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Editorial

Welcome from the Editors

Welcome to the forty-first (41^{st}) issue of Malaysian Construction Research Journal (MCRJ). In this issue, we are pleased to include eight papers that cover a wide range of research areas in the construction industry. The editorial team would like to express our sincere gratitude to all contributing authors and reviewers for their contributions, continuous support and comments.

In this issue:

Hasnida Harun et al., synthesized a natural bamboo biochar adsorbent for instantaneous methyl blue (MB) dye adsorption from an aqueous solution. The bamboo biochar was analysed using scanning electron microscopy (SEM), energy-dispersive X-ray (EDX) spectroscopy, and Fourier Transform Infrared (FTIR) spectroscopy to identify the functional groups and their correlation with adsorption efficiency. In addition, the influence of several parameters on the removal percentage and adsorption capacity was investigated. Specifically, this study investigated the impact of changing the following parameters: the initial MB concentration, adsorbent dose, and contact time. This study elucidates the adsorption of MB dye by bamboo biochar, which is a promising natural adsorbent. It also provides important insights into the adsorption process and the influence of each parameter, which fills the gap in this field.

Peniel Ang Soon Ern et al., identify the awareness and involvement of Malaysian design consultants in BIM-VR in Selangor and determine the challenges of BIM-VR implementation in the Selangor construction industry. This research adopted a quantitative approach by conducting a questionnaire survey with 55 architects from different companies located in Selangor. The data obtained were analysed by using Statistical Package for Social Science (SPSS) software version 28.0, where the test conducted were frequency analysis, descriptive analysis, and Pearson correlation. The findings revealed that most respondents are aware of BIM and VR adoption in the architecture firm, even though they comprehend well. In conclusion, the respondents are aware and willing to be involved actively in this integrated technology whilst seeing the need to collectively overcome the challenges BIM-VR. Government push and support in this area will definitely be a catalyst in BIM-VR update and hence will contribute.

Nurul Nadiah Zainol et al., established a structural model of green cleaning components for green buildings in Malaysia. The quantitative method is used in this research and the data were analysed using partial least squares structural equation modelling (PLS-SEM). The finding shows that five components of green cleaning have a significant relationship with the benefits rendered by green buildings.

Muhamad Nadjmi Md Nasir et al., examine alternative protection structures as a secure and fast defensive element, mostly as emergency structural protection for riverbank and coastal erosion. This study focused on three main aspects, including Malaysia's current riverbank and coastal erosion protection practices, the potential use of geobag for riverbank and coastal erosion protection, and the feasibility of using natural fibers as an alternative geobag container. The first and second aspects were examined via a questionnaire survey, while the third aspect involved a comparative study. Questionnaire analysis showed that the retaining wall, gabion, riprap, and geobag were common practices for protecting riverbank and coastal erosion in Malaysia. This paper also discusses issues with existing geobags, including cost, environmental effect, and their strength properties. A comparative study found that flux and pineapple fibres have the highest tensile strength and Young's modulus among other fibres and can potentially produce geobag containers. This study provides insight to the industry on technical knowledge regarding innovative and sustainable riverbank and coastal protection as well as the alternative material to promote sustainable development.

Nurfarissa Mohamed Nazim et al., investigated the impacts of building opening in both subtropical and tropical climate zones as a popular architectural element to yield adequate ventilation around buildings. Nevertheless, only a handful of studies have examined building opening in any systematic way especially on wind speed at pedestrian-level for multiple buildings area. As such, this study assessed the effect of different building opening heights (BOHs) on pedestrian-level wind speed at multiple buildings area. The mean value for wind velocity ratio (MVR) was calculated by using data obtained from computational fluid dynamics (CFD) simulation. The study outcomes revealed that the optimum opening height at a range of 42%-64% generated the highest MVR = 0.39. In addition, the building opening elevation above than 86% of average building height has no longer affect the pedestrian level wind speed. In conclusion, the study findings provide evidence that optimum building opening design can effectively increase the mean value of wind speed at pedestrian level.

Muhammad Shahzad et al., analyse the Functions of the Project Manager's Behavior in the Successful Delivery of Construction Projects. The data has been collected through a quantitative research approach by circulating the questionnaires among the respondents. It has been revealed through regression and correlation analysis, that all five behavioral categories have a significant impact on the successful delivery of projects. The most influential behavioral forecaster in delivering a successful project is the Neuroticism (inverse relation). The successful delivery of projects by their Project Managers can be ensured by focusing on discovering new and creative approaches for the completion of various tasks.

Muhamad Haziq Ikhwan Mohd Hair et al., aimed to examine the tendency of kitchen space modification based on terraced houses compared to the need to change it. The site selected for this study was Taman Bukit Tiram, Johor. The data collection technique was in quantitative form with a questionnaire survey method involving 54 respondents, and the study sample selection uses purposive sampling specific to single-story terraced houses that only undergo kitchen modification. The data analysis technique uses a one-way ANOVA test to show the influence between the 'number of years occupied' and the 'reason for home kitchen space modification' with a p-value of 0.005. The second data analysis technique uses descriptive statistical analysis by looking at the mean score, which showed the highest level of homeowner perception that they were satisfied with the results of home kitchen space modification with a mean score of 3.72. The Pearson correlation coefficient showed a relationship between the 'reason for home kitchen space modification' and the 'general perception after kitchen space modification' with a p-value of .548. In conclusion, the findings from the study, show that the tendency for kitchen modification is due to the need for space.

Solahuddin Azuwa examines the behaviour of damaged concrete using an external posttensioning steel rod system (EPT) and the ABAQUS CDP model for concrete-damaged plasticity. The CDP model for concrete characteristics and a perfect connection between steel and concrete were assumed throughout the ABAQUS simulation for concrete beams. The simulation's fracture patterns are consistent with those seen in the testing. The analytical responses, including the strength, deflection, and stress of external rods, agree with the observed responses. When the damage in the specimen surpasses its tensile stress, the fracture strain of the concrete is reached. The ABAQUS results for concrete under tensile stress are consistent with those obtained in the experiment. In conclusion, the analytical results for the external rod's strength, deflection, and stress are consistent with the experimental data acquired. This research is conducted to analyse the experimental results using finite element modelling (FEM). Both experimental and FEM results show consistency. No significant differences are seen between experimental results and FEM, so FEM proves and acknowledges the experimental results.

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DEVELOPMENT OF THE TREATMENT TECHNOLOGY FOR DYE REMOVAL BY BAMBOO BIOCHAR

Hasnida Harun¹, Nur Afiqah Chailan¹, Nor Hazren Abdul Hamid¹, Mimi Suliza Muhamad¹, Dalila Saji¹ and Faridahanim Ahmad²

¹Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia.

²Department of Structure and Material, School of Civil Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia.

Abstract

Bamboo belongs to a family of gigantic woody grasses, categorized as the fastest-growing high-yield plants. These characteristics have allowed bamboo to be explored in many ways, including in construction materials, food profiling, and the production of green materials. In this study, a natural bamboo biochar adsorbent was synthesized for instantaneous methyl blue (MB) dye adsorption from an aqueous solution. The bamboo biochar was analyzed using scanning electron microscopy (SEM), energy-dispersive X-ray (EDX) spectroscopy, and Fourier Transform Infrared (FTIR) spectroscopy to identify the functional groups and their correlation with adsorption efficiency. In addition, the influence of several parameters on the removal percentage and adsorption capacity was investigated. Specifically, this study investigated the impact of changing the following parameters: the initial MB concentration (1.5 - 5 mg/L), adsorbent dose (0.5 to 1.5 g), and contact time (30-90 min). The characterization study revealed that the bamboo biochar has -OH functional groups and large pores, enhancing adsorption capacity. In addition, it showed excellent efficiency, where the MB removal percentage reached 98.77% at the optimal operating conditions, with the maximum adsorption capacity was 7.56 mg/g. This study elucidates the adsorption of MB dye by bamboo biochar, which is a promising natural adsorbent. It also provides important insights into the adsorption process and the influence of each parameter, which fills the gap in this field.

Keywords: Bamboo Biochar; Pyrolysis; Methyl Blue Dye; Adsorbent

INTRODUCTION

Dyes comprise soluble compounds, mostly reactive, direct, essential, and acids (Benkhaya, Said, Souad M'rabet, and Ahmed El Harfi, 2020). Dye molecules are generally organic compounds with two major functional groups. Dyes are either natural or synthetic substances that are chemical molecules that can attach to the surface of fabrics and provide colour (Yagub et al., 2014). Most dyes enter the wastewater stream because they do not adhere to the fabric and flow into the current river. Dyes are discharged into the environment during dyeing, making the effluent highly toxic and aesthetically unpleasant. The dye adsorbs and reflects sunlight from entering the water, affects bacterial growth, inhibits photosynthesis, and hampers aquatic ecosystems.

In recent years, various chemical compounds, as well as physical and biological processes, have been developed and used to treat contaminated water. Among these treatments, the adsorption method has long been recognized as one of the most effective wastewater treatment processes for reducing dangerous inorganic and primary contaminants in the discharge. Adsorption has the advantage of not leaving harmful residues and treating vast amounts of water while being reused multiple times in the treatment process (Saxena, Megha, Niharika Sharma, and Reena Saxena, 2020). Biochar, which is environmentally friendly and highly adjustable, has been used as a novel adsorbent for wastewater treatment. The essential properties of good adsorbents are high selectivity, high adsorption capacity,

and good physical properties, including large pore size, large pore volume, large surface area, small particle size, and excellent chemical and thermal strength. Owing to these adsorption properties, biochar is a reasonable adsorbent to adsorb colorants that are toxic and harmful to the ecosystem. Besides, converting low-cost biomass to biochar presents a viable technique to minimize solid waste handling challenges while generating useful energy.

Therefore, this study investigated the potential of bamboo pyrolyzed into biochar as a natural adsorbent. The effectiveness of bamboo biochar in removing methylene blue dye was examined by different contact times, initial concentrations, and adsorbent dosages. Hence, the removal percentage of methylene blue and the adsorption capacity were determined.

MATERIALS AND METHODS

Preparation of Bamboo Biochar

In this study, bamboo powder used is a by-product of a bamboo fiber process. The bamboo powder was collected and washed with distilled water to remove dirt and dust. Then, the bamboo powder was oven dried at 105°C for 24 h to remove the moisture content. The dried bamboo powder was pyrolyzed into biochar in a muffle furnace at 600°C for 1 h and kept in a desiccator. After pyrolysis, the bamboo biochar was washed several times with distilled water and dried at 105°C for 24 h. Finally, the prepared adsorbent was kept in an airtight container. The adsorbent was weighed to determine its ash content, volatile content, and biochar yield.

Characterization of Bamboo Biochar

The bamboo biochar was characterized using Fourier Transform InfraRed (FTIR) spectroscopy and scanning electron microscopy (SEM). The presence of functional groups on the bamboo biochar surface was captured using FTIR in the range of 400-4000 cm⁻¹ spectral region. The morphology of the bamboo biochar was visualized using SEM. Both analyses were performed on bamboo biochar before and after the adsorption process.

Preparation of Methylene Blue Solution

Methylene blue (MB) with the empirical solution formula $C_{16}H_8C_1N_3S$ and a molar mass of 319.85 g/mol was used as the adsorbate. The MB stock solution was prepared by mixing 1 g of MB and 1 L of distilled water in a volumetric flask to make 1000 mg/L of MB dye solution. The MB dye stock solution was then further diluted to 15, 20, and 50 mg/L.

Proximate Analysis

A proximate analysis was conducted to determine the moisture, volatile matter, ash, and biochar yield of the prepared bamboo biochar. The proximate characteristics were determined based on the ASTM D3173 standard practice for proximate and ultimate analyses of coal and coke (ASTM D3173, 2013). The moisture content of the bamboo biochar was determined by the weight loss after the biochar was heated and was calculated using Equation 1.

Moisture, wt (%) =
$$\frac{W_o - W_d(after heated at 105^\circ \text{C})}{W_o} \ge 100\%$$
 (1)

Where W_o is the initial weight of prepared bamboo biochar, W_d is the weight of bamboo biochar after being heated at 105°C for 2 h. The volatile matter was measured by the weight loss after combustion of 1 g of bamboo biochar and was calculated using Equation 2.

Volatile matter, wt (%) =
$$\frac{W_o - W_d(after \ combusted \ at \ 950^\circ \ C)}{W_o} \ge 100\%$$
 (2)

Where W_0 is the initial weight of prepared bamboo biochar, W_d is the weight of bamboo biochar after being combusted at 950°C for 6 min. The ash content was calculated using Equation 3.

Ash content, wt (%) =
$$\frac{W_d(after \ combusted \ at \ 750^\circ \text{C})}{W_o} \ge 100 \ \%$$
 (3)

Where W_d is the weight of 1 g of bamboo biochar after combusted at 750°C for 6 h to complete carbonization to obtain white ash. The total yield was calculated using Equation 4.

$$\text{Yield}_{\text{biochar}}, (\%) = \frac{W_{(biochar)}}{W_{(raw)}} \ge 100 \%$$
(4)

Where $W_{(biochar)}$ is the weight of the biochar, and $W_{(raw)}$ is the weight of the raw biomass (bamboo powder).

Batch Adsorption Experiments

The applicability of bamboo biochar as an adsorbent for methylene blue was studied in a batch system. The effects of contact time, adsorbent dosage, and initial concentration parameters were investigated. All adsorption experiments were performed in a 250 mL conical flask at a constant speed of 200 rpm at room temperature $(26\pm1^{\circ}C)$. The effects of different parameters, such as adsorbent dosage (0.5, 1.0, and 1.5 g), initial MB dye concentration (1.5 mg/L, 2.5 mg/L, and 5.0 mg/L), and contact time (30, 60, and 90 min) on MB dye removal were investigated. After the experiments, the dye solution was filtered through Whatman filter paper, and the MB dye concentration was analysed. The dye removal and adsorption capacities of the bamboo biochar were measured analytically using a UV-vis spectrophotometer at 664 nm. All experiments were conducted in triplicate to obtain an average value. An overview of the experiment is shown in Figure 1.

The MB dye removal capability of the bamboo biochar adsorbent, Removal (%), was calculated using Equation 5.

Removal (%) =
$$\frac{C_o - C_e}{C_e} \ge 100 \%$$
 (5)

Where C_o and C_e are the initial and final concentrations of MB dye, respectively. The adsorbent's adsorption capacity (q_e) was calculated using Equation 6.

$$q_{e} = (C_{o} - C_{e}) x \frac{V, volume MB \, dye}{m, mass \, adsorbent}$$
(6)



Where V is the volume of the solution, and m is the mass of the adsorbent used.

Figure 1. Schematic Diagram of Batch Adsorption of Bamboo Biochar

RESULTS AND DISCUSSIONS

Proximate Analysis of Bamboo Biochar

Table 1 summarizes the proximate analysis results for the bamboo biochar. The bamboo biochar had a moisture content of 5.21%, which was lower than the ideal moisture content for biochar from feedstock (11%), as reported by Canal et al. (2020). The lower moisture content in the bamboo resulted in less energy required for the pyrolysis process to yield higher biochar content (Canal et al., 2020). According to Sahoo et al. (2021), the biochar formation was caused by the presence of inorganic and lignin contents in the bamboo. The high mass fraction of lignin leads to a higher biochar yield due to the low volatile matter. This result is in good agreement with Canal et al. (2020), who reported a higher biochar yield of 27% at a lower moisture content (1.28%) compared to a biochar yield (21.7%) at a higher moisture content (6.04%) by pyrolysis at 600°C. Meanwhile, this study successfully yields 29.34% of bamboo biochar at a pyrolysis temperature of 600°C. Ash bamboo is an inorganic constituent, which is a white substance formed when bamboo biochar is entirely burned at a constant temperature of 600°C. After slow pyrolysis, the ash percentage in the bamboo biochar was 3.29%. It has been observed that the ash composition increases with the temperature during pyrolysis due to the release of volatile matter.

Table 1. Proximate Analysis	s of Bamboo Biochar
Bamboo Biochar	Wt. (%)
Moisture Content	5.21
Ash Content	3.29
Volatile Matter	17.64
Biochar Yield	29.34

At 600°C, the bamboo biochar contained a significant amount of volatile matter (17.64%). At the same temperature, the bamboo biochar had a higher amount of volatile matter compared to other agricultural biomass such as coconut fiber (16.72%), reported by Dhar et al. (2022), and rice husk (6.13%), reported by Zhang et al. (2017). These

volatile components occupy the micropores and control the biochar surface (Denyes et al., 2014). Furthermore, the structure of biochar is affected by the pyrolysis temperature owing to the release of volatiles and the formation and volatilization of intermediate melts (Shaaban et al., 2014).

Characterization of Bamboo Biochar

The functional groups present on the surface of the adsorbent play a crucial role in determining the chemical reaction between the adsorbent and adsorbate. Figure 2 shows the FTIR spectra of the functional groups of the bamboo biochar in the wavelength range of 4000– 450 cm^{-1} . A strong and broad peak at the wavelength 3356 cm⁻¹ indicates the presence of hydroxyl (O-H) functional groups. According to Johari et al. (2013), these groups originate from the alcohol present in the adsorbent material. Furthermore, the hydroxyl groups in the adsorbent material signify the hydrogen molecules that are bonded together due to the presence of water (Abdul Rahim et al., 2020). Meanwhile, the peak at 1578 cm⁻¹ is in accordance with the C=C vibrations contributed by the aromatic ring mode (Seredych et al., 2011). According to Srivatsav et al. (2020), the peaks found at 1102 cm⁻¹ on the surface of adsorbent suggest the presence of amine groups. These groups are electron-rich and can significantly enhance the adsorption of dyes. Since dye molecules are electron-deficient, the interaction between these functional groups can facilitate the adsorption process.



Figure 2. FTIR Spectra of The Bamboo Biochar

The SEM images of the bamboo biochar's surface morphology before and after the dye adsorption process are shown in Figures 3a and 3b, respectively. Figure 3a shows that the surface of the adsorbent is composed of pores of uniform shapes with varying sizes of hollowed and deep pores. This indicates that the surface can be an excellent active site for methylene blue adsorption, as more dye molecules can be accommodated in the pores on the surface of the bamboo biochar. After the adsorption of the methylene blue dye, the pores on the biochar surface were covered with thin layers, as shown in Figure 3b. This could be surface precipitation or physical adsorption that occurs on the surface of the adsorbent (Ji et al., 2019). Generally, the rough surface and pores of bamboo biochar become binding sites for methylene blue dye molecules.



Figure 3. Surface Morphology of Bamboo Biochar: (a) Before Adsorption and (b) After Adsorption

The bamboo biochar surface was further measured for the EDX analysis. As shown in Figure 4, the abundance of C, O, Ca, and Si elements, were the essential components of active functional groups, such as -OH and C=C.



Figure 4. EDX Spectra of Bamboo Biochar

Effect of Initial MB Dye Concentration

The effect of initial methylene blue dye concentration at different contact time is shown in Figure 5. The best percentage present extinguish its maximum value of 98.77% at 60 minutes for initial concentration 1.5 mg/L. At the same contact time, also give the highest adsorption capacity among others which are 3.043 mg/g.

The data prove that the methylene blue removal decreases with the initial concentration increase while decrease adsorption capacity. This due to driving force to overcome all mass transfer resistance (Ghani et al., 2013). This phenomenon where if the dye concentration increase, a large number of the dye concentrations increase, a large number of dye species compete on a limited number of the available active sites.



Figure 5. Methylene Blue Removal (a) and Adsorption Capacity (b) of Methylene Blue at Dosage 1.5g

Effect of Contact Time

Contact time is one of crutial parameter for an efficiency of an adsorbent determination. To examine the effect of contact time on the MB dye removal efficiency, the contact time were varied from 30 to 90 min with varied adsorbent dosage. As shown in Figure 6, the MB dye removal of 30min contact time and 1.5 mg/L of bamboo biochar dosage are the highest which is 98%. It can be seen that the adsorption rates of bamboo biochar increase from 6 to 9mg/g when the contact time increase from 30 to 60 min at 5 mg of adsorbent dosage.



Figure 6. Methylene Blue Removal (a) and Adsorption Capacity (b) of Methylene Blue at Dosage 0.5g

Generally, by increase in contact time, increase the methylene blue removal while decrease of adsorption capacity of methylene blue. The trend of this graph due to many vacant binding active sites were available for dye at the start, and functional groups on the adsorbent were fully and efficiently completed. After 30 minutes, the relative increase in the removal extent of methylene blue was not significant, and with the increase of time, the adsorption rate decreased and gradually stabilized. This performance was due to the binding process between methylene blue dye and the adsorption active sites, and functional groups on the adsorbent were gradually saturated (Kuang et al., 2020).

Effect of Adsorbent Dosage

Adsorption dosage is a significance factor that affects adsorption performance. Therefore, the influences of adsorbent dose in adsorption methylene blue were studied to obtain the most appropriate amount of adsorbent at various methylene blue concentrations (Salleh et al., 2011).



Figure 7. Methylene Blue Removal (a) and Adsorption Capacity (b) of Methylene Blue at Contact Time 60 Minutes

Figure 7 shows 86.95% was the best methylene blue removal at dosage 0.5 g and decrease to 68.86% at dosage 1.5 g in the same initial concentration 2.5 mg/L. Another initial concentration at 1.5 mg/L, an increase adsorbent dosage, increase of methylene blue removal. For adsorption capacity, the highest adsorption was 7.56 mg/g in dosage 0.5 g at initial concentration 5.0 mg/L and decrease to 3.01 mg/g in dosage 1.5 g. Generally, increase the methylene blue removal, decrease of adsorption capacity in increase of adsorbent dosage. This adsorption trend is due to an increase in the surface, hence the number of active sites provided by the adsorbent material (El Jamal et al., 2012).

CONCLUSION

According to the findings of the experiments, biochar produced under a range of pyrolysis temperatures demonstrated variations in their structures and physical and chemical properties. The findings of this paper deducted that bamboo fibre waste was remarkable for biochar production with the higher volatile matter, low moisture content, and ash constituent. The yield of biochar, volatile matter and moisture decreases in 600°C pyrolysis temperature. In addition, the existence of the functional groups of -OH in its surface of bamboo biochar cause the existence of porous structure and large pores that enable it to adsorb and remove methylene blue in aqueous solution. The percentage of methylene blue removal increased with contact time and adsorbent dosage for various parameters while decreasing with the increased initial methylene blue dye solution concentration. The optimum condition of methylene blue via bamboo biochar as natural adsorbent are 60 minutes of contact time, 0.5g of adsorbent dosage and 1.5 mg/L of initial concentration of methylene blue. Meanwhile, the maximum adsorption capacity of bamboo biochar was 7.56 mg/g. This proved that an increasing amount of adsorbent dosage would decrease the adsorption capacity due to the overlapping and aggregation of adsorbent sites due to overcrowding of biochar particles. Therefore, it has been proved that bamboo biochar is an effective adsorbent for methylene blue due to the characteristics of bamboo.

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ACCEPTANCE OF BUILDING INFORMATION MODELLING-VIRTUAL REALITY (BIM–VR) IN SELANGOR CONSTRUCTION INDUSTRY

Peniel Ang Soon Ern¹, Nurhana Jannah Abdul Halim¹, Tsai Kai Len¹, Narimah Kasim² and Tuan Noor Hasanah Tuan Ismail¹

¹Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia.

²Department of Construction Management, Faculty of Technology Management & Business, Universiti Tun Hussein Onn Malaysia, Johor, Malaysia.

Abstract

The integration of Building Information Modelling and Virtual Reality (BIM-VR) technology allows users to experience BIM model and view BIM data such as cost and material type in real-time in an immersive visualisation system. However, the future applicability and practicality of BIM-VR integration has yet to be established in Malaysia's construction industry. Hence, the aim of this paper is to study the acceptance of BIM-VR amongst the Selangor design consultant and the objectives are to identify the awareness and involvement of Malaysian design consultants in BIM-VR in Selangor and to determine the challenges of BIM-VR implementation in the Selangor construction industry. This research adopted a quantitative approach by conducting questionnaire survey with architects from different companies located in Selangor. The data obtained from 33 respondents were analysed by using Statistical Package for Social Science (SPSS) where the test conducted were frequency analysis, descriptive analysis, and Pearson correlation. The findings revealed that most respondents are aware of BIM and VR adoption in the architecture firm. However, the lack of BIM-VR implementation was due to training and software cost and a lack of exposure to BIM-VR technology among other construction players. In conclusion, the respondents are aware and willing to involve actively in this integrated technology whilst seeing the need to collectively overcome the challenges BIM-VR. Government push and support in this area will be a catalyst in BIM-VR update and hence will contribute significantly to the efficiency of design and construction process.

Keywords: Building Information Modelling; Virtual Reality; Acceptance; Construction Industry; Malaysia

INTRODUCTION

One of the most important contributors to the Malaysian economy is the building industry. Modern times, along with increasingly complicated buildings and architecture, necessarily require a revolution that will significantly satisfy the growing demand. Building Information Modelling BIM has begun to attract the attention of construction stakeholders around the world, where BIM has been introduced in the field of construction to ensure that every process in a construction project runs smoothly. BIM is more than just a representation method or a way to create a concept or prototype that generates intelligent input (Goulding, Rahimian & Wang, 2014). BIM increases productivity and efficiency, evaluates the time and cost associated with the design change, and eliminates conflicts in the design of the construction project (Al-Ashmori et al., 2020).

Virtual Reality (VR) is a medium in the sense that it is a collection of technical hardware similar to the telephone and television. VR is a mediated environment that gives the user the sense of being there in a (physical) environment. By artificially stimulating our senses, our bodies are duped into accepting a different version of reality (Lavalle, 2019). The visual and

acoustic realism of things such as 3D effect, degree of detail, specularity, colour, and texture are distinct renderings of VR applications. Realtime visual response (60ms = 16-18Hz), natural-like interaction metaphors (many degrees of freedom input), and peripheral visual inputs will also be rendered by VR (Seipel, 2006).

With the emergence of the Fourth Industrial Revolution (IR 4.0), a major transition happens in the construction industry, converting the industry on the path of further technologically developed trades (Musa, Marshall-Ponting, Nifa & Shahron, 2018) including the integration of BIM with VR which gave lots of benefits to the designer, consultant, architect and client. During task simulations and through monitoring worker roles, knowledge is elicited (Zaker & Coloma, 2018). The approach is applied to improve construction site workspace planning. As for the client, they can feel like they were at the construction site too where the VR allow them to immerse into a near-actual environment, the application of textures, materials and site development were found to create a life-like feeling and this life-like experience of performing tasks in a risk-free environment. For the construction safety and job site management (Froehlich & Azhar, 2016).

In Malaysia, the maturity of BIM-VR-based applications is still low, implying that the Malaysian construction sector has yet to adopt new technologies. Besides, the world has been hit by the COVID-19 pandemic nowadays, which has harmed the construction industry. All construction works have been halted as a result of the outbreak, with the Malaysian government issuing a Movement Control Order (MCO). Because physical exercise must be performed on location, working from home may not be feasible. If big construction projects are delayed, it will have a significant influence on Malaysia's economic growth. Hence, this research aims to study the acceptance of BIM-VR in the Selangor design consultant and the objectives that formulate from these research questions are to identify the awareness and involvement of Malaysian design consultants in BIM-VR in Selangor and determine the challenges of BIM-VR implementation in the Selangor construction industry.

THE INTEGRATION OF BIM-VR IMPLEMENTATION

Real-time visualisations and virtual reality have been shown to provide an effective communication platform. Although the application of this technology has generally been limited due to a shortage of usable 3D data from the design process, the recent introduction of BIM within the AEC sector has opened up new possibilities (Alizadehsalehi, Hadavi, & Huang, 2020).

Using BIM, the necessary 3D data can be derived from the architect's design environment, rather than designing it from scratch using 2D plans, elevations, and sketches as a reference point. As a result, the use of real-time visualisations has become more widely available in practice (Alizadehsalehi et al., 2020).

All aspects of the BIM model, from architecture and construction to Mechanical, Electrical, and Plumbing (MEP), can be addressed in greater depth by analysing the design details. One of the most significant benefits of BIM-VR is the model's ability to reflect real-time shifts (Johansson, Roupé & Tallgren, 2014).

CHALLENGES OF BIM-VR IMPLEMENTATION

BIM-VR is less frequent in Malaysia despite its widespread usage in other developed countries. This is owing to the numerous difficulties connected with implementing VR in BIM. Research findings highlighted a few challenge factors are which are mainly in terms of cost, skills, software capacity in VR devices.

Cost

Economically, construction firms are hesitant to spend owing to high implementation costs, which include investments in technical equipment, training and education, and infrastructure maintenance. In the early phases, the return on investment is not obvious (Kumar et al., 2018).

Since the BIM-VR tool requires the purchase of buying software, an upgrade VR-ready laptop and a headset (Boton, 2018), the cost of a set was very high which not all construction companies affordable to buy.

Even though the cost of the display and PC hardware has been steadily declining in recent years, totally or semi-immersive options such as CAVEs or PowerWalls remain prohibitively costly (Alizadehsalehi et al., 2020).

Skills

A study was done by (Froehlich & Azhar, 2016), this was about a demonstration of how VR headsets can be used for coaching and some users complained about motion sickness affecting the participants for some time. This indicates a limited ability to interact with all objects in the game. Furthermore, because the VR environment is only used to show a predetermined model, personnel lacking BIM-VR capabilities are unable to conduct fully interactive and collaborative 4D defining sessions (Getuli, Capone, Bruttini & Isaac, 2020).

Software Capacity in VR Devices

Not every programme is compatible with and supported by VR. VR storage was so limited that it couldn't sustain the software for lengthy periods. A study found that VR is unable to support all software, with a decrease in software that addresses the VR scene during VR practise, especially when the model is large enough (Zaker & Coloma, 2018).

METHODOLOGY

This research adopted a quantitative approach with a questionnaire survey as the research instrument. Since this study is based on quantitative methods, data collection was made specifically for the population related to the construction industry. Quantitative research necessitates the reduction of phenomena to numerical values to conduct statistical analysis (Wang, Li & Kho, 2018). The study is characterized as quantitative if the researcher is interested in quantifying the variation in a phenomenon, situation, problem, or problem.

The data can be measured in quantitative research because the samples are broad and represent the population, the results are viewed as a general and thorough overview of the population (Queirós, Faria & Almeida, 2017). Quantitative research focuses on objectives and is especially useful when quantitative measures of variables and conclusions can be obtained from population samples. It makes use of defined procedures as well as formal data collecting methods. The data has been obtained objectively and thoroughly. Finally, statistical methods are used to analyse numerical data, which is often done with Statistical Package for Social Science (SPSS) (Wang et al., 2018). The process of the research methodology is shown in Figure 1.



Figure 1. Process of Research Methodology

In this paper, the research is focused on architect which is one of the roles involved in BIM. The areas conducted are in Selangor. Questionnaires was distributed to 55 architecture firms who are active in Selangor and registered in the PAM Directory. The minimum sample size needed for this research is 31 respondents.

Questionnaire Design

A questionnaire is a sort of research instrument that consists of a series of questions designed to elicit feedback that can be used to evaluate data. The questionnaire type is structured and consists of four sections, A, B, C and D. Section A is about respondents' demographic questions; B and C are Likert-scale questions; section D is about comments and suggestions. This study used Likert-scale questions from four alternatives which are strongly agreed, agree, disagree and strongly disagree. Likert-scale items are excellent for eliciting respondents' feelings, opinions, attitudes, and so on concerning any language-related issues.

The researchers only needed a positive or negative response for this study. Questionnaires was distributed via email and other social media such as WhatsApp and Telegram.

Pilot Study

Pilot studies are an essential part of excellent research design. The consistency of measurements is linked to reliability. Participants who complete a motivational instrument should get around one sample for each test. Although exact dependability calculations are impossible to offer, reliability estimates can be obtained through several methods (Kumar et al., 2018).

To eliminate data inaccuracies in this investigation, a series of structured questions was evaluated by one lecturer, one industry professional and one researcher.

Reliability examines the link between all things that comprise a construct to ensure that the things measure the same concept. Inter-rater reliability examines whether ratings from one sample are consistent when more than one observer recorded the respondent's behaviour at the same time using the same instrument. The SPSS Statistic which uses Cronbach's Alpha (α) was used to value the category of the questionnaire. Cronbach's alpha is the most often used indicator of internal consistency ("reliability") (Heale & Twycross, 2015). Figure 2 depict the outcome of the reliability test for sections B and C of the questionnaire survey form for the pilot study, where all data is valid. Cronbach's Alpha for sections B and C is 0.935. This resulted in a suitable questionnaire for the survey's Likert scale part. According to the Cronbach's Alpha Score, both of these parts are in the >0.80 - 1.00 range, indicating that the level of reliability is very reliable.



Figure 2. Reliability Test Result for Sections B and C

Data Analysis

IBM SPSS Version 28.0 software was used to analyse the questionnaire data. In this study, the data was translated into tables, and the findings was displayed in graphs. SPSS software was used in this paper for frequency distribution, which is a graphical or tabular representation that shows the number of observations in a given time interval, descriptive, which summarises the sample and the measures, and finally, Pearson correlation, the rank of the strength. Table 1 shows the guideline to interpret the data gained from Pearson coefficient correlation.

Range of Correlation Coefficient Values	Level of Correlation	Range of Correlation Coefficient Values	Level of Correlation
0.80 to 1.00	Very strong Positive	-0.80 to -1.00	Very strong Negative
0.60 to 0.79	Strong Positive	-0.60 to -0.79	Strong Negative
0.40 to 0.59	Moderate Positive	-0.40 to -0.59	Moderate Negative
0.20 to 0.39	Weak Positive	-0.20 to -0.39	Weak Negative
0.00 to 0.19	Very Weak Positive	-0.00 to -0.19	Very Weak Negative

Table 1. Guideline for Interpretation of Pearson (Ranked) Correlation

RESULT AND DISCUSSION

This section described the findings and discussed the acceptance of BIM-VR among Selangor architects. The questionnaire is divided into four sections: demographic information, BIM-VR awareness and involvement, BIM-VR challenges in construction projects, and comments. This study used a survey form to collect and analyse data from an architecture firm. Out of the 55 questionnaires provided, 33 completed the questionnaire completely, earning a 60% response rate.

Section A: Demographic Information

The demographics section includes six items from respondents' backgrounds: age, company size, position in the company, length of service, years of experience operating BIM and experience using VR in BIM projects. Table 2 shows a summary of the respondents' backgrounds. From the table, the majority of companies are small based on data for company item size and most of the respondents have no experience in operating and adopting BIM and VR based on data for items number 5 and 6.

No.	Items	Classes	Frequency	Percent
1	Age	20-30 years old	13	39.4
	-	31-40 years old	15	45.5
		41-50 years old	4	12.1
		51 years old & above	1	3.0
2	Size of company	50 staff & below	23	69.7
		51-150 staff	8	24.2
	-	151 staff & above	2	6.1
3	Position in company	Architect	26	78.8
		Architectural engineer	2	6.1
	-	Project manager	4	12.1
		Senior BIM executive	1	3.0
4	Length of service	5 years & below	19	57.6
		6-15 years	12	36.4
		16-25 years	1	3.0
		26 years & above	1	3.0
5	Years of experience in handling BIM	0 years	13	39.4
		1-3 years	17	51.5
		4-6 years	2	6.1
	-	7-9 years	1	3.0
6	Experience of adopting VR in BIM projects	0 years	27	81.8
	-	1-3 years	6	18.2

Table 2. Summary of The Frequency of The Respondent's Background

Section B: Awareness and Involvement of BIM-VR

This part consists of ten questions of the Likert pattern. The Likert scale simply provides four response options: The first three questions are designed to gauge respondents' awareness of BIM-VR, while the next seven are designed to gauge respondents' involvement and participation in BIM and VR. Table 3 shows the ranking by mean for awareness and involvement of BIM-VR in Selangor construction industry.

Table 3. Ranking by Mean for Awareness and Involvement of BIM-VR							
	Rating (%)						
Awareness and Involvement	N	Strongly Disagree	Disagree	Agree	Strongly Agree	Mean	Rank
		1	2	3	4		
BIM-VR can smoothen the communication in the design consultant team.	33	3.0	21.2	42.4	33.3	3.06	1
I often use VR tools in my daily life such as in gaming.	33	18.2	15.2	12.1	54.5	3.03	2
BIM-VR can reduce the time for finishing the project.	33	6.1	18.2	45.5	30.3	3.00	3
BIM-VR helps visualize the design as in an actual construction site.	33	3.0	18.2	60.2	18.2	2.94	4
I would choose BIM-VR to be used often in the project's discussion.	33	12.1	33.3	54.5	-	2.42	5
I've been to at least one VR showroom in the construction industry.	33	36.4	30.3	24.2	9.1	2.06	6
I explained the drawing of the project by using VR to the client.	33	45.5	42.4	9.1	3.0	1.70	7
I was able to address the difficulty of arranging construction areas while drawing using BIM-VR.	33	54.5	27.3	18.2	-	1.64	8
I've been introduced to BIM-VR in construction before starting my career.	33	54.4	27.3	18.2	-	1.64	9
I use VR in architect drawings.	33	60.6	30.3	6.1	3.0	1.52	10
Total Average Mean					2.30		

Table 3 shows the ranking of the mean for the data in section B where the highest is 3.06 where BIM-VR can smoothen the communication in the design consultant team. Data may be immediately evaluated on-site and compared to the original building model. This strategy delivers dependable sources of information without requiring a visit to the site. Furthermore, it enables site managers to report to the project manager to maintain track of operational progress (Ahdika, 2017). The lowest mean is 1.52, and the item indicates whether or not respondents used VR in architect drawings. Referring to Table 13, the average for the total mean is 2.30, an overall low mean indicating that majority of the respondents may be aware of the symbiosis of BIM and VR, but hardly are directly involved in the implementation of the technology tools. This weak score may be affected by 'lack of information,' 'lack of skilled personnel,' and 'time to master' (Hassanein, 2020).

Section C: Challenges of BIM-VR in Construction Project

This section also includes 10 Likert-type questions. The Likert scale has four response options: strongly agree, agree, disagree, and strongly disagree. All of the questions revolve around the challenges of using BIM-VR in construction projects.

	Rating (%)						
Awareness and Involvement	Ν	Strongly Disagree	Disagree	Agree	Strongly Agree	Mean	Rank
		1	2	3	4		
Lack of initiative on the part of government	22	2.0	2.0	6 1	97.0	2 70	4
in BIM.	33	3.0	3.0	0.1	07.9	3.79	
Incompatibility between VR and BIM peer software.	33	3.0	9.1	6.1	81.8	3.67	2
Training someone to utilise BIM-VR takes a lengthy time.	33	-	18.2	15.2	66.7	3.48	3
The cost of implementing BIM in VR is too high.	33	3.0	18.2	15.2	63.6	3.39	4
At the moment, the application of BIM-VR has a little significant impact.	33	-	27.3	12.1	60.6	3.33	5
Lack of experts in handling VR in BIM projects.	33	3.0	9.1	39.4	48.5	3.33	6
Only a few VR devices are compatible with BIM software.	33	3.0	15.2	36.4	45.5	3.24	7
Require much time to set up VR with BIM application.	33	-	18.2	48.5	33.3	3.15	8
The usage of BIM in VR does not provide a clear return on investment.	33	-	57.6	27.3	15.2	2.58	9
Adverse effects on the body, such as drunkenness and weariness.	33	36.4	30.3	18.2	15.2	2.12	10
Total A	verag	e Mean				3.21	

Table 4. Ranking by Mean for Challenges of BIM-VR in Construction Projects

Table 4 shows the mean ranking of Challenges in BIM-VR from highest to lowest. The average for the total mean is 3.21, an overall moderate mean indicating that majority of the respondents agree with the challenges suggested, which are mainly on "Lack of initiative on the part of government authorities in adopting and implementing VR in BIM" (Rank 1) and "Incompatibility between VR and BIM peer software" (Rank 2). Indeed, the government's support and enforcement of BIM-VR deployment can lead to a faster implementation of BIM-VR (Wu et al., 2019). Only two challenges are not agreed upon by the respondents which are "BIM-VR does not deliver a clear return on investment" (mean: 2.58) and "BIM-VR harms the body" (mean: 2.12). This is owing to the numerous difficulties connected with implementing VR in BIM. The high cost of installation, restricted accessibility to VR, and limited BIM support are the obstacles that prevent Malaysia from broadly using BIM-VR (Alizadehsalehi et al., 2020).

Pearson Correlation of Size of Company Versus Awareness and Involvement / Challenges for BIM-VR

Table 5 shows the Pearson correlation matrix for the size of the company versus two variables which are awareness and involvement in BIM-VR and challenges of BIM-VR. Based on the table, "Size of Company" show a strong positive relationship (coeff: 0.880) with

"I use VR in architect drawings". This is the fact that the involvement in VR increases as the size of the company increases. In addition, in the correlation between "Size of Company" and "Challenges of BIM-VR", a strong negative correlation (coeff:-0.900) is formed with "Training Someone to Utilise BIM-VR Take a Lengthy Time". This finding reflects that bigger companies consider BIM-VR training indispensable and are willing to place a huge investment in the training of BIM-VR for their workers.

	Pearson Correlation	Coefficient	Rank of Strength
	Size of company	1.00	-
	BIM-VR Helps Visualize the Design as in An Actual Construction Site	0.642	6
	BIM Can Smoothen the Communication in the Design Consultant Team	0.581	8
	BIM-VR Can Reduce the Time for Finishing the Project	0.598	7
Awaranaaa 8	I've Been Introduced to BIM-VR in Construction Before Starting My Career	0.818	3
Involvement in	I've Been to At Least One VR Showroom in the Construction Industry	0.845	2
DIIVI-VK	I Was Able to Address the Difficulty of Arranging Construction Areas While Drawing Using BIM-VR	0.818	4
	I use VR in Architect Drawings	0.880	1
	I Explained the Drawing of the Project by Using VR to the Client	0.783	5
	I Would Choose BIM-VR to be Used Often in the Project's Discussion	0.505	9
Challenges of	The Cost of Implementing BIM in VR is Too High	-0.791	5
BIM-VR	Lack of Experts in Handling VR in BIM Projects	-0.800	4
	Only A Few VR Devices Are Compatible with BIM Software	-0.244	9
	Incompatibility Between VR and BIM Peer Software	-0.800	3
	Require Much Time to Set Up VR in BIM Application	-0.714	6
	Lack of Initiative on the Part of Government Authorities in Adopting and Implementing VR in BIM	0.208	10
	The Usage of BIM in VR Does Not Provide a Clear Return on Investment	-0.477	8
	Training Someone to Utilise BIM-VR Take a Lengthy Time	-0.900	1
	At the Moment, the Application of BIM-VR Has a Little Significant Impact	-0.874	2
	Adverse Effects on the Body, Such as Drunkenness and Weariness	-0.644	7

Table 5. Pearson correlation matrix for the size of the company versus awareness and
involvement/challenges/drivers for BIM-VR

CONCLUSION

The research found that the most respondents are aware of the symbiosis of BIM and VR, but hardly are involved directly in the implementation of the technology tools. These findings have justified the need for Objective 2, which is to gauge the challenges the industry faces in adopting BIM-VR. Besides, major challenges the industry encountered are mainly on "Lack of initiative on the part of government authorities in adopting and implementing VR in BIM" and "Incompatibility between VR and BIM peer software". In addition, Pearson correlation test analysis also revealed that there is the strongest positive relationship (coeff: 0.880) between "Size of Company" with with "I use VR in architect drawings" and also a strong negative correlation (coeff: -0.900) is formed between "Size of Company" with "Training Someone to Utilise BIM-VR Has a Little Significant Impact". In conclusion, the research showed the respondents are aware and willing to involve actively in this integrated technology

whilst seeing the need to collectively overcome the challenges BIM-VR. It also cannot be denied that the government push and support in this area will definitely be a catalyst in BIM-VR update and hence will contribute significantly to the efficiency of design and construction process as a whole.

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STRUCTURAL MODEL OF GREEN CLEANING COMPONENTS FOR GREEN BUILDINGS

Nurul Nadiah Zainol, Muhammad Azwan Sulaiman, Mona Isa, Anis Syazwani Sukereman and Muhamad Saiful Alizan Nordin

College of Built Environment, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia

Abstract

This paper aims to assess and develop a structural model of green cleaning for green buildings in Malavsia. Green cleaning has become one of the key components that need to be considered for the well-being and performance of a building, particularly in green building operations and maintenance. As a major contributor to indoor environmental quality (IEQ) performance, green cleaning is believed to help green buildings achieve its benefits, especially in terms of improvement of occupant's health, safety, and productivity; operational cost savings; and reduced natural resources consumption There is the need to identify clear and proper components and requirements of green cleaning so it can help in preventing errors, improving quality, and lowering risk while cleaning work is being carried out in the green building. A guestionnaire survey involving cleaning service providers and Green Building Index (GBI) facilitators was carried out. The data were analyzed in two phases i.e., measurement model analysis and structural model analysis using partial least squares structural equation modeling (PLS-SEM). However, this paper will be focusing on the structural model analysis. Out of eight green cleaning components, only five components have a significant relationship with the benefits rendered by green buildings namely Planning; Products and Materials; Equipment; Cleaning Procedures; and Training. The findings of this study can be used to provide an initial overview of the components and requirements of green cleaning, as well as how these components can help the industry, particularly cleaning service providers and green building management teams, conduct sustainable cleaning activities and achieve green building benefits.

Keywords: Green building; green cleaning; component; requirement; structural model

INTRODUCTION

Sustainability has become a popular concept and has been widely adopted in many fields, especially in the built environment. As defined in Brundtland Commission Report 1987, sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". It is a simple definition with a profound meaning where any economic activity in any country must consider its impact on the environment, natural resources, local communities, and their surrounding areas, as well as ensure continuous development to ensure that future generations are protected from harmful effects. To put it another way, sustainable development is long-term development characterized by the preservation or regeneration of natural resources, environmental conservation, and the assurance of community welfare quality.

In the built environment, one of the efforts in achieving sustainable development is by developing green buildings. Green building is intended to alleviate environmental issues like climate change while also delivering healthy, equitable, and resilient buildings, communities, and cities. The materials and technologies applied in green building development also contribute to the regeneration of natural resources and systems, resulting in socioeconomic advantages through a healthy circular economy. Many assessment tools, rating systems, and certification systems were developed to award green or sustainable buildings. For example, the U.S. Green Building Council (USGBC) established Leadership in Energy and

Environmental Design (LEED), and the Building Research Establishment (BRE) has blished Building Research Establishment Environmental Assessment Methodology (BREEAM) in 1990 in the United Kingdom. In Malaysia, there are several rating tools developed by professional associations such as Green Building Index (GBI), GreenRE while MyCREST, Penarafan Hijau JKR (pHJKR), and a few more are government-driven.

However, most of the rating tools in Malaysia are mainly focused on the design and construction phase of a building. Only MyCREST and Green PASS apply its tool from design to the operational phase. Both MyCREST and Green PASS involve carbon calculation and the assessment of metrics provide information on performance with regard to carbon reduction measures (Foo Chee Hung and Fuhairah, 2018). Green building, according to many scholars, is more than just the accumulation of new materials, high technology, and environmentally friendly innovation; it should be a full solution for ensuring sustainable development throughout the building's life cycle, especially during the operation and maintenance phase – the longest phase in building's life cycle.

As people nowadays spend over 90% of their time indoors due to the COVID-19 pandemic, there are several health, happiness, and productivity implications for building occupants. According to Dodo et al. (2020), people that are staying immobile for an extended amount of time suffer from a variety of negative consequences including poor air quality, stress, bad dietary choices, poor posture, etc. As a result, many have suggested that transforming the building's indoor environment will aid in the creation of a built environment that increases occupant productivity and well-being. Indoor environmental quality (IEQ) is one of the assessment criteria for most green building rating tools, indicating that transforming the building's indoor environment has long been used in a green building. The IEQ criteria are primarily concerned with air quality, thermal comfort, lighting, and visual and acoustic comfort. However, many people are not aware that a daily activity such as cleaning is one of the factors that affect a building's IEQ performance.

Cleaning is a substantial contributor to indoor environmental quality (Zainol, 2016). Cleaning products, tools, and equipment that are safer can improve IEQ and occupant health while also improving workplace safety and lowering healthcare costs and lost time from work (Fischer, 2011; Ramli et al., 2018; Young et al., 2010). The incorporation of green cleaning requirements in well-known green building rating tools such as LEED: Existing Building Operations and Maintenance; and Green Star: Performance demonstrates the importance of a green cleaning program in a green building. In GBI, the use of environmentally non-polluting procedures and chemicals for cleaning the building exterior was the only indicator relating to cleaning. The GBI rating tool has not mentioned green cleaning. Therefore, this research aims to determine the components and requirements of green cleaning and how green cleaning helps in achieving benefits rendered by green buildings.

LITERATURE REVIEW

A healthy and comfortable environment is created by good indoor air quality, which is achieved by good air circulation, proper temperature and humidity control, and the control of airborne contaminants. Cleaning, from the facilities management perspective, is a vital support service to any sort of core business and aids in the creation of a healthy environment. According to Garland (2009), facilities managers are paying more attention to cleaning now since they understand the negative effects of poor environmental conditions, highly hazardous cleaning agents, and dust on their employees and occupants. Chemicals with high amounts of volatile organic compound (VOC) emissions and other carcinogens, as well as dust from improperly filtered vacuums, can have a significant impact on the health of workers and inhabitants (Garland, 2009). Therefore, it is an ideal time for facilities managers to switch to green cleaning, as an increasing variety of green cleaning products that are far more effective are becoming accessible.

Many researchers have emphasized the importance of green cleaning and the benefits that may be derived from the program. The benefits of green cleaning have been discovered from the viewpoint of sustainable development, which includes benefits from economic, social, and environmental aspects. Green cleaning, which comprises many components and requirements, is believed to help green buildings achieve potential benefits in economic, social, and environmental aspects, which is in line with the goals of green building development itself.

Benefits Rendered by Green Buildings

Apart from the environmental benefits, the economic and social benefits of green building development must be exposed to excite investors, developers, and other stakeholders in adopting new sustainable approaches and technology. During the development and operation phase, a building will generate a large amount of solid waste and water effluent, water will be consumed for day-to-day activities, and the use of energy particularly non-renewable energy. This will contribute to increased pollution levels in the environment. All of these activities have an "environmental footprint" in terms of resource consumption and waste generation.

The largest challenge facing the green building sector is a misunderstanding regarding the expense of green building development. More than 60% of people assume that green building approaches and processes are significantly more expensive than conventional buildings. The upfront cost of a green building is, on average, 17 percent higher than the original cost of an equivalent conventional building, according to a study done by the World Business Council for Sustainable Development (WBCSD). However, based on the study conducted by U.S. Green Construction Council (USGBC), the initial cost of a green building is only 2% to 3% greater than that of a non-green building (Hamad, 2020).

Although the upfront cost is said to be higher, it can be recovered by lowering maintenance and renovation expenses, as well as utility costs such as electricity, gas, and water. It can also be recovered by improving occupant health and productivity, extending the life of building components, and retaining workers (Heung, 2019; Molinski, 2017; Ghodrati et al., 2012). Green buildings are estimated to save 8-9 percent in terms of operational costs (Alias et al., 2012). The majority of operational savings in green buildings come from maintenance and utility expenditures, which have a significant impact on the financial aspect of the organization (Samari et al., 2013).

Green buildings are built with the impact on human health and the environment in mind, maximizing the use of natural resources such as energy and water while minimizing waste. Green buildings are said to be 25-30% more energy efficient when compared to conventional buildings; can save water usage and materials up to 40% (Amjad et al., 2017; Alias et al.,

2012; Turner and Frankel, 2008). Green buildings also encourage waste-reduction techniques such as reuse and recycling programs, which limit the amount of waste that needs to be disposed of. This technique will lower waste disposal expenses as well as the societal costs of landfill construction and maintenance.

Besides that, the green building takes into account aspects of the appropriate site, such as planned access to public transportation, community services, spaces, and landscaping, which is how green building contributes to ecosystem capacity. Furthermore, the construction of green buildings considers aspects such as avoiding and conserving environmentally sensitive areas through the redevelopment of existing sites and brownfields, as well as proper construction management, stormwater management, and a reduction in the strain on existing infrastructure capacity (Zainol, 2016).

Green building is also considered to be capable of generating positive psychological and social experiences, as well as well-being and a healthy atmosphere, which leads to increased productivity among occupants. Better indoor surroundings, including improved lighting conditions, thermal comfort, and other green features of green buildings, will boost employee or occupant motivation, reduce sick days, and ultimately increase employee productivity (Masoud et al., 2017; Breisinger, Diez, & Tagwerker, 2012).

"Importing" or "imitating" the technologies of the western model is not what "green building" entails. Many people choose the gleaming glass pattern in tropical, desert, and other extreme climates, despite the fact that this pattern is unsuited for such environments (Zainol, 2016). This leads to land deterioration as a result of climate change and may have an impact on local culture. Green building, according to Larsen et al. (2011), incorporates mitigation and adaptation measures such that buildings are designed to be responsive and resilient to future climate extremes. Green building also considers the location's cultural and vernacular traditions. This is necessary in order to preserve the cultural integrity and continuity of any urban realm that is not heavily impacted by western models.

Last but not least, green buildings can be seen as different goods that can be utilized for marketing, attracting and maintaining staff, and enhancing the company's image. Green buildings with lower operating expenses are said to boost asset values by roughly 7.5 percent (Alias et al., 2012; Eichholtz, Kok, & Quigley, 2013). There is growing evidence that a building's value rises as a result of increased performance and market recognition linked with green certification. A green building's assessed value and market value are affected by its certification (Yaron, 2013).

Therefore, the authors have concluded that there are at least thirteen (13) benefits rendered by green buildings as follows:

- i. Occupant's health and safety
- ii. Property's rental value and income
- iii. Enhances indoor air quality (IAQ)
- iv. Improves worker recruitment and retention
- v. Operational Savings
- vi. Saves natural resources
- vii. Enhances the organization's public image

viii.Extends the life of the building and facilities in the building

- ix. Lessens the environmental impact
- x. Improves market competitiveness
- xi. Improves worker's productivity
- xii. Reduces funds spent to purchase any products and chemicals
- xiii.Reduces lost labor hours due to sickness

Green Cleaning Components and Requirements

As previously stated, green building development could provide benefits in terms of the environment, economy, and social elements. If the development of green buildings is solely based on green design and technology, the benefits will not be achieved. Implementing a green cleaning program can be a significant part of the effort to ensure that green buildings are performed and maintained in a sustainable manner, so contributing to the achievement of benefits.

Conventional cleaning products, which may contain chemicals, can cause many health problems (Gerster et al., 2014; Zota et al., 2017). Some cleaning or housekeeping activities require extensive manual work, which is dangerous for health due mainly to bad working postures, poor ergonomic work and workplace design, and poor cleaning equipment design, among other factors (Kumar, 2006; Pelissier et al., 2014; Rathi, M. et al., 2017; Wami, Dessie, & Chercos, 2019). The use of ecologically or environmentally friendly cleaning products and taking into account the ergonomics of cleaning equipment will reduce health issues, provide a healthy indoor environment, and ultimately improve the health, morale, and productivity of cleaning personnel and occupants. (Zainol et al., 2015). In line with the benefit of green buildings in terms of occupant health and productivity, safer cleaning products, materials, and equipment can considerably enhance indoor air quality (IAQ) and occupant health; workplace safety; and reduce healthcare costs and lost time from work (Young et al., 2010; BETCO, 2008).

Besides that, saving operations costs and extending the life of buildings and facilities are among the benefits rendered by green buildings, and green cleaning helps the green building saves up to 30% of water use (BETCO, 2008; Zainol et al., 2015) by using green cleaning equipment such as ultra-low-flow dispensing floor scrubber (which allows workers to decide where to apply extra water or detergent). The use of this equipment will cut water usage up to 70% (Kohls, 2011). This modern cleaning equipment not only focuses on minimizing the use of water but also minimizes the use of cleaning chemical and energy; and as a result, contribute to extending the life of facilities and buildings and reducing the cost of repairing or replacing in long term (Osagie, 2018; Kohls, 2011). This is due to the fact that excessive cleaning resources can damage and prematurely age building materials, resulting in costly maintenance and replacement costs.

There are various benefits that can be achieved by green buildings from a green cleaning program. Practitioners, particularly those in the green building industry, are aware of the necessity of employing "green" materials and "green" procedures in buildings, but their knowledge of the green cleaning idea remains hazy. There is no requirement specifically highlighting green cleaning in the green building rating tool in Malaysia. In GBI for example, green cleaning is just generally highlighted in the Indoor Environment Quality (IEQ)

requirement, which mostly concentrates on the quality of the air (Atifi, 2012). Cleaning programs in green buildings will not meet the organization's and occupants' needs to produce a healthy environment if there are no unclear requirements. Besides, building owners and cleaning service providers also are not sure of what services or activities should be included in a green cleaning program for green buildings (Zainol, 2016).

Table 1 shows the compilation of green cleaning components and requirements from various literature. There are a total of eight (8) green cleaning components and thirty-four (34) green cleaning requirements which will be the basis for the formation of the model in this study.

No	Green Cleaning Components	Green Cleaning Bequirement
1	Planning	Green cleaning Requirement
1.	Fianning	Standard Operating Procedure (SOPs)
		Ruilding specific groop cleaning plan
		Meintenance plan for powered equipment
	Desident and Materials	Maintenance plan for powered equipment
2.	Product and Materials	Environmentally preferable products and materials
		Disposable janitorial paper products and trash bags
		Hand soaps
3.	Equipment	Environmentally preferable cleaning equipment
		Equipment inventory lists
4.	Cleaning Procedures	Efficient use of chemical
		Reducing solid waste
		Vacuum use and maintenance
		Dusting and Dust Mopping
		Entryways
		Floorcare
		Disinfection
		Restroom care
		Pantry/Cafeteria
		Furniture
		Trash collection & recycling
		Vulnerable populations
		Integrated pest management (IPM)
5.	Communication	Communication Plan
		Communication channels
		Notification of cleaning products
		Building occupants with special needs or sensitivities
6.	Training	Initial training
		Standard safety training (annually)
		Site-specific training (annually)
		Training record
7.	Certification and Labeling	Meeting all the criteria provided by environmental-related standard
		Monitoring of certified products & services
8.	Custodial Effectiveness Assessment	Evaluate the effectiveness of the green cleaning program

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There are eight hypotheses that were established to be tested in this study:

Hypothesis 1: The planning component has a significant relationship with the benefits rendered by green buildings.

Hypothesis 2: The product and Materials component has a significant relationship with the benefits rendered by green buildings.

Hypothesis 3: The equipment component has a significant relationship with the benefits rendered by green buildings.

Hypothesis 4: The cleaning Procedure component has a significant relationship with the benefits rendered by green buildings.

Hypothesis 5: The communication component has a significant relationship with the benefits rendered by green buildings.

Hypothesis 6: The training component has a significant relationship with the benefits rendered by green buildings.

Hypothesis 7: The certification and labeling components have a significant relationship with the benefits rendered by green buildings.

Hypothesis 8: The Custodial Effectiveness Assessment component has a significant relationship with the benefits rendered by green buildings.

RESEARCH METHODOLOGY

Data Collection

Green Building Index (GBI) accredited facilitators and cleaning service providers were among the respondents in this study. Prior to the distribution of the questionnaires, potential respondents were contacted by phone and e-mail to obtain their permission to participate in the survey, and once they had given their permission, the questionnaires were distributed using both an online (Google form) and an offline (hardcopy via mail or face-to-face) approach. The questions were developed using a 5-point Likert scale, and the questionnaire was written in two languages (English and Bahasa Melayu) to ensure that language incompetency will not be a barrier for the respondents to participate in this research.

Data Analysis

The data were analyzed using the partial least squares structural equation modeling (PLS-SEM) technique, which is ideal for theory development. The researcher has suggested a conceptual model in this study that determines the relationship between green cleaning components and green building benefits. In this study, there will be two sub-models as shown in Figure 1.

The outer model or also known as the "Measurement Model" specifies the relationships between the latent variables and their observed indicators. As shown in Figure 1, the latent variables in the measurement model are the "green cleaning components" and the observed indicators are "green cleaning requirements". Meanwhile, the inner model or "Structural Model" describes the relationships between the independent latent variables i.e., "green cleaning components" and dependent latent variables i.e., "the benefits rendered by green buildings".



Hence, the model is analyzed in two phases i.e., "measurement model analysis" (Phase 1) and "structural model analysis" (Phase 2). For the first phase, the analysis will assess the reliability and validity of green cleaning requirements in each green cleaning component and as well as the benefits rendered by green buildings; while the relationship between exogenous variables (green cleaning components) and endogenous variables (the benefit) will be evaluated in the second phase of model analysis. Table 2 shows the summary of requirements when analyzing the model.

Table 2. Summary of Analysis Requirement					
Phase	Types of Analysis	Requirement	Sources		
	Composite Reliability (CR)	$0.6 \le CR \le 0.7$: Acceptable CR ≥ 0.7 : Satisfactory	Hair et al. (2011)		
	Indicator Reliability	Loading value > 0.7: Acceptable	Hair Jr. et al. (2013); Hair et al. (2011)		
ase 1		0.4 < Loading value < 0.7: Should be considered eliminated from the model if deleting the indicators increase the value of CR or AVE			
РЧ		Loading value < 0.4: Eliminate			
	Average Variance Extracted (AVE)	The AVE value must be more than 0.5	Hair Jr. et al. (2013)		
	Discriminant Validity	Fornell-Larcker Criterion The square root of the AVE of each construct should be higher than its highest correlation with any other construct.	Hair et al. (2011)		
	Coefficient of Determination (R ²)	$R^2 > 0.26$ = Substantial (Cohen's rule of thumb)	Chin (1998); Cohen (1988)		
hase 2	Path Coefficient (β)	t value = 2.57 (p<0.01) t value = 1.96 (p<0.05) t value = 1.65 (p<0.10)	Hair et al. (2014); Jose and Manuel (2012); Gotz et al. (2010)		
ď	Effect Size (f ²)	$f^{2} = 0.02$ (small effect) $f^{2} = 0.15$ (medium effect) $f^{2} = 0.35$ (large effect)	Hair Jr. et al. (2013)		

Phase	Types of Analysis	Requirement	Sources
	Predictive Relevance (Q^2) and Relative Impact (q^2)	$Q^2 > 0 = Relevant prediction$	Hair Jr et al. (2013); Jose and Manuel (2012)
		$q^2 = 0.02$ (small effect) $q^2 = 0.15$ (medium effect)	
		$q^2 = 0.35$ (large effect)	

However, for the purpose of this paper, the authors will only emphasize the "structural model analysis" with a short summary of the "measurement model analysis".

FINDINGS

Phase 1: Measurement Model Analysis

Table 3 shows the summary of the measurement model analysis. Based on the findings, out of thirty-four (34) green cleaning requirements, two (2) requirements were eliminated from the model i.e., "hand soap" and "integrated pest management".

Types of Analysis	Summary of Findings
Composite Reliability (CR)	All 8 constructs (green cleaning components) have CR values ranging from 0.789 to 0.961 - indicating that all variables are reliable.
Indicator Reliability *Require CR and AVE testing before being considered eliminated. **Eliminate	 There are 6 indicators with a loading value of less than 0.70: i. Hand soap (0.437) * ii. Pantry/cafeteria (0.698) * iii. Furniture (0.497) * iv. Integrated pest management (0.219) ** v. Adds competitive market value (0.438) * vi. Reduces lost labor hours from accidents and sick leaves (0.502) *
Average Variance Extracted (AVE)	All latent variables have well and satisfying convergent validity with AVE values greater than 0.50 except for the "Product and Material" component (AVE=0.495). CR value rose from 0.789 to 0.827 and the AVE value rose from 0.495 to 0.616 after eliminating "hand soap". Therefore, "hand soap" has to be eliminated. The other 4 indicators will be retained in the scale as the elimination does not give any significant impact on the value because the CR value is still greater than 0.70 and the AVE value is still more than 0.50
Discriminant Validity	Each indicator of the construct has good discriminant validity because all variables share more variance with their own block of indicators rather than share with other variables in the measurement model.

Phase 2: Structural Model Analysis

Coefficient of Determination (R^2)

 R^2 is the most often used measure for determining a model's predictive accuracy. It represents the combined effects of the exogenous latent factors on the endogenous latent variables. According to Hair et al. (2013), providing R^2 value rules of thumb is challenging because it depends on the model's complexity and research discipline. R^2 values of 0.75 are deemed large, while 0.50 and 0.25 are considered moderate and weak (Hair et al., 2011; Henseler et al., 2009). However, Cohen (1988) considers R^2 >0.26 to be substantial. There is no reference model for this study because it is new and exploratory. For calculating the value of R^2 , the researcher did not have any comparable reference studies. Thus, the researcher has

decided to use the Cohen's rule of thumb, where an R^2 value of more than 0.26 is regarded as substantial, after following other researchers such as Suwaibatul (2014) and Mariah (2014) in an almost equivalent research topic i.e. Facilities Management. The R^2 of the model is 0.470, where 47% of the variance for "Benefits Rendered by Green Buildings" is contributed by all green cleaning components.

Path Coefficient (β)

Each line or path connecting two latent variables in the structural model represents one hypothesis. The values of the t-statistic are calculated using the bootstrapping function to establish the level of significance of each path. To put it another way, this analysis will establish whether the hypothesis is significant or non-significant. To evaluate the specific effect in a structural model, Hair et al. (2011) recommend a path coefficient of at least 0.1. Meanwhile, the value of the t-statistic is used to assess whether the results of the presented hypothesis are accepted or rejected. Less than 1.65 t-statistic values are regarded as non-significant, and their hypotheses are rejected. Table 4 shows the summary of the hypothesis testing result.

Hypothesis	Relationship	Path Coefficient (β)	t-statistic	Significance	Result	
H1	Planning - Benefits	-0.254	2.285	p < 0.05	Accepted	
H2	Product and Materials - Benefits	-0.348	1.834	p < 0.10	Accepted	
H3	Equipment - Benefits	0.383	3.259	p < 0.01	Accepted	
H4	Cleaning Procedure - Benefits	0.475	2.454	p < 0.01	Accepted	
H5	Communication - Benefits	0.022	0.154	Not significant	Rejected	
H6	Training - Benefits	0.291	2.248	p < 0.05	Accepted	
H7	Certification and Labeling - Benefits	0.010	0.050	Not significant	Rejected	
H8	Custodial Effectiveness Assessment - Benefits	0.121	1.022	Not significant	Rejected	

Table 4. Summary of The Hypothesis Testing Result

Effect Size (f²)

The effect size was determined to ascertain how powerful each exogenous construct was in relation to the endogenous construct. When a specific exogenous construct is removed from the model, the change in the R^2 value can be used to determine whether the construct has a significant impact on the endogenous construct. The f^2 can be calculated as follows:

$$f^{2} = \frac{R^{2}_{\text{included}} - R^{2}_{\text{excluded}}}{1 - R^{2}_{\text{included}}}$$

 $R^{2}_{included}$ and $R^{2}_{excluded}$ are the R^{2} value of the endogenous variables when a selected exogenous variable is included or excluded from the model. Table 5 shows the result of f^{2} for each green cleaning component.

Exogenous - Endogenous	R ² included	R ² excluded	f ² Value	Effect Size		
Planning - Benefits	0.470	0.438	0.06	Weak		
Product and Materials - Benefits	0.470	0.447	0.04	Weak		
Equipment - Benefits	0.470	0.395	0.14	Weak		
Cleaning Procedure - Benefits	0.470	0.410	0.11	Weak		
Communication - Benefits	0.470	0.470	0.00	-		
Training - Benefits	0.470	0.427	0.08	Weak		
Certification and Labeling - Benefits	0.470	0.470	0.00	-		
Custodial Effectiveness Assessment - Benefits	0.470	0.465	0.01	-		

Predictive Relevance (Q^2) and Relative Impact (q^2)

The blindfolding technique in Smart PLS is used to obtain the O^2 value. Blindfolding is a sample reuse approach that estimates the parameters with the remaining data points after omitting every dth data point in the endogenous construct's indicators (Chin, 1998; Henseler et al., 2009; Tenenhaus, Vinzi, Chatelin, & Lauro, 2005). The omission distance (D), which must be calculated in order to conduct the blindfolding operation, affects data point elimination and prediction. Hair Jr et al. (2013) proposed a range of 5 to 10 for the D and a D of 7 is commonly utilized in numerous research. The Q^2 value is a measure of how effectively the path model can predict the values that were originally observed. The relative impact of predictive relevance can be compared to the q^2 effect size by performing the following calculation:

$$q^{2} = \frac{Q^{2}_{included} - Q^{2}_{excluded}}{1 - Q^{2}_{included}}$$

Based on the result with 7 as a D, the predictive relevance Q^2 value for this model is 0.298, which is considered a relevant prediction. Table 6 shows the result of relative impact $(q^2).$

Table 6. The Result of Relative Impact (q ²)					
Exogenous - Endogenous	Q ² included	Q ² excluded	q ² Value	Relative Impact	
Planning - Benefits	0.298	0.267	0.04	Small	
Product and Materials - Benefits	0.298	0.283	0.02	Small	
Equipment - Benefits	0.298	0.247	0.07	Small	
Cleaning Procedure - Benefits	0.298	0.266	0.05		
Communication - Benefits	0.298	0.291	0.01	-	
Training - Benefits	0.298	0.264	0.05	Small	
Certification and Labeling - Benefits	0.298	0.301	0.00	-	
Custodial Effectiveness Assessment - Benefits	0.298	0.291	0.01	-	

DISCUSSION

The measurement model was carried out to determine the relationship between latent variables (green cleaning components) and their indicators (green cleaning requirements). In the measurement model analysis, two (2) green cleaning requirements were eliminated from the model i.e., "hand soap" in the "Product and Materials" component and "integrated pest management" in the "Cleaning Procedures" component. For reducing healthcare-associated illnesses, hand hygiene is a critical infection control practice. It is as simple as washing our hands with regular soap and water. This requirement, however, may be appropriate and useful in the clinical and food-handling fields. The usage of "green" hand soap is not a vital component of Malaysia's green cleaning program for green buildings and therefore has no effect on the benefits. Hence, the "hand soap" requirement was removed from the model. The same goes for the "Integrated Pest Management" (IPM) requirement which was found unreliable in this study. Cleaning workers may play a significant role in the IPM program because they are more familiar with the buildings than anyone else. They are more likely to detect pests, signs of pests, or situations conducive to pests in and around the buildings, but they may not recognize or connect the conditions that may contribute to pest problems (Zainol, 2015; Nalyanya et al., 2006). IPM professionals play a critical part in the IPM program's design, procedure, and delegation of responsibilities. Therefore, IPM should be under another program that may be linked with the green cleaning program.

In the structural model analysis, the relationship between exogenous variables (green cleaning components) and endogenous variables (the benefits) was determined. Out of eight (8) green cleaning components, only five (5) components have a significant relationship with the benefits rendered by green buildings as follows:

Planning

A green cleaning program's measurable success depends on proper planning. Planning acts as a blueprint for the building maintenance team to review what they have been doing, set goals, and track their progress. In general, most of the green rating tools or green cleaning guidelines emphasize the need for a planning component in the green cleaning program. Many studies also have proved that there is a positive relationship between planning and organizational or project performance. This has been mentioned by several authors such as Jayawarna and Dissanayake (2019); Naeem et al. (2018) and Papke-Shields, K.E. and Boyer-Wright, K. M. (2017) where good planning at the start of the project life cycle has a beneficial impact on the project's outcome. This can be applied to any project or program including a green cleaning program. The mission of the green cleaning program is not just to keep the building environment clean but to clean without compromising the occupant's health, reducing adverse effects on the environment, and using all the resources efficiently (Zainol et al., 2023).

Products and Materials

Environmental quality and human health are frequently linked to product and material quality. The use of the proper product and materials in a green cleaning program has a good impact on green building to achieve the benefits. Inappropriate products and harmful materials lead to poor indoor environmental quality, which has an impact on occupants' health issues such as asthma or respiratory problems (Cummings & Virji, 2018; Garza et al., 2020). Proper cleaning products and materials will create a healthy environment such as improved indoor air quality which leads to increased productivity and reduced absenteeism; enhanced occupants' health and safety which leads to lower healthcare costs and other operational savings. Therefore, the finding of this study also shows that the "Product and Material" component has a significant relationship with the benefits rendered by green buildings.

Equipment

Cleaning requires a variety of powered-cleaning equipment due to the many duties involved, such as dusting, mopping, sweeping, vacuuming, lifting, and carrying garbage bags. Cleaning equipment must be less detrimental to the environment, for example, equipment that minimizes the use of cleaning chemical, have noise control, able to cut water usage, energy efficient, and equipment that is ergonomically designed to ease the cleaning activities by cleaning workers (Kohls, 2010; Corbett-Shramo et al., 2011; Simmons, 2013, Zainol, 2016; Zainol et al., 2023). The finding from this study shows that the "Equipment" component which consists of the use of environmentally preferable cleaning equipment and an equipment inventory list has a significant impact on green building in achieving its benefits.

Cleaning Procedures

The "Cleaning Procedures" component covers the cleaning procedures in various areas, as well as the strategy utilized to prevent pollution and minimize the impact of cleaning on health and the environment. If cleaning activities are not carried out properly, the use of green products and equipment will be ineffective. Carelessness with chemicals, waste, cleaning equipment, and cleaning products and equipment in designated locations, among other things, might affect the environment as well as the building's occupants (Berry, 2011). The appropriate technique will result in operational cost reductions and promote healthful surroundings (Espinoza et al., 2010; Goldin, 2007). Although there is no established theory that addresses the relationship between "Cleaning Procedure" and the benefits rendered by green buildings; the findings suggest that there is a significant relationship between these two variables and based on the author's perspective, it should be integrated with the SOPs' requirement in the "Planning" component.

Training

There have been numerous studies that have effectively demonstrated that proper training improves employee performance and, as a result, contributes to organizational success. It is essential to ensure that employees have the necessary knowledge, skills, and abilities to undertake their responsibilities (Niazi, 2011). Some employees prefer training to enhance professional abilities that allow them to operate more efficiently and productively (Jehanzeb & Bashir, 2013; Naqvi & Khan, 2013), and having the necessary skills would help the organization perform better (Aguinis and Kraiger, 2009). In the context of a green cleaning program, it is essential to assure that cleaning workers are well-trained and educated to do cleaning duties ranging from the simplest to the most difficult (depending on their skills and ability), cleaning product handling, and use cleaning equipment in the right way (Zainol et al., 2023). Cleaning workers must know how to utilize microfiber tools, dilute concentrated cleaning solutions, use ergonomic equipment, maintain workplace safety, resolve conflicts, perform preventive maintenance on cleaning equipment, etc. Misuse and overuse of cleaning chemicals and equipment due to the lack of training are very common (Corbett-Shramo et al., 2011) and this mistake leads to an increase in operational costs (Cox et al., 2009). Based on the findings of this study, green buildings can achieve the benefits with proper worker training in green cleaning programs.

CONCLUSION

This research has explored the green cleaning components and requirements that are relevant to be implemented in Malaysian green buildings, as well as how the components help in obtaining benefits rendered by green buildings. In brief, the measurement model was assessed using several types of analysis i.e., composite reliability; convergent validity (indicator reliability and Average Variance Extracted), and discriminant validity. There were two (2) green cleaning requirements that were removed from the model i.e., Integrated Pest Management and Hand Soaps due to lower factor loadings.

The focus of this study is the assessment of the structural model. The assessment requires the author to determine the model's predictive accuracy (value of R^2), path coefficient (β), effect size (f^2), predictive relevance (Q^2), and relative impact (q^2). The findings show that out of eight (8) green cleaning components, only five (5) components have significant relationships with the benefits rendered by green buildings as discussed in the previous subtopic. The other three (3) components i.e., "Communication", "Certification and Labeling" and "Custodial Effectiveness Assessment" (CEA) were found to have no significant relationship with the benefits rendered by green buildings. Though many studies have emphasized the importance of communication toward organizational performance and success; many rating tools and service level agreements put certification and labeling as a prerequisite requirement, and CEA is helpful to improve the quality of cleaning in a building, these three (3) components are considered as insignificant for a green cleaning program of green buildings in Malaysia. However, the authors suggest that this study be further expanded by considering the opinions of parties in the government sector and recognized organizations such as SIRIM so that the findings are more comprehensive and reliable.

This research enables facility managers and cleaning service providers to assess their available resources and determine what should be considered and prioritized before implementing a green cleaning program in green buildings. They will know which components and requirements are most important, and they will gradually improve the requirements and resources they have in order to achieve the benefits rendered by green buildings.

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FEASIBILITY STUDY OF THE ALTERNATIVE RIVERBANK AND COASTAL EROSION PROTECTION STRUCTURES IN MALAYSIA

Muhamad Nadjmi Md Nasir¹, Tuan Noor Hasanah Tuan Ismail^{1,2}, Tengku Nur Azila Raja Mamat³, Reventheran Ganasan^{2,4}, Alvin John Lim Meng Siang⁵ and Salina Sani¹

¹Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Malaysia.

²Sustainable Engineering Technology Research Centre (SETechRC), Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Malaysia.

³Department of Mechanical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Malaysia.

⁴Department of Transportation Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Malaysia.

⁵Research Center for Soft Soils, Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, Malaysia.

Abstract

Erosion of riverbank and coastal are of great concern and an endemic natural hazard. Thus, several areas of the banks will require sufficient erosion protection to avoid further structural failure and loss of valuable property, posing a threat to nearby residents. Numerous innovations have been introduced to overcome or at least reduce erosion problems that conventionally use gabions, rocks, concrete blocks, riprap, retaining walls, geotube and vegetation. However, some of these methods are constrained by technical feasibility, difficult to handle, expensive process and limited time. Therefore, this study aimed to examine alternative protection structures as a secure and fast defensive element, mostly as emergency structural protection for riverbank and coastal erosion. This study focused on three main aspects, including Malaysia's current riverbank and coastal erosion protection practices, the potential use of geobag for riverbank and coastal erosion protection, and the feasibility of using natural fibres as an alternative geobag container. The first and second aspects were examined via a questionnaire survey, while the third aspect involved a comparative study. Questionnaire analysis showed that the retaining wall, gabion, riprap and geobag were common practices for protecting riverbank and coastal erosion in Malaysia. This paper also discusses issues with existing geobags, including cost, environmental effect, and their strength properties. A comparative study found that flux and pineapple fibres have the highest tensile strength and Young's modulus among other fibres and can potentially produce geobag containers. This study provides insight to the industry on technical knowledge regarding innovative and sustainable riverbank and coastal protection as well as the alternative material to promote sustainable development.

Keywords: Erosion Protection; Geobag Natural Fibre; Questionnaire; Comparative Study

INTRODUCTION

Riverbank and coastal erosion in Malaysia are major and impulsive threats to sediment accumulation leading to increased fluvial pollution (Suhaimi et al., 2018). In addition, erosion of floods and riverbanks in the world is almost frequent. This is due to the detachment of soil on the riverbanks stemming from hydraulic erosion due to aerial erosion and channel flow as the bank materials are weakened and weathered (Tho, 2020; Abidin et al., 2017). Without proper action, it will cause failure to other structures, thus threatening nearby residents. It also has short-term or long-term impacts on the environment in the area (Bhuiyan et al., 2017). Therefore, erosion protection structures must be undertaken promptly with appropriate protection methods to prevent or mitigate further structural failure and loss of valuable

property.

There are numerous techniques available for controlling riverbank and coastal erosion, including three relevant erosion counter-measures (Islam, 2011). These are:

- i. Structural measure, which involve resisting the force of the stream by using hard material protection, also known as resistive bank protection (e.g., revetment, boulder, brick matressing). Structural measures can also redirect the flow and energy of stream flow away from eroding bank by using a barrier across the river, also known as a redirectional bank protection (e.g., groynes, vanes, wooden log, etc.).
- ii. Non-structure measure, which aim to reduce the hydraulic impacts of the bank in front of the area (e.g., geobag), reduces flow velocity (e.g., flow area increases by dredging) and flow diversion at the upstream of the problem by channelization.
- Biological protection measures, which reduce shear stress on the bank. Example of the biological protection measures include using vegetation, wooden pilling, and crisscross porcupines.

Until now, there are numerous methods that have been introduced and practiced to protect riverbank and coastal erosion worldwide and locally, including riprap (Jafarnejad et al., 2019), retaining wall (Young & Ashford, 2006), concrete mattress (Safari et al., 2021), gabion and mattress (Tseng & Fu, 2009; King, 2009), loose block (Peirson et al., 2008), geotextile (Broda et al., 2018), geotube (Lee & Douglas, 2012), geobag (Neill, Mannerstrom & Azad, 2008; Cruz et al., 2018; Thomson, Oberhagemann & She, 2020), bioengineering (Evette et al., 2009), and vegetation (Matić, 2009). However, some of these methods are constrained by technical feasibility, difficult to handle, expensive process and limited time. Geobag technology is currently gaining attention as a secure and fast defensive element mostly as an emergency structure protection at various locations, either as permanent or temporary structures (Hataf and Sayadi, 2018). Pilarczyk (2010) claimed that geobags are also easier to build, less expensive, and have a lower environmental impact. According to Cruz et al. (2018), this technology has been used globally for the protection of structures from riverbank erosion since 1999 due to its simpler installation and maintenance works, cost-effectiveness and excellent technical performance which has made it widely popular recently. Moreover, Akter, Crapper and Pender (2013) also reported that the concept of earth-filled bags (geobags) as hydraulic or permanent river systems has been applied for more than 20 years. Recently, natural fibres have been widely used as the main alternative material in geotechnical engineering applications, especially in soil stabilisation (Ariffin & Yusof, 2017). The fibres provide high strength, cost-effectiveness, environmentally friendly and are locally available (Karimah et al., 2021; Ismail et al., 2021). Such advantages meet the technological requirements for temporary conservation in short-term geotechnical applications, thus enabling natural growth of local foil in land and waterways restoration, restructuring or development (Desai & Kant, 2016).

Hence, the aim of this study was to investigate alternate riverbank and coastal erosion prevention structures as safe, economical, and hastening defensive elements by using a qualitative approach which is questionnaire survey and comparative study. To achieve this aim, the following objectives are manifested:

- i. To identify current riverbank and coastal erosion protection in Malaysia through questionnaire survey.
- ii. To evaluate the potential use of geobag/sandbag for riverbank and coastal erosion protection based on the questionnaire survey.
- iii. To examine the feasibility of using natural fibre as an alternative geobag container focusing on its strength properties based on the comparative study.

METHODOLOGY

This study collected data via two methods, namely questionnaire survey and comparative study. The questionnaire survey was conducted to obtain responses from engineers on the current riverbank and coastal erosion protection practices in Malaysia as well as the potential use of geobag or sandbag as an alternative erosion protection method. comparative study was conducted to identify appropriate alternative natural fiber-based materials to be applied as geobag container to produce sustainable, economical, and strong geobag containers including their physical and mechanical properties.

Questionnaire Survey

The questionnaire survey was conducted to obtain information and opinions of respondents on riverbank and coastal erosion protection methods used in Malaysia. The survey was used as primary data in this study, which aimed to identify current riverbank erosion protection methods in Malaysia, and to evaluate the potential use of geobag/sandbag for riverbank erosion protection.

Survey Framework

The unit of analysis for this survey was the individual or representative from the selected organisation or industry. Respondents must have expertise and work experience related to civil engineering which comprised industry and academic personnel so that the data obtained to be reliable and valid. Based on their knowledge and experience in related field, around 50 respondents were targeted. A total of 20 respondents among industry personnel were selected, including Jabatan Kerja Raya (JKR), Jabatan Persisiran Sungai (JPS), and several private companies around Malaysia involved in geotechnical, hydraulic and coastal engineering. Meanwhile, about 20 respondents were selected among academic personnel from geotechnical, hydraulic, and coastal engineering, Universiti Tun Hussein Onn were selected to be involved in this survey.

The distribution of questionnaire for this research was executed via email as an online platform, which is more efficient, cost-effective and environmentally friendly. Google form was used to develop the questionnaire, and the link was sent via email to potential respondents.

Questionnaire Design and Development

The stages in questionnaire design and development comprised content development, content validity, and pilot survey, as illustrated in Figure 1.



Figure 1. Stages of Questionnaire Design and Development

a) Content Development

The content of this questionnaire was divided into three parts, namely Section A, B and C. Section A contained demographic data of respondents, such as gender, education level, and work experience. Section B was related to the erosion issues and protection methods that have been used in Malaysia, especially at the riverbank and coastal areas. Section C inquired about existing protections that have been applied in the construction industry and the potential use of geobag for riverbank erosion. In addition, a cover letter was prepared to explain the purpose of this study, role of the respondent, the authorisation for this study, and assurance of respondent anonymity.

b) Content Validity

The developed questionnaire was examined for its validity and reliability. A valid questionnaire should be formulated with questions that the respondents understand. Thus, the questionnaire must be examined by the "content expert". For example, if the target respondents are experts in the field of study, then they should comment on whether they understand the questionnaire. Any question or uncertainty should be clarified until the matter is understood, and responses and comments from the respondents are considered to improve and simplify the questions for the respondents. A reliable questionnaire can be achieved when the same answers are given to the same question repeatedly within a short period of time. This can be performed through "test-retest", where the same questionnaire can be given to the respondent a second time, and the consistency of the answer can be checked. Any discrepancies in responses could be caused by a lack of clarity and should be rectified. Thus, in this study, two experts in this study area consisting of industry and academic personnel were selected to review the questionnaire content. Subsequently, improvements were implemented based on their suggestions.

c) Pilot Survey

A pilot survey may be performed after developing the survey to determine the necessary sample size for the actual survey, and to improve the survey by detecting errors and restricting the survey questionnaire before the actual survey is carried out (Taherdoost, 2020). A pilot survey often provides ideas, approaches and insights that are overlooked prior to the main survey. Such ideas and clues increase the likelihood of clarification and elimination of issues that can mislead the main research project. A total of 5 respondents from the academic and industrial sectors in civil engineering field were involved in this pilot survey. The questionnaire was sent by email to the respondents

accordingly. The questionnaire review form was attached with the pilot survey so that the respondents were able to provide their responses, opinions and comments related to the topic of this questionnaire survey. In general, the pilot study can form an important part of field research and must be carried out. The results of the pilot study must be included in the main study, and the method section must indicate success or retention rates to determine whether a larger study is possible. After the pilot study was conducted, it was found that there were several issues that occurred during the pilot survey, namely not receiving responses from the respondents and the response rate. Therefore, several measures were taken to resolve the issues found during the pilot survey.

Full Survey

A full survey was designated after acquiring data and responses from the pilot survey. This full survey involved a total of 40 respondents from the academic (20 respondents) and industrial sectors (20 respondents) in the related field. An email consisting of a cover letter and link to the questionnaire in Google Form was sent to each potential respondent.

Comparative Study

A comparative study was performed on various natural fibres and existing geobag container materials such as polypropylene (PP) and high-density polyethylene (HDPE). The primary purpose was to identify natural fibres with the potential to produce or fabricate alternative geobag containers. References and publications cited for this section were retrieved from lens.org, Science Direct, and Google Scholar, incorporating data from journals and review papers from 2010 to 2022. Keywords used to search for articles were "natural fibre for civil engineering", "agricultural fibre", "geobag" and "characteristics of geobag". As a result, the natural fibres selected were coir, sisal, jute, kenaf, pineapple, bamboo, palm, banana, hemp, flax and sugar bagasse due to their application and function in civil engineering field; for example, they have been used as composite materials for reinforcement and structural as shown in Figure 2. It was discovered that approximately 1,504 and 864 papers, respectively, have discussed on the use of natural fibres in composite materials and structural engineering. Their performance was also examined that which gave positive results and potential materials to overcome the lack of performance of geobags. This comparative study was primarily focused on the strength characteristics of natural fibres to find out their viability as an alternative material for geobag containers instead of polymer.



Figure 2. Data Screening

RESULTS AND DISCUSSION

General Characteristics of Respondents

A total of 40 participants took part in this survey. Table 1 summarises the general characteristics of the sample (respondents). The sample was divided into two categories, namely 52.5% from the industrial sector and 47.5% from the education sector. In this survey, 37.5% of them were civil engineers, 5% were geotechnical engineers, 7.5% were technologists, 3.5% were consultants, 42.5% were academicians, and the remaining was categorised as others. It can be inferred that most of the respondents have direct experience in the field, thereby providing a high-reliability and accurate questionnaire analysis. Moreover, 35% of the selected respondents worked in the geotechnical engineering field, which was also the same for civil and environmental engineering. Meanwhile, 7.5%, 5%, and 2.5%, respectively, were in the hydraulic engineering, water resources engineering and erosion control fields. The remaining respondents were experts in other civil engineering field, namely construction, road and highway engineering, oil and gas, and water treatment. It is important to note that the respondents have relevant expertise and knowledge in the study field, which was mainly related to riverbank and coastal erosion protection methods.

Variable	Number of Respondents	Percentage (%)	
Respondent's Category:			
Industry Sector	21	52.5	
Education Sector	19	47.5	
Education Level:			
Diploma	1	2.5	
Bachelor's Degree	20	50	
Master's	8	20	
Ph.D	11	27.5	
Type of Designation:			
Civil Engineer	15	37.5	
Geotechnical Engineer	2	5.0	
Technologist	3	7.5	
Consultant	1	3.5	
Academician	17	42.5	
Others	2	5.0	
Work Experience in Related Field (In Years):			
0 – 3 years	8	20.0	
5 – 6 years	6	15.0	
7 – 9 years	2	5.0	
> 9 years	24	60	
Field/profession Expertise:			
Geotechnical engineering	14	35.0	
Civil and environmental engineering	14	35.0	
Hydraulic engineering	3	7.5	
Water resources engineering	2	5.0	
Erosion control	1	2.5	
Others	6	15.0	

Table 1. General Characteristics of The Respondents

Riverbank and Coastal Erosion Protection Methods and Related Issues

Respondent's Knowledge and Experience Regarding Riverbank and Coastal Erosion Protection

Table 2 shows the responses of all respondents on their knowledge and experience regarding riverbank and coastal erosion protection. This study showed that 100% of respondents have either basic or advanced knowledge about riverbank or coastal protection methods. Though, some of the respondents were not experts in this field. The results of this study also demonstrated that about 60% of respondents have experience in constructing riverbank or coastal protection, while the remaining 40% were the opposite. However, they realised the significance of riverbank or coastal erosion protection in Malaysia as it has long been a crucial issue.

Table 2. Survey Response on The Knowled	je and Experience of Riverbank and Coastal Erosi	ion
	Instantion	

Theetion						
Question	Yes (%)	No (%)	Total response, (number, %)			
Have you heard or know about riverbank or coastal protection method	100	0	40, 100			
Do you realize the importance of riverbank and coastal protection	100	0	40, 100			
Do you have any work experience on riverbank or coastal protection	60	40	40, 100			

Common Riverbank and Coastal Erosion Protection Method in Malaysia

Figure 3 shows the survey analysis on the current riverbank and coastal erosion protection methods in Malaysia. Among the most common methods in Malaysia with 70% responses are retaining wall, gabion and mattress and geobag / sandbag. Other methods are geotextile and bioengineering and vegetation (66.7%), riprap (56.7%), concrete mattress (46.7%), geotube (43.3%), coir mats (26.7%), and loose block (16.7%). Hence, geobag is one of the most popular methods in Malaysia, and it was investigated further in this study.



Figure 3. Common Riverbank and Coastal Erosion Protection Methods in Malaysia

Jafarnejad et al. (2017) stated that riprap is the most common technique for reinforcing riverbanks as it is flexible, durable, easy to build and natural. In terms of installation on stable foundations, gabions have major advantages that are often highlighted compared to other types of engineering structures (Reeve et al., 2019). However, the land-filled geo-bag approach has been prominent in many riparian and coastal projects, particularly in emergencies due to its simple, fast, and cost-effective construction.

Issues Encountered During the Installation of Riverbank and Coastal Erosion Protection

Referring to Figure 4, it can be concluded that construction cost was the greatest concern for constructing riverbank erosion protection (22 responses, 81.5%). Meanwhile, failure mechanism in structure and wave impact were also voted as the common issues apart from construction cost (19 responses, 70.4%). In a previous study, the global issues of riverbank erosion protection are concerns about the dominant erosion process, its mechanism, and environmental factors (Chassiot et al., 2020). Furthermore, funding problems and material shortages can also cause delays in construction (Thompson et al., 2020a: Thompson et al., 2020b). It is also similar to the traditional approach of riverbank protection work, such as revetment, which is costly and not environmentally friendly. Furthermore, King (2015) reported that riprap is extremely expensive due to its transportation and handling costs. Concrete and gabion have a similar situation to riprap (King, 2015).



Figure 4. Common Issues of Riverbank and Coastal Erosion Protection

The Potential Use of Geobag for Riverbank Erosion Protection Structures

Geobags have gained popularity in recent years as an alternative solution to traditional structures, especially in situations where rapid implementation of stabilization measures is required, such as riverbank and coastal areas. Geobag are categorised as geosystem, also known as soilbags, sandbags, geotextile bags or containers, that are typically made of polymers including polyester, polypropylene or polyethylene (Gunawan et al., 2022). Geobag is designed to be filled with local soil, sand, or gravel, and then placed directly on the slope (Hataf & Sayadi, 2018). In this survey, the challenges of riverbank and coastal protection in Malaysia using geobag technology when compared to retaining walls, gabion and mattress, riprap, concrete mattress, and geotextile are cost, installation process, environmental impact, and other related factors.

Cost-Related Factor: Geobag Protection Structures Are Cheaper Than Other Methods

Figure 5 shows the comparison of cost-related factor of the geobag with other methods. For the item 'geobag protection structures are cheaper than riprap, retaining wall, concrete mattress, gabion and mattress as well as geotextile', most of the respondents agreed that geobag are the cheapest relative to other methods. Several reliable studies have reported that geobags can be provided at lower cost due to easier installation and maintenance work as well

as more economic efficiency and outstanding technical performance compared to other methods that may require heavy machinery for the installation process (Hossain & Hasan, 2016; Wahed et al., 2011).



Installation-Related Factor: Installation of Geobag is Easy and Faster Than Other Methods

The installation process, time and cost are important factors that should be considered, especially when dealing with riverbanks and coastal area. This factor was associated with the item 'The installation of geobag is easy and faster than other methods. Referring to Figure 6, most respondents agreed that the installation of geobag is easier and faster than other methods, such as retaining wall, concrete mattress, gabion and geotube. According to King (2015), riprap is expensive, and its transportation and handling are difficult which requires high cost. In fact, concrete and gabion encounter the same problem as riprap.



Figure 6. Installation-Related Factor Toward Riverbank Erosion Protection Structures Compared with Other Methods

Environmental-Related Factor: Biopolymer Geobag Structure is Able to Withstand Extreme Environmental Conditions

In this study, environmental effects were focused on alkaline water, acidic water, ultraviolet and wave impact. Based on Figure 7, respondents neither agreed nor disagreed that the biopolymer geobag structures are affected by alkaline water and acidic water. For high ultraviolet radiation factor, only a few respondents strongly agreed that biopolymer geobag can withstand it. The respondents also had the same responses to the temperature fluctuations and wave impact factors and answered with the other factors in this question. In fact, previous study stated that the mechanical and interfacial properties of natural fibres can be improved by alkaline treatment (Mohammed & Dauda, 2014).



Other-Related Factors

Other-related factors focused on natural fibre characteristics and their workability as an alternative material for geobag container. The criteria surveyed are summarised in Table 3. Most of the respondents agreed (42.5%) that existing geobags are too expensive. According to Ariffin and Yusof (2017), natural fibre geobag is a cost-effective solution to riverbank erosion protection as the material can be found locally and is environmentally friendly. It was also shown that most of the respondent agreed (35%) that biopolymer geobag decompose/decay more easily compared to natural fibre geobag when exposed to high UV radiation and temperature. Moreover, it showed that most respondents agreed (47.5%) that natural coir geobag can promote vegetation growth on its surface. However, natural fibre geobag recorded neutral response (42.5%) for strength and durability. Overall, it can be stated that natural fibres have potential to be used as an alternative and sustainable geobag material for future riverbank erosion protection.

Question	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)	Total Response, (number, %)
The existing bank erosion protection is too expensive.	5.0	17.5	22.5	42.5	12.5	40, 100
The natural coir has comparable strength and durability with the existing geobag container.	12.5	10.0	42.5	14.0	0	40, 100
Biopolymer geobag easy to decompose/decay compared to natural coir geobag when exposed to high UV radiation.	7.5	17.5	30.0	35.0	10.0	40, 100
The natural coir geobag containers can promote vegetation growth on its surface.	0	10.0	27.5	47.5	15.0	40, 100
Natural coir geobag is a sustainable and cost-effective solution to riverbank erosion.	0	12.5	40.0	35.0	12.5	40, 100

Table 3. Survey Response on Other-Related Issues Related to Geobag

TRENDS OF USING GEOBAG AS RIVERBANK EROSION PROTECTION

A Google Scholar search via Len.org application was used to analyse current trends and possible geobag structure for riverbank and coastal erosion protection. It analysed all articles related to geobags published in Google Scholar. However, this study only retrieved the database from 2010 to 2020. The keyword 'geobag' was used in the search tab on the lens.org application to find relevant published articles. The data from the search was then used to

synthesize the findings from the questionnaire survey. Figure 8 shows the map visualization generated in leng.org when the keyword 'geobag' was inserted in the search tab in terms of geotechnical engineering, geology and environmental science. In addition, important criteria or elements can also be observed from this figure include geobag application (e.g., coastal erosion, environmental effect, structural condition and revetment), field or expertise (e.g., geotechnical engineering, structural engineering and environmental engineering) and related material (e.g., geotextile, waste materials, sludge, climate change, etc.). These criteria were also used to design and develop the questionnaire.



Figure 8. Major Field of Data Scholar Search



Figure 9. Geobag Trends Within 10 Years (From 2010 to 2020)

Figure 9 shows the geobag trends based on the total number of articles published in Google Scholar including book chapter, journal, conference proceeding, report, dissertation and others. The data were taken over a period of 10 years from 2010 to 2020. It was evidenced that geobags have recently gained growing attention for riverbank and coastal erosion protection structures. Therefore, the analysis of the questionnaire also found that geobags are one of the current riverbank and coastal erosion protection practice in Malaysia. It can be concluded that the potential use of geobags as riverbank protection has been adapted to the current technology over the years.

COMPARATIVE STUDY OF NATURAL FIBRE AS AN ALTERNATIVE MATERIAL FOR GEOBAG CONTAINER

A comparative study was conducted to examine the feasibility of using natural fibres as an alternative geobag container. Approximately ten articles related to natural fibres and four articles related to geopolymers were referred for this analysis. In this study, the natural fibres commonly used in geotechnical applications were compared with existing geobag materials (polypropylene and high-density polyethylene). This comparative study focused mainly on strength characteristics of materials and also other criteria that may be available to support the analysis. Table 4 summarises the strength properties of various natural fibres used in geotechnical application. Eleven types of natural fibres have been studied, namely coir, sisal, jute, kenaf, pineapple, bamboo, palm, banana, hemp, flux and sugar bagasse (Kumar & Allamraju, 2019; Sgriccia et al., 2008). Table 5 shows the strength properties of the existing geobag materials, such as polypropylene (PP) and high-density polyethylene (HDPE) from various research.

Cibree.	Properties				
Fibres -	Tensile Strength (MPa)	Young's Modulus (GPa)			
Coir	22 - 500	2.0-6.0			
Sisal	31 – 855	3.79 - 38.00			
Jute	29 - 800	3 – 55			
Kenaf	223 – 930	11 - 60			
Pineapple	170 – 1627	6.21 - 82.00			
Bamboo	140 - 862	17 – 89			
Palm	50 - 400	0.6 - 9.0			
Banana	364 – 914	7.7 – 32.0			
Hemp	310 – 1110	3 – 90			
Flax	343 – 1830	27 – 80			
Sugar Bagasse	20 - 350	2.7 – 19			

 Table 4. Strength Properties of Various Natural Fibres Used in Geotechnical Applications

Table 5. Strength Properties of The Existing Geobag Material (PP/HDPE) from Various Research

Material	Properties		
	Tensile Strength (MPa)	Young's Modulus (GPa)	
PP/HDPE	9.0 - 457.1	1.200 – 7.526	

(Source: Yuan et al., 2008; Mengeloglu et al., 2007; Strapasson et al., 2005)

Figure 10 presents the tensile strength properties based on the data from Tables 4 and 5, with the purpose of comparing the strength of natural fibres with the existing geobag materials. Based on the results, flax fibre indicated the highest tensile strength properties, followed by pineapple fibre, hemp fibre, kenaf fibre and others. Flax fibers are generally 50% lightweight, cheaper and more environmentally friendly than glass fiber. Composites of flax fibers have specific rigidity and tensile strength but lower impact strength (Longana et al., 2018: Joffe et al., 2003). Furthermore, it was discovered that most natural fibres have greater tensile strength properties than conventional geobag materials (PP/HDPE). In addition, renewed interest in natural fibers has led to a few amendments that make them equal and even greater than synthetic fibers (Diani et al., 2006). Natural fibers, on the other hand, have a few problems and disadvantages when used as polymeric composite strengthening, in terms of degradability, fireproofing, interfacial adhesion (Yousif et al., 2012), high moisture

absorption and low thermal stability (Diani et al., 2006). Therefore, the drawback of the natural fibres can overcome by treatment to improves the interfacial adhesion and mechanical, physical, and thermal properties of natural fibers (Vardhini et al., 2016).



Figure 10. Comparison of Tensile Strength of Natural Fibres

Figure 11 shows Young's modulus of various natural fibres, which exhibited superior results compared to conventional geobag materials. Pineapple, bamboo, flax, hemp and sugar bagasse showed the highest Young's modulus among other natural fibres.



Figure 11. Young's Modulus of Various Natural Fibres Compared to Conventional Geobag Materials

Therefore, it can be concluded that the natural fibres have good strength properties, and suitable to be used as an alternative material for geobag containers. Nevertheless, the natural fibres were claimed by the respondents to have drawbacks in terms of weathering and chemical reaction issues that could not be solved for geobag application. The drawbacks can be mitigated by improving the mechanical and physical properties of the natural fibres through chemical treatment. It protects the fibres and increases their durability and resistance (Bachtiar et al., 2011).

CONCLUSION

Based on the survey, it was found that the retaining wall, gabion and mattress, riprap and geobag are the common methods for protecting riverbank and coastal erosion in Malaysia due to their performance and technical feasibility. Recently, the land-filled geobag approach is prominent in many riparian and coastal projects, particularly for emergencies due to its simple, fast and cost-effective construction. However, conventional geobag materials

produced by polymers have a few drawbacks. Therefore, a comparative study was conducted to identify alternative geobag materials. It was found that flux and pineapple fibres have the highest tensile strength and Young's modulus among other fibres and conventional geobag materials, thereby it may have the potential to be applied as a geobag container. Moreover, the innovative use of natural fibre materials can meet cost-effective and sustainable development goals, while also presenting an appealing solution to reduce carbon footprint. In addition, the natural fibre geobag containers has the potential to improve soil retention and promote vegetation growth. This study is valuable as it equips engineers with technical knowledge on innovative riverbank and coastal protection techniques, as well as alternative materials that promote sustainable development.

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BUILDING OPENING MODIFICATIONS AFFECTING WIND SPEED AT PEDESTRIAN LEVEL

Nurfarissa Mohamed Nazim¹, Mohd Hafizal Hanipah^{1*}, Mohd Azuan Zakaria¹, Wan Amizah Wan Jusoh², Riduan Yunus¹, Mohamad Hairi Osman², Mohd Fahmi Abdul Rahman², Mohamad Luthfi Ahmad Jeni², Muhammad Noor Afiq Witri Muhammad Yazid³ and Mohd Zakwan Ramli⁴

¹Faculty of Civil Engineering & Built Environment, Universiti Tun Hussein Onn Malaysia, Malaysia ²Intelligent Construction Centre, Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, Malaysia ³Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia ⁴Institute of Energy Infrastructure, Universiti Tenaga Nasional, Malaysia

Abstract

High land costs and shortage of accessible urban areas are some of the leading causes for the construction of highly dense high-rise structures. As a result, undesired low wind speeds that are generated due to excessive shielding contribute to heat stress issue. Recent studies have investigated the impacts of building opening in both subtropical and tropical climate zones as a popular architectural element to yield adequate ventilation around buildings. Nevertheless, only a handful of studies have examined building opening in any systematic way especially on wind speed at pedestrian-level for multiple buildings area. As such, this study assessed the effect of different building opening heights (BOHs) on pedestrian-level wind speed at multiple buildings area. The mean value for wind velocity ratio (MVR) was calculated by using data obtained from computational fluid dynamics (CFD) simulation. The study outcomes revealed that the optimum opening height at a range of 42%-64% generated the highest MVR = 0.39. In addition, the building opening elevation above than 86% of average building height has no longer affect the pedestrian level wind speed. In conclusion, the study findings provide evidence that optimum building opening design can effectively increase the mean value of wind speed at pedestrian level.

Keywords: Building Opening Heights; Multiple Buildings; Pedestrian-Level; Wind Speed

INTRODUCTION

The rapid advancement of urban development, as well as the congregation of sophisticated mega-cities with tall and narrowly-spaced skyscrapers, has contributed to reduction in air flow at pedestrian level. Lack of air ventilation at the pedestrian level has sparked several issues, including heat stress and rising temperature, along with amassed air pollution Du, Y., & Mak, C. M. (2018). The rapid progress of urbanisation has led to open space shortages in complex building areas. Simply put, high-rise and high-density construction causes several environmental concerns, such as lower wind speed and poor atmospheric ventilation. The impact of wind on human that ranges from gentle breeze on the body to being driven over is called 'wind comfort'. This effect of wind comfort has been vastly investigated, along with thermal comfort, in numerous pedestrian-related wind research projects. Wind speed ranging at 1.0-1.5 m/s may reduce the air temperature by up to 2 °C Hanipah, M. H. et al. (2017). This particular finding has garnered the interest of many researchers and building specialists to explore building modifications implemented in complex building structures. The adequate resources or necessities to determine an alternative way that offers an economic impact on pedestrian wind-level thermal comfort are in scarcity. The limited supply of urban space has led to the excessive construction of tall structures as an essential means of addressing urban congestion issue.

While climate change is a serious global issue, rapid urban growth with tightly-spaced buildings in city regions has exacerbated the outdoor microclimate at pedestrian level.

Although health professionals are promoting to lower emissions and to safeguard people from climate change, such initiatives are scarce. One of the urban effects of climate change is heat stress Sadeghi, M et al. (2021) due to its adverse effect on urban residents spanning from economy to social issues, the ecosystem, and one's health Du, Y., Mak, C. M., & Li, Y. (2019). As such, the outcomes of this present study are beneficial to the environment due to the crucial role of the environment and the surrounding atmosphere in the economy of developing cities and metropolitans in certain countries. Building modification has become a series of revolutions to improve pedestrian-level wind comfort in urban regions. Urban progress with building modification, such as building opening, enables contractors and architects of construction projects to optimise the use of land and to retain pedestrian-level thermal comfort simultaneously. Improvement in the construction sector promotes sustainable development. Hence, this present study highlights the building architecture design and strategies that should benefit the environment and city dwellers.

This study explored the correlation between different building opening elevations and pedestrian-level wind speed. Therefore, the following research objectives were formulated: 1) to identify building opening strategies that determine pedestrian-level wind speed performance, 2) to investigate the effect of different BOHs on pedestrian-level wind speed performance at multiple buildings area by using CFD simulation software, and 3) to elucidate the relationship between BOH and wind speed ratio by using Pearson Correlation Coefficient. In precise, the primary aim of this study is to assess the effect of different BOHs on pedestrian-level wind speed at the academic buildings in the Universiti Tun Hussein Onn Malaysia (UTHM) Pagoh Campus.

Building Modification

This study assessed the effect of opening on a building at varying heights in complex or urban areas. In precise, this study investigated the specific height for building opening elevation that could exert optimum effect on pedestrian-level wind speed around buildings in urban regions. Essentially, this study verifies previous findings and contributes more evidence that suggests various building element modification strategies can effectively mitigate heat stress. More research work is needed to better understand the extent to which building element modification strategies can yield the best outcomes to increase pedestrian-level wind speed. This qualitative study sheds light on popular building element modifications. So far, four elements have been identified as integral, namely: Building Opening (see Figure 1), Lift-Up Design, Aerodynamic Features, and Building Height. Half of the world population who reside in urban areas Bazdidi-Tehrani et al. (2020) are exposed to heat flux, which is a serious risk to urbanites as a result of raising heat stress. Increased heat stress can adversely affect the wellbeing of the elderly Nations, U., Programme, D., & Nations, U. (1973).



(Source: Du, Y., & Mak, C. M. (2018)) Figure 1. (a) Schematic Diagram of a Building Opening; (b) Photo of a Building with An Opening

MATERIAL AND METHODS

The flat surface for all cases was assumed for the topographic map in this study. A static condition, such as buildings without vegetation and human being, had been assumed. This differs from the actual situation with dynamic conditions, which is not viable to explore the urban region at macro-scale as a supercomputer is required to run the simulation.

Two-dimensional (2D) data (building footprints) were exported from AutoCAD to Design Modeler to extract building height based on the relative quantity of building floor (see Figure 2) by adhering to the approach used in Burian et al. (2005). The height values of singlestory and multi-story structures were ~ 4.0 m and 3.5 m, respectively. In this study, flat surface was considered for all examples in the topographic map. Validating models against experimental evidence is a fundamental step to verify the dependability of CFD simulation. Buildings with natural ventilation near a compact city was studied based on two fundamental flow issues: (1) single-sided natural ventilation with a linked interior and exterior flow field and (2) canyon flow street with the interaction of flows within and overhead the street canyon Du, Y., Mak, C. M., & Li, Y. (2019). Referring to these comparisons, the use of CFD model was justified to assess the single-sided cross natural ventilation on buildings. The grid size was set at 1/10 of the building scale ranging from 0.5 m to 5.0 m around the measurement points, while grid shapes in the area of steep gradient velocity (e.g., upstream of the first building & downstream of the last building) and beyond canyons were expanded to a maximum ratio of 1.3 Mochida, A. et al. (2006). In addition, Reynolds Averaged Navier Stokes (RANS) equation was applied to predict the wind flow and the approaching vertical profile of mean wind speed and turbulence intensity in the actual case studies were set to the 1/3 power law at wall function. This approach requires that the assessment height above ground (1.5-5.0 m) to be established on the third or upward grids Tominaga, Y. et al. (2008).



(Source: S. N. M et al. (2019)) Figure 2. UTHM Pagoh Campus Buildings Razali

Building Opening Elevation Configuration

To assess the building opening elevation parameter, five topologies of building opening elevation are illustrated; whereby both width and depth of the buildings were not the parameters tested and retained as constant values. Case 1 is a reference case (control case) with an average building height of 11.24 m and a building without opening. As for Cases 2 and 3, the building opening elevation started at 21% and 42% for average building heights of 2.3 m and 4.6 m from the ground, respectively. Meanwhile, Cases 4 and 5 started the building opening at 64% and 86% for average building heights of 7.2 m and 9.7 m from the ground, respectively. All the cases had different building opening elevations due to the following reasons: i) the minimum height of the first floor of a building is 4 m and ii) the consideration of 5H (H is pedestrian-level at 1.5 m) to ensure that the wind flow is optimized underneath the elevated building. Full scale models were used for all cases and the pedestrian-level is defined as z/H = 1.5 m, where z denotes vertical direction. Similarly, all cases were subjected to an incoming wind flow from positive x direction.

Data Extraction Location for Analysis

Turbulence was measured in the vertical section of the middle of the building (y/H = 0) and in the horizontal section (z/H = 1.5 m) of the height of the building. Both position and place of the measurements are illustrated in Figure 3. The mean value of MVR was combined with a wind climate to determine wind comfort. The mean value of wind speed at pedestrian-level of 1.5 m is displayed in Figure 3. Notably, higher MVR value generated more available wind at the specific location Chew, L. W. & Norford, L. K. (2019).



Figure 3. The Illustration of Data Extraction Location

The size of the opening was 4 m x 4 m. The building opening reflected cross ventilation and was supposed to be at least 2% of the floor area Bhatia, A. (2014). Figure 4: Case 1 is the reference case without opening, Figure 5: Case 2 with an opening at 21% of the average building height (2.3 m), Figure 6: Case 3 with an opening at 42% of the average building height (4.6 m). Meanwhile, Figure 7: Case 4 with an opening at 64% of the average building height (7.2 m) and Figure 8: Case 5 with an opening at 86% of the average building height (9.7 m). The average floor area was used to determine the suitable opening size in order to increase the wind speed at pedestrian level. In this study, the average error is less than 20% was considered appropriate as the tolerance value for CFD simulation (in comparison to the experimental data of wind tunnel test) Setaih, K., Hamza et al. (2014). If the simulation outcomes are similar to the experimental findings, only then can the real case simulations be performed with the same simulation configuration as the validation cases. Last, the Pearson Correlation Coefficient was deployed to test the simulation data in order to analyse the relationship between building opening elevation and MVR. Building Opening Modifications Affecting Wind Speed 63 at Pedestrian Level



Figure 4. Case 1 As Reference Case with No Opening



Figure 6. Case 3 with Opening At 42% of Average Building Height (4.6 M)



Figure 8. Case 5 with Opening At 86% of Average Building Height (9.7 M)

RESULTS AND DISCUSSION

The average wind speed values from different building opening elevations towards wind speed ratio using CFD software are presented in Table 1. Cases 2, 3, and 4 demonstrated higher wind speed, while Case 5 showed lower wind speed than the reference case (Case 1). The wind speed in Case 4 scored the highest average value of 1.24 m/s with 64% elevation, whereby the building opening was 7.2 m from the ground. This result is attributed to the wider open space available and the relatively lower building opening elevation. Higher wind speed at ground level is more likely to be built in such areas as the wind flow is unobstructed Tsichritzis, L., & Nikolopoulou, M. (2019). As for Cases 2 and 3 with building opening elevation lower than that of Case 4, a decrease in wind speed to 1.06 m/s and 1.23 m/s



Figure 5. Case 2 with Opening At 21% of Average Building Height (2.3 M)



Figure 7. Case 4 with Opening At 64% of Average Building Height (7.2 M)

respectively had been observed. The wind speed for Case 1 (reference case without building opening) resulted in the second lowest average value of wind speed at 1.00 m/s. This outcome is ascribed to the absence of building opening modification, as well as the lower wind permeability as no wind flow passed through the building to reach the lower ground and if any, the wind flow was blocked by the buildings Tsichritzis, L., & Nikolopoulou, M. (2019).

Referring to Case 5, the wind speed was at the lowest value of 0.97 m/s, while the building elevation height is the maximum in this study. The MVR value for Case 5 had decreased and was slightly lower than the reference case because the building opening elevation at 9.7 m from the ground failed to increase the wind speed around the building at 1.5 m pedestrian level. This finding is attributable to the wind flow that passed through the opening at 86% elevation and did not reach the ground. If the target building opening elevation is increased up to 64%, the wind comfort at the site boundary region can result in optimum performance. This is because the downwash flow from the windward face of the building can increase as the opening elevation escalates up to 64%. As wind velocity of lateral zones at pedestrian level can increase dramatically, wind comfort of lateral area can also display significant increment Sha, C., Wang et al. (2018). In Case 5, the average wind speed began to decrease from 0.97 m/s. As building opening elevation increases, wind speed also increases until it reaches a constant velocity called gradient velocity. However, building opening that exceeds 86% does not affect the pedestrian-level wind speed.

Imminently, all the five cases scored good rating (Rating A) for fast walking, walking, and sitting criteria in terms of pedestrian wind comfort (see Table 2). As observed, different building opening elevations displayed a strong effect on wind speed as the values fell within the reasonable wind comfort range (0.7-1.7 m/s) (Murakami & Morikawa, 1985). Wind distributions at pedestrian level (z/H = 1.5 m) around buildings for all the 5 cases are presented in Table 2. Any wind gust, breeze or unusual air condition was dismissed (Allegrini & Carmeliat (2017)). If the lateral boundaries were established in a different manner or when the air temperatures in lateral directions changed dramatically, the outcomes could differ.

Cases	Elevation (%)	Elevation Height (m)	Average Wind Speed (ms ⁻¹)	Mean Velocity Ratio (MVR)
1 (RC)	0	0	1.00	0.31
2	21	2.3	1.06	0.33
3	42	4.6	1.23	0.39
4	64	7.2	1.24	0.39
5	86	9.7	0.97	0.30

Table 1. Summarized Results of Different Building Opening Elevation

Mean Velocity Ratio

Results The maximum value of wind speed at incoming flow for inlet profile was considered the same at 3.20 m/s for all the five cases. The wind speed mean value for each case was divided with the wind speed mean value of the reference to obtain the MVR values (see Figure 9). The graph of MVR against building opening elevation (%) was plotted to study their relationship (see Figure 9). The MVR values are related to wind speed; lower wind speed showcased a decrease in MVR value. The MVR value increased when the elevation rose from 20% to 40%. When the elevation hit 40%, the MVR value began to increase and turned constant as the elevation reached 64%. Next, the MVR decreased to its normal rate with higher

elevation. This is ascribed to two factors: (1) the absence of an opening area near the pedestrian level to higher elevation of building opening and (2) the identical wind speeds for the varying building opening elevation (see Table 1) as a result of slight variance Du, Y., Mak, C. M., & Li, Y. (2018) Sha, C., Wang et al. (2018).



Figure 9. Graph of Pearson Correlation Coefficient

CONCLUSION

High MVR values were retrieved when the building opening elevation ranged at 64%-86% of the average building height. Building opening elevation that exceeds 86% did not affect the pedestrian-level wind speed. Notably, the relationship between MVR and building opening elevation can be expressed as follows: $MVR = -10^{-6}E^3 \times 9 \times 10^{-5}E^2 - 0.0002E + 0.3088$, which may serve as a reference design for multiple building areas. As a conclusion, the building opening design has an optimum height in determining pedestrian-level wind speed at 42% to 64% of average building height.

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INFLUENCE OF PROJECT MANAGER'S PERSONALITY TRAITS ON SUCCESSFUL DELIVERY OF CONSTRUCTION PROJECTS

Muhammad Shahzad¹, Fahad-ur-Rehman¹, Sajjad Mubin¹, Khalil-ur-Rehman² and Ekaterina Gavrishyk³

¹Department of Architectural Engineering & Design, UET Lahore, Punjab, Pakistan ²Khawaja Fareed University of Engineering and Information Technology, Punjab Pakistan ³Institute of Languages & Linguistics, University of Punjab Lahore-54000, Pakistan

Abstract

The present research has been conducted to analyze the Functions of the Project Manager's Behavior in the Successful Delivery of Development Projects. The data has been collected through a quantitative research approach by circulating the questionnaires among the respondents. 103 Project Managers recorded their responses. Five-Factor Modal (FFM) / five behavioral categories have been used as a scale to test the successful delivery of a project. It has been revealed through regression and correlation analysis that all five behavioral categories have a significant impact on the successful delivery of development projects. The most influential behavioral forecaster in delivering a successful project is the Neuroticism (inverse relation). Openness to experience has been exposed to be the second most significant behavioral predictor in deciding the fate of a development project. The successful delivery of development projects by their Project Managers can be ensured by focusing on discovering new and creative approaches for the completion of various tasks.

Keywords: Project Manager's Behavior; Five-Factor Modal (FFM); Construction Projects

INTRODUCTION

It's been the need of the day for all the governments, institutions, firms, corporations, and enterprises to promote research for the improvement of the "Project Management Model" to achieve the best results in future ventures. Certainly, Project Management is the precise method for supervising the planned opportunities. The world enterprisers have been compelled to realize the need for a Project Leader rather than depending only upon a Project Manager, who can lead from the front (Venkatesh et al., 2014).

The personalities of project managers contribute significantly to effectively completing project deliverables. The main goal of this study project is to examine the relationship between project manager personality traits (the big five model) and project performance. The impacts of personality on work performance, organizational devotion and satisfaction with work have been studied in the literature. The literature on project success factors, however, has not taken into account how the personalities of the project managers may have an influence on the project's performance (Doan et al., 2020).

(De Vale et al., 2018) recently emphasized the need to identify the relationship between project managers' competencies in the context of organizational and project success, and (Joslin et al., 2016), similarly emphasized the effects of the moderator or mediator that might influence this relationship. According to the person-organization fit speculation, a project manager's personality has been determined to be extremely important for success and high performance (Kulkarni, G., 2021), whereas failure is typically brought on by a lack of project management expertise and leadership abilities (Ali et al., 2021). When compared to general

management literature, project management literature demonstrated that the literature on factors that contribute to project success did not cover the importance of leadership style as a project success factor.

The personal abilities of project managers have been identified as one of the most important success elements in construction and other types of projects (Chandler et al., 2021). (Peterson et al., 2009) investigated the influence of leaders' psychological features on company performance and discovered that positive leader psychological attributes are highly associated with firm success. (Hassan et al., 2017), investigated the importance of the big five personality traits (extraversion, conscientiousness, openness, agreeableness, neuroticism) in relation to project success in NGOs and discovered that neuroticism, extraversion, and openness to experience were directly linked with project success. Another study found that two personality qualities, awareness and openness, were positively associated with the effectiveness of project managers (Thal et al., 2010).

External environmental elements, on the other hand, have a significant impact on project success. (Musa et al., 2015) investigated the impact of external environmental elements (political, economic, and social) on project success and discovered that they had a significant impact. Furthermore, these effects might be evident at various stages of the projects. The project management team's major responsibility is to complete the project on time, with the specified quality standards, and within the budget. As a result, the personality of project managers is significant for effectively completing project deliverables.

There is a scarcity of thorough studies on the personality features of project managers, Furthermore, the features are frequently enhanced by external assistance, which can lead to unfavorable project decisions. In light of the discussions, a team with the appropriate experience, personality qualities, and dynamics is necessary, the requirements for which are not yet fully specified. The importance of successful achievement of construction work is highly depends on productivity of labour (Ismail et al., 2019). The workers demotivate if they are working under unprofessional supervisors which results in unproductive tasks, improper project schedules and planning, frequent work breaks and increases of inactive time in resources (Kai Shen et al., 2021).

As a result, the current study attempts to investigate personality with regard to project success. The case is restricted to projects in Pakistan, a country with turbulent political disagreements, economic instability (payment delay and other financial concerns), and societal sensitivities.

Comprehensive research on the effect of big five behavioral characters on project success is mandatory to advance in literature on project. The presence of various behavioral characters of individuals, a variety of leadership style can be predicted including transformational management has a significant impact on project manager's performance as a team player as well as in personal capacity. This research will eventually contribute to a valuable addition in explaining that how successful delivery of a project is highly dependent on Big Five Behavioral characters, (Roberts et al., 2007).

The Five Factor Model (FFM) of human behavior/character are self-governing qualities of behavior accommodating in shaping Conscientiousness, Extraversion, Neuroticism,

Agreeableness and Openness to knowledge. Because of fewer resources, sometimes, administration of all progressive projects cannot afford to arrange training opportunities for their Project Managers. So, the impact of guaranteeing personality-job in development projects can be well explained. This research is being undertaken to highlight Public Sector Development Projects, participating a momentous position in development of the state (Cohen et al., 2013).

REVIEW OF LITERATURE

Behavior of any human can be judged through Big Five behavior qualities. Big Five Factors also can be termed as FFM i.e. the Five Factor Model has been considered as a base for the hypothesis of Big Five behavior Types. Digman (Sleep et al., 2021) offered a five-factor personality concept that includes extraversion, conscientiousness, openness, agreeableness, and neuroticism as criteria that might be utilized to access the personality. (McCrae and John, 1992) later put the major five-factor approach into practice. Behaviors are the prototypes of thinking, observations or acts that have consistency and assist in distinguishing persons from one another (Judge & Zapata, 2015). These human behavior qualities are the psychological trends that explain uniformity throughout over a life span of any person, but using adaptive routines behavior can differ significantly.

Human attribute is in fact an inner feature of a personality that portrays an intense position on graph of behavior. From numerous earlier researches, it has been revealed that there is a range of notional views in behavior and psychology that comprise human motivation, the entire personality and variation between people (Leutner, et al., 2014). According to Bradley et al. (2013), Big-Five Behavior Qualities of any individual can be considered to define the inclusive personality in detail. Hence it is authentic to assume this psychological feature for project managers to assess their individuality and its effect on their performance in delivering successful projects.

The process of acquiring knowledge cannot be considered as a base to define the degree of Five Factor Model (FFM), having forcefulness across diverse civilizations and have high consistency over a long time span. Consequently, some meticulous events can not affect the Big Five behavior characteristics due to high consistency factor. By following the daily routine, it is suggested that through Big Five Behavior Categories, some important distinctions are forecasted and can be verified in actions and reactions of the individuals.

"Five Factor model" is not used to expose vibrant and progressive measures of behavior. Being self-governing features of a character, a personality can be defined through Big Five Behavior types, which comprises of Conscientiousness, Extraversion, Neuroticism, Agreeableness and Openness to experience. Careful, Accountable, Protecting, Cautious and Vigilant are some of the key features considered to be the part of conscientiousness behavior.

Individuals are typically systematic; demonstrate reluctance to risk and dependency on others in case of high conscientiousness (Deinert, et al., 2015). Besides this, Extraversion is a behavioral character explains that persons are friendly, self-confident, expressive, chatty and lively. Neuroticism is a behavior type, clarifies that an individual is highly worried, annoyed, touching, depressed and insecure (Cohen, et al., 2013). An individual has a flexible, helpful and soft-hearted approach in case of agreeableness. Being the last behavioral category,

openness to experience enlightens about curiosity, imagination, broad mindedness, intellect and creative sensitivity (Creasy & Anantatmula, 2013).

Success of a Project

It is evident that, the outcome and result of a project engage the criteria and standard to assess the success of a project. According to (Kappe & van der Flier, 2010), the project success builds up a fine and unanimously acknowledged criteria in terms of time, cost and scope, over a definite time frame. Another criterion of a winning project can be observed through monitoring the different approaches like fulfilling the financial benefits of a business and meeting the targets of planned objectives of an enterprise (Migliore, 2011). The introduction of the project prosperity through wider structure was made by Milfont & Sibley (2012), according to them, "Successful delivery of a project is highly dependable on Internal (project) and External (client) factors".

Project managers must control three critical areas: improving construction speed, increasing delivery speed, and decreasing time length (Ingle et al., 2020). Large and complex projects typically take a long time and are expensive. As the construction market expands at a quick pace (Kaynat Afzal et al., 2020), estimating the quality cost is becoming an essential necessity, with the goal of achieving a high-quality product at a cheap cost while meeting the needs of the consumers (Moradi et al., 2020). The effectiveness of project management is dependent on the project process and the successful achievement of 'cost' and 'time' objectives. The third criterion for building projects has been suggested to be something different from quality, such as scope, performance, or requirements (Yap, & Skitmore, 2020). It was claimed that including scope rather than quality as the third vertex of the iron triangle would be more appropriate.

Critical Success Factors (CSFs) of a project is the criteria used to define the arguments related to the success of project. CSFs are unavoidable to achieve the targeted objectives of any project (Brandstätter, 2011). It is significant to keep in mind that the critical success factors do not acquire any alteration, instead they are liable to be updated and revised occasionally (Bradley, et al., 2013).

Big Five Behavioral Categories and Success of a Project

The theory of FFM, the five factor model explaining the psychological behavioral characteristics of the individuals was described by (Digman, 1990) and afterwards outfitted by (Derue et al., 2011) through the name of Big Five Behavioral Characteristics or personality traits, categorized in Conscientiousness, Extraversion, Neuroticism, Agreeableness and Openness to Experience.

These five natures of behavioral characteristics have a strong and extensive assortment of analytical influence, because of the reality of the significant control on leadership approach and efficiency of a working team. The project success is directly linked with the teamwork and also has a strong influence of the acknowledged dispositional features of Big five behavioral natures. Figure 1 shows a theoretical research framework is used to illustrate the overall picture of the research. According to the framework, there are two types of variables presented in this research. Extraversion, conscientiousness, openness, agreeableness, and neuroticism are regarded as independent variables, whereas project success parameters such as time, cost, and quality/scope are considered dependent variables.



Figure 1. Theoretical Framework

Hypotheses

H1: There is a considerable influence of conscientiousness on successful project delivery.
H2: There is a considerable influence of extraversion on successful project delivery.
H3: There is a considerable inverse influence of neuroticism on successful project delivery.
H4: There is a considerable influence of agreeableness on successful project delivery.
H5: There is a considerable influence of openness to experience on successful project delivery.

MATERIALS AND METHODS

This study's approach involves a review of the literature, an online questionnaire Survey. In the initial phase of this research, the topic domain was studied and understood, and the goals and objectives of the research project were determined. The next step was to collect project data and carry out a study to get more information for the purpose of research. To gather the pertinent information for this activity, literature research was conducted using secondary data from published resources including books, seminar papers, articles, journals, and associated websites. After that, use an online questionnaire to collect primary data in order to fulfil the study's goals.

The identification of a sample is considered to be the most important task from the large population for getting the data from the respondents. (Bell, 2018), claimed that, the reliability of a research can be ensured through a sample size of less than 500 and more than 30 respondents. Considering this as a base, the present research was conducted on a sample size of 100 respondents. The sample size of 100 respondents has been preferred through suitable sampling collection method. In order to determine whether this sample size is the true representative of the whole population, more than 30000 engineers in the civil engineering domain have been registered with the Pakistan Engineering Council, which can be consumed as the size of the population. 95% level of confidence was chosen. The answers were expected to be reliable and they would establish the p-value to 0.5 (the probability of occurrence 50%). Ease to the accessibility of the respondents is the basic reason of selecting this sampling collection method (Flick, 2016).

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A significant geographic region can be covered by quantitative research conducted via an online survey. Quantitative research approach helped the researcher to test the hypothesis through statistical measurement of the collected data from all the respondents. (Bryman, 2015), claimed to preferably adopt the research method of testing hypothesis, as this study is based upon five hypotheses. Therefore, the current study was undertaken through the quantitative research approach. The present research is based upon a cross-sectional survey design in order to analyse the functions of the project manager's behavior in successful delivery of development projects.

The questionnaire encompassing all five behavioral features has been finalized after the consultation of the psychologists and engineering professionals. The distribution strategy was being submitted in Google Forms to the managers who were responsible to deliver various projects in various fields. Before sending out the questionnaires, Cronbach's alpha test has been used to check the reliability of the questionnaire and the researcher informed the respondents that they will call them to ensure they have responded to all the questions. 103 project managers recorded their responses out of 142 which was more than sample size of 100. All of the data acquired from the questionnaire, as well as the secondary and primary data, evaluated collectively. For the questionnaire survey, the data was examined using the Statistical Package for the Social Sciences (SPSS).

The evaluation of managers' response has been completed through the percentages and frequencies. After that, the correlation analysis and Pearson's coefficient for construing the link among various variables has been done in this study. Linear regression analysis has been completed for the detection of the connection among project manager's behavior and successful project delivery. Extraversion, Conscientiousness, Neuroticism, Agreeableness and Openness to experience as a behavioral feature have been identified as independent variables versus the dependent variable of successful project delivery.

DATA ANALYSIS AND FINDINGS

The analysis of the gathered information has been completed through the statistical approach. The evaluation of managers' response has been completed through the percentages and frequencies. After that, the correlation analysis and Pearson's coefficient for construing the link among various variables has been done in this study. Linear regression analysis has been completed for the detection of the connection among project manager's behavior and successful project delivery. Extraversion, Conscientiousness, Neuroticism, Agreeableness and Openness to experience as behavioral features have been identified as independent variables versus the dependent variable of successful project delivery.

Demographic Data of Respondents

The relevant data of the research has been obtained from the Project Managers, Construction Managers and Assistant Project Managers of different development projects. The respondents among them were 80.6% males and 19.4% females. Most of the respondents were working in client and consultant firms. About 31.1% and 33% for each category. 26.2% of respondents were working in contractor firms. About 10% of respondents were doing jobs in other firms.

Reliability Analysis

The reliability statistics is used to check that whether or not research instrument used for data collection is consistent with the research topic. In order to have reliable questionnaire, the value of Cronbach's alpha must be greater than 0.6. In current case, as value of Cronbach's alpha is 0.901 as depicted in Table 1, so it means the questionnaire used for data collection is reliable.

Table 1. Reliability Statistics Check				
Cronbach's Alpha N of Items				
0.901	28			

Regression Analysis

Cohen et al. (2013) claimed, that the regression analysis can be defined as the most powerful tool, researchers may utilize to point out a relationship between one dependent and other independent variables to investigate different matters e.g., To identify the change in any dependent variable because of the independent variable and to evaluate the strength of a relationship in between the variables of the research for further selection.

Identification of the limit of the dependent variable in research (A researcher is allowed to influence the change) can be fixed through regression analysis. Furthermore, the regression analysis marks the boundary of a relationship among scrutinized variables. Regression does not advocate various significant relations between variables and represented through R. More precision can be attained through the value of R2, as it defines the amount of change in scores through examining the independent variables. Value of R2 ranges between 0 to 1 and the researcher is free in inferring of R2 value reliant on the studies relationship.

Model summary of regression analysis portrays collective result of five independent variables on dependent variable as shown in Table 2. The value of R is 0.642, indicating change in one unit in all five behavioral features will result 64.2% boost in successful project delivery.

Table 2. Regression Analyses – Model Summary							
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate			
1	0.642a	.412	.381	.59199			
a. Predictors: (Constant), O, C, N, A, E							

The Analysis of Variance (ANOVA) test as depicted in Table 3 is used to check the significant relationship between independent and dependent variables. The value of F must be greater than 2 and significance value must be less than 0.05 for a significant relationship between independent and dependent variables, which is true for this research study i.e. 13.580 and 0.000. Therefore, the relationship between all five behavioral features and successful project delivery is significant.

I able 3. Analysis of Variance (ANOVA)							
	Model	Sum of Squares	df	Mean Square	F	Sig.	
1	Regression	23.795	5	4.579	13.580	.000b	
	Residual	33.99	97	0.350			
	Total	57.79	102				
a. Dependent Variable: PS							
b. Predictors: (Constant), O, C, N, A, E							

Table 4 will help to test all five hypotheses located at Figure 1 at start of this research. According to the below mentioned table, it is evident for the relationship between conscientiousness and successful project delivery that the value of slope (B) is 0.490, which is indicating that the change in one unit in conscientiousness will result as a 49% boost in successful project delivery. Furthermore, the value of t is greater than 2 and significance value is less than 0.05 i.e. 5.686 and 0.000, so H1 is valid and accepted.

	Table 4. Coefficients						
	Model	Un-Standardiz	ed Coefficients		C:m	Panking	
	MOGEI	В	Std. Error	Ľ	Sig.	Kanking	
1	(Constant)	1.288	0.400	3.221	0.002		
	С	0.490	0.090	5.686	0.000	03	
	E	0.387	0.099	3.919	0.000	04	
	Ν	0.536	0.076	7.059	0.000	01	
	А	0.358	0.086	4.152	0.000	05	
_	0	0.513	0.072	6.973	0.000	02	

Similarly, for the relationship between extraversion and successful project delivery the value of slope (B) is 0.387, which is indicating that the change in one unit in extraversion will result as a 38.7% boost in successful project delivery. Furthermore, the value of t is greater than 2 and significance value is less than 0.05 i.e., 3.919 and 0.000, so H2 is valid and accepted.

In order to test the regression between neuroticism (inverse) and successful project delivery, the slope (B) value is obtained as 0.536, which is indicating that the decrease in one unit in neuroticism will result as a 53.6% boost in successful project delivery. Furthermore, the value of t is greater than 2 and significance value is less than 0.05 i.e., 7.059 and 0.000, so H3 is valid and accepted.

In order to test the regression between agreeableness and successful project delivery, the slope (B) value is obtained as 0.358, which is indicating that the increase in one unit in agreeableness will result as a 35.8% boost in successful project delivery. Furthermore, the value of t is greater than 2 and significance value is less than 0.05 i.e., 4.152 and 0.000, so H4 is valid and accepted. According to the above mentioned table, it is evident for the relationship between openness to experience and successful project delivery that the value of slope (B) is 0.513, which is indicating that the change in one unit in openness to experience will result as a 51.3% boost in successful project delivery. Furthermore, the value of t is greater than 2 and significance value is less than 0.05 i.e., 6.973 and 0.000, so H5 is valid and accepted.

CONCLUSIONS

This research has been undertaken to analyse the Functions of The Project Manager's Behavior in the Successful Delivery of Development Projects. The behavioral features of the project managers have been studied by the researcher through the big five behavioral categories also known as five-factor model. Five types of behaviors have been studied in recent research. Professionals and practitioners can devise some important conclusions as this research helps in finding the relationship between behavioral categories and the successful delivery of a project.

It has been revealed from the research that **neuroticism** is the major predictor in defining the successful delivery of a project in terms of its performance. The second most influencing predictor is **openness to experience** as per the outcomes of the current study. Despite following the conventional approach, the problematic issues can be solved through the innovative and creative approach to achieve better results and fall under the basic responsibility of a leader/project manager. **Conscientiousness** behavior is the 3rd most dominating predictor that can influence successful project delivery. A self-disciplined project manager can be a true example of delivering a successful project as he owns a moral authority to lead from the front and guide his teammates.

Extraversion behavior falls after that as a fourth dominant predictor to achieve a successful project. According to (Brandstätter, 2011), better results in achieving a successful project can be ensured through innovative and creative approaches that can be resulted from interaction with different types of individuals in an effective way. It has been concluded from a recent study, that **agreeableness** is another important forecaster to ensure the winning project deliverance. Agreeableness can be elaborated by the detail that the project managers, who own this behavior are generally kind and understand the issues of their subordinates. According to (Deinert et al., 2015), the project managers concentrate on considering the suggestions of their subordinates by giving them importance, and as a result, their subordinates deliver their best through motivation in achieving the best possible results.

This has been concluded from a recent research that all five behavioral features are important positive forecasters to ensure the success of any project. An extrovert project manager has the talent to socialize and communicate with his assistants in a valuable way. These behavioral features help the project manager to be open in front of his subordinates and make him available to discuss their problems and solutions as one team.

This behavior encourages employees to put their maximum in executing any work due to the close relationship and trust with the higher management, resulting in high performance of the organization and delivering successful projects. The results of the current study complement the previous findings of Labbé & Fobes (2010). The recent study would certainly contribute to the current literature by establishing behavioral character in form of five-factor model and successful project delivery.

The hypotheses set in the recent study have been admitted thoroughly and it has been concluded that each behaviour category plays a vital role in delivering a successful project. These results can be evaluated according to the background of the outcomes of (Culp & Smith (2001), who claimed that the success of a project can be ensured through appreciation and understanding of various behavioral features according to the psychology.

Behavioral characteristics of any individual can be described through five-factor model and are widely accepted. This study is much beneficial for project managers to evaluate themselves in terms of their behavior and performance. The extent of the big five behavior model is not dependent upon cognitive dispositions, owning toughness throughout different civilizations and holding constancy for an extended period. Consequently, because of the reason for high firmness big five behavioral features cannot be altered by any specific event.

Usually, it is suggested some of the variations can be observed through the big five behavior categories in actions/reactions. According to (Helle et al., 2010), an individual's action in a precise state of affairs might not be forecasted through characteristic scores but have fair dependability in spotting behavioral inclinations in different conditions over that particular time frame.

Practical Implications

The recent study of psychological behavioral features of project managers is extremely constructive for experts and academicians. According to (Fletcher, 2013), in case of realistic suggestion, the results of the recent study can be considered to be the scale for employing and selecting suitable project managers, who are responsible for the successful delivery of projects. Furthermore, the outcomes of this research are food for thought for the project managers to make them vigilant by concluding the most dominant behavioral category as a positive forecaster of a successful project.

All project managers must be aware of these behavioral categories and must adopt the most dominant type to achieve better results in terms of success. Similarly, the results of this research are very vital for all the stakeholders of the organizations. This study can prove to be a guideline for the management of the organizations to set criteria for recruiting the human resource. Valuable project management can be guaranteed through the selection of right kind of project managers and chances of success can be enhanced through their training concerning behavioral trends. Suitable guidance plans can improve the behavioral inclinations of the project managers and these trends can be functional for the successful completion of projects.

RECOMMENDATIONS

There must be a wider acceptance at the organizational level for providing the training opportunities to the project managers to the improvement of their behavioral trends. These trends/inclinations can be the key to success in achieving desired results in terms of project delivery. This can be further explained through the example of motivation, which can lead to delivering an efficient project delivery.

The group work can be enhanced by following the agreeableness trend in behavior from the project leader. Agreeableness tendency in behavior of project managers can prove to be the accelerating agent for the businesses where teamwork is required, because of their cooperative nature. Furthermore, the extrovert project managers have more tendencies to interact with others and, this results in achieving their set deadlines due to a collective working approach.

FUTURE GUIDELINES

Although the Professionals and experts can get benefit from the findings of the current research, some restrictions are also necessary to mention for future guidelines. The data has been collected from the project managers of the development projects in Pakistan, so it would not be fair to generalize its results to other research fields. Furthermore, the behavioral inclinations can be further elaborated by the designated positions through organizational type.

The results of the current research can be strongly generalized by focusing on the behavioral tendencies of project managers of various countries. The results of the current research can be affected in the case of evaluating the collected data gathered from the project managers of different countries as the culture and customs of various regions vary from one another. The current data has been collected from the project managers of Pakistan. The results can be generalized to a larger sample size collected from project managers belonging to different regions in the future.

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AUTHOR'S CONTRIBUTION

Muhammad Shahzad; (Proposed Idea, Data Collection and Manuscript Writing), Sajjad Mubin; (Conceptualization, Supervision, Planning and Quality Ensuring), Fahad-ur-Rehman; (Conceptualization, Statistical Analysis, Writing-Review & editing). Ekaterina Gavrishyk: Review

Conflict of Interest

The authors have declared no conflict of interest.

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THE TENDENCY OF KITCHEN SPATIAL MODIFICATION AS OPPOSED TO ESSENTIALITY IN TERRACED HOUSE

Muhamad Haziq Ikhwan Mohd Hair, Nurdalila Saji*, Noor Aini Azmi and Hasnida Harun

Department of Civil Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Campus Pagoh, Muar, Johor, Malaysia

Abstract

Terraced houses are considered affordable housing in Malaysia. Mainly, terraced houses in Malaysia are designed following a standard residential design. However, homeowners oftentimes were unsatisfied with the existing kitchen space of the terraced house thus, tend to modify it. Therefore, this study presents the aimed to examine the tendency of kitchen space modification based on terraced houses compared to the need to change it. The site selected for this study was Taman Bukit Tiram, Johor. The data collection technique was in quantitative form with a questionnaire survey method involving 54 respondents, and the study sample selection uses purposive sampling specific to single-story terraced houses that only undergo kitchen modification. The data analysis technique for objective (1) uses a one-way ANOVA test showed the influence between the 'number of years occupied' by with the 'reason for home kitchen space modification' with a p-value of 0.005. Data analysis technique for objective (2) uses descriptive statistical analysis by looking at the mean score which showed the highest level of homeowner perception which they were satisfied with the results of home kitchen space modification with a mean score of 3.72. The Pearson correlation coefficient used to analyse objective (3) showed a relationship between the 'reason for home kitchen space modification' with the 'general perception after kitchen space modification' with a p-value of .548. In conclusion, based on the findings from the study, it shows that the tendency of kitchen modification is due to the need for space.

Keywords: Terraced House; Renovation; Modification; Kitchen Space

INTRODUCTION

The current economic trend is focused not only on the skyscraper construction sector but also on the housing development sector. In Malaysia, the housing needs are expected to increase very high due to population growth, interstate migration, changes in the economic status of the people, changes in appetite, and declining existing housing stocks (Olanrewaju et al., 2016). For the past forty years, terraced houses have existed and been widely developed in Malaysia. As shown in Figure 1 a typical layout of a Malaysian single-storey terraced house.

Developers widely built this terraced house. It is now the most popular form of property in the country because it can be categorized as an affordable house by every Malaysian (Omar, Endut & Saruwono, 2017). Renovations may be part of planned maintenance and improvements. This could be a conversion, renovation, or remodelling of a building as part of modernization or adaptation to a changed use (Jensen & Maslesa, 2015). It is also a solution to homeowners in solving the problems they face, especially in terms of insufficient space and the comfort of occupants in going about daily life (Mikhaleva et al., 2018). However, there are several areas for improvement in terms of the design of this type of housing, including the lack of social and cultural considerations, as well as the privacy required by homeowners (Saji, 2015). Modification of the terraced house can meet the homeowners' personal needs that were overlooked during early planning. Therefore, homeowners can support their needs if they can treat the flexibility and ability to adapt to the design well (Mohit & Mahfoud, 2015).



Figure 1. A Typical Layout of a Malaysian Single-Storey Terraced House

Problem Statement

Many terrace houses were designed to conform to the standard residential designs, which may require some modification by the homeowner once purchased (Sazally, Omar, Hamdan & Bajunid, 2016). Studies have shown that cases where wet kitchens were added are very significant. Homeowners tend to modify the backyard into a kitchen section. This modification is because there is an insignificant need for the backyard, causing the kitchen space to be enlarged (Omar, Endut & Saruwono, 2012). Residents' satisfaction can be seen in how significant changes occur while living in their residences. The more dissatisfied the population, the more renovation activities will be undertaken (Aryani, Mulyadi & Wahyuningsih, 2015).

The question that arises from the partial modification of the kitchen space in a terraced house is the need for a larger kitchen space area that causes homeowners to modify an existing house. In addition, what is the level of homeowners' perception on the results of the kitchen modification? To determine the tendency of the kitchen space modification in a terraced house compared to the need to change it, is there a relationship between the reasons for kitchen space modification? Thus,

the formulation of objectives on the next page. The renovation that has been done by the homeowners were influence by many factors. Hence, this study is conducted to find a reason on why the house need to be modified.

Objectives

The purpose of this study was to examine the tendency of the modification of the kitchen space of a terraced house compared to the need to change it. Among the objectives of this study are:

- i. To identify the kitchen space requirements that cause homeowners to modify existing terraced houses.
- ii. To assess the homeowners' perceptions on the results of kitchen modification.
- iii. To investigate the relationship between 'kitchen space requirements that cause homeowners to modify the house' with their 'perceptions of kitchen modifications'.

METHODOLOGY

Data Collection

To achieve the objectives of this study, a quantitative research method was applied for this study. The survey approach uses a questionnaire to determine differences between individuals and opinions which cannot be observed. This study is based on a questionnaire survey conducted on residents living in Taman Bukit Tiram, Johor. Taman Bukit Tiram, Johor, consists of single and double-story terraced houses. The sample selection is based on purposive sampling, which consists of intermediate, end lot and single-storey low mediumcost terraced house. This research involves studying changes made in the kitchen space of terraced houses where observations, surveys, and some notes were made to obtain information from the residents in the residential area.

The number of respondents who have modified the kitchen space alone is 54 respondents. During the field survey, the selection of respondents was by visiting from house to house. In some cases, an allocation of time to answer was given to the respondents with the questionnaire taken later, agreed by the respondents. Therefore, 54 questionnaires were obtained and used for data analysis. Statistical Package for the Social Sciences (SPSS) software was used to complete this study's analysis. The methodology flowchart as shown in Figure 2 is used in this study.



Figure 2. The Methodology Flow Chart

Research Criteria

The intermediate, end lot and single storey terraced house is the main focus of this study to achieve the objectives because of any modification that has been done will be seen more clearly when there is a physical change in terms of its exterior from the original plan of the terrace house (Saji, 2015). The criteria for choosing the terrace house and the respondents are created in detail to make sure good results can be obtained linearly with the objectives of the study. The background profiles of the respondents were identified to look into the pattern of respondents in the housing areas.

- i. Criteria for selecting a terrace housing area in Taman Bukit Tiram, Johor:
 - The house has undergone modifications in the kitchen section,
 - Medium low-cost terraced house,
 - Intermediate and end lot of terraced houses.
- ii. Criteria for selecting respondents:
 - Purposeful population selection for survey questionnaires,
 - Homeowners of residential areas of various ages and socio-economic status.

Questionnaire Development

The questionnaire is used by respondents to provide details concerning their present situation, attitudes, and views. The design of the questionnaire in this research was based on a previous study from (Saji, 2015). The question has been developed related to the modification of the kitchen spaces of the homeowners' terraced house. The questionnaire consists of three sections: A, B and C. Questions for section A consist of six items about the homeowner's profiles. Questions for section B are about the factors that contribute to modification of kitchen space in terraced houses consisting of nine items, and the questions for section C consist of seven items that asked about the homeowners' perception of the results of their kitchen modification. Questions for sections B and C are closed-ended questions where the respondents must choose based on their satisfaction following the Likert scale, and one question in section C is an open-ended question that asks about the reason if the homeowners are unsatisfied with their kitchen space modification.

Code	Households Profile Questionnaire Survey Questions	
A1	Number of households	
A2	Household income	
A3	Races	
A4	Number of years residing	
A5	Floor plan approved by the local authorities	
A6	The extend of modifications made	

Table 1. Code for Household Profiles Questionnaire Survey Questions

Table 2. Code for Part B Questionnaire Survey Questions

Code	Factors That Contribute to Renovation of Kitchen Space in Terraced Houses
B1	I modified the kitchen because it is an investment
B2	I modified the kitchen to indicate my status in the community
B3	I modified the kitchen space to add aesthetic value in the space
B4	I modified the kitchen space because I was not satisfied with the original spaciousness of my home kitchen
B5	I modified the kitchen space because I want to extend the kitchen space
B6	I modified the kitchen space because it could cater to the religious and cultural aspects of the household
B7	I modified the kitchen space because it could symbolize my personality
B8	I modified the kitchen space to eliminate certain spaces in my house
B9	I modified the kitchen space due to lack of privacy while in the kitchen space of my own home

Table 3.	Code for	Part C	Questionnaire	Survey	Questions
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Code	Homeowners' Perception of The Results of Their Kitchen Modification
C1	I might modify my house again in the future
C2	After my home modification, it has accommodated my household
C3	Modification of home kitchen space is necessary because in my opinion, the previous kitchen space design was inappropriate
C4	The modification of the home kitchen space is necessary to reflect my taste towards aesthetical design
C5	Modification of the kitchen space can replace the space in my house that is not needed
C6	The modification of the kitchen space simplifies my daily life in doing housework
C7i	I am satisfied with the outcome after the house modification

RESULT AND DISCUSSION

The Factors that Contribute to Renovation of Kitchen Space in Terraced Houses

The mean score interpretation in this section is made based on (Moidunny, 2009). Based on the mean shown in Table 4, the findings show that respondents chose the factors of renovation of the kitchen space because it is an investment (B1), modified the kitchen space to add aesthetic value in the space (B3), modified the kitchen space because of not satisfied with the original spaciousness of the kitchen (B4), modified the kitchen space to extend the kitchen space (B5), modified the kitchen space to eliminate certain spaces in the house (B8) and modified the kitchen space due to lack of privacy while in the kitchen space (B9) needs with mean score values of 3.89, 3.52, 4.20 4.07, 3.22 and 3.28. This interpretation of the mean score says that the mean score value is between 3.21 to 4.20 is high. On the other hand, the rest of the respondents chose modified the kitchen space because it could cater to the religious and cultural aspects of the household (B6) and modified the kitchen space modification with mean score values of 3.06, 2.65 and 2.91. This interpretation of the mean score says that the mean for kitchen space modification with mean score value is between 2.61 to 3.20 is medium.

Item	Mean
B1	3.89
B2	3.06
B3	3.52
B4	4.20
B5	4.07
B6	2.65
B7	2.91
B8	3.22
B9	3.28

 Table 4. Mean Score Values of Factors that Contribute to Renovation of Kitchen Space in Terrace

 Houses

 Table 5. Summary of the Relationship Between Household Profiles and Factors That Contribute to Renovation of Kitchen Space in Terraced Houses

The Kitchen Space Requirements That Cause Homeow Influence Terraced House					wners to	Modify Ex	isting		
	B1	B2	B3	B4	B5	B6	B7	B8	B9
A1									
A2									
A3									
A4								Х	
A5									
A6									

To answer the research question for the need for kitchen space that causes homeowners in Taman Bukit Tiram to modify their existing houses, a one-way ANOVA test analysis was conducted. Table 5 above summarises the relationship between 'household profile' and 'kitchen space requirements that cause homeowners to modify their homes'. The mark (X) indicates that the two variables are mutually influencing, and it is considered significant. Only the A4 which is 'number of years of occupying the house' from the study sample profile that affected question B8, which is 'I modified the kitchen space to eliminate certain spaces in my house' with a p-value of 0.005, while the study sample profile other than the number of years occupying the house did not affect question B8. This is because the respondents lived in their house for a quite long time, it influenced the respondents in Taman Bukit Tiram, Johor, to perform modification in the kitchen.

The Kitchen Space Requirements That Cause Homeowners to Modify Existing Terraced Houses

Based on the mean score shown in Table 6, it can be observed that respondents chose items C2, C3, C5 and C7 for homeowners' perceptions of the results of kitchen modification with mean score values of 3.65, 3.63, 3.37 and 3.72. This interpretation of the mean score says that the mean score value between 3.21 to 4.20 is high (Mikhaleva et al., 2018). In addition, respondents chose items C1, C4 and C6 for homeowners' perceptions of kitchen modification of the mean score values of 3.15, 2.89 and 3.09. This interpretation of the mean score, it indicates that respondents' perceptions in Taman Bukit Tiram are more likely to support the 'reasons for kitchen space modification'.

ltem	Mean
C1	3.15
C2	3.65
C3	3.63
C4	2.89
C5	3.37
C6	3.09
C7i	3.72

Table 6. Mean Score of Homeowners' Perception Level on the Results of Kitchen Modification

The Relationship Between Factors that Contributes to Renovation of Kitchen Space in Terraced Houses with Their Perceptions of Kitchen Modifications

There is a relationship between 'factors that contributes to renovation of kitchen space in terraced houses' with their 'perceptions of kitchen modifications' with a p-value of .548 from Pearson correlation. From Table 8, the p-value of "FACTORS" is statistically significant at the .001 level against "PERCEPTION", which means a relationship between these variables. In the future, terrace housing design should consider these aspects into a housing development to ensure better performance in the quality of life and reduce the number of excessive modifications from homeowners. Since place attachment is a spatial assessment (Rahim & Hasim, 2012), there is a significant effect on the 'perception of modification' results. If the respondents' desire to modify the kitchen space is high, then the expected perception of the results of the home kitchen modification will also be high.

		Reason	Perception
	Pearson Correlation	1	.548**
Reason	Sig. (2-tailed)		.000
	Ν		54
	Pearson Correlation	.548**	1
Perception	Sig. (2-tailed)	.000	
	Ν	54	

Table 7. Pearson Correlation Coefficients for Reason and Perception

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

rable of Caminary of Contolation for Readon and Foroption	Table 8. Summary	of Correlation	for Reason and	d Perception
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	REASON	REASON	
	Pearson Correlation**	Sig.	
FACTORS	1	0.000**	
PERCEPTION	.548	0.000**	

**Correlation was significant at the 0.001 (2-tailed) level.

CONCLUSION

In summary, this study has successfully achieved its main objectives based on the analysis and discussion of the findings on the residents of Taman Bukit Tiram, Johor shows the tendency of homeowners to modify the kitchen is due to the need for space. It can be concluded that the majority of respondents support the statement that modifying the kitchen space is an investment, indicating status among the community, adding aesthetic value in the kitchen space, being dissatisfied with the original area of the kitchen, wanting to extend the kitchen space, getting rid of unnecessary space in the house, and lack of privacy when in the kitchen space itself. Another theory that contradicts the study results is that the respondents in Taman Bukit Tiram, Johor do not support the statement that modifying the kitchen space can meet the religious and cultural aspects and symbolize their personalities.

Only three out of thirteen respondents provided feedback related to their dissatisfaction with the size of the kitchen space even after their house has completed modification. The rest provided focused feedback on the physical and quality of the kitchen space after the modification.

All profiles for the sample of the study, which is the number of households, household income, race, number of years occupied, floor plan approved by the Local Authority (PBT) and the extent to which the modification did not directly affect eight items in the factors that contribute to the modification of kitchen space in a terraced house for section B. The eight items include modifying the kitchen space because it is an investment, indicating the homeowners' status in the community, adding aesthetic value to the area, not being satisfied with the original spaciousness of the kitchen space, and the homeowners wanting to extend the kitchen space. The modification of kitchen space could cater to the religious and cultural aspects of the household, could symbolize the homeowners' personality and modify the kitchen space due to lack of privacy while in the kitchen space of their own home. Only the number of years occupied by the house from the study sample profile alone affected item B8, which is the homeowners' modified their kitchen space to eliminate specific areas in their home with a p-score value of 0.005 due to one-way ANOVA test analysis. Furthermore, there

was a correlation between 'the reason for kitchen space modification' with the 'general perception after kitchen space modification' with a p-value of .548 from Pearson correlation.

Recommendations for Homeowners

Based on the analysis and discussions, several suggestions have been recommended to homeowners before modifying the kitchen space. Among them is that homeowners need to identify the status of homeownership whether the home unit can be modified or not. This matter can be referred to the authorities such as the Municipal Council and the housing area management because every space modified in a terrace house must comply with the law.

In addition, homeowners need to choose a registered contractor. Ensure that the contractor selected to perform home modification is registered with a professional body such as the Malaysian Construction Industry Development Board (CIDB). Things like this need to be taken seriously, so any complication will not happen in the future, such as having to tear down a space that has been modified.

Furthermore, the homeowners need to choose services for home modification or modification from those who are skilled in home design because these skilled people, such as Interior Designers and registered contractors, have extensive knowledge regarding the selection of materials used, extensive experience and ideas in their field, and following the prescribed laws.

Finally, the homeowners need to ask the contractor for the defect liability period after modifying the house. Any damage or defect found during that time, the contractor needs to repair the damage and defects, so it is not detrimental to the homeowner instead, provide benefits to them.

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FINITE ELEMENT MODELLING OF POST-TENSIONED REINFORCED CONCRETE BEAM

Solahuddin Azuwa

Faculty of Civil Engineering Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, Gambang, Kuantan, Pahang Darul Makmur, Malaysia

Abstract

Concrete, a ubiquitous building material, has a wide range of properties, including inelastic and non-linear behaviour in compression and tension. Unfortunately, concrete is notoriously challenging for modelling and simulation due to its unique physical properties and behaviour. Reinforced concrete faces special difficulties because of the bond-slip interaction between concrete and steel. The finite element analysis software, ABAQUS, was used to analyse posttensioned reinforced concrete beams (PTRCB) with dimensions of 1000 millimetres in length, 200 millimetres in width, and 300 millimetres in height using finite element analysis (FEA) method. This research examines the behaviour of damaged concrete using an external posttensioning steel rod system (EPT) and the ABAQUS CDP model for concrete-damaged plasticity. The CDP model for concrete characteristics and a perfect connection between steel and concrete were assumed throughout the ABAQUS simulation for concrete beams. The simulation's fracture patterns are consistent with those seen in the testing. The analytical responses, including the strength, deflection, and stress of external rods, agree with the observed responses. When the damage in the specimen surpasses its tensile stress, the fracture strain of the concrete is reached. The ABAQUS results for concrete under tensile stress are consistent with those obtained in the experiment. In conclusion, the analytical results for the external rod's strength, deflection, and stress are consistent with the experimental data acquired. This research is conducted to analyse the experimental results using finite element modelling (FEM). Both experimental and FEM results show consistency. No significant differences are seen between experimental results and FEM, so FEM proves and acknowledges the experimental results.

Keywords: Finite Element Modelling; Post-Tensioned; Reinforced Concrete Beam

INTRODUCTION

A finite element modelling (FEM) software is used in this study. The software used is called ABAQUS. The function of this ABAQUS software is to investigate and determine the structural performance of normal reinforced concrete beams (RCB) and post-tensioned reinforced concrete beams (PTRCB). Besides that, this study also examines the influence of shear/flexural behaviour, loading pattern, deviator number and depth, support conditions, and steel rod diameter on the structural reactions for RCB and PTRCB utilising external steel rods, allowing the reader to determine the best numerical possibilities for a PTRCB in ABAQUS. Without reliable models regulating the design of this member, parametric studies have been performed in ABAQUS using the numerical modelling references provided by several researchers before this, such as Jankowiak and Odygowski (2005), Kmiecik and Kaminski (2011) and Tao et al. (2013).

The increased processing capacity of modern computers has allowed for more in-depth research on concrete performance. Non-linear stress-strain relationships, anisotropic stiffness reduction, crack and propagation due to tensile deformation, and the link between the concrete and steel reinforcements are only some complicated behaviours that FEA implementation struggles to capture. Many researchers before this had looked into reinforced concrete buildings, such as Nazem et al. (2009) and Yu et al. (2010). Commercial software like

ABAQUS and ANSYS are available for non-linear analysis. They are called for wellinformed technical input (Chaudhari and Chakrabarti, 2012). To be clear, they are not the type of tailor-made programmes that can run autonomously with minimal input from the user.

The concrete constitutive model in compression and tension has been developed by some researchers (Park et al., 1991; Scott et al., 2012; Wang and Hsu, 2011; Seow and Swaddiwudhipong, 2015) to understand concrete behaviour. The input values, particularly the material properties, determine whether or not an FEA of structures is permissible. Despite the wide variety of approaches, many areas still need further exploration. Concrete is commonly used among building materials but behaves very nonlinearly in uniaxial compression as a composite material. Cracking and crushing are impossible in concrete due to their extreme brittleness. In concrete structures, concrete failure modelling has recently become a problem. Scalar failure models are used for compression and tension. The crack propagation is investigated using concrete damaged plasticity (CDP). This research aims to perform finite element modelling (FEM) of PSTRCB based on previous experimental results.

EXPERIMENTAL INVESTIGATION

Full-scale testing indicated that the load-carrying capacity and stiffness in flexure and shear of each control beam with External Post-Tensioning (EPT) were much higher than those of the beams without EPT. When steel rods were used in an EPT, the ductility of the strengthened beams was significantly increased. For instance, the EPT steel rods' catenary motion increases the beams' load-carrying capacity, which also helps to forestall load-capacity drops (Han and Tao, 2007; Nagy et al., 2010). Without resorting to hydraulics, beam deflections can be repaired with EPT. A steel rod with a wider diameter and deeper depth of strength is preferable. Concrete crushing in a balanced state determines the ultimate load state. Hence limiting the number of EPT steel rods is necessary to make sure that the rods will yield at a certain point. A standard PTRCB measures 1000 mm in length (L), 200 mm in width (W) and 300 mm in height (H).

FINITE ELEMENT MODELLING (FEM)

This section discusses general details of FEA and steel and concrete materials modelling.

General Details

This FEM of a PTRCB was constructed and analysed using the general purpose of the FEA programme, ABAQUS (Simulia, 2013). Members of the structure were modelled using a 4-node bilinear shell element (CPS4R) for concrete and strengthening members, including deviators and pins, and two 2-node linear truss elements (T2D2 and B21) for interior reinforcements. 4-node bilinear shell element was used to model the concrete structural member. Moreover, 2-node linear truss elements (T2D2 and B21) were used for interior reinforcement. Deviators and pins also supported the FEM during the analysis running. This ABAQUS software is essential to use for getting the results.

Based on the findings of the sensitivity analysis, 20 mm mesh size was used. 20 mm is the optimum value to get the output results. This analysis of the theoretical section also used the same assumption called the embedded command. The embedded command was used to get the simple modelling and combine the concrete, including internal reinforcements. The links between concrete slab and hole, saddle plate and pin, and anchor pin were produced using the surface-to-surface command. Since the RCB and PTRCB are mirror images of one another in Figure 1(b), we only need to model half of them to save time and computing power. As contact interaction qualities, Lam et al. (2012) considered the hard contact quality in common behaviour, and the 0.3 value is for the standard friction coefficient for tangential behaviour.

This analysis was performed using only two-dimensional elements rather than the more time-consuming three-dimensional modelling that would have been required for the steel rod ends with bolt threads. The 'Equation' function merges the two joints instead of thoroughly modelling. Since thread failure is not the predominant mode of failure in this research, this simplification appears appropriate. There is no analytical difficulty when the simulation begins because there are no distances between contact elements Dai et al. (2010).

Steel Modelling

The Equation function was used to merge the two joints instead of doing detailed modelling. Given that thread failure is not the predominant mode of failure in this research, this simplification appears appropriate.

$$\sigma_{true} = \sigma_{nom} (1 + \varepsilon_{nom})$$
(Equation 1)
$$\varepsilon = \ln(1 + \varepsilon_{nom}) - \sigma_{true}/E$$
(Equation 2)

where σ_{true} =true stress, $\varepsilon^{\text{plln}}$ =log strain, σ_{nom} =nominal stress, and ε_{nom} =nominal strain, E=Young's modulus. Based on the AIK, E=200,000 MPa, and 205,000 MPa are the values utilised for reinforcement and external rods.

Concrete Modelling

ABAQUS has a "Concrete Damaged Plasticity (CDP)" option that can be used to analyse the concrete damage. Some important parameters used in this investigation such as:

- 1) Angle of dilation (ψ)
- 2) Modulus of elasticity of concrete (E_c)
- 3) Eccentricity (e)
- 4) 1 direction of compression strength under biaxial loading to uniaxial compressive strength (fb_0/fc_0)
- 5) Compression and tensile behaviour (S)
- 6) Compressive meridian ratio (K)
- 7) Viscosity (µ)

 $E_c = 4700(f'c) 0.5$ MPa was defined as f'c from the compressive strength test, according to AIK (2016) standards. This strength of compressive used a unit called MPa according to the ACI code. Eccentricity (e) was set to 0.1. A compromise was reached between the formulas proposed by Papanikolaou and Kappos (2007) and Tao et al. (2013): $fb_0/fc_0=1.5(fc_0)^{0.075}$. Based on the ACI code, $fc_0=f'c$. It was not quantified in the experiments

and its data is rare in other studies. Based on a review of 14 scholarly sources, they devised their own definition separately. The concrete yield surface is determined by the ratio of the second stress invariant on the tensile meridian (K) to the compressive meridian (S). Many researchers, including Seow and Swaddiwudhipong (2005), have used 2/3 as the K default value, despite the K range being between 0.5 and 1.0. This research use Yu et al. (2010)'s equation of K14(5.5fb₀)/(2f'_c5fb₀). Table 1 summarises all the equation details used.

Table 1. Equation Details				
Equations	References			
E _c = 4700(f′c)0.5 MPa	AIK (2016)			
fb ₀ /fc ₀ =1.5(fc ₀) ^{0.075}	Tao et al. (2013)			
K14(5.5fb ₀)/(2f' _c 5f _{b0})	Yu et al. (2010)			

ABAQUS has a range of 0^0 to 56^0 for defining the plastic flow potential (Tao et al., 2013). This study relies heavily on the dilation angle (ψ) and viscosity parameter, even though previous studies have found these to be difficult to quantify. Several researchers have used different values but have embraced them on a case-by-case basis. Numerous careful analyses led to the conclusion, which is 38^0 used in this study. Load-deflection behaviour was unaffected by its value, whereas plastic behaviour followed the elastic behaviour. The viscosity parameter (μ) is used in ABAQUS standard analysis for the visco-plastic regularisation of the concrete constitutive equation, and its default value is 0. 0 value was not usable because the FEA did not advance into elastic behaviour. In comparison, Tao et al. (2013) observed no influence on the parameter value's prediction accuracy. This study determined that the values of 0.1, 0.5, 0.5, and 0.005 should be used for Series I, II, III, and IV.

Concrete compressive and tensile behaviour generally does not impact how the structural concrete beams perform in terms of their structural performance. The following formula expresses compressive stress in concrete: where f'c is the compressive strength of the concrete in the cylinder, c_u is the ultimate compressive strain, and 0 is the maximum compressive strain. The stress-strain relationship was determined as depicted in Figure 1(d) as stated by Lou et al. (2013) and Hognestad (1981). The tensile strength is achieved when the stressstrain increase consistently. The concrete tension curve is also required and ABAQUS software was used to get the concrete tension curve (output) values by inserting the input values. The ABAQUS was run and analysed to get the output results. The higher the input values, the higher the output values. It is important to get a good input to get better output results. Here, the concrete uses a tensile strength of 0.1f'c with 10ft/E_c ultimate tensile strain. The properties of concrete were analysed with ABAQUS software for Series II (Shin and Lee, 2010). The damage in the specimen surpasses its tensile stress when the fracture strain of concrete is exceeded, as shown in Figure 1-3. Similar to what was found in the experiment, the concrete under tensile stress has been deformed in ABAQUS simulation. Tables 2, 3, and 4 show the concrete properties values and data kept in ABAQUS software to generate the FEM of the PTRCB.
Compressive Damage		Compressive Behaviour		
Damage Parameter	Inelastic Strain	Yield Stress (MPa)	Inelastic Strain	
0	0	7.29	0	
0	0.00011	9.16	0.00011	
0	0.00053	16.16	0.00053	
0	0.00095	21.01	0.00095	
0	0.00137	23.70	0.00137	
0	0.00169	24.30	0.00169	
0.15	0.00319	20.66	0.00319	

	Table 2.	Concrete	Properties	in ABAQUS
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Concrete Tensile Damage		Concrete Tensile Behaviour		
Damage Parameter	Cracking Strain	Yield Stress (MPa)	Cracking Strain	
0	0	2.43	0	
0.979	0.00094	0.05	0.00094	

Table 4. Concrete Properties in ABAQUS		
Tensile meridian (K)	0.7294	
Eccentricity (e)	0.1	
Viscosity parameter (µ)	0.5	
f_{b0}/f_{c0}	1.1808	
Dilation angle (ψ)	38 ⁰	
Poisson's ratio (v)	0.2	
Modulus of Elasticity (E _c)	4700√f′c = 23,169 [20]	



Figure 1. The Stress-Strain Relationship for T18V-H-R, T28V-H-R, T18U-H-P and T22U-H-P





COMPARISON BETWEEN FINITE ELEMENT MODELLING AND EXPERIMENTAL RESULTS

The ABAQUS methods described above have been used to model each tested beam. The results of the simulations and the experiments are compared in this section to ensure the confirmation and validity of the FEM method. Figure 4 compares the test findings and FEA results for various specimens plotted as load vs mid-span deflection curves. Overall, the analytical results were very near to the experimental results. The FEA results somewhat overestimated the strength. Displacement control was used for numerical analysis to see load degradation. However, unlike the experimental behaviour, it didn't happen until the simulation ended (except for the shear analysis in Figure 4(d)). Once the concrete had reached its maximum compression and tension strains, the element deletion was not considered, even though the fully bonded assumption between concrete and internal reinforcement was considered. The Series II T18V-LC specimen test was aborted early due to the thread stripping of the steel rod. The numerical analysis could not reproduce the failure because the steel rod properties were not included and represented in the ABAQUS. The threads of the steel rod were also not included.



Figure 4. Load-Deflection Curves

After conducting full-scale tests, researchers found that the external post-tensioning EPT utilising the steel rod approach improved the load-carrying capacity and stiffness in flexure and shear compared to the control RCB lacking EPT. High ductility results are produced using RCB with EPT. Control RCB with lacking EPT produce load-carrying capacity, shear, and flexure stiffness compared with control RCB with higher EPT. This EPT is better with steel rod consumption because it can improve the RCB strength. The RCB can carry more weight without experiencing any sudden decreases in capacity. This occurrence is because of the EPT's catenary motion. Steel rods used in EPT can also be used to repair an already damaged beam, and the technique requires no hydraulic jacks for post- or re-tensioning. Steel rods with greater diameters and deeper strengthening are more powerful. However, EPT steel rods should be utilised in intermediate quantities to grant the steel rods' yield at the ultimate load state. This effect would cause the equilibrium state of concrete crushing.

The comparative results also depict that the simulation results were not too far off. 1.02 is the value recorded for the average discrepancy between the measured and simulated load capacity, while 0.04 is the value recorded for the standard deviation of the measured and simulated load capacity. The corresponding figures for the steel rod's stress are 1.10 and 0.08. (fps). 10% is the error value for the simulated load capacity. In addition, the simulated fps is typically larger than the 10% error value of the simulated load capacity. Sometimes, the error could occur while running the software analysis, which cannot be prevented. The concrete damage contour for tensile stress is delineated in Figure 2(b) previously. This damage corresponds to the damage that occurred in the crack strain, which is slightly higher. The results of the experimental investigation are linear with the concrete tensile deformation using ABAQUS's simulation and modelling.

The RCB strengthened with EPT steel rods produces shear and flexural test results delineated in Figure 5. The simply supported beams in Series I and II (Shin et al., 2007; Shin and Lee, 2010) were loaded at two points and at a single point, respectively. They were loaded at the internal span from two directions. Each beam's rectangular cross-section measured 400 mm by 600 mm, and its span measured 6m. The 3 spans of continuous RCB produced a posttensioning effect and were investigated by performing Series III and IV tests (Lee et al., 2014; Lee et al., 2015). The inside span of the constant 400 mm by 600 mm beams was 6000 mm, whereas the outside span was just 1500 mm long. Flexure failure occurred in Series I through Series III beams, while shear failure occurred in Series IV beams. This is a brief overview of the primary factors for the tests.

Several factors influence the simulation results, including but not limited to: (1) support condition, (2) deviator numbers, (3) diameter of EPT steel rods, (4) amount of internal reinforcement, (5) loading pattern and (6) diameter of EPT steel rods at deviator position. In several experiments and practical applications, seven-wire strands have proven to be the most effective for post-tensioning. However, this research uses a high property of steel rod with high strength as the post-tensioning material to produce better results than low strength steel with low strength. The member end requires jacking working space and a hydraulic jack when the post-tensioning is completed to its strands. In comparison, a building with a confined space and a limited area also requires steel rods. These steel rods need to be tightened with nuts to prevent them from getting divorced from each other.



(d) Flexural Test for Continuous RCB, Lee et al. (2015) Figure 5. RCB Specimens Tested in Previous Research

CONCLUSION

In conclusion, the external steel rods affect the behaviour of both RC and post-tensioned concrete beams. The multipurpose programme ABAQUS was utilised to develop a finite element model. The ABAQUS software uses concrete damaged plasticity (CDP) to investigate and get the results for the concrete behaviour produced. The CDP values are limited to several values and parameters. The CDP model has several parameters, such as flow potential eccentricity (e), viscosity (μ), dilation angle (ψ), and fb₀/fc₀ ratio of compressive strength under biaxial to uniaxial loading. All these parameters influence the numerical results of the external rod's deflection, strength, stress and strain, which are the same as the experimental investigation results. The CDP model also allows for the correct prediction of concrete tensile deformation compared to the observed crack pattern. ABAQUS is the most compatible software for numerical modelling and finite element analysis.

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CODIFICATION AND APPLICATION OF SEMI-LOOF ELEMENTS FOR COMPLEX STRUCTURES

(FULL NAME) Ahmad Abd Rahman¹, Maria Diyana Musa² and Sumiana Yusoff²

¹Department of Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Sarawak, Malaysia ²Institute of Ocean and Earth Sciences (IOES), University of Malaya, Malaysia

Abstract (Arial Bold, 9pt) Damage assessment (Arial, 9pt. Left and right indent 0.64 cm, it should be single paragraph of about 100 – 250 words)

Keywords: (Arial Bold, 9pt) *Finite Element Analysis; Modal Analysis; Mode Shape; Natural Frequency; Plate Structure (Time New Roman, 9pt)*

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Figure 8. Computed Attic Temperature with Sealed and Ventilated Attic

Tables: Arial, 8pt. Table should be incorporated in the text.

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Table Line: 0.5pt.

Table 1. Recommended/Acceptable Physical Water Quality Criteria		
Parameter	Raw Water Quality	Drinking Water Quality
Total coliform (MPN/100ml)	500	0
Turbidity (NTU)	1000	5
Color (Hazen)	300	15
рН	5.5-9.0	6.5-9.0

(Source: Twort et al., 1985; MWA, 1994)

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