeding RM10 million in value; however, projects funded by the RMAF have yet to adopt BIM, and the CMOs associated with these projects remain unacquainted with its implementation. Thus, it is vital to explore the level of awareness of BIM among CMOs' RMAF in the form of rubric scores and further improve the service offered by BIM.

A COMPARATIVE REVIEW OF THE MATURITY MODEL AND MATURITY GRID

The maturity model concept is said to be the assembling of process maturity levels that illustrate the starting point (immaturity) to highly mature (Adekunle et al., 2022). Maturity models are designed as an assessment tool that is employed to assess the competence or effectiveness level of a system and offer a solution by classifying the proficiencies required to attain optimal effectiveness (Adekunle et al., 2022). To enrich the understanding of the

current BIM maturity model, eighteen (18) existing BIM maturity models were identified and reviewed from 2007 to 2021: The characteristics of existing BIM maturity models have been summarised in Table 1.

Table 1. A Comparative Review on BIM Maturity Model

No.	Maturity Model (Name the model)	Purpose of Model	Assessment Method
1	The NBIMS-CMM (2007)	To evaluate business practices along with a continuum or spectrum of desired technical-level functionality	Questionnaire
2	The Bew-Richards BIM Maturity Model (iBIM) (2008)	To examine the BIM maturity in an industry or an organization	-
3	BIM Maturity Index (BIMMI) (2009)	To assess the quality of teams and organizations rather than evaluating information management on a BIM-assisted project	Multi-method
4	VDC/BIM Scorecard (2009)	To conduct a methodological, adaptive, quantifiable, holistic, and practical assessment	Questionnaire
5	TNO'S BIM Quickscan (2010)	To assess the BIM performance of firms executing technology and processes.	Online Questionnaire
6	BIM QuickScan (2011)	To evaluate the BIM Performance level of organizations providing BIM services	The external certified evaluator or online assessment
7	IU's BIM Proficiency Matrix/Index (2012)	To evaluate the BIM experience of potential designers	Questionnaire
8	The Organisational BIM Assessment Profile (2012)	To establish a standardized methodology that empowers facility owners to strategically incorporate Building Information Modelling (BIM) across their organization and throughout a facility's lifecycle, with the added ability to evaluate the components of BIM planning more efficiently	Interviews, Document Analysis, Process Observation, Workflow Analysis
9	CIC Research Program's Owner Matrix (2012)	To support project teams by directing them through a planning process for BIM implementation	Questionnaire
10	Vico's BIM Score (2013)	To evaluate their current 234 solutions for clash detection, scheduling, and estimating in terms of three aspects: functionality/capability, best practices, and enterprise integration	Multi-Method
11	Building Information Modelling Maturity Measure (BIM-MM) (2014)	To measure and associate the maturity of BIM implementation within a project	Questionnaire
12	Owner's BIMCAT (2015)	A tool that regards owners as significant users.	Questionnaire
13	BIM Maturity Model for Design Team (2015)	To support the design team in BIM projects at design stage	-
14	Multifunctional BIM Maturity Model (2016)	To identify components needed in terms of technological, process change, organization readiness, and protocols.	Rubrics Assessment
15	Migration Path of BIM for Construction Professionals	To review and improve the current performance level of BIM among construction players in projects.	Rubrics Assessment
16	BIM and Lean Construction Maturity Model (IDEAL) (2018)	To assess and analyse the performances of the projects implementing BIM and Lean together.	-
17	BIM Cloud Score (BIMCS) (2018)	To assess the maturity level of BIM modelling techniques	Multiple Mathematical Tests
18	Building Information Modelling Application Maturity Model (BIM-AMM) (2021)	To predict the real level of BIM application in different actual projects, carry out a comprehensive pre-evaluation of the project BIM conditions.	Questionnaire

(Sources: Brahim, 2018; Dib et al., 2012; Du et al., 2014; Giel & Issa, 2016; Jayasena & Weddikkara, 2013; Kam et al., 2017; Liang et al., 2016; Mohd et al., 2017; Mollasalehi et al., 2018; Succar & Kassem, 2016; Suermann & Issa, 2010; Team, 2002; Van Berlo et al., 2012; Wu et al., 2017)

As indicated by Adenkule et al. (2022), the maturity model can be classified into different categories, which correspond to the three (3) elements outlined in Table 1. While the methods employed might exhibit differences, both concepts are utilised to assess and enhance processes. Furthermore, both approaches incorporate maturity levels and process areas, yet their mode of presentation stands out as a prominent distinction (Adekunle et al., 2022). Nonetheless, companies tend to favour the utilisation of maturity grids due to their cost-effectiveness and time-efficiency. However, it's worth noting that despite these advantages, maturity grids have not reaped as much prevalence as maturity models, particularly within academic circles. The differences between them are as stated in Table 2. It is worth mentioning that maturity assessment in the construction industry has been through maturity models.

Table 2. Difference Between Maturity Grid and Maturity Model

No	Aspects Maturity	Grid	Maturity Model
1	Orientation	This applies to companies in an industry, it is company-focused	It is a process-specific
2	Mode of Assessment	The structure shows levels of maturity against KPIs of performance in a cell. These cells normally contain descriptions in text form describing the required performance level	Assessment is done by: Likert or binary yes/no questionnaires Checklist to assess the performance
3	Intent	They are complex	They are more complex assessment tools and they follow an internationally recognised standard format

(Source: Adekunle et al., 2022)

A comparative literature review shows that fourteen (14) models adopted the maturity model concept that shows the performance level in BIM-related matters and as a reference for the individual or organisation to evaluate and classify their performance. This concept aligns with previous researchers, where maturity is a concept used to show the development stage and assist in measuring BIM capability (Dakhil et al., 2019; Sun et al., 2021). These maturity models concept also consist of assessment tools like Likert or binary yes/no questionnaires or a checklist to assess the performance. The assessment was used to test steps or growth of technological undertakings. Moreover, the models show a details process of cultivating construction professionals in related matters. On the other hand, four (4) models (The Bew-Richards BIM Maturity Model, The Organisational BIM Assessment Profile, BIM Maturity Model for Design Team and BIM and Lean Construction Maturity Model (IDEAL)) use the concept of maturity grid to identify the current performance level contain descriptions in text form describing the required performance level.

For this research, the maturity model concept is more suitable to be adopted compared to the maturity grid, as it consists of details amount of individual/organisation' performance with a uniform format. Hence, the Migration Path Model of BIM for Construction Professionals was most related to be used to review the current awareness of BIM among different construction professionals and the use of BIM tools in projects such as the process of developing the digital model. Moreover, The Migration Path Model of BIM for Construction Professionals has been developed for the Malaysian construction industry. Therefore, the Migration Path Model of BIM for Construction Professionals has been used as a maturity model to explore the current level of BIM awareness among CMOs involved in public building projects in Malaysia as it is not limited to specific project phases and can be used generally in BIM projects.

RESEARCH METHOD

A comparative literature review was conducted on the past literature from 2007 to 2021 related to the maturity model related to BIM. The primary intent of this comparative review was to assess existing maturity models associated with BIM and their applicability in gauging the awareness level of construction professionals in BIM. Concurrently, this review aimed to observe the ongoing evolution of maturity models within the BIM context. Specifically, the study employed the "Building Information Modelling (BIM) Migration Path Model for Construction Professionals," formulated by Brahim (2018), to ascertain the current level of BIM awareness among construction professionals engaged in BIM projects. Employing a survey instrument in a manner replicative to its original version is closely akin to adapting it, primarily contingent upon the alignment with research objectives (Alankarage et al., 2022).

Subsequently, a survey employing a questionnaire was distributed to Complex Maintenance Officers (CMOs) participating in public building projects within Malaysia that are financially supported by the Royal Malaysian Air Force (RMAF). As the Malaysian construction industry aims to incorporate BIM into projects with a value exceeding RM10 million, however, projects funded by the RMAF have not yet embraced BIM, and the CMOs overseeing these projects lack familiarity with its implementation. Therefore, it is crucial to assess the awareness level of BIM among RMAF's CMOs and enhance the utilisation of BIM to improve service delivery. Among various sampling techniques, the non-probability method of purposive sampling was selected as being most suited for this research context. This approach aligns well when the targeted groups possess pertinent perspectives, ideas, or insights concerning the matter under investigation (Chan et al., 2022). Hence, purposive sampling was employed to select respondents in accordance with the established criteria. Given the limited number of CMOs involved in public projects under the aegis of RMAF within the Malaysian setting, a non-probability sampling technique was deemed suitable. This technique denotes that each unit within the population does not possess a quantifiable probability of being chosen. Consequently, CMOs engaged in RMAF projects were approached to elicit insights regarding their understanding of BIM.

This study employed a descriptive analysis approach, combining manual calculation of maturity level scores with the utilisation of Statistical Package for the Social Sciences (SPSS) software for data analysis derived from the survey. SPSS is a software application, functions as a statistical package that simplifies the process of conducting comparisons and establishing correlations using a variety of statistical tests. These tests encompass univariate, bivariate, and multivariate analyses, encompassing both parametric and nonparametric statistical methods.

In light of the Malaysian construction sector's aspirations to incorporate BIM into public projects exceeding RM10 million in value, it remains noteworthy that projects funded by the RMAF and overseen by the Malaysian Public Works Department (PWD) have yet to embrace BIM. Hence, the survey aimed to investigate the current level of BIM awareness among construction professionals. The questionnaire utilised, as outlined by Brahim (2018), incorporates five maturity levels (Level 1: BIM Awareness, Level 2: Develop BIM Strategies, Level 3: Implement BIM, Level 4: Monitor BIM Implementation, and Level 5: Expand BIM Implementation). Each level encompasses three (3) BIM enablers: BIM work contract, process, and technology. Respondents assessed their performance based on their current

comprehension of BIM within projects. Further details of the model are available in Figure 1, illustrating the migration path alongside its enablers and requisite actions. Adopting a replicated survey instrument by Brahim (2018) is nearly verbatim as the instrument has been significantly based on the suitability of the research objective. Hence, this model serves as a tool tailored for use by construction professionals engaged in projects employing BIM. Its purpose is to equip these professionals with a comprehensive understanding of how BIM should be integrated and implemented.

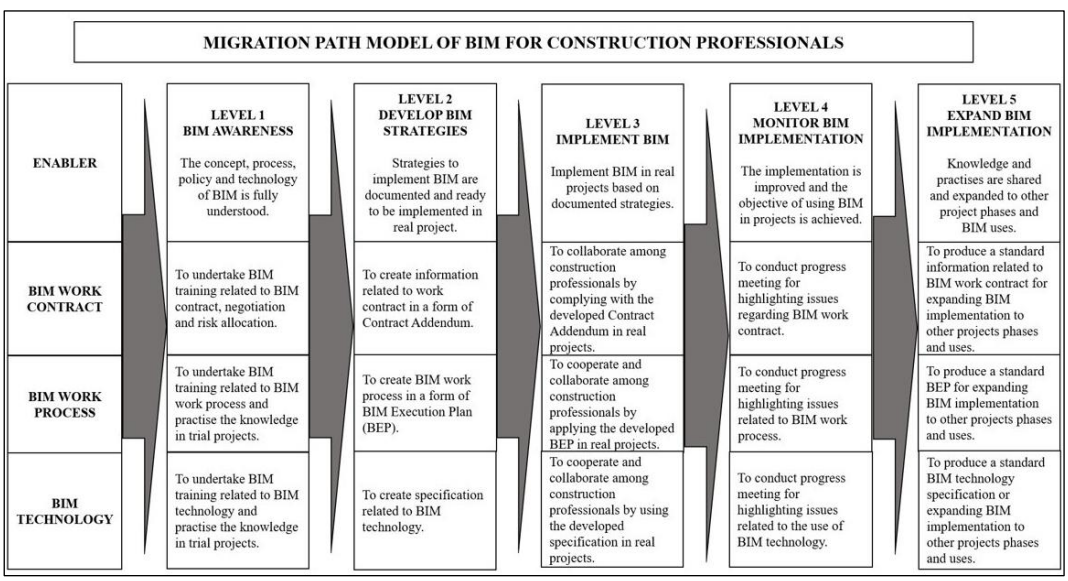

Figure 1. Migration Path Model of BIM for construction Professionals

Within the model, every tier comprises a specific action required to advance to the subsequent level of maturity. Concurrently, the arrows shown in the model represent the transition from the present level of maturity to the succeeding level. The rationale underpinning these levels is rooted in the activities capable of driving construction professionals from their present state of maturity to the subsequent level, indicative of more effective BIM implementation within projects. Adhering to the principles of the maturity and migration path model, the enablers outlined within each tier should be regarded as strategies for enhancing the current BIM practices of construction professionals. The progression from one level to another is anticipated to serve as a navigational tool, directing construction professionals toward their targeted optimal proficiency. Each level is underpinned by a comprehensive questionnaire that necessitates completion by the respondents. A detailed breakdown of the assessment process is outlined as follows:

- Expectation Output for Level 1: Construction professionals possess a comprehension of the BIM concept and possess a grasp of the appropriate implementation of BIM within projects. This grasp of BIM must encompass a comprehensive understanding of the BIM work contract, the BIM work process, and BIM technology.
- Expectation Output for Level 2: Construction professionals have recognised the essential strategies required for the effective implementation of BIM. These formulated strategies encompass the domains of BIM work contracts, BIM work processes, and BIM technology.

- Expectation Output for Level 3: Construction professionals execute BIM by adhering to the formulated strategies. The execution of BIM mandates adherence to the strategies delineated within the BIM work contract, BIM work process, and BIM technology domains.
- Expectation Output for Level 4: Enhancement are observed in the advancement of tasks linked to the BIM work contract, leading to the attainment of the specified BIM objectives. The oversight of work advancement necessitates encompassing the realms of the BIM work contract, BIM work process, and BIM technology.
- Expectation Output for Level 5: Construction professionals proficient in executing BIM within distinct projects through a structured process. These skilled professionals are capable of extending the implementation to encompass the domains of the BIM work contract, BIM work process, and BIM technology.

The answers from the respondents will remark on the specific score of the performance level. According to Brahim (2018), for a range score of between 0% to 60%, construction professionals are considered as not achieving the maturity level and incompetent. Therefore, they need to fulfil the minimum requirement of each current level. Meanwhile, construction professionals with a range score of 61% to 100% are said to have achieved this level of maturity. Therefore, they could proceed to the next level of maturity. Details of the score are explained as follows:

- To advance from a score within the range of 0% to 20%, construction professionals must enhance their performance by meeting all the activities associated with the current maturity level.
- In the bracket of 21% to 40%, construction professionals should complete several activities, each earning a minimum score of 3 points on the Likert Scale.
- Within the range of 41% to 60%, construction professionals have attained the current level of maturity by satisfying its basic requirements. Hence, they should now focus on fulfilling activities with a minimum score of 3 points on the Likert Scale.
- Construction professionals who score within the range of 61% to 80% are considered to have reached this level of maturity and can progress to the next level.
- Achieving a score between 81% and 100% indicates that construction professionals have reached the highest level of maturity.

FINDINGS AND DISCUSSION

As depicted in the following Table 2, a comprehensive of fifty (50) questionnaires were dispatched to the CMOs within the RMAF. The selection of 50 respondents was based on the total number of CMOs engaged in construction projects funded by the RMAF, which amounted to 50 individuals. Of these 50 recipients, 32 questionnaires were diligently completed and returned within a span of seven weeks, constituting a response rate of 64%. This response rate of 64% is regarded as suitable and robust in the realm of construction management research (Mohd Nordin, 2015). Thus, the response rates approximating 60 % for most research should be the researchers' goal. According to Nordin (2015), the norm response rate in the construction industry postal questionnaire survey is around 20 to 30 %. Hence, the response rate was deemed adequate for this research to provide information for BIM implementation.

Table 2. Response Data

Respondents	Sent	Return	Percentage (%)
CMO's	50	32	64

Respondents' Experience in BIM Projects

The respondent's experience in BIM projects was generated from SPSS. From the result, six (6) respondents have less than five years of experience. Meanwhile, seven (7) respondents have 6 – 10 years of experience in the construction industry. Respondents with 11 -15 years are represented by eight (8) respondents, 16 to 20 years by 4 respondents and seven (7) respondents have more than 20 years' experience. Hence, it is reasonable to infer that the majority of respondents possess a solid understanding of the industry and are well-acquainted with the traditional construction procedures (Noghabaei et al., 2020). This observation is corroborated by prior research, which suggests that individuals with over five (5) years of experience in the construction sector typically possess substantial knowledge and are adept at addressing fundamental issues (Zaira & Hadikusumo, 2017). For that reason, the respondents could be assumed to be capable of providing relevant information because the duration of their involvement in the construction industry has made them familiar with current construction industry practices and issues.

Awareness of Respondents in BIM Implementation

This section discusses the awareness of BIM among respondents related to BIM. A self-rating Likert scale assessment has been conducted to gauge the degree of awareness. The outcomes, comprising the total scores, have been condensed and presented in Table 3:

Table 3. Total Score of Respondents' BIM Competencies

R	Level 1 (%)	Level 2 (%)	Level 3 (%)	Level 4 (%)	Level 5 (%)
1	29.52	1.96	2.37	3.18	2.72
2	68.36	5.89	6.44	6.59	6.44
3	59.04	5.50	4.86	3.96	4.11
4	52.82	2.75	2.71	3.03	3.41
5	27.97	3.34	3.16	3.96	3.96
6	27.97	2.16	3.05	3.26	2.64
7	31.07	2.75	2.71	2.64	2.64
8	15.54	2.75	2.71	2.64	2.56
9	46.61	4.13	4.07	3.96	3.96
10	31.07	2.75	2.71	2.64	2.64
11	15.54	2.75	2.71	2.64	2.64
12	31.07	2.75	2.82	2.64	2.64
13	15.54	1.38	1.36	2.64	2.56
14	31.07	2.75	2.71	2.64	2.64
15	31.07	2.75	2.71	2.64	2.64
16	31.07	2.75	2.71	2.64	2.64

R	Level 1 (%)	Level 2 (%)	Level 3 (%)	Level 4 (%)	Level 5 (%)
17	31.07	2.75	2.71	2.64	2.64
18	62.15	5.50	5.42	5.28	5.28
19	31.07	2.75	2.71	2.64	2.64
20	15.54	1.38	1.36	1.32	1.32
21	46.61	4.13	4.07	3.96	3.96
22	31.07	2.75	2.71	2.64	2.64
23	31.07	2.75	2.71	2.64	2.64
24	15.54	1.38	1.36	1.32	1.32
25	31.07	2.75	2.71	2.64	2.64
26	46.61	4.13	4.07	3.96	3.96
27	31.07	2.75	2.71	2.64	2.64
28	31.07	2.75	2.71	2.64	2.64
29	34.18	3.34	3.39	2.72	2.95
30	23.31	2.75	2.94	2.40	2.95
31	31.07	2.75	2.71	2.64	2.64
32	62.15	6.29	5.88	6.28	6.36

Based on the data presented in Table 3, the experience of five (5) respondents reflects their attainment of a score within Level 1: BIM Awareness at 15.54%. This score falls within the range of 0%-20%, showing that these respondents have not met the minimal prerequisites for BIM awareness and are required to complete all the activities associated with this level.

As underscored by Brahim (2018), it is emphasised that respondents must fulfil a set of activities at their current level in order to progress to the subsequent level. Furthermore, the score range also underscores the immaturity of each level's maturity. This immaturity is a evidence to the low state of BIM maturity, pointing to a corresponding low level of BIM awareness (Marzouk et al., 2022). This could be attributed to challenges such as inadequate top management support and a limited understanding of BIM(Da Silva et al., 2022).

In contrast, nineteen (19) respondents reaped scores ranging from 23.31% to 31.07%. This range of scores aligns with the interval between 21% to 40%, indicating that these respondents need to accomplish several activities with a minimum score of 3 points on the Likert Scale. Furthermore, this score range denotes that the respondents have not yet fully grasped the BIM concept. The cause for this could be attributed to a lack of comprehension and readiness, making the extensive implementation of BIM within the construction industry a challenging pursuit (Sinoh et al., 2020). Subsequently, only five (5) respondents achieved scores between 46.61% to 59.04%. These scores position within the range of 41% to 60%, signifying that these respondents are on the cusp of attaining BIM awareness. However, they still need to address certain activities within their current maturity level to achieve comprehensive BIM awareness.

Conversely, merely three (3) respondents have attained BIM awareness, securing scores ranging from 62.15% to 68.36%. These scores correspond to the range of 61% to 80%, signifying the accomplishment of this level of maturity. Consequently, they are now poised to advance to the subsequent maturity level, namely Level 2: Develop BIM Strategies. This underscores that the BIM awareness within CMOs of the RMAF organisation remains limited. Notably, there exists a notable difference between the current level of BIM awareness and the goals and initiatives set by the Malaysian Government to enhance BIM implementation. Furthermore, a pronounced inappropriateness persists in terms of BIM awareness, adoption, and implementation across various construction firms and professionals. To facilitate the shift from conventional practices to BIM, entities like the PWD and relevant authorities must assume a pivotal role and invest substantial efforts in driving widespread BIM adoption within the country. This, in turn, would ensure the propagation of BIM awareness across all sectors, including the RMAF.

CONCLUSION AND FURTHER RECOMMENDATION

The primary aim of this research is to delve into the extent of BIM awareness among construction professionals, with a specific focus on CMOs within the RMAF. The evaluation has been undertaken based on three critical enablers: process, contract, and technology. Prior investigations have posited that the pivotal driving enablers encompassing people, processes, policies, and technology must be addressed to facilitate future enhancements in BIM (Jamal et al., 2019; Kamari & Kirkegaard, 2019). Upon analysing the outcomes of self-assessed BIM awareness by the respondents, it becomes evident that the awareness of BIM has yet to achieve maturity across all five levels, given that its implementation does not align with the requisites of BIM in projects. Only a limited three (3) respondents have exhibited a comprehensive understanding of the BIM concept. Drawing insights from this appraisal of existing BIM awareness, there arises a necessity to delve into the underlying issues responsible for the insufficient BIM awareness among CMOs within the RMAF. Such an inquiry should scrutinize the question of 'why,' considering the ongoing stream of BIM initiatives outlined by the Malaysian government to enhance and expand BIM implementation across all public projects within the Malaysian construction sector. Through this exploration, gaps can be pinpointed, and subsequently, a set of improvements can be devised to narrow the existing gap in BIM awareness specifically among CMOs in the RMAF. This holds particular significance in a country such as Malaysia, where the implementation of BIM is still relatively new.

ACKNOWLEDGMENT

The author would like to express special gratitude to the Research Management Centre of Universiti Teknologi MARA (UiTM) and the Ministry of Higher Education for supporting this research.

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THE CHALLENGES AND ENABLING FACTOR OF ADOPTING BUILDING INFORMATION MODELLING (BIM) AMONG CONTRACTORS IN SAUDI ARABIA

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Abstract
Building Information Modelling (BIM) is well-known by most people involved in the Architecture, Engineering, Construction and Operation (AECO) industry, due to the potential benefits that BIM can provide in all stages of construction. However, the adoption of BIM remains low in Saudi Arabia due to a lack of knowledge and understanding of BIM, a lack of skills, and a low number of local studies about BIM. This paper aims to study the BIM adoption in Saudi AECO industry and its influencing factors. A literature review was carried out to study the adoption of BIM and its significant benefits throughout a project's lifecycle, in addition to its challenges and the influencing factors. A quantitative research approach was adopted using questionnaire surveys to collect data from G4 and G5 contractors in Saudi Arabia. Descriptive statistics were used to analyse the data obtained from the surveys. The findings show that stakeholders are generally aware of the potential benefits BIM can provide during pre-construction, construction, and post-construction phases, including accuracy of technical drawings and visualization, details of construction progress, and a sufficient database for the client and project team. However, several challenges were discovered which limit the implementation of BIM, such as a lack of BIM education and training, poor collaboration, cost and time, lack of available expertise, resistance to change, and lack of publicity. In order to push the construction players to implement BIM, external and internal factors have been found to influence them, including enhancing the publicity of potential BIM methods, providing standards and guidelines, training for staff, and securing the necessary resources to adopt BIM. The study concludes that the implementation of BIM in construction projects in Saudi Arabia has the potential to enhance project performance in terms of time, cost, and quality, and overcome common issues associated with these factors throughout all stages of a project.

Keywords: *Adoption; Building Information Modelling; Small Medium Company; Saudi Arabia*

INTRODUCTION

The construction industry remains one of the greatest fields that enhances the efficiency of the economy. The construction industry is believed to be necessary to provide infrastructure and generate job opportunities (Sodangi et al., 2018). The complex process of construction may lead to a project's failure and cause difficulties in management among the parties involved. During the construction process, there is a major need for better coordination between stakeholders and other parties involved all of whom have different professional backgrounds (Zaini et al., 2020).

Construction in Saudi Arabia plays an essential role to support the growth of the economy and develop quality of life. According to Al-Hammadi & Tian, (2020), the Saudi government mentioned in a political, economic, and social development plan in 2017 that the expectations are high to double its value, jumping from $45.33 billion in 2016 to $96.52 billion in 2025. Nevertheless, after establishing the Kingdom's 2030 vision and dedicating a huge budget for investments, all industries have been encouraged by the government to be inventive, effective, and environmentally friendly. Lately, the development has been effectively improved from

the contribution of the Architecture, Engineering, Construction and Operation (AECO) industry. However, the AECO industry is facing many challenges in order to accomplish the huge construction development which is a part of KSA 2030 Vision (Elhendawi, 2018).

The use of advanced information technology has led the construction industry to experience a paradigm shift to improve quality, achieve sustainability, decrease the cost of lifecycle, and enhance communication between the involved parties (Arayici et al., 2012). After exploring the complexity on the construction industry and the revolution of technologies, Building Information Modelling (BIM) seems to be the best solution for most of those issues occur in the AECO industry. BIM presents a process that assists in managing an entire project, from the early design stage until its demolition (Hassan, 2012).

Since BIM technology has proven to develop better outcomes in the AECO industry, many countries have started to implement BIM technology in their projects to improve the overall performance during design, construction, and operation (Gerges et al., 2017). According to Elhendawi (2018), a mandate has been issued by the government of some developed countries after becoming aware of the significance of BIM implementation, which is growing fast and becoming the future language around the world in the AECO industry. The adoption of BIM has shown an extensive improvement in the quality of entire construction work due to the consistency and precision of data. This includes maintaining the quality of structure in a way which is rational, economical, and durable (Choi et al., 2020).

Features from adopting BIM proven to empower projects include strengthening the communication between designers and contractors during work process to avoid any failure in documentation, as well as the simulation of time and cost in early phases, which will give a further boost to the quality of the project (Aljobaly & Banawi, 2020). Moreover, Al Daoor (2018) confirmed that BIM is an added tool and an essential part of the design stage which contributes to providing solutions to construction issues. It also minimizes redoing the work. It provides access to a project's information in a single database, allowing the involved parties to follow the progress of the entire project.

There has been an obvious increase in the adoption of the Building Information Modelling (BIM) technology among the Architecture, Engineering, Construction and Operation (AECO) industry due to the great potential to develop solutions to problems which occur during different stages of the project's lifecycle (Almuntaser et al., 2018). However, it has been found that BIM has neither been extensively adopted by the AECO industry nor mandated by the government of Saudi Arabia, due to the countless number of functional gaps between the involved parties such as poor cooperation and coordination, lack of communication, ineffective building performance, and lack of sustainability (Al-Hammadi & Tian, 2020; Elhendawi, 2018). There are three (3) main issues causing Saudi Arabia to lag behind to adopt BIM in the AECO industry: lack of knowledge and understanding BIM adoption (Almuntaser et al., 2018; Banawi & Aljobaly, 2020; Btoush & Haron, 2017; Kouch et al., 2018); lack of skill in BIM (Almutiri, 2016; Neto, 2016); and lack of studies on BIM (Al-Naim, 2018; Alhumayn, 2018; Elhendawi et al., 2019).

In the context of small and medium size of contractors, the implementation of Building Information Modelling (BIM) has been relatively limited compared to larger organizations (Alghamdi et al., 2022). BIM implementation requires significant resources, including funds

for software and hardware, continuous maintenance, and staff training (Al-Mohammad et al., 2022). Small and medium contractors may face challenges in allocating these resources, which can hinder their adoption of BIM. Studies have shown that BIM usage in Saudi Arabia is primarily carried out by a small number of large organizations, while the subcontracting sector, which includes small and medium contractors, is relatively underdeveloped in terms of BIM implementation (Alghamdi et al., 2022). This indicates that small and medium contractors in Saudi Arabia have been slower in adopting BIM compared to their larger counterparts. This will contribute to fill up the gap of knowledge regarding BIM at Saudi Arabia in general, and the small medium contractors in particular. Nevertheless, this research will focus on the challenges to BIM adoption and the factors influencing the adoption of BIM in the Saudi AECO industry particularly small and medium size contractors.

CHALLENGES TO IMPLEMENTING BIM IN SAUDI ARABIA

Small and medium contractors in Saudi Arabia face various challenges and opportunities in their operations. The construction industry in Saudi Arabia is indeed booming, and small and medium contractors play a significant role in the sector Suresh et al. (2017). However, their adoption of technologies such as Building Information Modelling (BIM) has been relatively limited compared to larger organizations.

There are many challenges when adopting BIM technology into the AECO industry. Gusta & Neiburgs (2020) and Tulenheimo (2015) have stated that the complex of BIM technology implementation is one of the main challenges. However, the complexity of the process is leading to other challenges, such as cost of training and implementation, time required, staff acceptance, client demand, skills, knowledge and top management support (Hamada et al., 2016). Nevertheless, Abdulaal et al. (2017) has stated that the lack of interest and motivation to adopt BIM in the AECO industry is due to a lack of market demand to implement integrated BIM, caused by the lack of solid evidence for the benefits of BIM implementation, as well as the absence of software tools to be used in real projects incorporating BIM. According to Almuntaser et al. (2018), clients and stakeholders of AECO industry are not interested in implementing BIM due to a lack of awareness of its potential benefits. Zaini et al. (2020) identified the top three challenges to implement BIM in Malaysia as: (1) lack of top management support; (2) lack of guidelines and standards by the government; and (3) the high cost to implement BIM.

A number of authors have discussed BIM adoption challenges and classified them mainly into organizational challenges, personal challenges, process and technology challenges, and market demand challenges (S. Ahmed et al., 2018; Elhendawi, 2018; Tulenheimo, 2015; Venkatachalam, 2017). According to Elhendawi (2018), personal barriers are at the top of challenges found in BIM implementation at the UAE construction industry. Table 1 provides an overview of the literature review's findings on the challenges associated with Building Information Modelling (BIM).

Table 1. Challenges of BIM Implementation

No.	The Challenges	Authors
1	Security of BIM	(Afsari et al., 2016; Georgiadou, 2019; Ghaffarianhoseini et al., 2017; Herr & Fischer, 2019; Kamel & Memari, 2019; Li et al., 2019; Musa et al., 2018)
2	Lack of knowledge on BIM benefits	(Ahmad Jamal et al., 2019; S. Ahmed et al., 2018; Al-Hammadi & Tian, 2020; Al Daoor, 2018; Almuntaser et al., 2018; Elmualim & Gilder, 2014; Gusta & Neiburgs, 2020; Hamada et al., 2016; Li et al., 2019; Puolitaival & Forsythe, 2016; Rokooei, 2015; Shirowzhan et al., 2020; Sodangi et al., 2018; Zaini et al., 2020)
3	Resistance to change the nature of work	(S. Ahmed et al., 2018; Al-Hammadi & Tian, 2020; A. I. N. Elhendawi, 2018; Elmualim & Gilder, 2014; Fountain & Langar, 2018; Georgiadou, 2019; Gerrish et al., 2017; Hamada et al., 2016; Herr & Fischer, 2019; Musa et al., 2018; Salmi, 2017; Tulenheimo, 2015; Vass & Gustavsson, 2017; Venkatachalam, 2017)
4	Complexity of Design and BIM process	(Ahmad Jamal et al., 2019; Costin et al., 2018; A. I. N. Elhendawi, 2018; Georgiadou, 2019; Kamel & Memari, 2019; Kerosuo et al., 2015; Raouf & Al-Ghamdi, 2019)
5	High cost of BIM implementation	(Abdulaal et al., 2017; Ahmad Jamal et al., 2019; Al-Hammadi & Tian, 2020; Aziz et al., 2017; Costin et al., 2018; A. Elhendawi et al., 2019; Fountain & Langar, 2018; Gardezi et al., 2014; Gusta & Neiburgs, 2020; Hamada et al., 2016; Miyamoto, 2016; Musa et al., 2018; Oduyemi et al., 2017; Sodangi et al., 2018; Xu, 2017; Zaini et al., 2020)
6	Share and exchange big amount of data	(Afsari et al., 2016; Kamel & Memari, 2019; Puolitaival & Forsythe, 2016; Shirowzhan et al., 2020)
7	Lack of BIM skills, capabilities and expertise	(Ahmad Jamal et al., 2019; Al-Hammadi & Tian, 2020; Al Daoor, 2018; Boton et al., 2018; A. I. N. Elhendawi, 2018; Hamada et al., 2016; Herr & Fischer, 2019; Li et al., 2019; Puolitaival & Forsythe, 2016; Shirowzhan et al., 2020; Sodangi et al., 2018; Tulenheimo, 2015; Venkatachalam, 2017)
8	Lack of BIM guidelines and standards	(Afsari et al., 2016; S. Ahmed et al., 2018; Al-Hammadi & Tian, 2020; A. Elhendawi et al., 2019; Gardezi et al., 2014; Gerrish et al., 2017; Gusta & Neiburgs, 2020; Herr & Fischer, 2019; Kamel & Memari, 2019; Musa et al., 2018; Venkatachalam, 2017)
9	Training on BIM application	(Abdulaal et al., 2017; Ahmad Jamal et al., 2019; S. Ahmed et al., 2018; Al-Hammadi & Tian, 2020; Al Daoor, 2018; Aziz et al., 2017; Boton et al., 2018; A. Elhendawi et al., 2019; A. I. N. Elhendawi, 2018; Fountain & Langar, 2018; Herr & Fischer, 2019; Musa et al., 2018; Tulenheimo, 2015; Venkatachalam, 2017; Zaini et al., 2020)
10	Contractual and legal issues	(Abd Jamil & Fathi, 2018; S. Ahmed et al., 2018; Al-Hammadi & Tian, 2020; Almuntaser et al., 2018; A. I. N. Elhendawi, 2018; Fountain & Langar, 2018; Gardezi et al., 2014; Gerrish et al., 2017; Oduyemi et al., 2017; Tulenheimo, 2015; Venkatachalam, 2017)
11	Appropriate education resources for BIM	(Boton et al., 2018; A. I. N. Elhendawi, 2018; Puolitaival & Forsythe, 2016; Tulenheimo, 2015; Venkatachalam, 2017)
12	Management and communication	(Arayici et al., 2012; Hamada et al., 2016; Kamel & Memari, 2019)
13	Lack of demand in the market	(S. Ahmed et al., 2018; Al-Hammadi & Tian, 2020; Almuntaser et al., 2018; Hamada et al., 2016; Oduyemi et al., 2017; Zaini et al., 2020)
14	Support from leaders (governments & stakeholders)	(Almuntaser et al., 2018; A. Elhendawi et al., 2019; A. I. N. Elhendawi, 2018; Fountain & Langar, 2018)
15	Readiness and competency	(Almuntaser et al., 2018; Oduyemi et al., 2017)

ENABLING FACTORS OF BIM ADOPTION

Adopting BIM may offer the chance to win new projects in the AECO industry, since it is an important trend within developing countries. The governments of such countries are strongly recommended to mandate and obtain the latest technologies in order to gain competitiveness and to be awarded more desired projects (Elhendawi, 2018). According to Ahmed (2019), it is important to study the factors that influence the adoption of BIM in order to increase the implementation of BIM in the upcoming projects.

Alenazi (2018) highlighted that the collaboration between industry teams is the most important factor influencing the implementation of BIM. The connection between stakeholders will be better when awareness and knowledge of BIM technology have increased (Ozumba et al., 2019). Education on BIM is an important factor that influences AECO industry professionals to adopt BIM in their projects and provides knowledge of the requirements to implement it (Alhumayn, 2018). A majority of construction industry players believe that government is the main factor that will influence the adoption of BIM (S. Ahmed et al., 2018). In the Middle East, competency has been determined as a major factor influencing BIM adoption (Gerges et al., 2017). Moreover, Neto (2016) highlighted three main factors that influence the implementation of BIM, namely the culture of organization, proper education and training, and managing information.

Elhendawi et al. (2019) stated that the major factors influencing BIM adoption in the AECO industry are: (1) support of the government; (2) BIM contracts; (3) official guidelines and standards; (4) protocols; (5) improvement of BIM performance; and (6) collaboration between the project's teams. Some strategies have been suggested by Alhumayn et al. (2017) to implement BIM in Saudi Arabia, including legal support, environmental support, governmental funds, education for industry players and gaining experience from other countries that have implemented BIM.

Analysis of the literature indicates that external factors such as governmental mandates, standards and guidelines, and the education system play essential roles in encouraging the adoption of BIM. In contrast, internal factors such as changing organizational culture, top management support, and resources like software, hardware, and budget require skilled management and stakeholder involvement to overcome challenges. Individuals are also encouraged to explore BIM to increase the likelihood of top management investing in it to benefit the organization. Table 2 shows the enabling factors that may contribute in BIM adoption among small medium contractors in Saudi Arabia.

Table 2. Enabling Factors of BIM Implementation

No.	Influencing Factors	Authors
	External Factors	
1	Governmental mandates and support	(A. L. Ahmed, 2019; Alhumayn, 2018; Almutiri, 2016; Amin & Abanda, 2019; Awwad et al., 2020; Banawi & Aljobaly, 2020; A. Elhendawi et al., 2019; Ghanim, 2017; Juan et al., 2017; Le et al., 2019; Liao & Teo, 2017; Thirumeni, 2019)
2	Demand and support of clients	(Alreshidi et al., 2017; Awwad et al., 2020; Le et al., 2019; Liang et al., 2019; Liao & Teo, 2017; Sawhney, 2014; Wang et al., 2020)
3	Raising knowledge and awareness of BIM	(Al-Ashmori et al., 2020; Alhumayn, 2018; Amin & Abanda, 2019; Awwad et al., 2020; Hong et al., 2016; Phang et al., 2020; Sawhney, 2014)
4	Provide proper education	(Alhumayn, 2018; Almutiri, 2016; Dakhil, 2017; A. Elhendawi et al., 2019; Neto, 2016; Olugboyega & Windapo, 2019; Phang et al., 2020; Sahil, 2016)
5	Provide standards and guidelines	(Al-Naim, 2018; Alhumayn, 2018; Dakhil, 2017; A. Elhendawi et al., 2019; Kouch et al., 2018; Le et al., 2019; Liang et al., 2019; Phang et al., 2020; Sawhney, 2014; Thirumeni, 2019)
6	Competency of BIM implementation	(Chen et al., 2018; A. Elhendawi et al., 2019; Gerges et al., 2017; Ghanim, 2017; Juan et al., 2017; Liao & Teo, 2017)
	Internal Factors	
1	Changing organizational culture	(A. L. Ahmed, 2019; Al-Naim, 2018; Alhumayn, 2018; A. Elhendawi et al., 2019; Liao & Teo, 2017; Neto, 2016; Phang et al., 2020; Wang et al., 2020; Xiii & August, 2015)
2	Top management support	(A. L. Ahmed, 2019; Awwad et al., 2020; Che Ibrahim et al., 2019; Hong et al., 2016; Liang et al., 2019; Phang et al., 2020; Wang et al., 2020)
3	Collaboration between the involved parties	(A. L. Ahmed, 2019; Alenazi, 2018; Alreshidi et al., 2017; Che Ibrahim et al., 2019; Kouch et al., 2018; Liang et al., 2019; Phang et al., 2020)
4	Resources (hardware, software and budget)	(Alhumayn, 2018; Alreshidi et al., 2017; Awwad et al., 2020; Chen et al., 2018; Dakhil, 2017; A. Elhendawi et al., 2019; Juan et al., 2017; Kouch et al., 2018; Le et al., 2019; Liang et al., 2019)
5	Training of BIM for staff	(Alreshidi et al., 2017; Awwad et al., 2020; Che Ibrahim et al., 2019; Dakhil, 2017; A. Elhendawi et al., 2019; Juan et al., 2017; Kouch et al., 2018; Neto, 2016; Phang et al., 2020)
6	Easy operation and communication	(Che Ibrahim et al., 2019; Chen et al., 2018; Hong et al., 2016; Juan et al., 2017; Kwofie et al., 2020; Liang et al., 2019; Mataloto et al., 2020)
7	Willingness to adopt innovations	(A. L. Ahmed, 2019; Alreshidi et al., 2017; A. Elhendawi et al., 2019; Hong et al., 2016; Juan et al., 2017)
8	Managing data sharing and storage	(Alreshidi et al., 2017; Che Ibrahim et al., 2019; Dakhil, 2017; Ganbat et al., 2018; Liang et al., 2019; Liao & Teo, 2017; Mataloto et al., 2020; Neto, 2016)

METHODOLOGY

This study aims to explore BIM implementation and adoption among G4 and G5 contractors in the Saudi Arabia AECO sector by focusing on Jeddah city, in the region of Makkah. Based on figures from the Saudi Contractor Authority (SCA), the current number of G4 & G5 contractors in the region of Makkah is 537, making up 80 percent of the total contractors in Saudi. Most of them are in Jeddah as it is the main city of the region and has undergone continuous development within the Saudi 2030 vision.

The principal objective addressed in this study was to identify the following aspects of SMEs:

- Perceptions on BIM adoption barriers; and
- Perceptions on BIM adoption enabling factors

The questionnaire structure was based on content analysis of the previous studies related to BIM adoption. The questionnaire is divided into four sections. The first part requests personal information such as employment category, organization type, organization activity, academic qualification, specialization, experience, and year of birth. The second part asks questions about the participant's awareness of the benefits of BIM for their organization. The third part determines six main challenges/barriers (Personal, Process, Business, Technical, and Organization) as identified in the systematic review. Each challenge is supported by a number of statements. The last part of the questionnaire measures the enabling factors for BIM adoption in Saudi Arabia, including both internal and external factors. Respondents were asked to rate these on a Likert scale from 1–5 (1 = strongly disagree, 5 = strongly agree).

The questionnaire survey was conducted in the region of Makkah, in Jeddah city. Using the stratified random sampling, the total number of sets of questionnaires distributed into G4 and G5 contractors is 280. The questionnaire surveys were distributed to executives and non-executive employees involved in the construction projects. The duration of the survey to be collected was four weeks. However, the number of responses received was only 89. Thus, the response rate is 31.8%. This low response rate was predicted due to the online survey method. It was mentioned by Fellows & Liu (2015) that it is not unusual to get a lower response rate using this method. The following Table 3 shows the demographic profiles of the respondents.

Table 3. Demographic Information

Demographic Information	Percentage	Demographic Information	Percentage
Gender		***Age***	
Male	77.5%	23-27 years old	47.1%
Female	22.5%	28-35 years old	39.3%
		36-50 years old	10.1%
Academic Qualification		Above 50 years old	3.4%
High School	3.4%		
Diploma	3.4%	***Experience***	
Bachelor	66.3%	Less than 5 years	51.7%
Higher Diploma	2.2%	5-10 years	30.3%
Masters	21.3%	11-15 years	10.1%
PhD	3.4%	16-20 years	1.1%
		More than 20 years	6.7%
Position			
Client	3.4%		
Project Manager	12.3%		
Architect	40.4%		
Interior Designer	10.1%		
Civil Engineer	19.1%		
Mechanical/Electrical Engineer	3.4%		
Others	11.3%		

RESULTS AND DISCUSSIONS

Challenges of BIM Adoption

The challenges of BIM Adoption were categorized into six categories. Results indicate the average score of challenges of adopting BIM in their projects where the average score in their answers is between 3.0 – 3.3. Table 4 summarizes the six categories of those challenges based on the respondents' opinions.

Table 4. Challenges of BIM Adoption in Different Categories

BIM Adoption Challenges	Mean	Std. Deviation
Personal Challenges		
Resistance to change	3.09	1.32
Lack of understanding of BIM and its benefits	3.36	1.31
Lack of training	3.43	1.21
Lack of BIM education	3.46	1.25
Process Challenges		
Complexity of BIM process	3.09	1.08
Time consuming	2.97	1.18
Changing work processes (poor collaboration between project team)	3.09	1.28
Business Challenges		
BIM is too expensive to implement	3.10	1.18
Fear of low Return on Investment (ROI)	3.12	1.07
Cost and time of training	3.33	1.18
Technical Challenges		
Lack of skills and expertise on BIM	3.47	1.23
Current available technology is enough	2.66	1.17
Absence of clear guidelines and standards	3.21	1.17
Insufficient technology infrastructure	2.94	1.12
Organization Challenges		
Lack of top management support	3.25	1.27
Resistance to change work nature	3.45	1.30
Hardship of managing the impacts of BIM	3.18	1.24
Market Challenges		
Low demand of BIM by clients and government	3.34	1.37
Lack of publicity to spread awareness of its potential benefits	3.51	1.26
The market is not ready yet to adopt BIM	2.90	1.30

Table 4 presents a comprehensive overview of the challenges encountered in the implementation of Building Information Modelling (BIM) among small and medium-sized enterprises (SMEs) in Saudi Arabia. Across various categories, it is evident that several impediments hinder BIM adoption. Personal challenges, including resistance to change, a lack of understanding of BIM and its benefits, and insufficient training and education, highlight the need for addressing knowledge gaps and fostering a culture of innovation within these SMEs (Elhendawi, 2018). Process challenges, such as the complexity of BIM processes and issues related to collaboration among project teams, emphasize the importance of streamlining workflows and enhancing communication. Business-related challenges, such as concerns about the cost of implementation and return on investment, underscore the need for cost-effective BIM solutions and clearer ROI demonstrations. Technical challenges, including a

shortage of skills and expertise, inadequate technology infrastructure, and a lack of standardized guidelines, call for improved training and the development of BIM-specific standards. Organizational challenges, such as limited top management support and resistance to changes in work nature, highlight the necessity of gaining leadership buy-in and fostering a more adaptable work environment. Finally, market challenges, including low client and government demand for BIM and limited awareness of its benefits, indicate the importance of advocacy, education, and demonstrating the value of BIM to potential clients and stakeholders in the Saudi Arabian construction industry. Addressing these multifaceted challenges is essential to promoting successful BIM implementation among SMEs in the region, ultimately unlocking the benefits of enhanced efficiency and collaboration in the construction sector.

Enabling Factors of BIM Implementation

The results in Table 5 indicate the importance of both external and internal factors that influence the implementation of BIM. External factors play a pivotal role in facilitating BIM adoption. Governmental mandates and support, coupled with the demand and support of clients, are crucial drivers for BIM implementation. Additionally, raising knowledge and awareness of BIM, providing relevant education at universities, and offering standards and guidelines are pivotal in creating a conducive environment for BIM adoption. Competency in BIM implementation, along with publicity campaigns highlighting its benefits and benchmarking projects using BIM, further encourage its uptake.

Internal factors within SMEs are equally essential. Transforming organizational culture to be more receptive to BIM, coupled with strong top management support, fosters a climate conducive to innovation. Effective collaboration among team members, backed by adequate resources, including hardware, software, and budget allocation, enhances BIM implementation. Prioritizing staff training in BIM, fostering a willingness to adopt innovations, and effectively managing data sharing and storage are critical internal factors that drive success. Organizational readiness, encompassing preparedness for change and adoption of BIM practices, is pivotal for SMEs in Saudi Arabia to leverage the full potential of BIM in the construction industry.

This shows how the industry players are concerned about implementing BIM, but in need of such influences in order to step forward into adopting this technology. Despite the blurred results on the challenges, people seem to be more encouraged if those external and internal pushes are taken into consideration, due to the real effects of making such a move. The high agreement on most of the given statements shows the link between the findings of this study and the previous studies. The need of relevant education about BIM as mentioned by Alhumayn (2018) where the education is one of the most important factors that influence the implementation of BIM. Another factor is the standards and guidelines about using BIM, which shows the important role of government into establishing such reference for them. This was also found in research by Elhendawi et al. (2019) and Ahmed et al. (2018). Moreover, the internal training of BIM given by the organization is highly expected to influence people into implementing BIM where that will show the potential benefits by investment on such technology along with its challenges and impacts. This is in line with what Neto (2016) confirmed in his research into other potential pushes towards implementing BIM.

Table 5. Enabling Factors Influencing BIM Adoption

Factors Influencing BIM Adoption	N	Mean	Std. Deviation
External Factor			
Governmental mandates and support	89	3.27	1.17
Demand and support of clients	89	3.31	1.10
Raising knowledge and awareness of BIM	89	3.60	1.08
Provide relevant education at universities	89	3.65	1.13
Provide standards and guidelines	89	3.65	1.11
Competency of BIM implementation	89	3.52	1.08
Publicity of BIM benefits to spread awareness	89	3.67	1.10
Benchmarking projects using BIM	89	3.56	1.16
Internal Factors			
Changing organizational culture	89	3.44	1.21
Top management support	89	3.56	1.23
Collaboration between the team members	89	3.55	1.17
Resources (hardware, software and budget)	89	3.57	1.14
Training of BIM for staff	89	3.74	1.18
Communication behaviours	89	3.38	1.13
Willingness to adopt innovations	89	3.49	1.16
Managing data sharing and storage	89	3.40	1.15
Organizational readiness	89	3.44	1.19

CONCLUSIONS

The Building Information Modelling (BIM) adoption in Saudi Arabia is low due to a lack of knowledge, skills, and local studies. This study aims to study the adoption of BIM in the Saudi AECO industry and its influencing factors. A literature review was conducted using questionnaire surveys from G4 and G5 contractors in Saudi Arabia. The findings showed that people are generally aware of the benefits of BIM during the pre-construction, construction, and post-construction phases, such as technical drawings accuracy, construction progress details, and sufficient databases. However, challenges such as lack of education, training, collaboration, cost, time, expertise, resistance to change, and publicity hinder the implementation of BIM. To encourage construction players to implement BIM, external and internal factors have been found to influence them, such as enhancing publicity, providing standards and guidelines, training staff, and securing resources. The study concludes that BIM implementation in construction projects in Saudi Arabia can enhance project performance in terms of time, cost, and quality, and overcome common issues associated with these factors throughout all stages of the project.

Although this research is limited to the Egyptian construction industry, the adopted methodology could be referred to when reforming other sectors in other countries or the Middle East region. To increase BIM adoption in the MENA region, it is essential to establish a long-term plan for sector development that can serve as a useful guide for policymakers and stakeholders seeking to enhance the sector and drive economic growth. In this regard, government policy and public procurement methods can serve as effective tools to facilitate positive change within the industry. Without strong leadership from the top down, the sector may continue to underinvest in information technology, resulting in suboptimal productivity levels and value for money, particularly in the diverse SME sector. Therefore, it is crucial for

the government and public sector organizations to lead the way in encouraging the industry to seize the untapped potential of digital technology, enabling them to provide better public services and enhance the value of public expenditure.

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ESTABLISHING RELATIONSHIP OF LIFE CYCLE COSTING COMPONENTS TO THE GREEN HIGHWAY PROJECTS IN MALAYSIA

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Abstract
Life Cycle Cost (LCC) analysis is a method introduced to highlight the return of investment and cost risks that possibly encounter during the life span of the buildings or infrastructures. Besides green building, "green highway" or "green road" is among the emerging concern in sustainable construction. The establishment of Green Highway & Road (H&R) Rating Tools such as Malaysia Green Highway Index (MyGHI), offers multi-criteria of sustainable initiatives that count towards the score of the green certification of H&R. This paper aims to establish relationship of life cycle costing components to the green highway projects using the highways certified by MyGHI to identify relationships between LCC components and the green highway's criteria cost. A questionnaire survey of 65 respondents was conducted. Friedman's Test and Spearman's Correlation Coefficient Analysis were used to validate LCC component and establish the relationship. Then PLS-SEM was used to validate the correlation coefficient of cost component towards total LCC of green criteria. Results show that the energy efficiency green criteria cost have a positive and significant relationship except for capital, maintenance, and replacement costs. This study innovation is novel in terms of an alternative for reducing the negative perception of green highways and exceptionally facilitates decision-making, hence, aiding the H&R stakeholders in foreseeing the green highway cost benefits.

Keywords: *Life Cycle Costing; Highway and Road; Energy Efficiency; Green Criteria Cost*

INTRODUCTION

Set against the global context, Malaysia, as a developing country, has a wide range of road network systems that link facilities and people across Malaysia. To provide the nation with a reliable, modern, and green transportation system, a basic framework, such as a standard or regulation, must be created for the sector, so that people move towards sustainability together with the environment. Equally important, sustainability issues have recently been widely discussed in the road construction industry (Cabeza et al., 2014). Major road construction projects have led to environmental problems such as exposure to harmful and hazardous substances, degradation of the resources of coastal areas, destruction of ecosystems, noise, contamination of the soil and the water. In support, according to Epstein et al. (2018), the operations of the road project have high environmental impacts, and this scenario can have negative environmental consequences and create a sustainable problem.

Increased awareness of climate and sustainability leads road authorities and government agencies to take the necessary measures to overcome carbon emissions from road infrastructure on a life-cycle basis (Griffiths et al., 2018). Combining awareness of green principles with the efforts of on-site contractors plays a significant role in implementing green practices, especially on the construction site (Zhou et al., 2018). In spite of this, recent green road studies deal with a wide range of topics in its construction and maintenance stages. Ismail et al. (2013) classified green road studies in five broad areas: water shielded stormwater

management, energy and emission controls; recycling, re-use and renewables; conservation, and ecosystem management, and ultimately overall social benefits. In addition, further explore transport efficiency and ecology elements and facets, and eventually establish geological, landscaping, waste management, materials, water saving and energy efficiencies elements and sub-elements of green road study. While past studies focused on the construction and maintenance stages, Zhou et al. (2018) study examines the difficulty levels of sustainable road design, taking the example of each item of sustainable road design.

On the other hand, since almost all efforts and initiatives for sustainable development are focused only on the building, Ismail et al. (2013) argued that road rating system would certainly give some ideas to alleviate green road construction projects. Ultimately, in the Malaysian road construction industry, MyGHI manual was developed as a guideline to validate the credential in the green highway construction sector. Although MyGHI was introduced by the Malaysian Highway Authority (MHA), the implementation of this guideline for H&R projects in Malaysia is still immature.

The implementation of a green project in the construction industry or infrastructure introduces a novel way for the use of green technology. This has the potential to influence the escalation of costs (Khan, J. S. et al., 2019). Furthermore, it is imperative to acknowledge that the current stage of green project technology is more sophisticated than ever before. As the global supply of non-renewable resources diminishes and becomes more expensive, the significance of green technology continues to grow.

Given the ongoing development of new technologies as complements to current practices for improved and environmentally friendly structures, the general goal of green road projects is to reduce the overall impact on natural environments and human health of the built environment (C. J. Kibert, 2016). However, there is a lack of sustainable awareness of how to restrict construction efficiency in green road management (X. Wu et al., 2019). The future will be faced with growing stresses and impacts on road infrastructure from a variety of issues, including changing weather patterns, capacity constraints, population growth, land, capital shortages, and technological changes that are beyond the speed of new infrastructure development. Likewise, the anticipated improvement in the behaviour of travel will have a significant impact on road construction and transportations (Attahiru et al., 2019). Despite this, the problem of global warming and natural resource depletion has been addressed differently by various nations. For example, Malaysia has embraced many alternative roadway materials and technologies for road industry to achieve green roads (Akmam Syed Zakaria et al., 2018). There is, however, still much room for improvement, and more research needs to be done to examine the issue more deeply. Also, in order to eliminate the impact of global warming and depleting the natural resources problems, the sustainability principle for road growth must be dealt with critically (Doppelt and McDonough, 2017).

When considering the highway and road (H&R) projects, it is important to acknowledge that the cost associated with utilising this infrastructure is a result of the cumulative expenses incurred by adhering to green criteria during the lifespan of the H&R. According to Abd Rahman et al. (2022), the implementation of measures aimed at reducing future costs, such as enhancing power efficiency and increasing the lifetime of heating and cooling components, frequently necessitates greater initial investment expenditures. These may include the incorporation of heat insulation and the utilisation of more resilient pavement materials. Abd.

Rahman and Zakaria (2018) provide additional support for the notion that a comprehensive evaluation of the financial aspects of different green project designs should be conducted using the LCC approach. This approach encompasses all expenses and income generated over the lifespan of the structure. To attain LCC optimisation in green highway projects, it is imperative to initially identify all aspects as either the green variable or criteria cost during the LCC component stage. Furthermore, it is essential to establish the correlation between these elements. The expense associated with utilising this infrastructure is a result of the cumulative cost of meeting all green standards throughout the lifespan of the H&R. Initiatives aimed at mitigating future expenses, such as enhancing power efficiency and increasing the longevity of heating and cooling components, frequently result in augmented investment expenditures, such as the incorporation of heat insulation and the utilisation of more resilient pavement materials. The implementation of automatic optimisation techniques can effectively replace the human manipulation of different design parameters, resulting in significant time and effort savings for H&R designers. Furthermore, this approach can guide designers towards the development of cost-effective H&R designs that yield exceptional outcomes (Kleppmann, 2017).

In the context of H&R construction projects, a highway can be classified as a public H&R when its primary objective is to stimulate economic development by generating substantial local employment opportunities and facilitating the generation of tax income for the local community. According to Xu and Nakajima (2017), H&R serve as vital conduits that facilitate the interconnection of several locations, hence contributing to the achievement of manufacturing efficiency, employment opportunities, and overall economic growth. The autonomous H&R is formed by the bridges, traffic signals, roadways, and lane dividers, which possess robust capabilities, high efficiency, and well-designed construction. Additionally, it is imperative to acknowledge the significance of H&R networks in fostering regional development. These networks are intricately connected to the core highway network system within the country, hence facilitating the establishment of novel trade routes and facilitating access to manufacturing hubs throughout the globe (Holl and Mariotti, 2018). Furthermore, the economic prosperity of the community is contingent upon the advancement of mobility within the H&Rs. Nevertheless, inadequately designed, constructed, and maintained road networks can have a significant impact on the social and economic dynamics of a sizable population. The detrimental effects commonly associated with habitat damage and biodiversity loss, the formation of air and water pollution, the generation of noise and vibration, the damage to natural places, and the destruction of social and cultural community structure have been identified as significant factors impacting the development of hospitality and tourism (Dandy et al., 2017). The construction and maintenance of H&R infrastructure must adhere to rigorous requirements and provide exceptional quality. The integration of environmental factors in the development, construction, and maintenance of H&Rs involves three significant processes, as outlined by Babashamsi et al. (2016).

Unfortunately, the H&R sector does not receive the same level of assistance as other industries (Diewald, 2001; Shaoul et al., 2006). Saif et al. (2019) posited that the condition is influenced by multiple factors. Initially, the industry is perceived as having a low level of technological advancement. The prevalence of the system and its utilisation of materials and technologies rooted in ancient times gives rise to the presumption that there is limited room for knowledge regarding H&R technology, and that the contemporary issues encountered by the industry are indistinguishable. Additionally, a highly decentralised H&R network

planning system has been proposed by Datta (1991, 1994). Government organisations commonly utilise H&Rs, for their operational needs, whilst private enterprises predominantly provide goods and services. It is noteworthy that most of these institutions do not solely finance the endeavours independently. Despite the proven and enormous benefits, the introduction of technologies becomes problematic due to the huge numbers involved. This is where the implementation of green technology in the context of green highway and road (H&R) projects can be beneficial. Green technology, such as energy efficiency measures, can be applied to both small and large-scale projects, aligning with the Sustainable Development Goals (SDGs) and the sustainability policies of organisations. By incorporating green criteria and considering environmental conditions throughout the planning, design, and construction phases, green highway projects can be categorised as a project model in accordance with the definition provided by Wu X. et al. (2019). This integration of green features not only improves the overall quality of the projects but also enhances the potential for financial support from agencies or government bodies to fund such initiatives (Diewald, 2001; Shaoul et al., 2006).

In the last 40 years, virtually all aspects of road planning, design, service, and development have improved, as a constant flow of developments has been implemented, despite modest investment in road and highway technology (Howe et al., 2019). Such developments were, however, mostly incremental, as aforementioned, with few significant advances which would be apparent to the public. Pressures on the road system have far outperformed capability growth in the past four decades. Although the way road research is organised and performed can be improved in large part, a structured research system involving direct operating entities and other stakeholders is essential for ensuring that the program remains relevant and for improving the possibilities for innovative products and techniques to move out of the facility. So long as the governance, management, and operation of the road system are decentralised, work remains relatively decentralised (Baum-Snow et al., 2017).

In brief, roads are being built, and existing roads are being rebuilt with additional features to support the cultural, environmental, and social objectives of the country. This research will explore new road development approaches to better balance social and environmental concerns with engineering and economic considerations. More specifically, new tools for facility design, impact assessment, and work with users and communities concerned would be created. Although research is currently underway in all these problem areas, the scale of the effort is too small to provide promising results for short-term research, which can substantially change practice.

The general social benefits of road construction should be considered to attain sustainability because this has an impact on the growth of the Triple Bottom Line (TBL), specifically on the economic factor (C. J. Kibert, 2016). According to Schweitzer and Tonn (2002), three kinds of sub-elements have environmental, economic, and social advantages that fall under a wide range of non-energy benefit variables in TBL. A green road is, therefore, a pressing question for road-related engineering firms both internally and externally.

The growing importance of sustainability in H&R infrastructure has underscored the need of competent investment management. This is particularly crucial since H&R funding aims to address the absence of financial support from the government at several levels (Dornan, 2016). The notion of engineering economics is employed in the field of human resources

development to investigate stakeholder investments with greater efficiency. This methodology evaluates not only the initial expenditure associated with the development of the H&R infrastructure, but also accounts for all subsequent maintenance and repair costs incurred during its operational lifespan. The utilisation of novel technologies in H&R infrastructure appears to be well-founded, however, there are deficiencies in current methodologies that have not been adequately addressed and fail to encompass certain crucial aspects of highway construction (Alirezaei et al., 2017).

Several studies have been conducted to examine the financial implications associated with the incorporation of green criteria in green highway projects (Abd Rahman et al., 2022; Rahman and Zakaria, 2018; Rahman et al., 2022). The determination of the cost of green criteria in the Energy Efficiency (EE) segment of the Malaysia Green Highway Index (MyGHI), as issued by the Public Works Department (PWD) of Malaysia, is based on five primary criteria related to energy efficiency. There are a total of nine distinct costs associated with the implementation of green criteria inside the MyGHI system. These costs are derived from the five key criteria within the field of energy efficiency and are incurred during the execution of green criteria. The initial cost associated with green criteria primarily centred around design expenses, such as Building Information Modelling (BIM). It has been noted that design fees hold significant importance in terms of cost (Heralova et al., 2014). The correct planning of green roadway development is essential. The second criterion pertaining to green costs encompasses the utilisation of technology that minimises energy consumption, such as LED streetlights or bulbs. The correlation between the green criterion and green H&R features is evident, as the advancement of energy efficiency is closely tied to the availability of green technology (Qin et al., 2014).

The evaluation of EE criteria involves conducting site inspections and making comparisons with the project plan, as well as assessing progress by comparing it to the plan. The cost associated with green criteria encompasses both documentation expenses, such as those related to green certification compliance, and supervision fees, such as those for green audits. These costs hold particular significance in green hospitality and tourism projects, as highlighted by Pučko et al. (2018). Subsequently, the subsequent aspect pertains to the imposition of taxes associated with renewable energy sources, such as solar lighting and signage. This is particularly relevant given the prevailing trend among several firms to adopt renewable energy practises as a means to mitigate their electricity consumption and reduce their overall carbon emissions (De Courchelle et al., 2019). Similarly, the inclusion of retroreflective panels and electrical sub-metering devices was identified as significant components of green criteria that resulted in financial expenses (Morini et al., 2018; C. Wang et al., 2017).

The process of monitoring green criterion systems involves the comparison of actual plant outcomes with expected outcomes, as well as the provision of information to end users. These systems consist principally of sensors, including electrical and environmental sensors, a data collection system, and communication protocols that are specifically designed to meet their requirements. Additionally, the process encompasses the utilisation of data analysis techniques as described by Triki-Lahiani et al. (2018). The cost breakdown for the green criteria encompasses routine maintenance, such as energy-efficient fixtures and equipment, as well as sensors and control devices that are associated with energy efficiency and power consumption for the budget of the green highway project (Cheng and Lee, 2014; E. Juntunen

et al., 2015; Eveliina Juntunen et al., 2018; Mellit et al., 2018). The implementation of green standards in highway developments incurs additional expenses. Implementing effective cost strategies is crucial to manage and optimise incurred expenses.

According to Russ et al. (2018), the implementation of green criteria in a project will result in the incurrence of a green cost. According to the research conducted by Taleizadeh et al. (2020), expenses related to green criteria arise while incorporating green materials and the procurement of environmentally friendly commodities. As a result, green highway projects have included green criteria into their planning procedures, starting from the design phase and continuing until the completion phase. Green criterion features differentiate green highway projects from standard highway projects by prioritising the preservation of resources and minimising harm to the built environment during both the construction and operational phases of the projects.

In lieu of that, LCC is a methodology used to determine the most economically efficient approach for several competing aspects of acquiring, possessing, running, maintaining, and ultimately disposing of an item or process, with each option being equally viable for technical execution (Goh & Sun, 2016). According to Gantner et al. (2018), the concept of life cycle costing examines potential future alternatives or alternative approaches. The authors assert that sustainable development necessitates sustainable investment strategies that optimise the benefits derived from allocated expenditures, hence facilitating sustainable growth. The comprehensive evaluation of the financial expenditure associated with green highway projects is conducted through the utilisation of the life cycle costing approach. This ensures that the allocated funds are justified in terms of their value, while also providing stakeholders with a clear understanding of each stage within the project's life cycle. In recent decades, multiple agencies and institutions have formulated methodologies for the analysis of LCCs in the context of construction projects focused on heating and cooling systems.

METHODOLOGY

The literature pertaining to the past research conducted on green H&R and the components of LCC was thoroughly examined by consulting primary sources such as books, scholarly journals, and conference papers. The analysis of secondary data has been conducted in order to get comprehensive understanding in the subject area and to find any deficiencies in the utilisation of LCC components pertaining to the cost associated with green criteria. This necessitates the selection and development of appropriate instruments and a comprehensive methodology for executing a pilot survey and conducting preliminary interviews. Furthermore, the study involved the administration of questionnaires and the conduction of semi-structured interviews with key industry stakeholders. The researchers utilised surveys as a means of identifying the specific LCC component that is associated with the expenses made in relation to green criteria in H&R infrastructure investments. This approach was previously employed by Wang (2014) and Yang (2005).

In the present investigation, it is customary to perform a power analysis prior to the collection of data in order to ascertain the minimum sample size necessary to detect an effect with an adequate level of statistical power. The utilisation of the G*power programme for this purpose has been shown in previous studies (Faul et al., 2009; Memon et al., 2020). The

minimal sample size for this investigation was determined to be 65 individuals, which aligns with the sample size used in a previous study conducted by Abd Rahman et al. (2022).

This study employs purposive sampling, drawing upon the research conducted by Patton (2014), Miles et al. (2018), and Chan et al. (2017). The suggested sample sizes for correlational, causal-comparative, and experimental study designs are based on the ability to detect a medium-sized effect (as defined by Cohen, 2013) with a one-tailed statistical significance threshold of 5% and a power of 80%. According to Onwuegbuzie et al. (2004), in order to achieve a statistical power of .80 at a significance level of 5%, a minimum of 21 participants is required for identifying moderate effect sizes.

RELATIONSHIP OF LIFE CYCLE COSTING COMPONENTS TO THE GREEN HIGHWAY PROJECTS IN MALAYSIA: ENERGY EFFICIENCY CRITERIA

There are nineteen (19) green criteria cost identified from the extensive literature reviews. Respondents were asked on the level of importance of LCC component in terms of green criteria. Table 1 on the next page shows the mean score of the Green Criteria Cost over LCC stages, for EE1- The Management Policies. There are 19 green criteria cost under management policies (EE1) in Table 1 with the mean score range from 2.70 to 3.30.

List of 19 green criteria cost under management policies (EE1) in Table 1 shows the mean score range from 2.70 to 3.30. For green criteria cost at RSAS and Lay-By (EE2), there are 14 criteria which mean score range from 2.90 to 3.55. Green criteria cost at Toll Plaza (EE3) yields range of mean score from 2.75 to 3.42. Green criteria cost at Compound and Car Park (EE4) depicts 8 criteria range from 2.71 to 3.20. 8 green criteria cost of EE5 (Interchange) presents mean score range of 2.85 to 3.36.

Lowest mean score are documentation fees of commissioning of specialist work related to green project in EE1, supervision fees for electrical sub-metering devices in operation at RSAS and Lay-By (EE2), documentation fees to create more than 80% of installed lighting fixture using the efficiency type at toll plaza (EE3), documentation fees for surveying the lighting intensity are dimmed by 70% by a control technology at car parks that fulfils MS 1525 or other relevant standards (brighten if there is movement of objects) (EE4), and system design for the use of alternative energy to power lighting that can reduce energy consumption by 1% to 5% at each interchange (EE5).

While highest mean score portrays highest green criteria cost in term of LCC component for application of EE type of Lighting (e.g. Light Emitting Diodes) in EE1, initiation of solar lighting and warning sign panels at RSAS and Lay-By in EE2, the Chiller air conditioner fulfils other rating requirements equivalent to the Malaysian Standard, like AHRI Certified and etc., in toll booths (EE3), initiation of a switch control technology for landscape lighting that has a percentage of energy reduction after midnight at car parks (EE4), and initiation of renewable energy equipment (e.g., solar panels) (EE5).

A mean score greater than 2.7 characterises an acceptable range cost for the green criteria in terms of the LCC component assessed (Abd Rahman et al., 2022; Rahman and Zakaria, 2018; Sadeli, 2015). As mentioned in Section 3.4.2 of Chapter 3, Sadeli (2015) renders range cost using Likert scale from 1 = no cost at all (0%), 2 = slightly costly (1-25%), 3 = moderate

costly (>25-50%), 4 = high cost (>50-75%), or 5 = very high cost (>75-100%). From the results, the overall mean of the green criteria cost demonstrates a significant level of importance for the LCC component, where mean scores greater than 2.70 were included in the LCC analysis. In terms of the LCC component, the initial cost was much more important than most of the future costs in the Table 1.

Table 1. The Following Mean Score Results of The LCC Component on Green Criteria Cost Are Attached in Appendix D – Management Policies

Code	Green criteria cost	(1) Capital Cost	(2) Construction (installation)	(3) Management cost	(4) Operation	(5) Maintenance/ service	(6) Replacement	(7) Demolition	(8) Contingencies cost/risk	(9) Management cost	Mean score
ID1.1.1_R1_ CI_1	▪ Design fees to prepare technical guideline for design reference	3.86	3.14	3.52	2.82	3.09	2.72	2.54	2.74	2.75	3.02
ID1.1.2_R1_ CI_3	▪ Design fees to create Building Information Modelling (BIM) plan	3.55	3.55	3.26	3.00	3.42	3.38	2.62	2.72	2.69	3.13
ID1.1.2_R1_ CI_5	▪ Implement Energy efficiency technology (e.g. LED Streetlight, System design using simulation software which applies hourly calculation method)	4.17	3.85	3.31	2.80	3.11	2.80	2.55	2.54	2.69	3.09
ID1.2.1_R4_ CI_1	▪ Documentation for provision of occupancy schedule that details the project schedule and identifies the progress	3.34	2.98	3.23	2.78	2.78	2.43	2.42	2.46	2.72	2.79
ID1.2.1_R4_ CI _2	▪ Supervision fees for identifies the progress is certified by the stakeholders	3.12	2.98	3.26	2.94	2.97	2.66	2.62	2.62	3.02	2.91
ID1.2.2_R2_ CI_1	▪ Training fees of mgmt. staff	3.11	2.88	3.32	2.89	2.98	2.57	2.37	2.46	2.94	2.84
ID1.2.2_R2_ CI_2	▪ Coaching fees of sustainable building operation	3.28	2.94	3.18	2.58	2.77	2.58	2.45	2.38	2.72	2.77
ID1.2.2_R3_ CI_1	▪ Supervision fees during commissioning of specialist work	3.20	3.12	3.52	2.85	2.83	2.63	2.52	2.54	2.92	2.90
ID1.2.2_R3_ CI_2	▪ Documentation fees of commissioning of specialist work	3.18	2.83	3.17	2.57	2.69	2.42	2.23	2.34	2.85	2.70
ID1.2.2_R4_ CI_1	▪ Supervision fees regarding the performance of the commissioned building's energy related systems	3.15	3.06	3.25	2.71	2.92	2.69	2.37	2.42	2.98	2.84
ID1.2.2_R4_ CI_2	▪ Documentation fees of final commissioning report includes recommendations to the client regarding the performance of the commissioned building's energy related systems	3.26	2.88	3.35	2.74	2.74	2.49	2.22	2.28	2.71	2.74
ID1.2.3_R1_ CI_1	▪ Application of Energy efficiency Lighting (e.g. Light Emitting Diodes)	3.77	3.54	3.77	3.35	3.46	3.14	2.95	2.80	2.89	3.30
ID1.2.3_R1_ CI_2	▪ Supervision fees of compliance with local laws and regulations regarding designing of lighting	3.29	3.02	3.45	2.85	3.08	2.66	2.52	2.63	2.94	2.94
ID1.2.3_R1_ CI_3	▪ Documentation fees of application of Energy efficiency Lighting	3.34	2.95	3.37	2.69	2.77	2.55	2.45	2.43	2.83	2.82
ID1.2.3_R1_ CI_4	▪ Design fees of reductions in energy for lighting intensity	3.40	3.09	3.46	2.58	2.91	2.54	2.54	2.52	2.82	2.87
ID1.3.1_R1_ CI_1	▪ Supervision fees for maintenance plan implementation	3.26	2.98	3.45	2.75	2.88	2.71	2.68	2.55	2.94	2.91
ID1.3.1_R1_ CI_3	▪ Routine maintenance works: Repair & Replacement of system and component	3.37	3.12	3.40	3.60	3.55	3.35	2.83	3.12	3.18	3.28
ID1.3.2_R2_ CI_1	▪ Documentation fees for evidence of energy efficient, renewable energy and other greenhouse gases emission reduction actions plan that may make important contributions towards achieving positive health and environmental impacts at a low cost	3.26	2.91	3.34	2.62	2.72	2.60	2.37	2.54	2.86	2.80
ID1.3.2_R2_ CI_2	▪ Supervision fees for monitoring emission reduction actions plan	3.26	3.25	3.43	2.85	2.94	2.80	2.63	2.65	2.95	2.97

RESULTS OF THE FRIEDMAN TEST MEAN RANKS FOR THE LCC COMPONENT IN TERMS OF GREEN CRITERIA RELATED TO COST

From the test, the data procured was presented in Table 2 above. The table exhibits the mean rank of the LCC components of the green criteria cost used to construct the LCC DSS framework. Data in Table 4.2 clearly shows the capital cost has the highest mean rank score (mean rank = 7.36), followed by the initial management cost (mean rank = 6.84). The rank is followed by construction/installation cost (mean rank = 6.50), maintenance/service cost

(mean rank = 5.32), operation cost (mean rank = 5.17), replacement cost (mean rank = 4.47), contingency/risk cost (mean rank 3.36), future management cost (mean rank = 3.15), and demolition cost (mean rank = 2.84). Friedman's test yields a significant result of $X2$ (9, N = 65) = 204.637, p<.05. Referring to Chua (2008), at a 5% confidence level, the respondent's opinion on the level of importance of nine LCC components is significantly different from each other and did not occur by chance. The result indicates that the respondents understand the LCC component is distinct because it was not perceived as same cost component. The significant difference of the Friedman test result between LCC components was based on the significant difference of twenty-six paired cost comparison test results, where the test results significant at p<0.0014. From the perspective of the respondents, the paired cost comparison indicated that there is significant median difference amongst each significant paired cost.

Table 2. Mean Ranks for The LCC Component in Terms of Green Criteria Related to Cost

Stage	Life Cycle Cost Components	Mean Ranks
Initial Cost	Capital Cost	7.36
	Construction/Installation Cost	6.50
	Management Cost	6.84
Future Cost	Operation Cost	5.17
	Maintenance/Service Cost	5.32
	Replacement Cost	4.47
	Demolition Cost	2.84
	Contingency/Risk Cost	3.36
	Management Cost	3.15

Understanding the components of LCC and identifying the costs associated with green criteria are of paramount importance in the construction of green highway projects (Abd Rahman et al., 2022; K. Goh and Yang, 2013). The incorporation of the mean ranks of the LCC component discussed in this study can alter the prioritisation of investments and developments by integrating this information into the decision-making process. For instance, stakeholders can make informed decisions regarding the most cost-effective approach among various green criteria technologies by considering the LCC associated with each option. Therefore, it is imperative for stakeholders to possess knowledge on the relevance level of the LCC components associated with green criteria in order to effectively assess the LCC of green projects (Cui and Levinson, 2018).

CORRELATION COEFFICIENT OF THE COST COMPONENT TOWARDS THE TOTAL LCC OF GREEN CRITERIA

The results in Figure 1 indicate a positive correlation among the various cost components in the relationship. The findings presented in this study provide empirical evidence that aligns with the assertions put forth in the scholarly work by J. Wang et al. (2020), which posited a positive correlation between operational costs and start-up costs. Collectively, the results presented indicate that the implementation of green criteria exerts a favourable and escalating impact on the overall life cycle cost (LCC) component within green highway projects. It is important to note that the findings do not align entirely with the concept of whole cycle cost. Limited empirical evidence exists in the existing body of literature regarding the associations between long-term cashflow analysis and the cost of implementing green criteria in highway projects. Moreover, the practise of doing such analyses in the context of green highway

projects is infrequent. The primary reason for this phenomenon can be attributed to stakeholders' limited inclination towards acquiring knowledge and understanding of prospective expenses (Cui and Levinson, 2018). The implementation of green highway projects and adherence to their requirements would necessitate financial expenditures and the allocation of substantial resources to effectively manage the LCC. However, an alternative explanation for the observed link in the study conducted by N. Wang (2014) is that a positive relationship was identified between capital cost and life cycle replacement cost. The findings obtained in this example had broad applicability, and it is justifiable to argue that the results derived from this investigation continue to maintain validity.

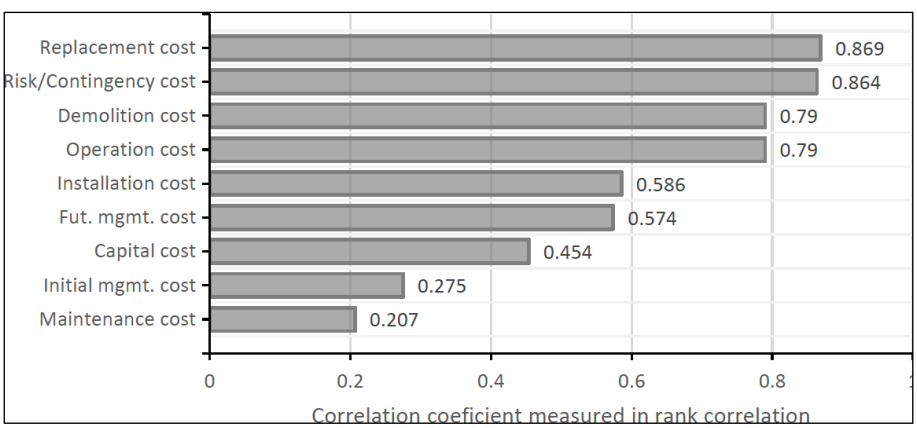

Figure 1. Correlation Coefficient of the Cost Component Towards the Total LCC of Green Criteria

ASSOCIATION OF COST COMPONENT TOWARDS TOTAL LCC OF GREEN CRITERIA

The basic premise of life-cycle cost is to minimize the total sum of money spent on a given system from conception through disposal, i.e., during the system's life. Therefore, the overall purpose of life cycle cost theory is to minimize cumulated costs. Life-cycle costing promotes a long-term perspective on investment decision-making, rather than focusing exclusively on short-term cost savings through the procurement of assets with lower initial acquisition costs (Rahman and Zakaria, 2018). However, current trends indicate that life-cycle expenses are becoming increasingly significant. This study utilised structural equation modelling using Smart-PLS software to analyse the model and the relationships between the constructs of the research.

The results of path analysis show that there is a significant relationship between demolition cost and LCC with the Beta of 0.160 (P value less than 0.05). Moreover, there is a positive significant relationship between initial and future management cost with a Beta value of 0.172 and 0.140 on the LCC (P value less than 0.05). There is also a significant positive relationship between installation cost on LCC with the Beta of 0.144 (P value less than 0.05). Consequently, risk contingency cost had the highest significant positive impact on LCC according to the results of this study with the Beta of 0.29 (P value = 0.005). The second highest positive relationship are operation cost with the Beta of 0.22. However, the results showed that there are no significant impacts of capital cost, maintenance cost, and replacement cost on the LCC of a green project due to the ¬p values being greater than 0.05, which resulted in it being a not statistically significant relationship. Respondent opinions on

these three costs are it is commonly used in the budget planning phase. While a green project is properly planned financially as an LCC, the effect of a positive or negative relationship towards the LCC between capital, maintenance, and replacement costs is not significant whenever those three green cost components are considered in budget planning, resulting in no significant relationship to the LCC (Abd Rahman et al., 2022; N. Wang, 2014). Figure 2 shows the PLS diagram illustrating the strengths of paths coefficients generated by Smart PLS.

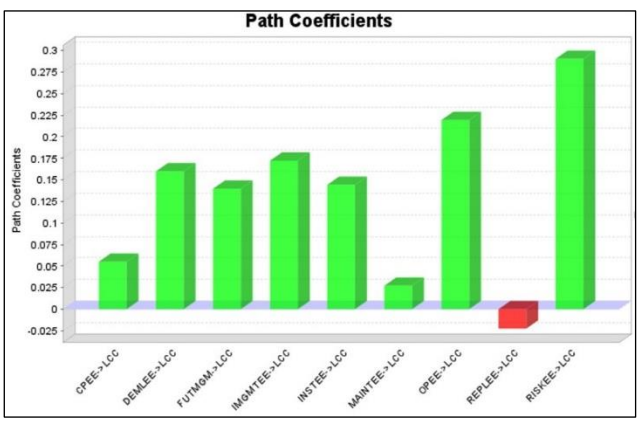

Figure 2. Paths Coefficients Between Total LCC of Green Criteria and Its Cost Components

RELATIONSHIP BETWEEN DEMOLITION COST AND TOTAL LCC

The results of path analysis show that there is a significant relationship between demolition cost and LCC. (Beta = 0.160, P value < 0.05). Other scientific research has established that demolition in construction operations will influence the environment, either directly or indirectly (J. Wang et al., 2020). These operations might span the whole green projects life cycle, from design to construction, operation and maintenance, and demolition. The financial aspects of green H&R provide a variety of considerations for LCC, one of which is demolition cost which is correlated with LCC. Additionally, demolition cost might be confirmed by risk probability, allowing for the establishment of a relationship between total LCC and demolition cost (Rahman and Zakaria, 2018).

Thus, one could claim that growing concerns about the scarcity of non-renewable materials for highway construction and the rising costs of generating natural resources prompted designers and engineers to seek an alternative solution to the challenges. Demolition works may contribute to harmful emissions, global climate change, ecological disruption, and the depletion of natural resources, particularly aggregates and binders, because of rising demand of green H&R project.

Although the demolition phase might be the most challenging phase in construction, Charrette sessions can be used to weight the advantages and cons of demolition from all angles. Additionally, the stages of demolition, operation, and maintenance are critical components of a structure because they are where most of the time and money is spent (Di Maria et al., 2020). Nonetheless, road construction operation considers a variety of cost-contributing factors, including integral demolition costs that might trigger operation and maintenance costs in overall cost of the road ownership.

Having a long highway can increase emissions and demolition work can deplete a variety of other natural resources, including water and soil. Significantly, the construction industry is seen as a key contributor to this overall environmental degradation. The green highway therefore should be based on the entire life cycle of construction projects, from planning to procurement, implementation, operation/maintenance, and demolition/deconstruction. At each stage of the project's life cycle, all activities must be designed to have a minimal impact on the environment. The true nature of green highway project should be considered in the present government policy toward mass transportation and environmentally friendly modes of transportation. Government officials at all levels should conduct a review of the permitting and regulatory requirements for transportation projects to reduce the demolition cost.

RELATIONSHIP BETWEEN INITIAL AND FUTURE MANAGEMENT COSTS AND LCC

Initial management expenses are the costs associated with paying wages and salaries to non-sales workers and giving benefits to them for green project implementation. Administration costs are classified as indirect expenses on a company's income statement since they do not directly contribute to the manufacturing or delivery of a product or service (Jasmi et al., 2018).

The results showed that there is a positive significant relationship between both initial and future management costs with a Beta value of 0.140 and 0.172 on the LCC (P values less than 0.05). Khalil et al. (2021) also argued that the total LCC of a green project can be defined as the sum of the initial investment, deferred operating costs, and management costs during the project's life. Therefore, respondents accepted that green projects such as green highway project can be costly, as it could require recruiting new representatives with experience in green project and investing new capital to get started, as well as increasing construction expenses over their ordinary cashflow planning while contractors typically did not include cost for it in the tender. The other conceivable reasoning for this outcome might be by practising green measures, new capitals are required to acquire equipment that is less noisy and so on, as well as the need to adapt to the new method, as the materials utilised in green project are not widely available, which could affect a project's cash flow and profitability of contractors.

Notwithstanding, it can be stated that while green project may initially be relatively costly, expenses will eventually diminish on the ground because all materials and equipment can be reused, while others stated that the cost of green project varies according to the approach and conditions in the field.

RELATIONSHIP BETWEEN INSTALLATION COST AND LCC

The results of path analysis showed a significant positive relationship between installation cost on LCC with the Beta of 0.144 (P value = 0.000). Installation costs incorporate all costs spent and paid by developers to third parties for work performed in connection with the construction or installation, as evidenced by invoices, receipts, contracts, and other documentation of payment and performance of the work as the developers may reasonably seek. Installation Costs may only include all costs, expenses, fees, and charges incurred and actually paid to contractors, engineers, surveyors, governmental agencies, and other third

parties for materials, labour, design, engineering, surveying, site excavation and preparation, and other direct costs and expenses reasonably necessary for the construction of the water line and sewer line, but excluding any general conditions and fees paid to the developer, attorney's fees, and any other third party costs and expenses.

Numerous structural modifications have been implemented in the building industry in recent years (Sexton and Barrett, 2003). The road construction industry is evolving, becoming more customer-oriented and adopting innovation to maintain a competitive edge (Oad, 2016). The developments in the sector should elevate the importance of innovation criteria to a strategic level. As can be seen, the road construction industry is not immune to these developments and is responding to the demand for conscious innovation adoption and management (Betts and Ofori, 1992). Innovation management is the process of integrating ideas to maximize the efficiency with which fresh ideas are implemented, resulting in market solutions that are effective (Drejer, 2002).

Innovation in the road building business might be extremely helpful, as it is certain to result in decreased installation costs, such as higher-performing roads with less negative environmental impacts, reduced prices, and enhanced quality that require little maintenance. It has been demonstrated that adopting innovative technology results in benefits such as greater market share and a more competitive position in the market (Detzel et al., 2021). Therefore, new approaches in the green project sector to achieve better outcomes can be observed and quantified in terms of cost savings associated with installation cost, as well as improved performance.

RELATIONSHIP BETWEEN OPERATION COST AND LCC

Operational cost showed the second highest significant positive impact on LCC according to the results of this study (Beta- 0. 220, P value < 0.05). Operational costs cost incurred while conducting business or operating a device, component, piece of equipment, or facility. They are the costs associated with the resources that an organization should use to be viable. Additionally, this result presupposes that existing construction materials, designs, and layouts should be available and utilised. The study's findings indicate the importance to lower operation cost such as by the usage of recycled materials in road construction, to replace road construction materials in most developed countries.

Operational costs are those incurred in the day-to-day operation of a firm and are incurred by a firm internally. They might comprise both fixed and variable costs. Fixed costs are described likewise the costs associated with keeping a streetlight on at highway (Izadi et al., 2020). Excise charges, insurances, operator's license fees, guaranteed wages, depreciations, and overhead are all examples of fixed costs.

Globally, innovative techniques are being implemented in several nations such as Hamburg, Germany, and the United Kingdom. These countries have policies requiring the construction of roads from recycled materials and the usage of solar and plastic roads. These practices demonstrate the critical necessity for all countries to transition to more environmentally friendly road construction methods to reduce operation cost.

Using technological innovations are the solution to decrease operational cost. For instance, the Smart Highway Project is a Dutch-led initiative. The goal of this project is to create roadways that are both interactive and sustainable. The highway will be painted with a glow-in-the-dark paint that absorbs energy during the day. These paints have a maximum glow time of eight hours (Sazali and Firdaus, 2019). This can be a highly smart and efficient way to save operation cost, as they can decrease electricity usage of streetlights. These futuristic roadways will pave the way for the development of safe and sustainable corridors (Oad, 2016). This technology has the potential to replace the streetlight that line the sides of highway. Additionally, this technology can serve as a more viable alternative to highway in locations lacking in lights and energy (Oad, 2016).

RELATIONSHIP BETWEEN RISK CONTINGENCY COST AND LCC

Risk contingency cost showed the highest significant positive effect on LCC according to the results of this study (Beta- 0. 290, P value < 0.05). Since all new projects operate in a risky and uncertain environment, susceptibility to loss is an unavoidable component of any commercial enterprise. Modern construction projects operate on such a large scale that they are vulnerable to catastrophic losses. Similarly, industrial, and technical advancements have exposed businesses to several new and growing hazards, such as those associated with new application of green technology in green project. Therefore, in addition to these more dramatic manifestations of risk, the contractors must be cognizant of the subtle contingency cost which included in green projects.

CONCLUSION

The total LCC of the Green Criteria model was mostly influenced by cost components other than capital cost, maintenance cost, and replacement cost. The relationship between risk contingency costs has the highest degree of positive correlation. In addition to the expenses associated with capital, maintenance, and replacement, there exists a noteworthy and affirmative correlation between the overall LCC of a green highway project and its cost related to energy efficiency green criteria. There is no statistically significant association observed between the LCC and the capital, maintenance, and replacement costs when these three components of green costs are taken into account during budget planning. In order for stakeholders to accurately assess the LCC of green highway projects, it is imperative to have an understanding of the relevance level associated with the LCC components of the green criteria. The concept of green project innovation supports an attractive green revolution for the benefit of emerging nations' environmental and economic sustainability. In this case, planning a so-called green project equipped with correlation data is projected to mitigate the risk of uncertainty on total LCC of green criteria. The first objective of this research intends to establish the correlation of LCC component related to the green project criteria. The path coefficient analysis results demonstrate that there is a considerable relationship between Total LCC of green project with cost component of green criteria except for the costs of capital cost, maintenance cost, and replacement cost. As a result of the study's findings, risk contingency cost should have the greatest positive effect on LCC. The significant relationship would then be used to do risk probability analysis using an Excel spreadsheet calculator developed specifically for this study to identify the total LCC for green project incorporating risk probability.

Life Cycle Costing standards and instruments can be utilised to accomplish and further develop sustainability improvement, particularly in green projects. The capacity analysis stage can be taken advantage of to separate the troublesome cycle phases into its practical units. There could be critical advantages of utilising life cycle costing as a medium for advancing and accomplishing green projects. Also, the experience and abilities of life cycle analysis experts could be utilized to speed up the agreement and executing of green project. During the method involved with fostering a project, life cycle costing standards and strategies mean to offer best benefit from an entire life viewpoint. This survey, in surveying life cycle costing and green projects, have investigated the conceptual linkages between the two components and surveyed how these can be utilised to accomplish best value over the entire existence of building projects. The relationship between the components should be visible as both underline similar elements to accomplish sustainability, which are the necessities of performance during the beginning phase (pre-construction and design stage) in construction industry. This study opens a way for future analysis to investigate further on how LCC can measurably help the economical construction, particularly to manage significant issues of in sustainability. This will be gainful to help the decision making towards more prominent environmental, social, and financial performance of green project which indirectly benefitted the society and the country.

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eISSN 2590-4140