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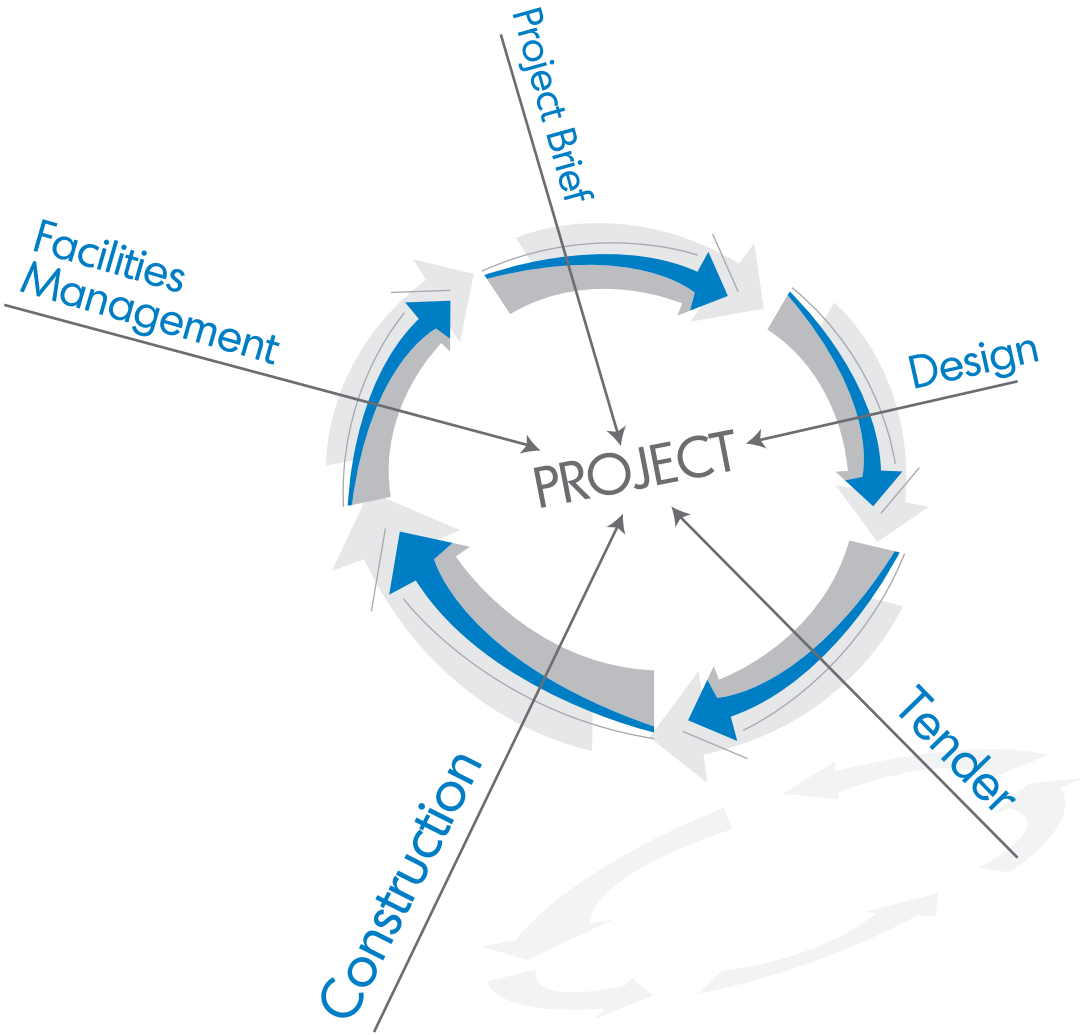

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Editorial

Welcome from the Editors

Welcome to the forty-second (42nd) issue of Malaysian Construction Research Journal (MCRJ). In this issue, we are pleased to include six 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:

Ahmed Mohammed Kamaruddeen et al., determined the extent of job satisfaction and identified the factors influencing job satisfaction among the Quantity Surveyors in Sarawak, Malaysia. A quantitative research approach was utilized in this research. The job satisfaction among quantity surveyors in Sarawak was found to be high. Job recognition, appreciation and feedback, and job achievement were the highest determinants of their job satisfaction. Job safety, consisting of job security, discrimination, harassment, and a sense of belonging, were the following determinants of their job satisfaction. Physiological needs consisting of salary, working conditions, and social interaction were the least ranked determinants of job satisfaction.

Nur Aisyah Azmi et al., explored the integration challenges of Building Information Modelling (BIM) within the Design & Build (D&B) contracts in Malaysia's construction sector. Through semi-structured interviews with seven experience professionals engaged in D&B BIM projects. They identified nine major contractual issues such as interoperability, fee allocation, risk allocation, model management, and intellectual property concerns. The study underscores the absence of clear BIM guidelines in current contracts leading to inefficiencies and disputes, suggesting the necessity for revised legal frameworks to support BIM adoption. Highlighting differences in issue management between public and private sectors, it calls for a standardized approach to BIM implementation in contracts to enhance project efficiency and reduce costs.

Muhammad Rafique et al., argued that it is inappropriate to consider projects just as a tool. Therefore, human resource management and behavioural schools are now being considered as essential components of research in project management. The current study investigated abusive supervision, its presence as well as its manifestation in the project environment by providing logical and contextual arguments and tried to shift the researcher’s perspective on investigating human aspect of the project. This study provided avenues and future research directions in order to instigate the research on the antecedents, consequences and boundary conditions of this behaviour. In addition, this study providing aid in enriching empirical evidence on this phenomenon in the project literature.

Fahad Ur Rehman et al., aims to determine the level of ICT adoption in a firm and the effectiveness of different software programs at various phases of the project. Identifying factors significantly hindering the use of ICT, possible benefits obtained through its utilization, and implementation strategies. The findings show that highly affecting factors hindering the use of ICT were a lack of commitment towards ICT by top management and

employee satisfaction with current workplace practices. By using ICT tools overall efficiency, profit margin, and productivity of the firm increased and it is a faster way to get timely authentic information regarding the project. For better ICT implementation strategies, senior management must play its role by conducting IT awareness workshops and should develop guidelines and policies.

Fakhira Khudzari et al., conducted a systematic literature review (SLR) focusing on the adoption of Emerging Technologies (ET) within the Malaysian construction industry. The analysis, based on 50 selected journal articles, scrutinizes the current state of ET implementation and identifies research gaps and future avenues. The study identifies nine groups of ETs studied previously, including Advanced Materials, Artificial Intelligence (AI), and Building Information Modelling (BIM), among others. Notably, it highlights the lack of research on five ETs integral to the national strategic plan, such as 3D Printing & Additive Manufacturing and Big Data & Predictive Analytics. This comprehensive overview contributes significantly to understanding ET adoption in Malaysian construction and provides valuable insights for industry professionals, policymakers, and researchers.

Mohd Azmi Ismail et al., have introduced the application of CFD in predicting thermal comfort for the football training center. The finite volume method (FVM) is employed in CFD code to solve governing and energy equations, and then predict the temperature on the football field. The transparent roof is a green method to reduce electric power consumption during the daytime, however, it generates high temperatures on the football field and building walls. Thus, it is suggested by the NHK consultant to use a double transparent roof ethylene tetrafluoroethylene (ETFE) to reduce wall temperature on both the building wall and the football field. Transparent EFTE material has high infrared radiation reflection, thus, less solar heat transmits to the football field and building wall.

Editorial Committee

ASSESSMENT OF THE DETERMINANTS OF JOB SATISFACTION AMONG CONSTRUCTION PROFESSIONALS

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Abstract
This study aims to determine the extent of job satisfaction and its determinants among the Quantity Surveyors in Sarawak, Malaysia. This research adopts a descriptive research design, quantitative research approach, and a simple random sampling technique to distribute 168 questionnaires to contractors' quantity surveyors and consulting quantity surveying firms operating in Sarawak, Malaysia. Thirty-four valid responses were received, yielding a 24.24% response rate. Statistical Package for Social Sciences (SPSS) tool, descriptive statistics, and the relative importance index (RII) were used to determine the extent and the determinants of job satisfaction among the respondents of this study. The level of job satisfaction among the quantity surveyors surveyed in this study was moderate. The result shows that esteem needs (job recognition, appreciation and feedback, and job achievement) were ranked first among the determinants of job satisfaction. Job safety (security and freedom from discrimination and harassment) and a sense of belonging were ranked second. Self-actualization was ranked third. Physiological needs (salary, working conditions, and social interaction) were the least ranked determinants of job satisfaction.

Keywords: *Construction industry; Job satisfaction; Quantity Surveyors; Sarawak, Malaysia.*

INTRODUCTION

Job satisfaction is essential for business organizations to sustain productivity (Ozpehlivan & Acar, 2015). It reflects an individual's psychological well-being and can positively motivate workers to improve their performance, increasing efficiency (Hajdukova et al., 2015). Job satisfaction can be viewed from two perspectives: the job satisfaction of professionals and the workers. Construction workers are the primary source of job satisfaction at construction sites. On the other hand, professionals are essential in guiding project quality and workforce issues. Hence, job satisfaction is critical for improving the overall productivity of workers. In addition, high job satisfaction can also retain professionals in the construction industry and reduce migration to other countries for better working conditions. The factors that can enhance job satisfaction may include the work environment given by the employers, teamwork, communication with supervisors, safety and health, personal development, and satisfaction with occupation (Hosseini et al., 2014; Yirenkyi-Fianko & Chileshe, 2012).

Although the Malaysian construction industry is vibrant with high demand for a skilled workforce, there is a concern for low Pay and benefits that could lead to job dissatisfaction and eventually trigger the loss of the local workforce (Bong, 2016). Few studies have examined job satisfaction in the Malaysian construction industry. However, the scope of the studies did not cover Sarawak, implying that these findings cannot be extended to Sarawak State. For example, Jaafar, Yaziz, Nuruddin, and Jalali (2014) assessed the satisfaction level of female quantity surveyors and the relationship between job satisfaction and turnover among female Quantity Surveyors in Peninsular Malaysia. It was found that the respondents were

least satisfied with their Pay compared to other variables examined in the study (work value, co-workers, working environment).

In a related study, Keng, Nor, and Ching (2018) assessed turnover intention and job satisfaction among quantity surveyors' firms in Klang Valley, Malaysia. It was found that 38.8% of respondents intended to quit their current jobs because they were unsatisfied with opportunities and rewards, specifically the firms' salaries, bonuses, benefits, and promotion opportunities. Unfortunately, a recent study by Abas, Saharan, Rahmat, Ghing, and Abas (2021) on the work-life balance among professionals in the Malaysian construction industry does not extend to Sarawak state. Due to the abovementioned gap, this study aims to determine the extent of job satisfaction and identify its determinants among Quantity Surveyors in Sarawak, Malaysia. The following section presents a literature review.

LITERATURE REVIEW

Job Satisfaction

Job satisfaction has received significant attention in recent times. This research is vital as most people spend a lot of time on their jobs. Job satisfaction is also a crucial aspect of organizational psychology and organizational success. It can significantly influence organizational performance, as satisfied employees have greater creativity and are more innovative. On the other hand, unsatisfied employees will tend to exemplify lower productivity and lousier life satisfaction, eventually leading to severe consequences such as job stress, work accidents, and absenteeism (Eyupoglu et al., 2016). Therefore, understanding the level of job satisfaction is vital for organizational success.

Job satisfaction can be defined in various ways. Job satisfaction generally refers to workers' reactions toward their occupations by comparing the actual working experience with the desired or anticipated ones. Furthermore, job satisfaction has been described in the literature as an individual's pleasurable and emotional state, which arises from an individual's working experience. Thus, it is the worker's appraisal of the fulfilment level of the working environment or the workers' reaction to their jobs or organizations (Saner & Eyüpoğlu, 2015). Furthermore, job satisfaction reflects a worker's positive attitude and behavior, which influences his/her commitment to the assigned tasks (Munir & Rahman, 2016). Moreover, job satisfaction refers to an inner feeling of a worker that arises from the overall evaluation of the working environment (Gozukara & Colakoglu, 2016). In addition, job satisfaction can be viewed as a worker's perspective on the job by judging the psychological and physiological well-being level.

Maslow's hierarchy of needs theory suggests that an individual's satisfaction is derived from the ability to fulfil his or her needs. Job satisfaction does not merely arise from self-satisfaction or happiness but is only subject to the work itself. Thus, job satisfaction represents many perspectives' emotions, thoughts, and feelings toward the work or workplace. Job satisfaction is a multidimensional construct affected by all kinds of intrinsic and extrinsic job elements (Ali et al., 2014). Internal factors include individuals' values, principles, and job expectations, while external factors include the nature of the job and opportunities provided by the organization. It is a subjective opinion that will vary from person to person, but the outcome is very useful in motivating workers (Belias et al., 2015).

Job Satisfaction in the Construction Industry

Construction professionals' job satisfaction has become an organizational objective in recent times. Organizations must use their limited resources to improve job satisfaction to survive in this competitive environment, especially when the construction industry is booming. Organizational technologies are no longer crucial because another organization can easily replicate or copy them. It is the human resource that makes an organization unique.

Thus, to retain their position in the industry, construction companies must uphold and maintain sufficient job satisfaction among their employees. Investing in every construction personnel by providing training, motivation, and compensation is essential, as their performance reflects their outputs. Hence, their level of job satisfaction can be increased, thus resulting in a higher organizational commitment (Giritli et al., 2013).

Research has shown that several factors can influence job satisfaction. For instance, while construction professionals may be satisfied with their work, other issues, such as job security, benefits, and salaries, should also be given considerable attention in the organization (Dabke, 2005). Due to the nature of construction activities, a safe workplace has always been an issue, regardless of the safety measures taken at the construction sites (Siu et al., 2003). Research on the job satisfaction of construction personnel can be categorized into employees' characteristics and job features. In the construction industry, motivation is essential in driving job satisfaction. While professionals' motivation arises from intrinsic factors, unskilled construction workers derive it from extrinsic factors (Bowen & Cattell, 2008).

Quantity surveyors are critical professionals in the construction industry who fulfil varied and comprehensive obligations in producing cost-effective construction projects. Therefore, variables and motivating factors impacting quantity surveyors' job satisfaction must be extensively examined to determine their extent of job satisfaction. These factors can be categorized as personal and organizational factors. Personal factors are employees' characteristics, including age, gender, length of service, education level, marital status, and race. Organizational factors include salary, promotion, job security, the relationship between colleagues, relationship with the superior, workload, and working environment (Famakin et al., 2014).

Previous Studies on Quantity Surveyors' Job Satisfaction

Jaafar, Yaziz, Nuruddin, and Jalali (2014) found that female quantity surveyors were most satisfied with the employer-employee relationship, followed by the value of work, relationship with colleagues, and working environment. The most dissatisfying factor was the pay level. Moreover, Bowen, Cattell, Distiller, and Edwards (2008) also showed that the demographic factors of the quantity surveyors significantly linked with job satisfaction were race and gender. Workplace characteristics significantly influencing job satisfaction were personal satisfaction, accomplishment, recognition, participation in decision-making, opportunities to perform challenging and varied tasks, supervision degree, and interaction with others. Oyewobi (2013) finds that the factors that positively influence the job satisfaction of quantity surveyors are intrinsic values such as adequate recognition, advancement opportunities in terms of proficiency and career promotion, and clarity of role and job that leads to self-accomplishment.

Samarasinghe (2016) finds that quantity surveyors were moderately satisfied with their jobs. The factors influencing their job satisfaction are Pay, personal satisfaction with work done, appreciation and feedback received, teamwork, working relationships with superiors and colleagues, job accomplishment, and awareness of career prospects. The result aligns with Oyewobi, Suleiman, and Muhammad-Jamil (2012), who found a positive relationship between job satisfaction and commitment among the public sector's quantity surveyors. Job satisfaction was significantly influenced by adequate recognition, opportunities for promotion, personal proficiency enhancement, role clarity, opportunities, and job clarity with planned goals and objectives. Onukwube (2012) added that consultant quantity surveyors' satisfaction is derived from the relationship with colleagues, the nature of work performed, and superior supervision, while massive dissatisfaction comes from promotion and salaries. Male quantity surveyors with older age and higher education levels can have greater job satisfaction. Additionally, Bowen, Cattell, Distiller, and Edwards (2008) outlined that quantity surveyors' significant motivators in the workplace include personal satisfaction for work done, relatively low degree of supervision, participation in decision-making, assigned challenging work, recognition of accomplishment, and regular feedback on performance. On the other hand, female quantity surveyors had lower job satisfaction due to long working hours.

RESEARCH METHODOLOGY

The research paradigm is essential in reviewing the assumptions and philosophical positions underpinning research methodologies that directly or indirectly influence the approaches applied to research (Easterby-Smith et al., 2015). This research adopts a quantitative and cross-sectional data collection method to achieve the study objectives. The questionnaire was the research instrument used to collect data. One hundred sixty-eight questionnaires were distributed to the respondents through email from December 2018 to January 2019 using a simple random sampling technique. The structured questionnaire consisted of two sections. Section A is for the respondents' demographic information, while Section B presents the factors that influence job satisfaction. The demographic information in section A of the questionnaires included employment sector, age, gender, job category, job position, marital status, race, level of education, and years of experience in the job and present organization. In Section B, the questionnaire was further divided into five parts based on Maslow's hierarchy of needs and contained twenty-one questions.

Following Kamaruddeen et al. (2020), the relative importance index (RII) was adopted in this study. RII values were obtained using Equation 1 with the statistical package for the social sciences (SPSS) software.

$$RII = \sum W / A*N \quad (1)$$

Where RII is the relative importance index,

W is the weight assigned to each factor by the respondent on a scale of one to five,

A is the highest weight (5 in this research), and

N is the total number of samples.

Based on Kamaruddeen, Sung, and Wahi (2020), the level of importance was used to interpret the RII values obtained as follows: high importance (RII = 0.8-1), high-medium

importance (RII = 0.6-0.8), medium importance (RII = 0.4-0.6), medium-low importance (RII = 0.2-0.4) and low importance (RII = 0-0.2).

RESULT

Table 1. Respondents' Profile

Classification	Category	Percentage
Employment sector	Public sector	23.5
	Private sector	76.5
Age	≤ 20 years old 21-30 years old	73.5
	31-40 years old	14.7
	41-50 years old	2.9
	≥ 51 years old	8.8
Gender	Male	55.9
	Female	44.1
Job category	Consultant Quantity Surveyor	8.8
	Contractor's Quantity Surveyor	58.8
	Quantity Surveyor in consulting and contracting firm	32.4
Marital status	Married	38.2
	Unmarried	58.8
	Divorced	2.9
Race	Malay	2.9
	Chinese	82.4
	Bumiputera	14.7
Level of education	PhD	8.8
	Degree Diploma STPM	52.9
	SPM or below	38.2
Years of experience in this job	≤ Five years	64.7
	5-10 years	20.6
	10-20 years	5.9
	≥ 20 years	8.8
Years with the present organization	≤ Five years	76.5
	5-10 years	20.6
	10-20 years	2.9

The descriptive statistics presented in Table 1 indicate that most of the respondents in this study are from the private sector, with 76.5% compared to 23.5% from the public sector. The majority of the respondents were aged 21-30 years old, which accounted for 73.5%, followed by 31-40 years old with 14.7%, more than 51 years old with 8.8%, 41-50 years old with 2.9%, and no respondent is less than 20 years old. Males accounted for 55.9%, while females accounted for 44.1%. Moreover, 58.8% of the respondents are from contractor firms, 32.4% are from consulting and contracting firms, and only 8.8% are from consulting firms. For the job position, 44.1% were senior Quantity Surveyors, 38.2% were junior Quantity Surveyors, and 8.8% each for both Chief Quantity Surveyors and Assistant Quantity Surveyors. Most respondents were unmarried, followed by married and divorced (58.8 %, 38.2 %, and 2.9 %). Regarding ethnic groups, Chinese had the highest response rate of 82.4%, while Bumiputera accounted for 14.7% of the respondents and only one from Malay (2.9%). 52.9 Of the respondents, 52.9% were degree holders, 38.2% were diploma holders, and 8.8% were doctorate holders. 64.7 Of the respondents, 64.7% worked as Quantity Surveyors for less than

five years, 20.6% worked as Quantity Surveyors for 5 to 10 years, 8.8% worked for more than 20 years, and 5.9% worked for 10 to 20 years. Lastly, 76.5% of the respondents worked in their organization for less than five years, 20.6% from 5 to 10 years, and 2.9% from 10 to 20 years.

Satisfaction with Physiological Needs

The extent of satisfaction with each element of physiological needs was determined based on the calculated average index. As shown in Table 2, respondents agreed that they were satisfied with the overall working conditions, with an average index of 3.56, flexible working hours with an average index of 3.68, and opportunity for social interaction with an average index of 3.68. However, the respondents had a neutral response to their satisfaction with monthly salary, with an average index of 3.06, and maternity and paternity leave entitlement with 3.32. The ranking between the elements in satisfaction with physiological needs was identified using the relative importance index calculation. Flexible working hours and opportunities for social interaction significantly influence satisfaction levels, as they scored the highest relative importance index of 0.385. The next is the overall working conditions with a relative importance index of 0.372, maternity and paternity leave entitlement with a relative importance index of 0.348, and monthly salary with a relative importance index of 0.320. In summary, the respondents had neutral satisfaction with physiological needs, with an average index of 3.46.

Table 2. Satisfaction with Physiological Needs Respondents' Profile

Physiological Needs	Scale (%)					Mean	Std. Dev	RII	Rank	Level
	1	2	3	4	5					
Monthly Salary	-	32	38	21	9	3.06	0.952	0.320	5	Neutral
Overall working conditions	-	9	26	65	-	3.56	0.660	0.372	3	Agree
Flexible working hours	3	3	27	59	9	3.68	0.806	0.385	1	Agree
Maternity and paternity leaves Entitlement	-	18	32	50	-	3.32	0.768	0.348	4	Neutral
Opportunity for social interaction	-	-	38	56	6	3.68	0.589	0.385	1	Agree
				AVERAGE		**3.46**	**0.755**	**0.362**		**Neutral**

The importance of monthly salary is in line with previous studies that showed that when employees receive a salary that matches those in other companies, it increases their job satisfaction (Bowen & Cattell, 2008). Furthermore, the overall working conditions align with the previous study, which confirmed that respondents agree with their satisfaction with the overall working conditions (Jaafar et al., 2014). Again, flexible working hours are also consistent with the result from a previous study where the employees agreed to be permitted flexible working hours. Furthermore, maternity and paternity leave entitlement are similar to the previous study, where they do not significantly affect job satisfaction. Finally, the opportunity for social interaction also shows a similar result with previous research, which significantly influences overall job satisfaction (Bowen & Cattell, 2008).

Satisfaction with Safety Needs

The extent of satisfaction with safety needs was identified based on the degree of the average index. Table 3 shows that respondents agreed on the importance of safety and job security (3.88). Non-discrimination on gender with an average index of (3.56). Non-

discrimination on race or ethnicity with an average of (3.94), and non-harassment condition with an average index of 3.56. Responses on all the elements in safety needs vary greatly except job security, as all three elements score around one standard deviation, while non-discrimination on gender score was the highest at 1.078. The ranking between the elements in satisfaction with safety needs was also identified according to their relative importance index. Non-discrimination on race or ethnicity was ranked the highest with a relative importance index of 0.412, followed by job security with a relative importance index of 0.406. In contrast, non-discrimination on gender and non-harassment conditions ranked the lowest with the same relative importance index of 0.372.

Respondents generally expressed their satisfaction with safety needs with an average index of 3.74, indicating that they were satisfied with their safety needs. Furthermore, the result on job security contrasts with the previous study result, where job security is not a significant factor in job satisfaction, as only half of the respondents agreed that their occupation provided a high level of security in employment. Similarly, the result on non-discrimination on gender contrasts with the previous study, where it is not a significant factor influencing job satisfaction. However, non-discrimination on race or ethnicity has similar results to the previous study, where most of the respondents had suffered from such discrimination. Last but not least, the result of the non-harassment is again contrasted with the previous study, where fewer respondents had such harassment experience, which leads to no significant factor influencing job satisfaction (Bowen & Cattell, 2008).

Table 3. Satisfaction with Safety Needs

Safety Needs	Scale (%)					Mean	Std. Dev	RII	Rank	Level
	1	2	3	4	5					
Job security	-	-	21	71	9	3.88	0.537	0.406	2	Agree
Non-discriminationon gender	3	18	18	44	18	3.56	1.078	0.372	3	Agree
Non-discrimination on race or ethnicity	3	3	18	50	27	3.94	0.919	0.412	1	Agree
Non-harassment Condition	6	12	12	62	9	3.56	1.021	0.372	3	Agree
				AVERAGE		**3.74**	**0.889**	**0.391**		**Agree**

Satisfaction About Belonging Needs

The average index also identified each element's extent of satisfaction with belonging needs. As shown in Table 4, respondents had neutral responses to job promotion, with an average index of 3.47. Meanwhile, respondents agreed on their teamwork and working environment relationships with colleagues, with an average index of 3.85 and 3.88. Responses on job promotion varied the most among elements in belonging needs, with a standard deviation of 0.896. The ranking between the elements in satisfaction with belonging needs was also identified according to their relative importance index. Working environment relationships ranked the highest, followed by teamwork with colleagues and, eventually, job promotion with relative importance indices of 0.406, 0.403, and 0.363, respectively.

Overall, respondents agreed on their satisfaction with belonging needs, with an average index of 3.73, indicating that respondents are satisfied with their job needs. The result on job promotion is in line with a previous study. The neutral responses on job promotion made this factor less significant on job satisfaction (Bowen & Cattell, 2008). However, the result on job promotion contrasts with another previous study, which found a strong relationship between

job promotion and job satisfaction (Salisu et al., 2015). Teamwork with colleagues is also in line with a previous study. Respondents agreed to have satisfaction with teamwork with colleagues, making it a significant factor in influencing job satisfaction (Yirenkyi-Fianko & Chileshe, 2012). Finally, the result on the working environment relationship is also similar to that of a previous study, which was found to influence job satisfaction significantly (Bowen & Cattell, 2008).

Table 4. Satisfaction About Belonging Needs

Belonging Needs	Scale (%)					Mean	Std. Dev	RII	Rank	Level
	1	2	3	4	5					
Job promotion	-	18	27	47	9	3.47	0.896	0.363	3	Neutral
Teamwork with colleagues	-	-	27	62	12	3.85	0.610	0.403	2	Agree
Working environment relationship with colleagues	-	-	18	77	6	3.88	0.478	0.406	1	Agree
				AVERAGE		**3.73**	**0.661**	**0.391**		**Agree**

Satisfaction on Need for Esteem

The average index also indicates the extent of satisfaction with esteem needs. As shown in Table 5, the respondents agreed on all elements of self-esteem, including job recognition by superiors or bosses, appreciation and feedback on work done, and job achievements, with an average index of 3.82, 3.65, and 3.94, respectively. Job recognition by superior or boss scores had the highest standard deviation in the need for esteem (0.626). Job achievements ranked the highest in need for esteem, followed by job recognition by superiors or bosses and appreciation and feedback on work done with relative importance indices of 0.412, 0.400, and 0.382, respectively. Overall, respondents agreed about their satisfaction with the need for esteem, indicating that respondents were satisfied with their need for esteem in a job with an average index of 3.80. 64 The result on job recognition by superiors or bosses is in line with the previous study, where it is a significant factor in job satisfaction. However, for appreciation and feedback on work done, the present study contrasts with the previous study, which found it insignificant. Last but not least, job achievements have similar results between the present study and previous studies in which job achievement is a significant factor in influencing job satisfaction (Bowen & Cattell, 2008).

Table 5. Satisfaction on Self-Esteem Need

Need for Esteem	Scale (%)					Mean	Std. Dev	RII	Rank	Level
	1	2	3	4	5					
Job recognition by superior or boss	-	-	29	59	12	3.82	0.626	0.400	2	Agree
Feedback and appreciation for work done	-	3	32	62	3	3.65	0.597	0.382	3	Agree
Job achievements	-	-	15	77	9	3.94	0.489	0.412	1	Agree
				AVERAGE		**3.80**	**0.571**	**0.398**		Agree

Satisfaction About Self-actualization Need

The average index determined the extent of satisfaction with the need for self-actualization. As shown in Table 6, the respondents revealed that satisfaction with work done, assigned non-repetitive work and challenging work, degree of supervision, and independence provided an opportunity for participation in decision-making with average indexes of 3.79,

3.59, 3.50, 3.62, and 3.68, respectively. The only element in need for self-actualization, in which the responses are neutral, is the amount of responsibility assigned, with an average index of 3.47. The assigned amount of responsibility is also the highest variation, with a standard deviation of 1.022. The ranking between the elements in satisfaction with self-actualization was also determined according to their relative importance index. The highest-ranked factor is self-satisfaction with work done, followed by the opportunity to participate in decision-making, independence provided, assigned non-repetitive work and challenging work, degree of supervision, and lastly, the amount of responsibility assigned with a relative importance index of 0.397, 0.385, 0.378, 0.375, 0.366, and 0.363, respectively.

The respondents generally agreed with the need for self-actualization in a job, with an average index of 3.61. For self-satisfaction of work done, the result is in line with previous research, which confirmed that it is a significant factor in influencing job satisfaction. Furthermore, assigned non-repetitive and challenging work has been found in previous studies to be one of the significant factors influencing job satisfaction. Moreover, most respondents agreed about their satisfaction with the degree of supervision, which does not agree with previous studies, as it is one of the insignificant factors influencing job satisfaction. In addition, the amount of responsibilities assigned is also a significant factor influencing job satisfaction. Lastly, the opportunity to participate in decision-making corresponds with a previous study where such a variable is a significant factor in influencing job satisfaction (Bowen & Cattell, 2008).

Table 6. Satisfaction About Self-Actualization Need

Need for Actualization	Scale (%)					Mean	Std. Dev	RII	Rank	Level
	1	2	3	4	5					
Self-satisfaction of work done	-	12	-	85	3	3.79	0.687	0.397	1	Agree
Assigned non-repetitive work, Challenging work	-	6	29	65	-	3.59	0.609	0.375	4	Agree
Degree of supervision	-	-	50	50	-	3.50	0.508	0.366	5	Agree
Independence provided	-	-	38	62	-	3.62	0.493	0.378	3	Agree
Amount of responsibility being assigned	-	21	29	32	18	3.47	1.022	0.363	6	Neutral

Table 7. Overall Determinants of Job Satisfaction

Job Satisfaction Indicators	Mean	RII	Rank
Esteem Need	3.80	0.398	1
Safety Need	3.74	0.391	2
Belonging Need	3.73	0.391	2
Self-Actualization Need	3.61	0.377	4
Physiological Need	3.46	0.362	5

Table 7 presents the overall level of satisfaction and the factors influencing job satisfaction among quantity surveyors in Sarawak. The respondents revealed their satisfaction on all the indicators of job satisfaction. The ranking for all indicators was based on the relative importance index values. The respondents were most satisfied with their esteem needs, followed by safety and belonging needs, ranked second, and need for self-actualization and physiological needs, having a relative importance index of 0.398, 0.391, 0.377, and 0.362, respectively. As shown in Table 7, the overall extent of job satisfaction was satisfactory, with a mean score of 3.67. Although only physiological needs have neutral responses, this finding is similar to the previous study (Bowen & Cattell, 2008). The means score of 3.67 indicates

that the overall level of job satisfaction among the quantity surveying surveyed in this research is high.

CONCLUSION

The objective of the present research was to identify the factors that affect the job satisfaction of Quantity Surveyors in Sarawak and to determine the extent of job satisfaction among Quantity Surveyors in Sarawak. Questionnaires were distributed to construction and consultant companies for their Quantity Surveyors to fill. As a result, their current extent of job satisfaction and factors influencing their job satisfaction were determined. Overall, the Quantity Surveyors in Sarawak agreed with their overall job satisfaction.

The criteria with the highest ranked Maslow's Hierarchy of Needs influencing Quantity Surveyors' job satisfaction are esteem needs: job recognition, appreciation and feedback, and job achievements. On the other hand, the factor that has the least influence on job satisfaction is physiological needs. Quantity Surveyors in Sarawak are most satisfied with their job achievements and non-discrimination on race or ethnicity, making these two factors the most significant factors affecting their job satisfaction. In contrast, Quantity Surveyors in Sarawak are more dissatisfied with their monthly salary than other factors, making it a minor significant factor affecting job satisfaction. However, although monthly salary is the lowest satisfaction among all the factors, it still falls under neutral satisfaction. Hence, the quantity surveyors in Sarawak agree with their overall job satisfaction, which also means that the current level of job satisfaction is high. Other than monthly salary, the factors that do not significantly influence job satisfaction include maternity and paternity leave entitlement, job promotion, and the amount of responsibility assigned.

Although Quantity Surveyors in Sarawak are satisfied with their current job satisfaction, there is still room for improvement, which allows them to be strongly satisfied with their job satisfaction. Thus, the highest factors in the present research should receive greater attention, including job achievements and non-discrimination on race or ethnicity. Employers, construction personnel, and professional bodies such as the Royal Institution of Chartered Surveyors, Board of Quantity Surveyors Malaysia, and Construction Industry Development Board can prevent Quantity Surveyors from discrimination on race or ethnicity environment in the Sarawak construction industry. Furthermore, top management should also focus on the most critical criteria in Maslow's hierarchy of needs: the need for esteem to enhance Sarawak Quantity Surveyors' job satisfaction.

Job satisfaction is a sensitive topic because it might be considered as exposing respondents' current organization. The sensitivity has resulted in a low response rate. Bias can be reduced by ensuring the confidentiality of the questionnaires through a declaration on the cover page of the questionnaires and the emails sent to them. Second, regarding the doubt about the confidentiality of the questionnaires, the respondents may tend to fill in positive responses and be conservative, thereby limiting the actual satisfaction result. Moreover, the present study only focused on identifying the characteristic workplace factors affecting job satisfaction of all Quantity Surveyors without considering demographic factors. Hence, future studies should identify the demographic factors affecting job satisfaction. Future research can also link demographic factors and workplace characteristics to identify the drivers of job satisfaction for each group of workers.

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ISSUES IN THE DESIGN AND BUILD (D&B) CONTRACT OF BUILDING INFORMATION MODELLING (BIM) PROJECT IMPLEMENTATION

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Abstract
Building Information Modelling (BIM) technology has been advocated as a highly efficient and effective approach thatcan minimize the cost, time and risk of construction from design to the state of construction of the project. In line withthat, appropriate legal commitments should be specified explicitly in a contract. On the reason of lack of clear guidelines on how to embrace and apply BIM in current contracts, BIM implementation in the Malaysian constructionsector has encountered disputes. This research is aimed to investigate the contractual issues in BIM as BIM implementation. Semi structured interviews were carried out with seven (7) respondents that have experienced and currently involved in full for the first time for D&B BIM projects in the Malaysian construction industry. There are nine (9) issues in the current contract which are interoperability, allocation of additional fee, allocation of risk, changes of model, model hosting and archiving, model ownership and intellectual property, privity and third-party reliance, requirement of model, spearin doctrine and standard of care. This paper is expected to give exposure to the government on the issue in the current Design & Build (D&B) contract in the implementation of BIM and direct thegovernment in improve D&B contract between client and contractor to be compatible with their specific context and needs.

Keywords: *BIM; Contract; Design and Build; Public Project; Contractual risk*

INTRODUCTION

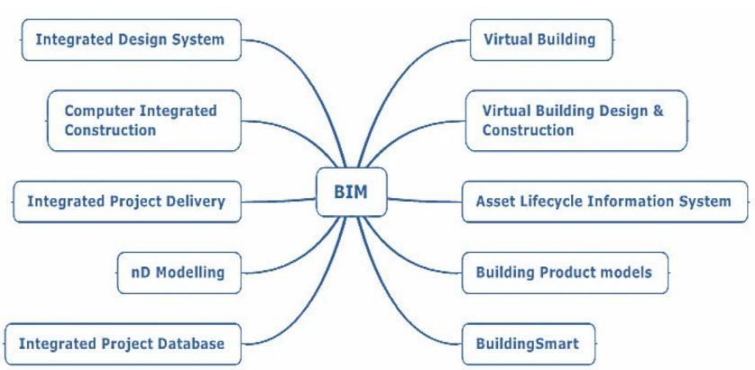
The Malaysian construction industry has been known as a significant sector that drives the Malaysian economy. Therefore, transforming the construction sector is one of the priority areas identified in the Eleventh Malaysia Plan (11th MP) as fundamental drivers for increasing economic growth momentum (CIDB, 2017). Building Information Modelling (BIM) technology has been emphasize as a highly efficient and effective approach that can minimize the cost, time and risk of construction from design to the state of construction of the project (Jo et al., 2018). BIM is also considered as an advanced information technology that can help the construction sector to increase efficiency, competitiveness, and quality (CIDB, 2017).

In addition, Dato Sri Haji Fadillah Bin Hj Yusof who is the Ministry of Public Works Department (PWD) reported that BIM can use the data built not only in the planning and design phase, but also in the execution phase while construction is ongoing (Fariza & Rashid, 2020). Due to that reason, the government has taken a critical role in supporting Malaysia's effective adoption and implementation of BIM. By year 2018, PWD was compelled to embrace BIM in Malaysia because of its potential to improve project execution and facilities management (Zainon et al., 2016). Thus, the government under RMK 12 had mentioned regarding the requirement to implement Building Information Modelling (BIM) in the construction to increase the productivity of construction (Fariza & Rashid, 2020). There are many initiatives provided by our government to promote the successful execution of BIM in the AEC industry. Similarly, Public Works Departments (PWD) created BIM Unit Projects

through the Asset Planning Branch (IAPB), which is in charge of creating BIM Standard Manuals and Guidelines as standard practice for construction participants to apply BIM in projects (Latiffi et al., 2013). Aside from that, the Construction Industry Development Board (CIDB) created a BIM Portal to give information on products, training, and consulting linked to BIM (Latiffi et al., 2016). However, due to a lack of clear guidelines on how to embrace and apply BIM in current contracts, BIM implementation in the Malaysian construction sector is still facing legal disputes. Therefore, it is important for this research to investigate the issues with the use of design and build contract in BIM implementation in the construction project.

BUILDING INFORMATION MODELLING (BIM)

Building Information Modelling (BIM), also known as n-Modelling or Virtual Prototyping Technology, is a breakthrough in the Architecture, Engineering, and Construction (AEC) sector (Azhar et al., 2012). BIM is both a technology and a process. It allows project stakeholders evaluate what should be presented in a virtual environment to identify potential design, building, or organizational issues (Azhar et al., 2012). BIM also is intended to replace drawing as the major source of design information and the main contact medium (Memon et al., 2014). Moreover, it contains all of the building data required to generate a technical construction document appropriate for building construction. The design includes the estimation, scheduling and costing for the production of Bills of Quantities, the derivation of productivity rates and the cost of labor (Memon et al., 2014). The Building Information Model is a project simulation from a technological point of view, that consists of 3D project models connected to all required information relating to project planning, architecture, development or activity, as seen in Figure 1.



(Source: Coates, 2013)

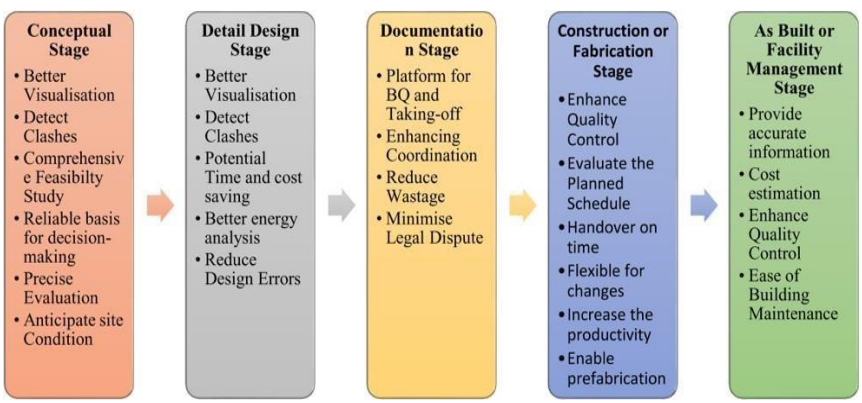
Figure 1. Relationship of BIM with Other Concept

BIM BENEFIT

As a highly efficient and effective solution, BIM can minimize the cost, time and risk of construction from the design stage to the construction building process (Jo et al., 2018). It establishes a design framework that can accommodate both design disciplines and project teams involved in the construction process. Architects often view BIM as a time-saving method of creating 3D models, while contractors focus on the benefits of reducing construction accidents and improving dispute detection, and engineers appreciate enhanced simulation and research models. Furthermore, by improving the consistency of schedule and

cost information across the project life cycle, the efficiency and usability of operations may be enhanced (Memon et al., 2014).

This would minimize faults and rework attempts and decrease the time required. Besides that, BIM is very useful in benchmarking as it assists in finding improved and innovative solutions. These processes are performed at multiple stages which assists all disciplines across. Apart than that, BIM benefits range from short- term to long-term commitment for a project or company improvement (Musa et al., 2018). As it includes several phases that serve all disciplines across. Further, the advantages of BIM's implementation may also be demonstrated by various phases of the life cycle, such as the conceptual, detailed design, documentation, construction or fabrication and the as built or facility management phases.



(Source: Teng et al., 2018)

Figure 2. The Benefit of BIM in Different Stages of The BIM Project

THE USE OF CURRENT CONTRACT IN BIM

In Malaysian construction industry, there are different types of contract forms used. Different types of contracts have different strategies for market control, risk transfer, performance responsibility, cost certainty and ambiguity (Zahrizan Zakaria et al., 2014). The contracting process for construction involves a range of different professionals or groups to contribute to the work at different times. Therefore, the intent of conventional contract forms is to foster mutual ties between the project participants. There are many standard contract forms in Malaysia, including Malaysian Institutes of Architect (PAM), Public Work Department (PWD) and the International Federation of Consulting Engineers (FIDIC) (Nisa Lau et al., 2018). The use of each traditional contract form is subject to the type of project associated, the project complexity and the funding involved.

The Malaysian Public Works Department (PWD), the government governing body of the PWD203A contract forms, finances all projects. Traditional construction and civil engineering contracts based on the bill of quantities (203A) are designed for usage in the public sector or government projects. On the other hand, the conventional PAM (Malaysia Institute of Architect) contract form has been extensively used by the construction industry, especially for private projects in Malaysia (PAM, 2006). PAM presented a complete overhaul of the 2018 PAM Form, which was replaced by the 2018 PAM Form. The PAM form is a home base form for problems that are deemed to be local industry, and it is intended to be utilized as a construction company rather than a structural engineering contract (PAM, 2006).

The International Federation of Consulting Engineers (FIDIC) is another type of contract that is utilized. It supplies standard civil engineering contract forms that may be used all over the world. FIDIC arrangements are also referred to as international standards. Accordance with the common arrangements for this type of contract, contractor shall construct the work in conjunction with the specifications given by the employer (Zarabizan Zakaria et al., 2013). However, this may involve certain aspects of the design of contractors, civil, mechanical and electrical work or construction work.

Selection of the type of contract used is a crucial component in the building project's success. It shows that whether FIDIC, PAM, or PWD 203A are used as contract agreements varies on the kind of project, the nature and the amount of financing involved (Nisa Lau et al., 2018). The parties participating in project management will be more successful and efficient if they grasp the substance of contract forms (Jo et al., 2018). In fact, despite advancements in technology, the use of standard form has not changed. Whereby nowadays, many technologies such as Autodesk Revit, Tekla, and Glodon, have been widely utilised in advanced digital construction in Malaysia, and it has become a key aspect of the construction sector (Jo et al., 2018).

Thus, it is proven that many contractual and regulatory issues occurred due to the implementation of BIM in the constructions. The collaboration and integration of work among different number of parties to exchange data in a 3D virtual model, such as architects, engineers, contractors and related supply chain representatives. As mentioned by Jo et al., (2018) several issues occurred during the implementation of BIM such as model rights, data transfer risk allocation, copyright and reliance of data insurance, interoperability between the parties in BIM (Jo et al., 2018).

PREVIOUS STUDIES RELATED TO CONTRACTUAL ASPECT OF BIM IMPLEMENTATION

Previous research has been reviewed from the year of 2015 to 2021 based on their titles, objectives and aims that are similarly related to the implementation of BIM from contract perspective in Table 1. Jo et al. (2018) studies on legal concerns and two typical local standard contract forms in order to demonstrate provisions that are important to BIM practice. Moreover, they also assess the PAM and CIDB contract forms using a content analysis method. Abd Jamil & Fathi (2017) on the other hand, conducted a study on contractual difficulties for Building Information Modelling (BIM) in Malaysia, concentrating on a specific public project. There are numerous impediments to the adoption of integrated BIM contract agreements, according to their research.

Apart from that, many researchers focused on the challenges and solutions from legal perspective that focusing on implementation of BIM in other than Malaysia construction industry (Memon et al., 2014); Eadie et al. (2015); Aibinu & Papadonikolaki (2016); Englund & Grönlund (2018); Fan et al. (2018); Bodea & Purnu (2018); and (Kaya et al. (2019). The capacity to define the model as a legal act and rank the model higher than drawings in a contract was discovered as a key difficulty throughout the investigation. Meanwhile, Holzer, (2015) conducted research regarding the impact of BIM in contract procurement methods. Whereas Holzer (2015) has identified that contract procurement methods in the construction industry have a major impact in the way BIM can be applied collaboratively throughout

different stages of design, construction, and operation.

Silius-Miettinen & Kähkönen (2017) have discovered judicial issues in BIM based operations particularly concerning the ownership and contracting trough BIM's life cycle. In the research, it addresses ways of avoiding legal issues which can help clients to achieve their objectives and promote business success. There also research had been made in Vietnam by Hai et al. (2020) which aim to analyze the trends of the world in establishing BIM contract terms.

Therefore, it can be concluded that most of the researchers have focused on the challenges of the contract in implementation of BIM. However, the issues in the current contract as BIM being implemented have never been discovered, especially in using design and build contracts. This is due to the numerous numbers of completed BIM public projects using design and build contracts. This research aim is to identify the issues in the use of design and build contract focusing on public project in Malaysia as now the legal contractual issues may become barriers to the benefits of BIM.

Table 1. Previous Studies Related to Contractual Aspect of BIM Implementation

Researcher	Details
(Jo, Ishak, and Rashid, 2018)	Legal concerns and two typical local standard contract forms in Malaysia
(Abd Jamil and Syazli Fathi, 2014)	Contractual difficulties for BIM in Malaysia
(Holzer, 2015)	Impact of Procurement Method
Memon et al. (2014), Eadie, McLernon and Patton (2015), Aibinu and Papadonikolaki (2016), Englund and Grönlund (2018), Fan et al. (2018), Bodea and Purnu (2018) and Kaya, Akcamete and Birgonul (2019)	Legal problems and solutions of BIM in other than Malaysia construction industry
(Silius-Miettinen and Kähkönen, 2017)	Current judicial problems in the BIM concerning the ownership and contracting trough BIM's life cycle
(Hai, Hai, Trung, and Huyen, 2020)	Analyze the trends of the world in establishing BIM contract terms

METHODOLOGY

This research used a qualitative method, by way of semi-structured interviews. A semi-structured interview is required due in-depth information is needed to identify the problem in the current practices of BIM as well as the potential improvement for BIM implementation in the contract. Moreover, this method is appropriate because previous studies have mostly used semi-structured interviews to obtain in-depth data. Semi-structured interviews have been conducted with seven (7) construction professional that have involved in implementing BIM in construction due to Zarabizan Zakaria et al. (2013) and Klassen et al. (2012) recommended a number of interviews between five (5) and twenty-five (25) as adequate for a phenomenological study where the researcher seeks to understand the different roles of humans as social actors and to understand their world based on their experiences in related matters. All of the interviewees are in the public and private sectors which have been involved in BIM design and building public projects. The question has been constructed based on an intensive literature review. The interview was divided into two (2) sections as in Table 2.

Table 2. The Questions

Section	Question	Aim
Section A	Respondents' Background	To review the respondents' backgrounds
Section B	Issues in the current practices of contract inBIM design and build project	To identify the issues in the current practices ofcontract in BIM D&B projects

Data has been collected from both primary and secondary sources for this study in order to acquire a diverse and appropriate amount of information on the topic. Meanwhile, for secondary data, it was done by obtaining all relevant information from journals, books and websites that related to the research. Then, content analysis was used as a method in analyzing qualitative data by using an Atlas TI.9. The software was designed to empower and help researchers to assess and improve their practices by establishing mechanisms that would allow properly planned strategies for change and be able to evaluate these for their effectiveness.

RESULTS AND FINDINGS

From the interviews, two (2) respondents are from the private sector, while the remaining five (5) are from the public sector. The respondents are all BIM practitioners who have used or are actively utilizing BIM in design and construction projects. Client, architect, structural engineer, M&E engineer, and contractor are among those who took part in the interviews. Apart from that, all responses are in charge of managing the design and construction project's operations.

Respondent Background

The purpose of this section is to discuss the respondents' background. All respondents have been in charge of managing the design and construction project's operations. The majority of BIM projects completed by respondents are residential and healthcare projects. The respondents will be represented by the indicators R1 to R7. Brief on respondent's background is shown in Table 3.

Table 3. Respondent's Background

Respondent	Category	Position	No of Project Using BIM
R1	Public Sector	Architect	6
R2	Public Sector	Civil Engineer	12
R3	Public Sector	Electrical Engineer	10
R4	Public Sector	Architect	10
R5	Public Sector	Quantity Surveyor	12
R6	Private Sector	Architect	3
R7	Private Sector	Quantity Surveyor	2

Based on Table 3, R1, R2, R3, R4 and R5 are the representative of the public sector. They are also the consultants on behalf of PWD client. R5 is the only quantity surveyor in the BIM unit that had managed twelve (12) projects in BIM. Apart from that, R2 and R3 were engineers in the public sector and had been involved in twelve (12) and ten (10) BIM projects. There were also architects under the public sector that has joined the interview which are R1 and R4 which both had involved in six (6) and tenth (10) BIM project. Moreover, there were two respondents under the private sector which are R6 and R7. R6 is the director of an architect firm that had involved in six (6) BIM projects while R7 is a director of the quantity surveyor

firm that had managed two (2) BIM project. Thus, the varieties of respondent designation could provide information related to BIM processes from pre-construction to post construction. Hence the info provided by the respondents could help to understand the BIM implementation throughout project life cycle. Experience of the private and public respondents are summarized in Figure 3.

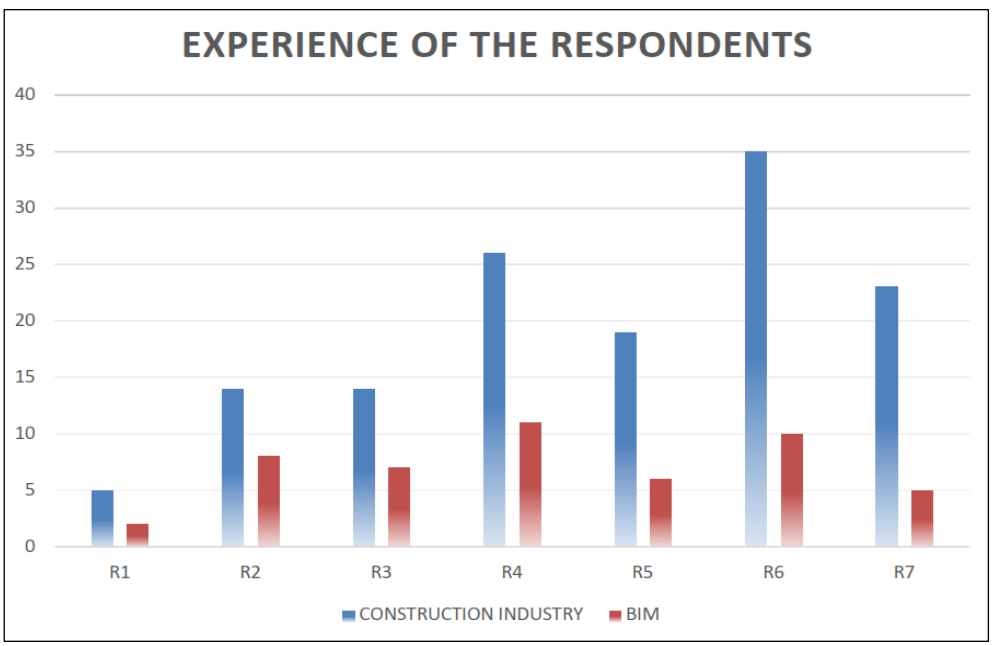


Figure 3. Respondents' Experience in Construction Industry and BIM Projects

Regarding the experience of the respondents, the blue bar in Figure 3 shows the experience of respondents in this study. It shows that most of the respondents had more than five years of experience in the construction industry. R6 has the highest number of experiences in the construction industry, which is 35 years. This is followed with R4 and R7 where both have the experience of twenty-six (26) and twenty-three (23) years. Apart from that, R5 which is from the public sector has been in the construction industry for 19 years. Furthermore, R2 and R5 which both was an engineer has the same number of experiences which are fourteen (14) years in the construction industry. Moreover, among those seven respondents R1 has the lowest number of experiences in the construction industry.

However, the number of experiences in BIM project was different among each of the respondents. The red bar in Figure 3 shows the experience of respondents in projects using BIM. It shows that R4 has the highest number of experiences in managing BIM project which is eleven (11) years as he was involved in the first project of BIM which is NCI. R6 also had the experience of managing the first BIM project which gave him have the experience of ten (10) years in BIM project. While R2, which is the engineer in the public sector has the experience of eight (8) years in BIM and followed with R3 which had managed BIM project for almost seven (7) years. In addition to that, R5 and R7 also have quite the same number of experiences in BIM which are six (6) and five (5) years. The lowest number of experiences is R1 with only two (2) years in BIM project.

Therefore, in-depth information related to BIM can be identified with various number of experiences of respondents. It is plausible to assume that all respondents have knowledge of BIM implementation in design and build projects based on their positions and experiences in projects using BIM. Furthermore, the longer a respondent has worked on a project utilizing BIM, the better their comprehension and expertise of BIM implementation in design and build projects. This is in sync with Latiffi et al. (2016) assertion that personal experience is the most important factor in developing knowledge on BIM implementation in construction project.

DISCUSSIONS

The purpose of this section is to discuss the issues stated by the respondents regarding the use of current contracts in D&B projects. From the network view from Atlas T.I 9 analysis as in Figure 4, ten (10) issues related to the use of current contract in BIM projects were identified from the extensive literature review. The issues are interoperability, allocation of additional fee, allocation of risk, model hosting and archiving, model ownership and intellectual property, privity and third-party reliance, requirement of model, spearin doctrine, standard of care and economic doctrine. Nevertheless, during the interview only nine (9) issues were mentioned by the respondents.

Table 4. The Issues in The Current Practices of Contract in BIM Design and Build Project

No	Issue	Respondents							Total Respondents
		R1	R2	R3	R4	R5	R6	R7	
1.	Interoperability	/	/	/	/		/	/	6
2.	Allocation of additional fee						/		1
3.	Allocation of risk	/	/				/	/	4
4.	Model Hosting and Archiving	/	/	/				/	4
5.	Model Ownership and Intellectual Property	/	/	/		/	/		5
6.	Privity and Third-Party Reliance	/	/	/	/	/	/		6
7.	Requirement of the model	/		/	/	/	/	/	6
8.	Spearin doctrine	/		/			/		3
9.	Standard of Care	/	/	/			/		4

The problem of interoperability has been mentioned by six (6) respondents as it occurred when BIM restricted interoperability between relevant software which has led to inadequate communication and workflow. This in line with (Couto et al., 2017; Huzaimi Abd Jamil & Syazli Fathi, 2019) where interoperability is the most challenging when considering scenarios where relevant information is managed by external data sources and must be integrated to extend and enrich BIM models. Moreover, R6 and R4 further explained that this problem occurs during the use of information during asset management. For example, the design phase begins in 2016, then when moving forward to asset management it will be 2021. That is where the problem began when the model from the software 2016 cannot be used to 2021 software. It is obvious that interoperability was a problem that occurred in the current contract as it was not clearly spelled out. Therefore, a structure of contractual procedures is therefore required to ensure that the data and structures of the project team are properly interoperable. This is in accordance with Winfield (2015), who claims that establishing standardized information sharing methods promotes consistency and reduces the risk of misunderstanding or misinterpretation.

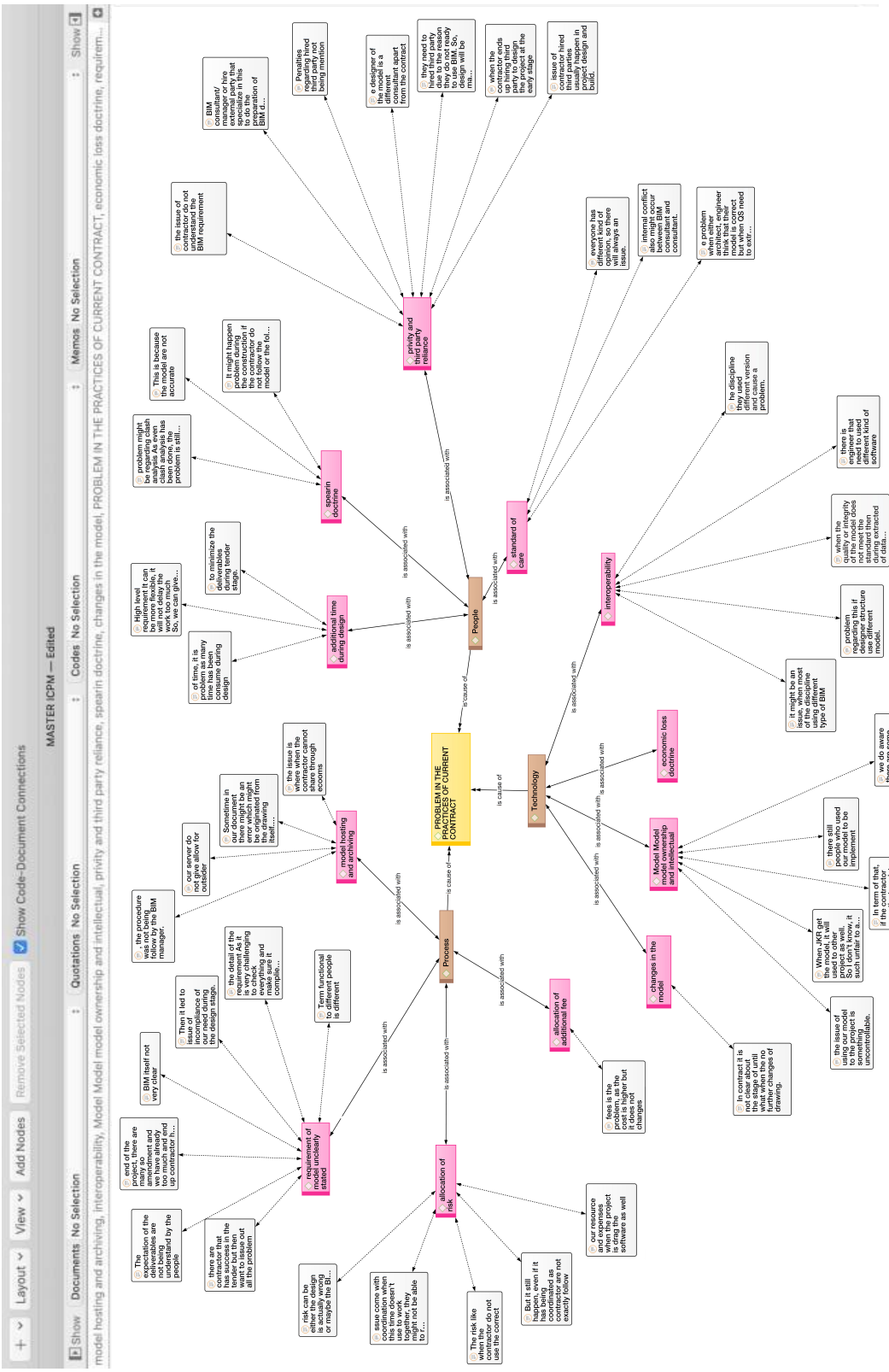


Figure 4. Network View for Issues in the Current Contract due to Implementation of BIM

The second issue is the additional fee which has been spelt out by R6 who is on the behalf of the private sector. R6 explained that conventional is very different as compared to BIM. Where R6 mention that by using BIM there required so much work as compared to the conventional construction method. This is because of the requirement needed by the project. As different phases has different type of Level of Detail (LOD) that required. This is in accordance with the findings of Jiang et al. (2018), who found that BIM adoption resulted in a significant initial cost and productivity loss. It also said that the integration of a BIM model and the requisite professionalism for the Client's benefit would invariably result in a higher consultation price. This problem was identified as a new finding during the interview.

Apart from that, the problem of allocation of risk also occurred. According to R1, R2, R6 and R7 where they explained that risk occurs when the contractor does not have the competency in using BIM. Where respondents further mentioned that most of contractors do not follow the correct procedures in the implementation of BIM. As explained by R1 where supposedly the contractor should have prepared the design using BIM at the early start of design stage but instead, they were using 2D then after that they model the 3D. This is where the problem and risk started to appear, as it became such a waste to the Client as they cannot see the model during the design phase. The issue occurred due to the lack of competency of the contractor. As explained by R2, most contractors and consultants do not specialize in BIM. This is where risk appears as it can be either the design is wrong or effected the project. This is in accordance with Mustaffa et al. (2020) who said that only a tiny fraction of construction industry are presently using 3D BIM due to a lack of awareness and understanding about its capabilities.

Furthermore, regarding the issue of model ownership and intellectual property R1, R2, R3, R4 and R5 explained that the owner of the model is the government, and it has been clearly stated in the guideline. Therefore, the contractor or even the consultants do not have any rights on the model, and it cannot be utilized in other projects. However, R2 further explained that there was a contractor that used part of the model to be implemented in another project. During the interview with R2, any penalties or regulations has never been clearly stated. Moreover, R6 explained that it is unfair for the designers as JKR also used part of the model to be implemented in other projects. In contrast, R3 also explained that the issue of using the model for other projects was uncontrollable as now they do not have any software yet to lock the model. This is in line with Leon L. Foster, P.E, PMP (2017) where stated that there are need of host because BIM risks associated with technology that must be considered and addressed within the contractual framework of the agreement.

Further, privity and third-party reliance has been mentioned by six (6) of the respondents. Respondents also further explained that the problem of hiring third party in model a project was usually a common problem in design and build project. This is because of the incompetence of the contractor and the consultant in design model during the early design stage. Public respondents also highlighted that due to contractors hiring third parties in doing the model, there were consultants that were reluctant to take responsibility. This is because the model was not created by the consultants. Moreover, it was identified that the issue of hiring a third party in the contract was an anticipated problem. Whereas R5 and R2 explained it has not been specified anywhere in the contract regarding any penalties of hiring third parties. However, the public respondents mentioned that this problem was not important on their side as they focus on the deliverables of the project. This is in accordance with (Nulton,

2013), who claims that the lack of a contract between the designer and the other project participants works as a shield, protecting the design team from a variety of responsibilities. It is feared that the collaborative nature of BIM procedures may accidentally establish a privity of contract if preventative measures are not implemented.

Apart from that, the problem of requirement of the model also occurred in the implementation of BIM as it was mentioned by six (6) respondents. The respondents explained that there is always a problem of consultants who cannot achieve the requirement due to the lack of understanding of the guidelines. In addition to that, private respondents also highlighted that they cannot comply with the requirement because it was highly strict. It was explained by them that due to highly strict requirement the contractor have to suffer delay as it takes too much time in design requirement of model has been stated in the contract but there were still contractor or consultant cannot achieve and cause problem in the project. However, there was no action taken by either consultant or contractor due to the problem. This is in accordance with the findings of Criminale & Langar (2017), who found that corporations face more opposition to BIM deployment than projects. The majority of the key hurdles were due to staff training and the lack of national BIM standards.

Results of this study also revealed the issues of spearin doctrine in current contract. Whereas according to R1 the problem of contractors does not following the model occurred in the implementation of BIM. This led to the issue on the construction site which further will cause delay. As explained by R3 the problem on the construction occurred due to the inaccuracy of the model. Whereas R3 explained that even the coordination has been made it does not mean that the model was free clashes. Moreover, R3 explained that the issue occurred due to the reason of multidisciplinary in a model. This is in accordance with Savitri et al. (2020) who claim that the major cause of the discovered disagreement is a lack of interdisciplinary cooperation between contractors and consultants. Further, R6 also explained that even though the clash analysis has been done, there was still problem occurred on site.

The problem of standard of care also has been revealed by R1 which explained that in a BIM project there will be BIM manager and BIM coordinator to handle the model. However, R1 further explained that the problem occurred when there were consultants that could not accept the opinions of the others. This is where the issues occurred due to the internal conflict between the design team. As explained by R2, R3 and R6 where internal conflict between consultants did occur due to, they have their own term, and its determination involves experience, insight and common sense in solving a problem. However, as mentioned by R3 that the problem of conflict between the consultants usually can be solved during coordination. This is because during that stage, the conflict in the clash analysis can be resolved.

There were many problems in the implementation of BIM but has never been mentioned clearly in the contract regarding the legal right for the parties. Thus, it has identified nine (9) problems that occurred in the current contract based on the interview with the respondents. It can be concluded that each background of the respondents has a different perspective about how the problem affected the BIM design and build project. Moreover, public and private sector had also shown differences in the way they handled the problem. This is because the impact of the problem was more towards the contractor and the designer especially for this design and build project.

Current practices of contract in the implementation of BIM in design and build project have been documented. The interviews have discovered similarities of understanding of BIM between all the respondents. Where BIM is a 3D model that consists of data and information that can help throughout the lifecycle. Thus, BIM can be used as a digital repository for an integrated system in which players can contribute and share data, simulate and visualize possible outcomes during design, embed virtual objects with robust information at various stages, and use a variety of collaboration tools to achieve project goals.

However, there is also a contrast in the understanding between each of the construction players depending on their scope of work in a project. Then, it also discovered the used of JKR BIM requirement and need of statement in complement the current contract. The requirement and need of statement were identified only cover the deliverables of the project and not the legal right of the party. Therefore, by adapting new legal instruments, BIM adoption can be enhanced, as BIM cannot support long-term solutions to the limits of traditional fragmented processes until obvious difficulties caused by gaps in its legal frameworks and business models are solved.

CONCLUSIONS

There are issues in the current practices of contract due to the implementation of BIM in design and build contract. There are nine (9) issues in the current practices of contract which are interoperability, allocation of time during design, allocation of additional fee, allocation of risk, model hosting and archiving, model ownership and intellectual property, privity and third-party reliance, requirement of the model, spearin doctrine and standard of care. These issues have shown different perspectives between public and private sectors. It has been identified that the public sector perceived that the issues occurred are manageable. In contrast with the private sector was stated that these issues have led to inefficiency and can affect the progress of a project. Nevertheless, lacking in legal dispute in the contract can cause issue of misinformation and misleading judgement. Due to the concern on the degree of complexity, the trustworthiness of the data, the absence of experimental backing, the potential of data manipulation, and judges' limited expertise, the reliability of the BIM model in settling disputes is regarded a major legal issue. Hence, results of this study are expected to help the government successfully adopt and implement BIM in design and build contracts which eventually reduce construction cost and improve the efficiency of their construction process. In terms of further research, studies exploring the issues in other types of contracts and the ways to overcome the issues are recommended. In which, there is limited research that explores the issues within the contract within the BIM implementation in the construction industry.

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UNVEILING ABUSIVE SUPERVISION IN PROJECTS: EVIDENCE AND FUTURE RESEARCH DIRECTIONS

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Abstract
The detrimental effect of abusive supervision on individuals and organizations is evident in studies across multiple fields and disciplines. However, scholars have greatly overlooked this phenomenon in the project context. Projects that involve a great deal of dynamism and uncertainty regarding performance outcomes provide a suitable context to investigate abusive supervision. This study highlighted the existence of abusive supervision in the project context and review extant research to provide opportunities for advancement of empirical research on abusive supervision in projects.

Keywords: *Abusive Supervision; Projects; Project Management*

INTRODUCTION

With globalization and technological advancement, new methodologies have been developed to assist organizations in achieving their goals and objectives successfully. To some extent, technological advancement has reduced human involvement in the processes. However, human participation remains crucial in achieving growth, progress and success. This is because at every step of a process, human involvement is required and it is vital in projects. Previously, project management theory building has been largely considered through practical application and defined as normative concepts and handy tools (Sydow & Braun, 2018). Recently, researchers have argued that it is inappropriate to consider projects just as a tool (Li, Lu, Cui & Han, 2019). Therefore, human resource management and behavioral schools are now being considered as essential components of research in project management (Li et al., 2019). Organizations are shifting their operations from traditional to project-based organizations exponentially (Cheng, Dainty & Moore, 2005). This shift requires research and empirical evidence in the project setting not only from technical but human aspect as well.

The objective of the current study is to shift the focus from methodologies, techniques, and tools in project management to human behavior because understanding human behavior has a central role in accomplishing the desired goals. To put this in perspective, a project manager can be seen as the captain of the ship, and responsible for project completion within multiple constraints. Therefore, it is significant to understand the project managers' behavior toward subordinates in the project. Within the context of projects, previous studies have emphasized more on positive leadership behavior (Hassan, Bashir & Abbas, 2017; Kabore, Sane & Abo, 2021; Tyssen, Wald & Speith, 2014). Nonetheless, very little is known about the negative leadership behavior in projects (Rafique, 2023; Rafique, Jaafar, Zafar & Ahmed, 2023). It is believed that abusive supervision exists in the project environment; however, the project management literature did not address this topic sufficiently (Rafique et al., 2023). Hence, the aim of this study is to highlight the presence of abusive supervision in projects. It also intends to describe its background and meaning to stimulate an effective application of empirical research in the project context.

ABUSIVE SUPERVISION IN PROJECT MANAGEMENT

Even though abusive supervision has long been acknowledged in research, measurement, and theory in other contexts and fields (e.g., military, health, education), however, it remains an overlooked area in project management. Due to the nature of projects, the interaction between supervisor and subordinates is vital to achieve the desired project objectives. Such an interaction can form strong and negative relationships, which makes the project contexts suitable for investigating the '*positive side'*, as well as '*dark side'* of organizational behavior. The focus of this study is abusive supervision that comes under the *dark side* of organizational behavior. Researchers have called for research on abusive supervision in contexts that are characterized by high workload and stress; and undoubtedly, project environment is full of uncertainty, complexity and work stress (Liu & Low, 2011; Sallehuddin, Omar & Sarpin, 2022; Tepper, 2007). Due to complexity and uncertainty in projects, the project manager has tedious responsibilities to adjust quickly to changing requirements and balance the stakeholders' demands (Gustavsson, 2016; Rezvani, Chang, Wiewiora, Ashkanasy, Jordan & Zolin, 2016). Although, the project managers' goal is to finish the project while adapting to changing circumstances, however, when goals are threatened by conditions, such as, stress and insecurity (Eissa & Lester, 2017), emotional and physical resources are depleted, thereby leading to a negative leadership behavior (Li, He & Sun, 2020). A study by Fordjour, Chan and Tuffour-Kwarteng (2020) revealed that construction employees ranked abusive supervisors as the prominent factor influencing the psychological health of employees. These authors further contended that studies ignored empirical testing of this phenomenon in the project context.

There are several reasons for the presence of abusive supervision in project management. Previously, researchers concentrated more on the technical dimension of projects rather than the behavioral aspect, and greatly overlooked the human involvement in project progress, which is paramount for project success (Hobday, 2000; Javed, Syed & Javed, 2018). In today's world, human resource has a major influence on project success (Belout & Gauvreau, 2004). According to Levasseur (2010), human related issues contribute 65% to project failure in information technology projects. Despite the fact that IT sector is more technically oriented as compared to the construction sector where human plays a major role (Javed et al., 2018). Researchers argue that abusive supervision is not limited to certain fields rather it is a universal workplace menace, which is evident from research on abusive supervision in various domains (Pradhan, Srivastava and Jena, 2019). Others contend that previous studies have not discussed industry-specific abusive supervision thoroughly and this phenomenon still needs to be investigated within the context of project management because the project environment is more vulnerable to abusive supervision (Gallagher, Mazur & Ashkansay, 2015). Similarly, the project environment has high dynamism, workload, uncertainty, and time pressure (Liu & Low, 2011), which is why such environments are more susceptible to abusive supervision (Richman, Flaherty, Rospenda & Christensen, 1992). Moreover, by definition, project is a temporary endeavor, with a specific start and end period. Project-based companies are a popular form of temporary organization (Klindžić & Vlahov, 2019). Temporary organization is defined as aggregates of individuals working together temporarily for a shared purpose (Spanuth, Heidenreich & Wald, 2020). In such settings, individuals are hired for a particular project and after completion; they are either terminated or shifted to another project. Temporary workers are less inclined to change and adapt to a specific leadership style than permanent workers (Von Hippel, Mangum, Greenberger, Heneman &

Skoglind, 1997). Similarly, project managers are more likely to be abusive because they are aware that temporary workers are less likely to seek help (Yu, Xu, Li & Kong, 2020). These arguments lend support for the presence and investigation of abusive supervision in project management.

BACKGROUND OF ABUSIVE SUPERVISION

Abusive supervision in the organizational context has been linked to several other negative leadership behaviors such as petty tyranny (Ashforth, 1994), typology of deviant organizational behavior (Robinson & Bennet, 1995), and non-physical workplace aggression (Newman & Baron, 1997). Though, there is a conceptual convergence of these constructs with abusive supervision, however, there is a difference in their meaning, which justifies considering abusive supervision as a separate construct (Tepper, 2000). After Tepper's (2000) seminal work on conceptualizing abusive supervision as a distinct construct, researchers examined its application in several disciplines and domains, such as, retail and telecommunication (Agarwal, 2019), services industry (Dirican & Erdil, 2020), military (Waldman, Wang, Hannah, Owens & Balthazard, 2018), manufacturing (Peltokorpi & Ramaswami, 2021), health (Pradhan & Jena, 2018), hospitality (Wang, Hsieh & Wang, 2020), and education (Meng, Tan & Li, 2017). Surprisingly, its application in the project management field is still limited; it might be possible that for a long-time project management scholar have mainly focused on the technical aspect of project, instead of human behavior and more specifically project manager behavior. Studies on abusive supervision in different contexts and industries provided support to the argument of Pradhan et al. (2019) who contend that abusive supervision is a universal threat, and is not confined to a particular nation, society, or industry.

MEANING OF ABUSIVE SUPERVISION

For reference to the project management domain in the current study, it is referred as project manager's abusive supervision, which is defined as "subordinate's perceptions of the extent to which supervisors engage in the sustained display of hostile verbal and nonverbal behaviors, excluding physical contact" (Tepper, 2000, p. 178). Different manifestations of abusive supervision are reported in the literature, such as angry and loud tantrums, inconsiderable actions, public criticism, coercion, and rudeness (Bies, 2000), humiliating, yelling, and screaming at employees (Mitchell & Ambrose, 2007), assigning blame, invasion of privacy, and taking undue credit (Tepper, Duffy, Henle & Lambert, 2006). Abusive supervision is different from other similar negative leadership behaviors (Tepper, 2000). First, the target of abusive supervision involves people that are below in rank and include subordinates. Second, it includes verbal and nonverbal hostility, excluding physical hostility. Third, it focuses only on hostility. Fourth, it does not refer to any intended outcomes. The conceptualization, meaning and essence of abusive supervision will be similar in the project context; the only difference is that it is referred as project manager abusive supervision in the current study. Past research in diverse contexts and industries adopted it in a similar manner.

ANTECEDENTS AND OUTCOMES OF ABUSIVE SUPERVISION IN OTHER CONTEXTS

In management and organizational behavior literature, scholars have emphasized exploring the consequences of abusive supervision. Studies have identified it as an interpersonal stressor and explored its impact on diverse outcomes (see Zhang & Liao, 2015), which are detrimental for subordinates (Dirican & Erdil, 2020), supervisors (Ju, Huang, Liu, Qin, Hu & Chen, 2019), and organizations (Chen, Wang, Cooke, Lin, Paillé & Boiral, 2021). Regarding the consequences of abusive supervision in the construction projects, only few studies have been conducted such as abusive supervision and its impact on work family conflict (Ju, Zhao, Wu, Li & Ning, 2020), voice behavior (Khan & Khan, 2021) and safety behavior (Zheng, Gou, Griffin, Goh & Zia, 2021). Recently, researchers started exploring antecedent factors of abusive supervision (for review, Zhang & Bednall, 2016). From the literature, only one study has been found on the antecedents of abusive supervision in project context (Rafique et al., 2023). Though, studies discussed the antecedent and consequences of abusive supervision in different other domains; however, literature is still silent on research from both the aspects in the project, except the above-mentioned studies on antecedents and consequences of abusive supervision.

METHODS

The objective of the current study was to instigate research on abusive supervision in the project context. Keeping in mind the context and objective of this study, the searching is confined to articles only on "abusive supervision". There are different other similar constructs like bullying, aggression, supervisor undermining and petty tyranny, but there is a difference between abusive supervision and these constructs. In abusive supervision, the interaction between supervisor and subordinate is involved. In the project setting the interaction between both is high as compared to traditional organizations.

To search for studies, Google Scholar, Web of Science and Scopus electronic databases were used by using keywords like "abusive supervision", "supervisor abuse", "abusive supervision in project", and "supervisor abuse in project". While searching for articles, two aspects were considered. First, the search was confined to only abusive supervision and did not include similar terms like aggression, bullying etc. Second, as the objective of was to instigate research on abusive supervision in the project context, hence, keywords like "abusive supervision in projects" were used in order to identify the studies that are conducted specifically in the project context.

The articles were filtered based on the following conditions:

1. Considered only those studies which are published after the seminal work of Tepper (2000) on abusive supervision.
2. Taken into account only those studies in which the authors examined either the antecedents or consequences of abusive supervision.
3. Articles which are published in English.

RESULTS

The studies selected for further analysis are provide in supplementary file Table 1 & 2. Out of all the studies that are presented, only three studies on abusive supervision were found in the project context, in which the authors examined the consequences of abusive supervision. Only one study is found that examined the antecedents of abusive supervision in the project context. Additionally, based on the analysis of these studies, different themes were identified that can be helpful for researchers to conduct studies on abusive supervision in the project context.

AVENUES FOR FUTURE RESEARCH ON ABUSIVE SUPERVISION IN PROJECT MANAGEMENT

The current study believes that for better understanding of abusive supervision in the project management, rigorous research is imperative. First, research in different contexts revealed that most studies have adopted the definition and measurement scale, which is conceptualized in the seminal work of Tepper (2000). Accordingly, the recommendation is that future researchers should adopt the original conceptualization of abusive supervision in the project context as well. It would be worthwhile if it can be defined and conceptualized particularly for the project context and more specifically from project managers' perspective. Second, various causes and outcomes of abusive supervision are evident in the literature. However, future researchers must adopt a more meticulous perspective to investigate project-specific antecedents and consequences of project managers' abusive supervision. The reason is that project management environment is complex and volatile (Goodwin, 1993), and there is a possibility that the characteristics of abusive supervision may differ in the project context. Regarding consequences, it is observed that in management and organizational behavior literature, studies have focused more on the detrimental consequences of abusive supervision from the subordinates' perspective (see Pradhan et al., 2019; Wang, Hsieh & Wang, 2020). Nevertheless, studies have not investigated the influence of abusive supervision on supervisors themselves. Therefore, it is essential to obtain a deeper understanding of how supervisors might be impacted by abusing subordinates (Ju et al., 2019).

One possible area for research could be to identify the possible stressors that hamper the project manager performance. The position of project manager intrinsically constitutes substantial stressors and demands (Gardner, Fischer & Hunt, 2009); such stressors exhibit themselves in terms of physiological and psychological symptoms and behavioral consequences (Wu, Qu, Dooley & Ma, 2020). Lazarus (1991) argued that individuals continuously assess and evaluate the events that happen in the workplace and consider those events that intimidate their well-being, which can eventually induce behavioral and psychological variations, thereby encouraging individuals to take actions that may be detrimental to other individuals and organizations (Zhao, Xiao, Mao & Liu, 2018). Studies are evident on the link between stressors and deviant or aggressive behaviors (Eissa & Lester, 2017; Adeoti, Shamsudin & Wan, 2017; Van den Brande, Baillien, De Witte, Van der Elst & Godderis, 2016; Reknes, Einersen, Knardahl & Lau, 2014). In addition, literature on the stressor-behavior relationship revealed that stressors have the ability to both directly and indirectly influence attitudinal and behavioral outcomes (Mortazavi, Pedhiwala, Shafiro & Hammer, 2009). Similarly, Gilboa, Shirom, Fried and Cooper (2008) contended that stressors are stimuli to instigate deviant behaviors (Colbert, Mount, Harter, Witt & Barrick, 2004).

Furthermore, recent research findings showed that stressors could lead to counterproductive work behavior (Bowling & Burns, 2015).

Project managers are involved in the project from its inception, it is their prime responsibility to interact with stakeholders, meet client expectations, and train subordinates. This can put extreme pressure on project manager; thus, they encounter several stressors in the working environment such as work family conflict (Enshassi & Al-Swaity, 2015; Palis, Yun, & Chuan, 2023), which may lead to abusive behavior (Gallagher et al., 2015). Panojan, Perera and Dilakshan (2019) argue that in construction projects, job demands can drive professionals to work longer than what they are required or able to do productively, which hampers their ability to perform well. Studies identified different stressors in project management and more particularly in construction projects, such as task, personal, physical and organizational stressors (Leung, Ng, Skitmore & Cheung, 2005). It is argued that due to the dynamic nature of project management, the intensity of stressors that individuals experience in this environment is much higher as compared to other industries and contexts. Therefore, it is suggested that future research should investigates these stressors in relation to the abusive supervision. This will help to enrich the project management literature and to provide a more comprehensive understanding.

Another promising direction for future research is to investigate stress and its detrimental influence on the behavior of project manager. Studies are evident on the impact of work stress on construction professional performance (Xiong, Newton & Skitmore, 2019). However, despite the advancement in research on stress and emotions in multiple fields, its exploration is limited in the project domain regardless of the fact that project environment is considered uncertain and stressful. Research shows that negative occupational stress affects job performance and extravagant stress adversely influences the construction industry performance (De Silva, Samanmali & De Silva, 2017). The importance of managing stress at the workplace has gained attention in research. However, occupational stress is neglected in the construction industry. The responsibility of project manager is to ensure the success of the project (Mir & Pinnington, 2014), provide feedback to clients, and deal with final account and settlement of claims (Leung, Chan & Yu, 2009). This puts extreme pressure on them (Senaratne & Rasagopalasingam, 2017), due to which they experience huge amount of stress (Leung et al., 2009). Therefore, it would be worthwhile if future studies explore the occupational stress experienced by project managers in response to different stressors, which may ultimately trigger abusive supervision.

Another favorable direction for future research is to investigate the personality factor. Individuals are different and unique from each other, and personality is one feature that differentiate an individual perception and behavior (Lee & Foo, 2020). Personality traits have widespread influence (Hassan et al., 2017). Different studies have investigated the project manager's personality in the project context. The most noticeable construct is the five-factor personality construct, such as, neuroticism, agreeableness, extraversion, conscientiousness, and openness to experience. However, studies that link personality with the behavior of project manager are limited. Tepper (2000) proposed that supervisor personality traits are significant concepts surrounding abusive supervision, but there is little discussion regarding individual differences related to abusive supervision (Breevaart & de Vries, 2017). Surprisingly, in organizational behavior literature, examining supervisor disposition in the presence of abusive supervision is rare (Camps, Stouten & Euwema, 2016). Though, some

studies revealed that supervisor emotional intelligence is related negatively to abusive supervision (Xiaqi, Kun, Chongsen & Sufang, 2012), while supervisor Machiavellianism is linked positively to abusive supervision (Kiazad, Restubog, Zagenczyk, Kiewitz & Tang, 2010). Recently, Camps et al. (2016) established the direct link between Big-five personality traits and abusive supervision. Breevaart and de Vries (2017) investigated HEXACO personality as an antecedent of abusive supervision, but these studies yielded contradicting findings, hence, they urge future researchers to investigate different personality frameworks simultaneously to compare their predictive powers.

Resilience is another important dispositional factor, which can help supervisors recover and bounce back from stressful situations and make them less inclined to indulge in abusive behavior. Resilience is an individual resource pool that helps in difficult situations (Waugh, Fredrickson & Taylor, 2008). Resilient individuals tend to prepare proactively for adversities and weaken the influence of stressful events by utilizing their psychological resources (Fredrickson, Cohn, Coffey, Pek & Finkel, 2008). Despite its importance for project professionals and effective leadership in project context (Turner, Scott-Young, & Holdsworth, 2019), its application is rare in project studies (Naderpajouh, Matinheikki, Keeys, Aldrich & Linkov, 2020). It is suggested to investigate resilience from the perspective of project manager as well as the subordinate. Turner et al. (2019) opined that resilience is a significant micro-level characteristic that can help in describing how individuals or groups manage uncertainty and the temporary nature of the project. From the project manager's perspective, researchers need to investigate whether psychological resilience can help to manage stressful situations and avoid indulging in abusive behavior. From the subordinate's perspective, researchers could investigate that in the presence of abusive supervision, whether psychological resilience can help to handle the negative situation. In addition, both the predictive and buffering power of supervisor personality requires investigation with respect to abusive supervision in the project.

The current study suggests that researchers apply theories of organizational behavior to the research of abusive supervision in the project context. Ample research is available in other contexts on abusive supervision, but these findings cannot be generalized to the project context due to the uncertain and dynamic nature. Further, the needs of individuals are completely different in project management as compared to traditional organizations. Therefore, this study emphasizes on theories that are applied in abusive supervision research and recommend that these should be applied to the project context as well. These may include and not be limited to theories, such as, affective event theory (Eissa & Lester, 2017), conservation of resources theory (Khan & Medica, 2020; Li et al., 2020), self-regulatory theory (Shillamkwese et al., 2019), resource drain theory (Courtright et al., 2016), cognitive theory of stress (Mawritz, Folger & Latham, 2014), social exchange theory (Mawritz, Dust & Resick, 2014), theory of displaced aggression (Burton, Hoobler & Scheuer, 2012), and theory of individual differences (Kiazad et al., 2010). The application of these theories can enrich the project management literature, particularly in respect to the human dimension of the project from both practical and theoretical perspective.

The current study emphasizes to take into account the concept of culture in research on abusive supervision (Tsui, Nifadkar & Ou, 2007). Attitudes, opinions, beliefs and perceptions of individuals are formed by their culture (Hofstede, 1980). Vogel et al. (2015) contend that culture shapes the foundation of whether individuals embrace specific values that influence

the nature of leader-subordinate interactions. It is generally accepted that culture plays a key role in forming a leader-follower relationship (Brislin, 2000; Hofstede, 1980). Majority studies on cross-cultural leadership have investigated effective and positive leader behavior (Tsui et al., 2007). However, in authority, not all individuals show effective leadership, some are hostile and abusive in their supervision (Martinko, Harvey, Brees & Mackey, 2013; Tepper, 2007). Unlike some positive leadership behavior, the findings of Vogel et al. (2015) revealed that abusive supervision is not generalized across cultures because employees assess it differently in terms of interpersonal fairness based on their cultural lens. Employees across different cultures may not view abusive behaviors in the same way. In some cultures, some behaviors are considered abusive, while in another culture, the same behaviors may not be considered as abusive (Zhang & Liu, 2018). The challenge is to interpret the meaning of being abused by supervisors in different cultures and contexts (Tepper, Simon & Park, 2017). For example, in high-power distance culture with high power values, employees respect their superiors and grant them the right to exercise their dominant position (Kernan, Watson, Chen & Kim, 2011). In such cultures, the presence of abusive supervision is high, and there is a possibility that the reaction to such behaviors may be less intense as compared to low-power distance culture (Tepper, 2007). Moreover, cross-cultural research is just in its infancy and the impact of cultural issues are under investigation (Vogel et al., 2015). Future researchers in the project management domain need to be conscious of cross-cultural aspects in research on abusive supervision as culture impacts abusive supervision (Kernan et al., 2011). Researchers are also aware that findings from research in one cultural context may not be applicable to another cultural (Tepper, 2007). Though, studies on abusive supervision have been conducted in non-U.S cultures, there is ample untapped research potential to examine the influence of cultural differences on abusive supervision instigators, perceptions and reactions (Martinko et al., 2013). Therefore, we recommend that researchers may incorporate specific culture by taking into account Hofstede cultural dimensions. In addition, there is a great need for cross-cultural research on abusive supervision to compare the findings from different cultures regarding abusive supervision.

Researchers found that the methodological issues and demographic characteristics might affect the link between abusive supervision and its outcomes (Tepper, 2007). According to Zhang and Liu (2018), researchers extensively reviewed abusive supervision both quantitatively and qualitatively. However, limited studies utilized experimental design for research on abusive supervision, hence, researchers suggested to conduct experiments for better apprehension (Tepper et al., 2017; Yu et al., 2020). Some researchers have applied the experimental design (e.g. Melwani & Barsade, 2011; Porath & Erez, 2007; Rodgers, Sauer & Proell, 2013), but the challenge in such designs is ecological validity (Tepper et al., 2017). These studies were unable to capture complexity, richness, and personal investment linked to the real world leader-subordinate relationships. Therefore, Tepper et al. (2017) suggested that measuring hostility in the lab is preferable, though it may not be easy, but it is more doable and provides insights and meaningful comparisons. Experimental studies will be beneficial to understand this phenomenon in the project management context. Furthermore, several studies have utilized field surveys. The problem in such designs is that they do not provide causal inferences, therefore, robust designs, such as, longitudinal or time lag designs are needed (Tepper, 2007; Tepper et al., 2011). Therefore, it is recommended to employ such designs while conducting a field study, as it provides causal inferences about a particular phenomenon. Moreover, we suggest that qualitative research may enrich the literature, since this approach permits researchers to investigate behaviors, life experiences and different

perspectives to uncover the complexities of situation through a holistic framework (Holloway & Wheeler, 2002).

Apart from the dark side of abusive behavior, there is a positive aspect of abusive supervision as well. Research indicates that abusive supervision is not necessarily negative (Oh & Farh, 2017). It is believed that there can be a positive impact of abusive supervision on both subordinates and project managers which may specifically be high in project environment. There are multiple reasons to this contention. First, it is obvious that projects must be completed within constraints including time constraint. This study anticipates that regardless of experiencing severe stressors, project managers may avoid abusive behavior because if managers indulge in such behavior, it is more likely to hamper project performance. Second, projects are conducted under temporary organizations and teams are hired for a particular project, if performance of subordinates is satisfactory, they are assigned to another project, otherwise, once the project is completed, they are laid off. The career progression of the subordinate is dependent on the performance of a particular project. Keeping in mind the performance and career progression, it is expected that subordinates will try to not be influenced by project managers' abusive behavior and respond constructively to it.

Zhang and Liu (2018) argued that in some conditions, individuals could respond constructively to organizations, supervisors and coworkers, when encountering abusive supervision. Tepper et al. (2017) defined this possible favorable mechanism process as the performance-enhancing pathway and urged researchers to compare and integrate favorable and unfavorable influence of abusive supervision. Furthermore, according to Vogel et al. (2015) differences in culture plays significant role in diminishing the negative influence of abusive supervision. Moral rules, concerns and norms about rights and fairness dictate our actions towards those individuals who are inside our scope of justice (Opotow & Weiss, 2000). For instance, in the Asian culture deference to authority, hierarchical status and differences in legitimacy of supervisors' hostility toward subordinates is emphasized, while in the Western culture there is greater focus on treating employees with love and dignity (Zhang & Liu, 2018). Based on these arguments it is proposed that future researchers may consider all those factors that have the potential to produce positive results in the presence of abusive supervision.

CONCLUSION

Conventionally in project studies, scholars emphasized on the importance of technical issues rather than soft or human issues. Though the topic of abusive supervision has been the focus of research in other fields, it has only just begun to claim the attention of researchers in project management. Due to the temporary, dynamic, uncertain, and stressful nature of project management, it is opined that systematic examination of all factors that cause abusive supervision and the mechanisms, mediators and moderators by which it effects project outcomes is a significant area of study. Additionally, it would be worthwhile to investigate the possible consequences with respect to individuals and project. Though provides a scope for future research, the current research will have its intended effect of making contribution to the understanding of abusive supervision in project management.

Table 1. Antecedents of Abusive Supervision

Authors	Unit of Analysis	Country	Antecedents	Theory	Factors Level
Rafique, Jaafar, Zafar, & Saira (2023)*	N=241, Project based organizations	Pakistan	**Time Pressure and Emotional Exhaustion**	Affective Event Theory	Supervisor Level Factors
Balabanova (2021)	N=1100, Multiple Industries	Russia	**Accidental and Zero Option Employment**	Social Exchange Theory	Organizational Factors
Khan (2021)	n=213, Public and Private Organizations	Pakistan	**Procedural Injustice Climate**	Affective Event Theory (AET)	Organizational Factors
Fan, Wang, Liu, Liu, and Cai (2020)	n=130, Services Industry	China	**Team Performance**	Conservation of Resource Theory	Subordinate Factors
Khan and Medica (2020)	n=504, Telecommunication Sector	Pakistan	**Subordinate Intimidation and Subordinate Emotional Exhaustion**	Conservation of Resource Theory	Subordinate Factors
Malik, Iqbal and Haq (2020)	n=306, Higher Education Institution	Pakistan	**Supervisor Stressors and Inter-role Conflict**	Resource Drain Theory and Ego Depletion Theory	Supervisor Factors
Yan, Wang, Su, and Luo (2020)	n=524, Health Sector	China	**Subordinate Core Self-Evaluation**	Social Exchange Theory and Self-Consistency Theory	Subordinate Factors
Le, He, Sun, and Zhang (2020)	n=228, Multi-Industry	China	**Challenge and Hindrance Stressors**	Conservation of Resource Theory	Supervisor Factors
Eissa, Lester and Gupta (2019	n=262, Multiple Industries	India and United States	**Subordinates' interpersonal deviance and supervisor negative emotions**	Emotion Centered Model of CWB and Affective Event Theory (AET)	Subordinate Factors
Graham, Mawritz, Dust, Greenbaum, and Ziegert (2019)	n=139, Multiple Organizations	United States	**Leader Follower Dominance and Relationship Conflict**	Social Dominance Theory and Interpersonal Interaction Theory	Organizational Factors

Table 1. Antecedents of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Antecedents	Theory	Factors Level
Shillamkwese, Tariq, Obaid, Weng, and Garavan (2019)	n=298, Services Industry	China	**Subordinate Deviance and Supervisor Hindrance Stress**	Self-Regulatory Theory	Subordinate Factors
Ng, Zhang, and Chen (2018)	n=358, Multiple Industries	China	**Perceived Competitiveness**	Transaction Theory of Stress, Jobs Demands Resources Model and Conservation of Resource Theory	Organizational Factors
Camps, Stouten, Euwema, and De Cremer (2018)	n=121, Multiple Organizations	Belgium	**Follower Hostility (Abusive Followership)**	Uncertainty Management Theory	Subordinate Factors
Khan, Moss, Quratulain, and Hameed (2018)	n=580, Private Sector Organizations	Pakistan	**Subordinate Performance**	Social Dominance Theory	Subordinate Factors
Eissa and Lester (2017)	n=190, Multiple Industries	United States	**Supervisor Role Overload and Frustration**	Affective Event Theory (AET)	Supervisor Factors
Lam, Walter, and Huang (2017)	n=219, Manufacturing and Telecommunication	China	**Supervisor Emotional Exhaustion**	Conservation of Resource Theory	Organizational, Supervisor and Subordinate Factors
Yam, Fehr, Keng-Highberger, Klotz, and Reynolds (2016)	n=184, Services Industry	United States	**Leader Surface Acting**	Ego-depletion Theory	Supervisor Factors
Courtright, Gardner, Smith, McCormick, and Colbert (2016)	n=580, Financial Service Organizations	United States	**Family Work Conflict (FWC)**	Resource Drain Theory	Work Related Factors
Liang, Lian, Brown, Ferris, Hanig and Keeping (2016)	n=206, Financial Sector	United States and Canada	**Subordinate Performance**	Self-Control Framework	Subordinate Factors
Lin, Ma, and Johnson (2016)	n=127, Multiple Industries	United States	**Ethical Leader Behavior**	Ego-depletion Theory	Supervisor Factors

Table 1. Antecedents of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Antecedents	Theory	Factors Level
Walter, Lam, van der Vegt, Huang, and Miao, (2015)	n=169, Manufacturing Industry	China	**Subordinate Performance**	Moral Exclusion Theory	Subordinate Factors
Mawritz, Folger and Latham (2014)	n=215, Multiple Industries	United States	**Difficult Goals and Emotions (Anger & Anxiety)**	Cognitive Theory of Stress	Supervisor Factors
Henle and Gross (2014)	n=222, Multiple Organizations	United States	**Subordinate Personality**	Victim Precipitation Theory	Subordinate Factors
Garcia, Restubog, and Kiewitz, Scott, and Tang (2014)	n=154, Multiple Industries	Philippines	**Supervisor History of Family Aggression**	Social Learning Theory	Supervisor Factors
Neves (2014)	n=153, Multiple Organizations	Portugal	**Subordinate Core Self-Evaluation and Coworker Support**	Perceived Organizational Support Theory	Subordinate Factors
Hoobler and Hu (2013)	n=200, Multiple Organizations	United States	**Interactional Justice and Negative Affect**	Organizational Justice Theory	Supervisor Factors
Mawritz, Dust, and Resick (2014)	n=221, Multiple Industries	United States	**Hostile Organizational Climate**	Social Exchange Theory	Organizational Factors
Burton, Hoobler, and Scheuer (2012)	n=98, Students	United States	**Supervisor Workplace Stress and Time Pressure**	Theory of Displaced Aggression	Supervisor Factors
Tepper, Moss, and Duffy (2011)	n=177, Health Organizations	United States	**Supervisor Workplace Stress and Time Pressure**	Theory of Displaced Aggression	Supervisor Factors
Restubog, Scott, and Zagenczyk (2011)	n=184, Various Industries	Philippines	**Aggressive Norms**	Social Learning Theory	Organizational Factors

Table 1. Antecedents of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Antecedents	Theory	Factors Level
Martinko, Harvey, Sikora, and Douglas (2011)	n=433, Multiple Industries	United States	**Subordinate Hostile Attribution Style**	Attribution Theory and LMX Theory	Subordinate Factors
Kiazad, Restubog, Zagenczyk, Kiewitz, and Tang (2010)	n=200, Multiple Business Sectors	Australia	**Machiavellianism**	Theory of Individual Differences	Supervisor Factors
Wu and Hu (2009)	n=200, Services Industry	Taiwan	**Subordinate Core Self-Evaluation**	Self-consistency Theory and Conservation of Resources Theory	Subordinate Factors
Aryee, Chen, Sun, and Debrah (2007)	n=178, Telecommunication Industry	China	**Supervisors Perception of Interactional Justice**	Trickle Down Model	Supervisor Factors

Note: *In literature, we found only one study on the antecedents or causes of abusive supervision in the projects and more specifically in the construction projects. The study is represented through asterisk *.*

Other than this study, no study has been found on antecedents of abusive supervision in projects.

Table 2. Consequences of Abusive Supervision

Authors	Unit of Analysis	Country	Consequences	Theory	Factors Level
Zheng, Gou, Griffin, Goh, and Zia (2022)*	n-402, Construction Industry	China	**Safety Specific Behaviors**	Social Information Processing Theory	Subordinate Factors
Bani-Melhem, Quratulain and Al-Hawari (2021)	n-205, Hospitality Industry	UAE	**Self-Esteem, Turnover Intention and Innovative Behaviors**	Self-Enhancement Theory	Subordinate Factors
Khan and Khan (2021)*	n-402, Construction Industry	China	**Employee Voice Behavior**	Conservation of Resources Theory	Subordinate Factors
Rani, Shah, Umrani, Syed and Afshan (2021)	n-307, Microfinance Banks	Pakistan	**Promotive and Prohibitive Voice**	Affective Event Theory	Subordinate Factors
Jain, Srivastava and Cooper (2021)	n-347, Manufacturing and Retail Industry	India	**Emotional Intelligence, Fear based Silence and Turnover Intention**	Relationship Theory	Subordinate Factors
Peltokorpi and Ramaswami (2021)	n=603, Multiple Industries	Japan	**Physical and Health related Problems**	Stressor-Strain Framework and Conservation of Resources Theory	Subordinate Factors
Zang, Liu, and Jiao (2021)	N=264, Hotel Industry	China	**Customer Service Performance**	Affective Event Theory and Social Cognitive Theory	Subordinate Factors
Lim, Koay and Chong (2021)	N=255, Public Sector	Malaysia	**Cyberloafing**	Social Exchange Theory and Conservation of Resources Theory	Subordinate Factors
Ayub, Ajmal, Iqbal, Ghazanfar, Anwaar and Ishaq (2021)	n-208, Service Sector	Pakistan	**Knowledge Hiding Behavior**	Several Theories	Subordinate Factors
Wang, Wei, Zhao, Zheng and Peng (2021)	n-208, Multiple Industries	China	**Creativity**	Conservation of Resources Theory	Subordinate Factors

Table 2. Consequences of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Consequences	Theory	Factors Level
Saleem, Yusaf, Sarwar, Raziq and Malik (2021)	n=250, Police	Pakistan	**Psychological Distress, Turnover Intention**	Conservation of Resources Theory	Subordinate Factors
Men, Yue, Weiwei, Liu and Li (2021)	n-208, Research and Development	China	**Team Creativity**	Social Identity Theory	Subordinate Factors
Liao, Lee. Johnson, Song and Liu (2021)	n-131, Multiple Industries	United States	**Task Reflexivity, Rumination. Task Performance**	Several Theories	Subordinate Factors
Chen, Wang, Cooke, Lin, Paillé and Boiral (2021)	n-151, Manufacturing Firms	China	**OCBE**	Social Exchange Theory	Organizational Factor
Ju, Zhao, Wu, Li, and Ning (2020)*	n-473, Multiple Industry	China	**Work Family Conflict**	Conservation of Resources Theory	Subordinate Factors
Al-Hawari, Bani-Melhem and Quratulain (2020)	n-355, Hospitality Organizations	UAE	**Silence Behavior**	Social Exchange Theory	Subordinate Factors
Islam, Ahmad, Kaleem and Mahmood (2020)	n-355, Services and Manufacturing Sectors	Pakistan	**Knowledge Sharing**	Several Theories	Subordinate Factors
Johnson, Priesemuth and Bigelow (2020)	n=555, Multiple Industries	United States	**Supervisor Directed OCB**	Deonance and Fairness Theory	Subordinate Factors
De Clercq, Jahanzeb and Fatima (2020)	n=234, Finance and Manufacturing	Pakistan	**Supervisor rated Job Performance**	Conservation of Resources Theory	Subordinate Factors
Shen, Zhang, Yang and Liu (2020)	n=341, Multiple Industries	China	**Employee Creativity**	Social Exchange Theory	Subordinate Factors
Wang, Hsieh and Wang (2020)	n=233, Hotels	Taiwan	**Work Engagement and Job Satisfaction**	Conservation of Resources Theory	Subordinate Factors

Table 2. Consequences of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Consequences	Theory	Factors Level
Osei, Asiedu-Appiah and Amoah (2020)	n=233, Banking Sector	Ghana	**Counterproductive Work Behaviors and Task Performance**	Several Theories	Subordinate Factors
Moin, Wei and Wang (2020)	n=210, Telecom	China	**Surface Acting and Deep Acting**	Conservation of Resources Theory	Subordinate Factors
Malik, Shahzad, Waheed and Yousaf (2020)	n=341, Public Sector Hospitals	Pakistan	**Malevolent Creativity**	Affective Event Theory	Subordinate Factors
Guan and Hsu (2020)	n=106, Multiple Industries	China	**Affective, Normative and Continuance Commitment**	General Deterrence Theory	Subordinate Factors
Ahmad and Begum (2020)	n=277, Banking Sector	Pakistan	**Intention to Leave**	Unfolding Model of Voluntary Turnover	Subordinate Factors
Dirican and Erdil (2020)	n=644, Multiple Industries	Turkey	**Job Embeddedness**	Social Exchange Theory and Conservation of Resources Theory	Subordinate Factors
Avey, Agarwal and Gill (2020)	n=293, Multiple Industries	United States	**Employee Health, Psychological Well-Being and Job Satisfaction**	Job Demand Resource Model	Subordinate Factors
Zhu and Zhang (2019)	n=253, Multiple Industries	China	**Innovative Behavior**	Antecedent-Benefit-Cost Framework and Social Cognitive Theory	Subordinate Factors
Feng and Wang (2019)	N=155, Educational and Manufacturing Sector	China	**Knowledge Hiding**	Reactance Theory and Conservation of Resources Theory	Subordinate Factors
Ju, Huang, Liu, Qin, Hu, and Chen (2019)	n=72, Multiple Industries	China	**Sense of Power and Managerial Self-Efficacy**	Self-Perception Theory and Power Dependence Theory	Supervisor Factors

Authors	Unit of Analysis	Country	Consequences	Theory	Factors Level
Kirrane, Kilroy, and O'Connor (2019)	n=191, Multiple Industries	Ireland	**Work Engagement**	Job Demand Resource Model	Subordinate Factors
Liu, Gul, Zhang, & Usman, (2019)	n=687, Multiple Industries	China	**Suicidal Ideation**	Self-Determination Theory	Subordinate Factors
Peng, Schaubroeck, Chong and Li (2019)	n=285, Information Technology	China	**Shame, Anger and Fear**	Appraisal Theory	Subordinate Factors
Pan, Sun, Sun, Li and Leung (2018)	n=198, Hotel Industry	Macau	**Job Dissatisfaction and Job-Oriented Constructive Deviance**	Activation Theory	Subordinate Factors
Caesens, Nguyen and Stinglhamber (2018)	N=212, Multiple Industries	United Kingdom	**Organizational Dehumanization**	Several Theories	Organizational Factors
Pradhan and Jena (2018)	n=353, Healthcare Industry	India	**Intention to Quit**	Conservation of Resources Theory	Subordinate Factors
Xu, Zhang and Chan (2017)	n=226, Hospitals	China	**Proactive Behavior**	Transaction Model of Stress	Subordinate Factors
Rauniyar, Ding and Rauniyar (2017)	n=325, Multiple Industries	Nepal	**Employee Creativity**	Social Cognitive Theory	Subordinate Factors
Qian, Song and Wang (2017)	n=248, High Tech Communication Company	China	**Job Dissatisfaction**	Social Identity Theory and Transactional Theory	Subordinate Factors
Qin, Huang, Johnson, Hu and Ju (2017)	n=100, Experimental Study	China and United States	**Work Engagement**	Conservation of Resources Theory	Supervisor Factors

Table 2. Consequences of Abusive Supervision (Continued)

Table 2. Consequences of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Consequences	Theory	Factors Level
Zheng and Liu (2017)	n=287, Manufacturing	China	**Creative Performance**	Social Cognitive Theory	Subordinate Factors
Velez and Neves (2017)	n=253, Department of City Hall	Portugal	**Distributive Justice**	Theory of Organizational Justice	Subordinate Factors
Mathieu and Babiak (2016)	n=99, Non-Profit Organizations	Canada	**Turnover Intention and Job Satisfaction**	Several Theories	Subordinate Factors
Yu et al. (2016)	N=480, Insurance	China	**Sales Performance and Affective Commitment**	Social Identity Theory and Self-Categorization Theory	Subordinate Factors
Harr, de Fluiter and Brougham (2016)	n=432, Multiple Industries	New Zealand	**Turnover Intention**	Social Exchange Theory	Subordinate Factors
Farh and Chen (2014)	n=280, Multiple Industries	China and United States	**Organization-Based Self Esteem and Relationship Conflict**	Several Theories	Team Factors
Rodwell, Brunetto, Demir, Shacklock and Farr-Wharton	n=250, Nursing	Australia	**Intent to Quit, Job Satisfaction and Strain**	Appraisal Theory	Subordinate Factors
Lee, Yun and Srivastava (2013)	n=203, Social Security and Labor Welfare	South Korea	**Employees Creativity**	Activation Theory	Subordinate Factors
Decoster, Camps, Stouten, Vandevyvere and Tripp (2013)	n=134, Multiple Industries	Belgium	**Perceive Cohesion and Gossiping Behavior**	Social Exchange Theory	Subordinate Factors
Jian, Kwan, Qiu, Liu, and Yim (2012)	n=324, Hotel	China	**Employees Service Performance**	Self-Consistency Theory	Subordinate Factors

Table 2. Consequences of Abusive Supervision (Continued)

Authors	Unit of Analysis	Country	Consequences	Theory	Factors Level
Lian, Ferris and Brown (2012)	n=260, Multiple Industries	N/A	**Subordinate Organizational Deviance**	Self-Determination Theory	Subordinate Factors
Carlson, Ferguson, Perrewé, and Whitten (2011)	n=280, Multiple Industries	United States	**Work Family Conflict and Relationship Tension**	Spillover and Crossover Theory	Subordinate Factors
Wu, Liu and Liu (2009)	N=338, Electronic Manufacturing Companies	China	**Task Performance and Organizational Citizenship Behavior**	Social Exchange Theory	Subordinate Factors
Tepper, Carr, Breaux, Geider, Hu and Hua (2009)	n=491, Fast Food Chains and Hospitals	United States	**Workplace Deviance**	Power Dependence Theory	Subordinate Factors
Harris, Kacmar and Zivnuska (2007)	N=207, Automobile Industry	United States	**Performance**	Conservation of Resources Theory and Social Exchange Theory	Subordinate Factors
Hoobler and Brass (2006)	n=630, Multiple Industries	United States	**Family Conflict**	Displaced Aggression Model	Subordinate Factors
Zellars, Tepper and Duffy (2002)	n=373, Military	United States	**Organizational Citizenship Behavior**	Several Theories	Subordinate Factors
Tepper, Duffy and Shaw (2001)	n=712, Multiple Industries	United States	**Dysfunctional Resistance**	Several Theories	Subordinate Factors
Tepper (2000)	n=712, Multiple Industries	United States	**Job Satisfaction and Organizational Commitment**	Justice Theory	Subordinate Factors

Note: *Based on the review of literature regarding abusive supervision, the current study found only three studies that examined abusive supervision and its consequences in the construction industry.*

*These studies are represented through asterisk *.*

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EVALUATING ICT INTEGRATION IN THE PAKISTANI CONSTRUCTION INDUSTRY: A PATH TO ENHANCING PRODUCTIVITY AND COMPETITIVE EDGE

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Abstract
The construction industry is the primary industry that contributes significantly to a state's economic growth. Monetarily, it has significantly increased the state's overall GDP. Many construction companies nowadays start believing that the significant use of ICT will increase their productivity and It could provide businesses with strong strategic and technical methods that, when properly implemented and used, can provide significant benefits in developing and promoting their competitive strength. Hence this article aims to determine the level of ICT adoption in a firm and the effectiveness of different software programs at various phases of the project. Identifying factors significantly hindering the use of ICT, possible benefits obtained through its utilization, and implementation strategies. A total of 100 responses were received through questionnaires from professionals in the construction industry providing empirical data for analysis. 80% response rate was achieved. The findings show that the majority of firms use computers for different operations. For administrative work MS Word and spreadsheets are commonly used. MS Project and Primavera for planning purposes, Spreadsheets, and Planswift for estimation and calculation, and AutoCAD as designing software. Highly affecting factors hindering the use of ICT were a lack of commitment towards ICT by top management and employee satisfaction with current workplace practices. By using ICT tools overall efficiency, profit margin, and productivity of the firm increased and it is a faster way to get timely authentic information regarding the project. For better ICT implementation strategies, senior management must play its role by conducting IT awareness workshops and should develop guidelines and policies.

Keywords: *Construction Industry; Information and Communication Technology; ICT Key Factors; ICT Strategies*

INTRODUCTION

Information and Communications Technology is an important technology that is used to control communications processes such as telecommunications, media broadcasting, intelligent management systems of building, audio-visual processing, systems of transmission, and network-based monitoring and control functions. Though ICT is often replicated as an extended substitute for information technology, its scope is more extensive. ICT is frequently used to describe the integration of several other technologies, and the use of transmission lines carrying varied data, forms, and formats of communication (Amusan, 2018).

In Construction projects ICT, Computer systems are used for apprehending, organizing statistics, storing necessary documents, designing, e-procurement, bidding, and sharing important information (J. Adwan, 2016). The use of ICT in e-procurement such as the Internet or web-based platforms to ease public or commercial organisation purchasing of products and services. It has played an important role in the effective administration of public resources, and, more crucially, the improvement of Government procurement integrity, transparency,

and accountability (Usman Musa et al., 2020). The use of personal computer systems capable of assembling, arranging, storing data, evaluating, exchanging information, transmitting, and sharing material is referred to as construction ICT. Automation and ICT have previously been acknowledged as tools for increasing competitive benefits in construction projects (Irtishad U. Ahmad, 2015).

The journey of ICT in Pakistan originated wherever in 1985 when the Federal govt officially revealed IT imports just for commercial purposes (Arif, 2018). This was also a period when the residents of this country, got first-time access to IT hardware. But time flew so quickly so does IT. In Pakistan, ICT started flourishing when massive customs and tax burdens were reduced. The fruitful results of this initiative were a considerable growth in direct foreign investments due to these reduced taxes and other duties. In 1995, Internet connections extended to approx. 3 million households within just a few years (Arif, 2018).

The construction sector of Pakistan has contributed its part between 2.3% - 2.85% of the last five years' GDP (according to Pakistan Economic Survey 2019 - 20, its value was approx. Rs 316 billion). Most economists estimated its value which lies between 10% to 12% of the overall GDP, the reason behind this is it motivates over 42 other secondary sectors, including aluminum work, brick masonry, cables, and other electrical systems, cement industry, lighting, and other fixtures, glass work, kitchenware, and bathroom fittings, marble and ceramic tiles, paint and varnishes, steel, tiles, transportation of labor and material, warehousing, woodwork sector every item related from starting to finishing work of the project.

The deployment of technologies in construction projects is expected to facilitate information sharing among project stakeholders and other team members. Meanwhile, the construction industries of today and tomorrow place a high value on the use of sustainable systems enabled by ICTs (Hassanain et al., 2007). The construction sector has shown great advancements in the use of ICT internationally in the last two decades, even in both small-scale and medium-scale business firms. Nevertheless, Industry-wide, a significant proportion of ICT solutions are practiced for exterior processes and site control, as well as many other projects related to ongoing activities have remained largely unaffected by the situation.

On the other hand, about 90 percent of ICT-related expenses are dedicated to technical administrative work or the main office of the company, with only 10% remaining for field work or site monitoring (Pablo Orihuelaa, 2016). At present, it is presumed that ICT will also provide construction engineering firms with new perspectives for improving information management practices, communication, and teamwork (Bowden, 2011), Despite rapid growth in the construction industry, a variety of unfavorable issues continue to have a psychological influence on the performance of mega projects.

Such issues include using ineffective methods, techniques, and management systems for communicating authentically among team members (Bhzad Sidawia, 2014). The roles of ICT implementation in construction projects can be highlighted in the following ongoing several phases of a project. The bidding process with all phases will be undertaken electronically online. Additionally, queries, addendums, updates, assessments of work, and payment notifications are all to be operated electronically on the internet via the office website systems and e-mails (Chilipunde, 2013).

The real-time transferring of info and data passes through familiar stations, where other transmission modes e.g., electronic mails, messaging, and cell phones, empower direct connections between projects and members (Sekou, 2019). The important benefits which can be obtained with the use of ICT as determined by the study are improved quality of work, ease to perform complex tasks, saving time, improved productivity, and enhancement in the public image (Oladapo, 2007). The adoption of ICT is vital to reduce the material management difficulties linked with the construction sector. Additionally, it has been discovered that effective ICT implementation has the huge potential to cause considerable improvements (Kasim, 2019).

ICT and Construction Industry

The construction industry and its partners face a variety of challenges in dealing with the huge amount of relevant data that circulates on construction sites in different phases, including initiation, designing, execution, time factors and cost constraints, economic effectiveness, and sustainability. For the fulfillment of these requirements, firms need to use suitable ICT tools and techniques (Peter Mesároš, 2017). ICT adoption in the projects is insufficient when compared to other sectors, particularly automotive and aviation (Dehlin et al., 2008). By using modern communication tools, construction practitioners at a site can easily connect with the head office (Alaghbandrad, 2019).

These new technologies must be monitored for their impact on the performance of large organizations (M. Kozlovská D. M., 2016). The observation of increasing company performance is mostly associated with increased cost-effectiveness and profitability. This means lowering expenses while increasing profit margins. There must be a cost reduction and profit increase as a result of ICT's impact on firms' performance (Peter Mesároš, 2017). The use of ICT in development and building projects is hampered by several obstacles. The firm lacks strategic decision problems, such as a lack of investment in ICT technology (Ravi Shanker, 2014). The misalignment of current organization structure and social standards to ICT models for an interconnected and collaborative work environment is one of the primary motivations for the difficulty in implementing ICT.

(Peansupap and Walker, 2005), also concluded that one other factor is construction companies with innovative CEOs have additional encouraging assertiveness towards ICT usage. The construction sector is dispersed and composed of isolated firms that must play their part in a joint venture by project basis. The multi-contender, the multi-firm approach is a significant impediment to incorporating Technology within the industry (Peter Mésároš, 2021). According to Davies (2019), most companies in New Zealand are using computers for administrative purposes instead of as a tool in the construction process. The use of mobile computing is very limited. The cost of investment in IT is the fundamental barrier as determined through study.

Based on the facts provided, it is clear that the construction industry cannot disregard the significance and increasing role of ICT in the construction industry (CI). According to (Andrew et al., 2016), the revolution in technology is a critical factor determining the growth of the construction business, but its penetration is disgracefully low. Despite several initiatives, ICT adoption in the construction industry remains low when compared to other industries, notably automotive and aviation (Dehlin et al., 2018). This may grow slightly since

the construction business is labor-intensive, as opposed to manufacturing industries, where output is practically entirely automated. Many scholars attribute this tendency to a lack of investment in development and research.

The construction sector is now undergoing a transition from conventional paper-based to electronically based data interchange, a transition that has already been deeply ingrained in other sectors such as aircraft manufacture and finance (Rivard et al., 2015). Building Information Modelling (BIM) and Integrated Design and Delivery Systems (IDDS) are becoming increasingly popular in building research and practice throughout the world (Owen et al., 2018). Building Information Modelling (BIM) has emerged as an ICT tool over the past few years to handle problems such as mistakes, rework, and so on. BIM is projected to significantly increase the intrinsic quality of architectural design details as well as means of communication such as design information shared throughout various construction project teams (Badr M. AlMashjary et al., 2020). According to (Anumba and Ruikar, 2015), the construction industry's outmoded information and communication flows are mostly the result of laborious and sluggish procedures, which result in the creation of many paper copies of papers and drawings. Document "archives" in libraries must be preserved in order to effectively access data when needed. Relying on third parties, such as shipping companies, might result in delays. The increased cost was incurred in the distribution of project papers to geographically dispersed project partners.

Therefore, conventional construction sectors throughout the world, including Pakistan, must innovate their goods and enhance their manufacturing processes in order to achieve improved productivity with commodities and production techniques. According to a study conducted in Poland, the era of prosperity for enterprises that do not use IT on a regular basis is not long-lasting (Kaplinski, O, 2018).

As a result, while the significant advantages offered by ICT in the construction industry appear to be recognized, its use and acceptance as a normal part of the construction process remains low; and contractors, among the major players, are frequently referred to as those who use ICT the least (Peansupap et al., 2015). Although this is most likely applicable to the Pakistani construction sector, particular facts regarding the degree of application and challenges associated with the usage of ICT remain unknown. The current study aims to examine the situation in Pakistani construction sector, evaluate the issues impeding ICT adoption, and provide implementation solutions to improve ICT spread.

EXPERIMENTAL PROCEDURES

For this research, the Questionnaire Survey method has been used. A variant of the highly renowned “IT Barometer” instrument survey has been used in research (Samuelson, 2008). A structured questionnaire was consist of four sections, first section included questions related to demographics information of respondents, second part involved in level of ICT being used in a firm, communication means and various software programs have been used at various phases of projects. The third section addressed hurdles to ICT use, while the last section addressed strategies for better ICT implementation.

Questions for the first, second, and fourth parts were compiled from interviews with construction industry professionals. The factors listed in Table 1 originated from the available literature. Between June and August 2021, a questionnaire was distributed to participants in architectural engineering, civil engineering, and associate engineering diploma programes, as well as university researchers in Pakistan, with the majority of the respondents working in client and consultant-based firms.

Table 1. Summary of Factors Hindering Use of ICT

Factors Hindering ICT Usage	References
Budget constraint for ICT investment	(Peansupap et al., 2006)
Hiring ICT professionals is expensive	(Amusan et al., 2018)
The cost of ICT proper training	(Peansupap et al., 2006)
Benefits are limited, and the return on investment in ICT is low	(Amusan et al., 2018)
Inadequate staff with necessary ICT expertise and training	(Sekou, 2012)
Top management reluctance to ICT in the workplace	(Aiswarya and R.N UMA, 2020)
Engineering curriculum ICT content is deficient	(Aiswarya and R.N UMA, 2020)
Inadequate understanding of the profitability on ICT adoption	(Sekou, 2012)
Gratification with the current working method	(Peansupap et al., 2006)
Afraid of job losses/professionals being retrenched.	(Sekou, 2012)
Access to a relatively cheap workforce	(Eric et al., 2016)
Problem of ICT compatibility in the organization	(Amusan et al., 2018)
Problems with software and hardware creditability	(Eric et al., 2016)
Concerns about security/privacy	(Sekou, 2012)
Rapid changes in ICT technologies	(Eric et al., 2016)
High rate of obsolescence ICT products	(Eric et al., 2016)
Inadequate job opportunities in the market	(Aiswarya and R.N UMA, 2020)
The most of clients are unwilling to engage in ICT based firms.	(Eric et al., 2016)
Liability threats	(Sekou, 2012)
Insufficient legal support for ICT use	(Eric et al., 2016)
Security implications of ICT transactions	(Eric et al., 2016)

A questionnaire survey based on the 1-5 Likert scale to weigh a variety of perspectives, such as 1 = strongly disagree, 2 = disagree, 3= not sure, 4= agree, 5= strongly agree, and so on. As per recommendations of (Israel, 1992), 96 sample size was calculated for this questionnaire survey, 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%).

The questionnaire was distributed through social media applications in google form link. 102 out of 150 digitally-distributed questionnaires were returned. Two of the returns were considered inadequately filled to be suitable for the assessment and therefore were rejected. This effectively brings total 100 completely filled surveys, resulting in a response rate of 66.6 percent. According to (Root, D., 2003) this response rate is considered suitable because a response rate of 30% is considered to be adequate in construction studies. The IBM SPSS-25 and importance index were used to analyze the data. El-Haram and Horner (2002) provide the following formula for the Relative importance index (RII) in Equation 1.

$$RII = \Sigma W / (A*N) \quad (1)$$

W = Weight (which was marked by the respondents ranges from1-5 to each factor).
A = Highest value of the weight 5.
N = Total No. of Respondent.

ANALYSIS AND FINDINGS OF SURVEY RESULTS

The questionnaire data were analyzed and discussed in this portion in terms of the current level of ICT use, the accessibility and use of computers in firms, effective communication channels, and the effectiveness of various software at various stages of the project lifecycle. The advantages and implications of ICT, the variables that affect ICT adoption, and the barriers to ICT use. The SPSS-25 statistical package was used for analysis.

Data Reliability Test

Cronbach's alpha is a parameter used to evaluate the reliability, or internal consistency, of a group of scale or test items. In other words, the validity of any particular measurement relates to how consistently it measures a notion, and Cronbach's alpha is one means of calculating the degree of that consistency. Cronbach's alpha is a commonly used metric of data internal consistency or reliability. The value is between 0.0 and +1.0. Internal consistency increases as the value approaches 1.0 (Ahmad Muhseen et al., 2023).

Table 2 shows the reliability againts different alpha values, Cronbach's Co-Efficient approach endorses reliability because an alpha value 0.70 or greater means that the observed data information is suitable for research analysis. If alpha coefficient value below 0.60 is not satisfactory and unacceptable for research (Hair et al., 2003). While Cronbach's alpha was determined using the data obtained, coefficient value in this study situation was achieved 0.966, determined using SPSS-25. This value for obtained data ensures that it is reliable and valid for analysis.

Table 2. Cronbach Alpha and Internal Reliability

Cronbach's Alpha Value	Internal Reliability
$\alpha \geq 0.9$	Excellent
$0.9 > \alpha \geq 0.8$	Good
$0.8 > \alpha \geq 0.7$	Acceptable
$0.7 > \alpha \geq 0.6$	Questionable
$0.6 > \alpha \geq 0.5$	Poor (unacceptable)

(Source: Siswaningsih et al., 2017)

General Demographic Data Analysis

Male and female respondents were divided into two groups based on their gender. The majority of respondents were male, accounting for 85 percent of the data and the remaining 15 percent being female professionals. Table 3. depicted the majority of respondents (58%) had MSc degree, 38 percent had BSc-Engineering degree while 6 percent had PhD in Engineering. Most of the respondents were working in the client and consultant firms about 35% and 40% respectively. 25% of respondents were working in the contractor's firms. 93% of respondents having above 5 years of experience and 07 % were below 5 years of experience exhibit in Table 3.

Table 3. Demographic Data of Respondents

Profile	Frequency
Male	85
Female	15
Contractor	25
Consultant	40
Client	35
0-5 Years	07
5-10 Years	30
10-15 Years	18
15-20 Years	45
PhD Degree	06
Master Degree	58
Bachelor Degree	36

ICT Level and Effective Communication Means

Survey respondents had to rate how often they used computers in their firm. 93% of the firm's employees used computers for different operations. A medium level of ICT was being applied in construction firms. 15 respondents said that ICT being applied was High. Six and four respondents voted in favor of Low and very low levels of ICT being applied respectively. Figure 1 exhibits in 50% of the firm's employees used computers in company offices only and 45% of firms allowed their employees to use computers both in company offices and project sites.

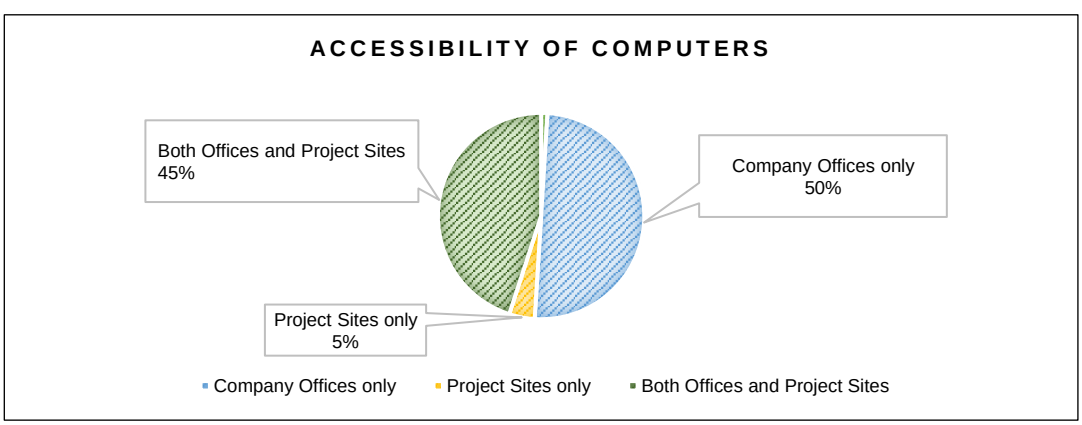

Figure 1. Accessibility of Computers to The Firm's Employees

Relative importance values (RII) of trusted communication means among project members were depicted in Table 4. It was clearly shown by data analysis meetings, WhatsApp, letters, and Emails as effective means of communication among the project team. The use of project intranet was not significant. Mostly, engineering professionals use computer software for making architectural drawings, technical calculations, cost estimation, and project planning. Figure 2 illustrates ICT tools were less used in site management, security, and managing suppliers' data.

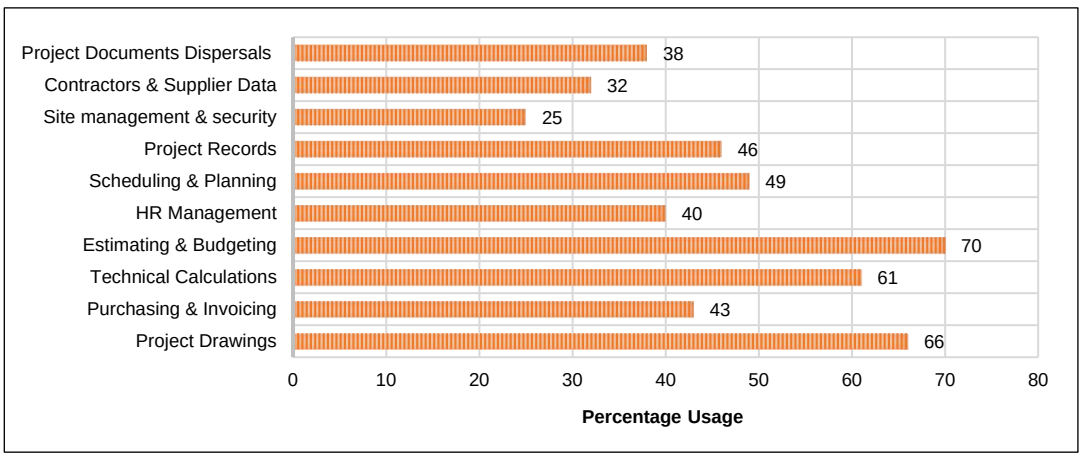

Figure 2. Use of Software for Various Activities in a Construction Firm

Table 4. Classification of Communication Means

Communication Means	Relative Importance Index	Ranking
Meetings/Minutes of meetings	0.872	01
WhatsApp Messenger	0.87	02
Letters, Memos & Notices	0.858	03
Telephone Calls	0.856	04
Emails	0.846	05
Text Messages/SMS	0.798	06
Video Conference	0.768	07
Project Intranet	0.734	08

Use of Software at The Different Projects Phases

The importance index (RII) was used to assess the importance of various software as shown in Table 5. Microsoft Excel and word were commonly used in general administration offices for routine work. AutoCAD and Sketchup were used for architectural designing and visualization. The use of Microsoft Project and Primavera as a project planning software was above average. Spreadsheets were used for cost and quantities estimation. Advanced software is struggling to penetrate the construction sector.

Table 5. Use of Various Software at Different Phases of Project Lifecycle

General Offices Software	RII	Designing Software	RII
Microsoft Word	0.924	AutoCAD	0.858
Microsoft Excel	0.912	Sketchup	0.738
Microsoft Power Point	0.88	ArchiCAD	0.71
Microsoft Access	0.642	Revit	0.702
Project Planning Software		**Estimation Software**	
Microsoft Project	0.814	MS Office	0.906
Primavera	0.732	Planswift	0.708
Power Project	0.602	Esti-mate	0.552
TeamWork	0.554	Buildsoft	0.536
GanttPRO	0.532	PRISM Estimate	0.504

FACTORS HINDERING ICT USAGE IN THE CONSTRUCTION INDUSTRY

Many factors effecting the use of ICT in construction industry. These factors are classified into five groups as mention below.

Financial Factors

Many factors are delaying the practice of ICT in the building industry. Financial Constraints are one of those factors. Referring to the Table 6 budget constraints for ICT investment, Cost for hiring IT professionals, and their training cost were the most important barriers hindering the ICT usage reported by respondents. Firms allocate very less amount of their budget for ICT.

Table 6. Overall RII Ranking of Factors Affecting ICT Implementation

Financial Factors Hindering ICT Usage	**Relative Importance Index (RII)**	**Ranking**
Budget constraint for ICT investment.	0.812	01
Hiring ICT professionals is expensive.	0.808	02
The cost of ICT proper training.	0.794	03
Benefits are limited, and the return on investment in ICT is low.	0.658	04
Social Constraints		
Inadequate staff with necessary ICT expertise and training.	0.87	01
Top management reluctance to ICT in the workplace.	0.862	02
Engineering curriculum ICT content is deficient.	0.828	03
Inadequate understanding of the profitability on ICT adoption.	0.818	04
Gratification with the current working method.	0.792	05
Afraid of job losses/professionals being retrenched.	0.79	06
Technical Constraints	**RII**	**Ranking**
Access to a relatively cheap workforce.	0.822	01
Problem of ICT compatibility in the organization.	0.786	02
Problems with software and hardware creditability.	0.778	03
Concerns about security/privacy.	0.778	04
Rapid changes in ICT technologies.	0.774	05
High rate of obsolescence ICT products.	0.748	06
Environmental Constraints	**RII**	**Ranking**
Inadequate job opportunities in the market.	0.802	01
The most of clients are unwilling to engage in ICT based firms.	0.794	02
Legal Constraints	**RII**	**Ranking**
Liability threats	0.796	01
Insufficient legal support for ICT use.	0.78	02
Security implications of ICT transactions.	0.776	03

Social Factors

All factors lying in social constraints that have a high value of relative importance as depicted in Table 6. Social factors were most affecting the ICT implementation in any firm than other barriers. The staff shortage with appropriate skill and knowledge in ICT was the most affecting factor. Respondents reported it to be highest affecting factor. Factors like an absence of commitment by firms' management towards ICT and People were satisfaction with their existing method of working were also affecting.

Technical Factors

The problem of ICT compatibility in the organization was considerably affecting the ICT usage among the technical constraints as shown by Table 7. Firms have limited resources they always wanted to consume fewer resources and increase profit margin. Therefore, they moved to access the relatively cheap workforce.

Environmental and Legal Factors

There were two types of factors explained by respondents in environmental constraints, lack of adequate jobs in the market, and second, the majority of the public was unwilling to engage in ICT-based companies Table 6. Risks for liability were at the top of the list among legal constraints. Firms did not take any risk. A deficit of legal support for use of ICT was the second important factor. The security implications of ICT transactions were the least affecting factors.

STRATEGIES FOR ICT IMPLEMENTATION

On a Likert scale of "Strongly Disagree" to "Strongly Agree," participants were asked to evaluate the alternative approaches to the use of ICT in their companies. Figure 3 shows the relative importance index analysis of their responses. Three leading proposed scenarios for the use of ICT in their companies were: ICT courses must be part of the engineering curriculum, top management must create an environment conducive to ICT, and CPD courses must be offered.

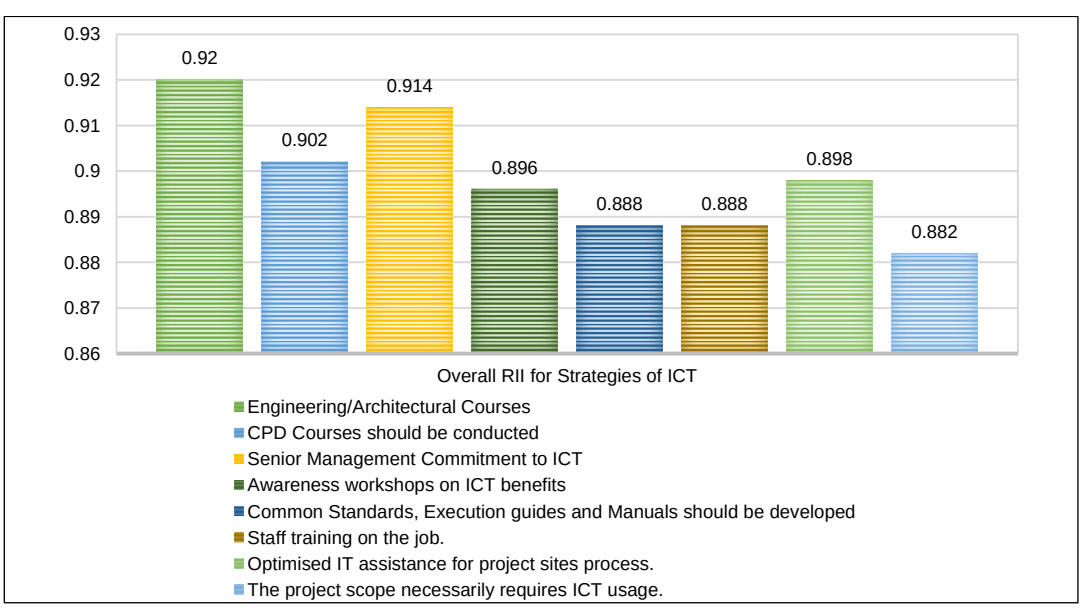

Figure 3. RII Ranking of Implementation Strategies for ICT

DISSCUSSION AND FINDINGS

Significance and the role of ICT cannot overlook in the Construction Project within Pakistan. ICT has influence on nearly all functional features of a modern business, principally

in industries such as financial services, travel and retailing (Shaw, 2014). According to (Andrew et al., 2016), revolution in technology is a fundamental feature that determine the growth of construction industry. However, its dissemination is low. In spite of many initiatives, ICT adoption in construction industry inadequate as compared to other industries particularly automotive and airspace.

This may to some degree rise on the grounds that the construction industry work is dependent on man power on other hand, manufacturing industries in which production is almost completely mechanized. Numerous researchers accuse the absence of investment in development of this field. The construction industry is right now confronting a change from conventional paper-based to digitally based data exchange, which has effectively profound established in different ventures, for example, airplane assembling and banking.

The outdated construction sector universally including Pakistan is needed to proceed towards advanced tools for their items, including production measures enhancement to accomplish more efficient and effective processes with products and production techniques. As per research did in Poland, it has been found that the time of prosperity for organizations who still not utilizing IT on the normal premise isn't long lasting (Kaplinski, O, 2018). Due to this explanation, the various benefits obtained by the ICT in the construction industry, however seems to be perceived, its usage as typical part of the construction process is still low and contractors are those major project stakeholders, who use ICT least of all (Peansupap et al., 2015).

Although this condition could perhaps be correct for the Pakistan construction trade, precise details concerning the degree of application and complications fronting the usage of ICT still remain unclear. The present study pursues to evaluate the situation in construction organizations in Pakistan. The questions in this reasearch sought to investigate the role of ICT and to find factors which hinder its adoption for success of construction projects in Pakistan. Various factors identified which affected the use of ICT in the construction sector.

These factors separated into five different groups financial, social, technical, environmental, and legal barriers. Findings from the result shown Lack of staff with appropriate skill and knowledge in ICT was the most affecting factor. It is because people in the construction industry do not want to learn new skills or enhanced their existing skills. Small scale Firms have limited resources, therefore they can not spend as much capital on ICT and less focus on training and skills development programs of their employees that is why Lack of commitment by firms' management towards ICT was the second most effecting factor. There were many other factors effecting the use of ICT in various firms of Pakistan.

From the findings various strategies were suggested to implement ICT in the construction industry. The initial step toward its implementation was it should be part of Engineering/Architectural Coursesand upgradation of previous cources according to need of market. Top management of firms should create a supportive environment conducive to Technology adoption within the organization. Pakistan Engineering Council should play its role as Continuing Professional Development courses should be conducted to increase the ICT skills of engineering professionals. IT support to the construction site process must be improved. Awareness workshops on ICT benefits should also be conducted. Competent

authorities should develop common standards, execution guides, and manuals for use of ICT in construction projects. Staff training on the job should be conducted.

CONCLUSION

The results of the questionnaire survey are presented in this paper. This survey can serve as a reminder of the current level of information and communication technology employed by construction companies on project sites and in company offices. It investigated the current state of ICT use, the advantages of ICT use, the barriers, and strategies for its implementation. MS Word processor, Excel Sheets, MS PowerPoint, and Access are the most commonly used software. As a result, it is possible to conclude that the computer is primarily used as a word processor and general administration software. Among other things, 76 % use computers for project activities. Meetings, WhatsApp messenger, Memos (Notices), Emails, and Video Conferences are the most popular practices of employer-employee communication. According to the survey participants, the three leading advantages of ICT were drastically increased firm efficiency, faster access to reliable information, and efficient collaboration among the entire project team. The major barriers to the use of ICT in the Pakistan construction industry are a shortage of manpower with necessary ICT skills and expertise, a lack of top management commitment to ICT in the workplace, the availability of reasonably cheap labor. Proposed implementation scenarios leading to an increase in the use of ICT in the Pakistan construction industry include ICT courses as part of the engineering curriculum, top executives must create an environment for ICT usage, CPD courses to increase ICT skills of professionals, awareness workshops on ICT benefits, and on-the-job ICT training for employees.

CONTRIBUTION AND FUTURE GUIDELINES

This is the first research of its kind in Pakistan that evaluates ICT use, its influence on the construction industry, and the impediments to adoption. This has the potential to help our building sector and policymakers figure out where our Construction Industry is in terms of ICT adoption and what initiatives are necessary to improve ICT usage in the Construction Industry. Furthermore, this research study may give an in-depth evaluation of ICT technologies in the industry, which could significantly contribute to project success. When deciding which ICT to put into use, the details might be a reference to the building sector. Furthermore, this research study might supply contractors and consultants with baseline information. They may readily choose which ICT Tool to be utilized. Moreover, the results of this research study may be used to develop selection criteria for the success of a building project. Following that, folks may use this as a reference when working on projects. Implementing ICT may aid the building process from start to finish.

Further research may compare traditional management projects with modern or ICT-based management initiatives. Furthermore, methodological research is needed to comprehend how ICT compatibility with organizational infrastructure influences project outcomes. More focused research regarding ICT use in the construction industry is needed, particularly on the use of more modern ICT technologies such as BIM, GIS, and barcoding, among others.

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CONFLICT OF INTEREST

The authors have stated no conflict of interest.

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EMERGING TECHNOLOGIES ADOPTION IN THE MALAYSIAN CONSTRUCTION INDUSTRY: A SYSTEMATIC REVIEW

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Abstract
Adopting Emerging Technologies (ET) can transform the Malaysian construction industry through improved productivity, efficiency, and sustainability. Although there is a growing body of literature on ET adoption, there remains a noticeable lack of comprehensive reviews specifically addressing the Malaysian construction industry. This study seeks to fill this gap by providing a systematic literature review (SLR) analysis of current research on ET adoption in the Malaysian construction industry. By examining 50 carefully selected and relevant journal articles, this investigation aims to highlight existing research gaps and potential future directions for industry professionals and academic researchers. The analysis revealed that prior research had studied nine groups of ETs: Advanced Materials, Artificial Intelligence (AI), Building Information Modelling (BIM), Blockchain, Cloud, Prefabrication & Modular, Internet of Things (IoT), Integrated, and Others. Also, the findings show no or limited research on five ETs that are part of the national strategic plan: 3D Printing & Additive Manufacturing, Autonomous Construction, 3D Scanning & Photogrammetry, and Big Data & Predictive Analytic. This study adds value to the existing literature by offering a comprehensive overview of research on ET adoption within the Malaysian construction industry. Moreover, identifying the knowledge gaps can illuminate potential avenues for future research in this domain. The study findings benefit industry practitioners, policymakers, and researchers interested in ET adoption in the Malaysian construction industry.

Keywords: *Malaysian Construction Industry*; *Emerging Technologies; Systematic Literature Review; Technology Adoption; Future Direction*

INTRODUCTION

The construction industry is vital to Malaysia's economic growth and progress (Musarat et al., 2022). Emerging technologies (ET) are showing promise in revolutionizing construction practices and improving productivity, efficiency, and sustainability (Roslan et al., 2022). However, as exciting as these developments may be, the consequences of not adopting ET could be dire and result in a range of consequences. One of the most significant consequences is increased environmental impact. As the global population grows and cities expand, there is a need to reduce the environmental impact of construction projects (Butt & Dimitrijević, 2022). Failing to adopt ET, including green building materials and energy-efficient systems, could lead to more pollution, carbon emissions, and resource depletion. In addition, not adopting ET could lead to reduced productivity, longer project timelines, and higher costs (Ismail et al., 2021; Al-Ashmori et al., 2020), and failing to adopt ET could put organisations at a disadvantage in the competitive market. Another critical issue is the safety risks to workers. The construction industry is one of the most dangerous in terms of working accidents and fatalities (Musarat et al., 2022). ET, such as drones and robotics, can reduce these risks by performing dangerous and labour-intensive tasks (Yap et al., 2021). Therefore, failure to adopt ET could increase safety in construction projects (Yap et al., 2022).

The construction industry is facing a pressing need to adopt ET to support its future growth and competitiveness (Roslan et al., 2022). Unfortunately, the slow adoption of ET in the construction industry can be attributed to a lack of knowledge and understanding among practitioners, which may result in a reluctance to embrace these innovations (Basaif et al., 2020). This reluctance to change puts the industry's future at risk and a competitive disadvantage, as it can lead to missed opportunities for innovation and growth (Khudzari et al., 2021). The guilt of this inaction should drive immediate steps to adopt ET and build a better future for all. The construction industry must recognize that innovation is critical to long-term success and sustainability (Nawi et al., 2018). Innovating requires a willingness to invest in ET and learn how to use them effectively. By doing so, the industry can improve its productivity, efficiency, and safety, as well as reduce its environmental impact (Ern et al., 2019).

To build a more innovative, efficient, and sustainable construction industry, addressing the challenges of ET adoption is essential (Bolhassan et al., 2022). This requires a comprehensive examination of prior research to identify and address knowledge gaps on ET adoption in the Malaysian construction industry (Glegg & Levac, 2018). This information can help identify areas where ET can be applied most effectively and provide guidance on overcoming adoption challenges (Darko & Chan, 2016). Additionally, it can help practitioners understand the potential benefits of ET and how to use them effectively, ultimately supporting the industry’s growth and competitiveness. In addition to addressing knowledge gaps, it is crucial to dispel fears and misconceptions surrounding ET. Stakeholders must work together to educate industry professionals and promote a culture of innovation and experimentation (Sim & Putuhena, 2015). By doing so, stakeholders can foster a conducive environment that encourages practitioners to embrace ET.

Hence, in addressing these issues, this study seeks to fill this gap by providing a systematic literature review (SLR) analysis of current research on ET adoption in the Malaysian construction industry. Through the SLR, this study aims to offer an in-depth understanding of technology adoption and expand the body of knowledge on ET within the country’s construction industry.

BACKGROUND

ET is a rapidly evolving and innovative technology that has the potential to impact society and economy. According to Rotolo et al. (2015), ET is characterized by a persistent level of coherence and is marked by the interaction of key players and organizations. However, the full benefits are unknown as ET is currently in an uncertain and unclear stage of development. Day and Schoemaker (2000) and Srinivasan (2008) emphasize that ET has transformative potential and can create new industries or disrupt and change existing ones. Therefore, organizations must embrace ET and recognize its potential to bring about major changes in how things are done. To remain competitive in respective industries, organizations must proactively adopt ET and stay ahead of the curve. Khudzari et al. (2021) and Srinivasan (2008) highlight the importance of staying informed about ET and the potential impact on making informed adoption decisions.

The Malaysian construction industry faces new and challenges due to the rapid advancements in ET. ET can transform the industry and improve efficiency, accuracy, safety,

and sustainability (Attaran, 2020). To fully leverage the potential of ET, the Malaysian construction industry must embrace a culture of innovation and continuous improvement (Mustafa Kamal & Flanagan, 2012). This culture includes investing in research and development (R&D), providing employee training and development programs, and developing partnerships with ET providers and academic institutions (World Economic Forum 2016; Youtie & Shapira, 2008). Along with the Construction Industry Transformation Programme (CITP) and to keep the Malaysian construction industry up-to-date and progressing, the Construction Industry Development Board (CIDB) has initiated the Construction 4.0 Strategic Plan (2021-2025). This five-year plan aims to modernise the local construction industry and make it smarter for the benefit of society. The goal is for Malaysia to become a leader in ET adoption in the region (Roslan et al., 2022). This plan also highlights twelve (12) ET that can transform the industry.

Emerging Technology Adoption Patterns in the Malaysian Construction Industry: A Contemporary Overview

The transformation of the Malaysian construction industry, marked by integrating ET, reflects national economic and development aspirations. This is articulated in the Twelfth Malaysia Plan 2021-2025, which lays out a strategic framework for the nation's growth, with a significant focus on ET in key industries (Economic Planning Unit, 2021). The plan emphasizes modernization through ET, such as building information modelling (BIM), artificial intelligence (A1), and advanced analytics, underscoring its role in enhancing efficiency and global competitiveness. It envisions a synergistic approach where government initiatives, private industry investments, and academia collaborate to foster a digital ecosystem conducive to innovation. Recognizing challenges such as the digital skill gaps and the need for substantial investments, the plan advocates for comprehensive strategies to facilitate the adoption, aligning the construction industry with the broader goals of transitioning Malaysia to a high-income economy.

Complementing this vision, the National Innovation Survey 2021 offers an analytical perspective on adopting ET in different industries, including construction (MOSTI, 2023). The survey indicates a positive trend towards ET, with a notable uptake among small and medium enterprises (SMEs). It highlights a correlation between ET and business growth, suggesting that organisations investing in ET are experiencing tangible benefits in productivity and profitability. However, it also highlights challenges like funding constraints and skill shortages, emphasizing the need for targeted solutions to promote wider ET adoption.

The BIM Report 2021, issued by CIDB Malaysia, represents a crucial aspect of the adoption journey. Published every three years, the reports provide a comprehensive analysis of the progression and impact of BIM on the local construction industry (CIDB Malaysia, 2023). The 2021 edition marks a significant milestone, revealing how BIM adoption has evolved. It details the increasing use of BIM in complex construction projects, illustrating its effectiveness in improving collaboration, reducing errors, and optimizing resource allocation. Notably, the report emphasizes the benefits of BIM in achieving greater project efficiency and accuracy, crucial for staying competitive in a rapidly advancing global industry. The triennial nature of the reports reflects a deliberate and strategic approach by the CIDB to monitor, assess, and guide the adoption of BIM. By providing a detailed snapshot every three

years, the reports serve as a barometer for technological progress within the industry, allowing stakeholders to understand trends, identify gaps, and adjust strategies accordingly. The 2021 report, in particular, sheds light on the increasing importance of BIM in the digital transformation of construction practices, highlighting its role in streamlining operations and enhancing overall project outcomes.

In addition to the technological and infrastructural advancements underscored in the BIM Report, the role of overarching national visions in shaping these developments cannot be overstated. Transitioning from the specificities of BIM implementation, it is imperative to consider how broader governmental strategies, including the Shared Prosperity Vision 2030, are framing the future of the Malaysian construction industry. This vision offers a strategic and comprehensive blueprint for equitable and sustainable growth in the country, with profound benefits for different industries (Ministry of Economic Affairs, 2019). Key to this vision is the integration of ET such as AI, Internet of Things (IoT), and green technologies. The emphasis is on leveraging ET to enhance efficiency and productivity and ensure the adoption contributes to sustainable and environmentally responsible practices. This aligns with the vision's overarching goals of balancing economic growth with environmental stewardship and societal well-being. The Shared Prosperity Vision 2030 also stresses the importance of human capital development in realizing ET ambitions. It acknowledges the need to upskill the existing workforce and nurture a new generation of professionals proficient in ET. The vision calls for educational reforms and continuous professional development programs to equip the workforce with the necessary skills to thrive in a digitally transforming industry. This focus on human capital is essential for driving innovation and maintaining Malaysia's competitiveness on the global stage.

Although the adoption of ET in the Malaysian construction industry is still nascent, there are encouraging indicators of progress (Khudzari et al., 2023). It is imperative for industry stakeholders to recognize the potential of ET and make the necessary investments. As a nation, Malaysia must strive to stay at the forefront of ET to avoid being left behind. This requires a concerted effort from all stakeholders, including government, industry, academia, and society. It also requires a conducive environment for innovation, which includes supportive policies, adequate funding, a skilled workforce, and a culture that embraces change and innovation.

Research Gap

The Malaysian construction industry has recognized the potential benefits of ET adoption and has made strides toward integrating them into construction processes. CIDB has identified 12 types of ET that are essential for driving innovation and growth in the industry: *Prefabrication and Modular Construction, 3D Printing & Additive Manufacturing, Autonomous Construction, Augmented Reality & Virtualisation, Cloud & Real-time Collaboration, 3D Scanning & Photogrammetry, AI, Blockchain, Big Data & Predictive Analytics, Advanced Materials, IoT & BIM*. Reviewing the existing literature in this area is crucial to understanding the state-of-the-art of ET adoption, as well as identifying challenges and opportunities for future development. Therefore, this study seeks to fill this gap by providing an SLR analysis of current research on ET adoption in the Malaysian construction industry. To accomplish this, this study conducts an SLR on ET adoption in the Malaysian construction industry.

METHODOLOGY

An SLR was conducted to identify, assess, and synthesise current literature on ET adoption in the Malaysian construction industry. SLR aims to provide a comprehensive summary of existing knowledge, highlight the weaknesses and strengths, as well as identify gaps in the current literature (Ghaleb et al., 2022; Wawak et al., 2020). Due to its rigorous and transparent method that uses explicit and systematic methods to minimize bias and ensure the reproducibility of results, SLR has grown over time among the scientific community (Mengist et al., 2019; Boell & Cecez-Kecmanovic, 2015). The SLR process is depicted in Figure 1, illustrating how this study refined from an initial pool of 174 articles down to a final selection of fifty articles through a series of consecutive screenings. A systematic desktop search was performed to identify suitable articles. Here, the Scopus database was chosen for the search as it is comprehensive and widely recognized to provide access to a vast collection of peer-reviewed articles from different fields (Baas et al., 2020; Schotten et al., 2017). The search involved selecting appropriate keywords and using the "article title/abstract/keywords" field. The query was designed to encompass different variations of the terms "technology" and "construction industry" or "construction project" or "construction projects," along with the term "Malaysia."

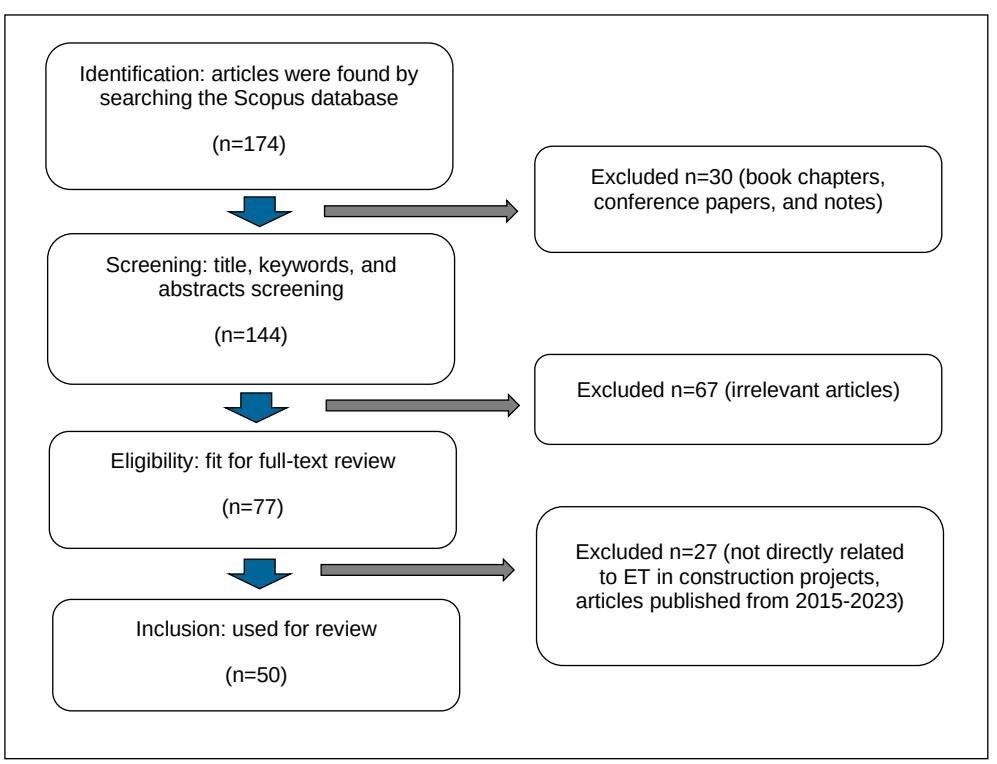

Figure 1. SLR Procedure

To narrow down the selection of articles for further investigation, a rigorous screening process was conducted. Initially, a search string retrieved 174 articles from the Scopus database. After removing book chapters, conference articles, and notes, 144 articles remained. These were excluded based on concerns about the quality. Additionally, only peer-reviewed journal articles that have undergone thorough review before included for further analyses.

During the screening procedure, the article titles, keywords, and abstracts were examined. Of the 144 articles, 67 were excluded due to not being directly related to ET in construction projects. Finally, articles that failed to satisfy the design standards or criteria were removed, resulting in a final selection of 50 valid articles for further investigation. The systematic screening process ensured that only high-quality and relevant articles were considered for the study.

OVERVIEW OF EXISTING RESEARCH

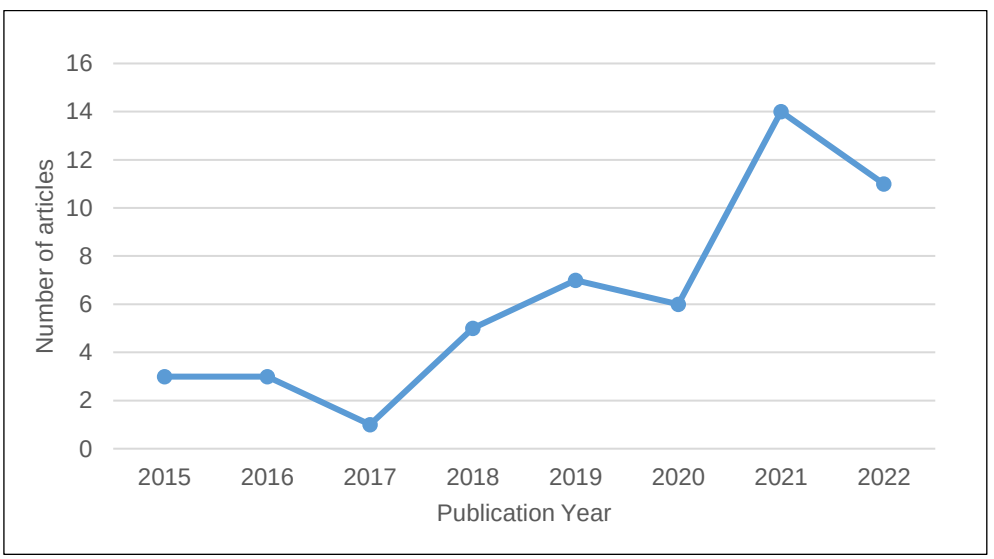

Figure 2. Publication Years of Reviewed Articles

As depicted in Figure 2, the number of articles on ET per year in the Malaysian construction industry has steadily increased from 2015 to 2022. Starting with just three articles in 2015, the number of articles remained relatively low in the early years, with only one article in 2017. However, interest in the topic grew significantly from 2018 onward, with five articles that year, followed by seven articles in 2019. The influence of the COVID-19 pandemic in 2020 can be seen in the sudden jump to six articles, as the construction industry sought to adopt ET to adapt to new challenges and maintain productivity amid restrictions. This trend continued in 2021 and 2022, with fourteen and eleven articles, respectively, reflecting the industry's ongoing pursuit of ET to enhance efficiency, safety, and resilience in the face of global uncertainties. *Malaysian Construction Research Journal (MCRJ)* is the leading journal (eleven articles), followed by the *International Journal of Sustainable Construction Engineering and Technology* (eight articles).

RESULTS AND DISCUSSION

Emerging Technologies in The Literature

Only fifty articles were found relevant after scrutinizing the articles using the specified search query in the Scopus database. From this selection, nine principal ET clusters have been identified, including Advanced Materials, AI, BIM, Blockchain, Cloud, Prefabrication & Modular Construction, IoT, Integrated, and 'Others'. The 'Others' cluster is not categorically

specific and encapsulates a range of ET related to safety, health, and information technology (IT). These clusters represent the diverse ET that are currently characterizing the local construction industry. Figure 3 offers a visual representation of the distribution of academic attention across these nine clusters, thereby providing a clear, empirical basis for understanding the landscape of ET adoption in the Malaysian Construction Industry.

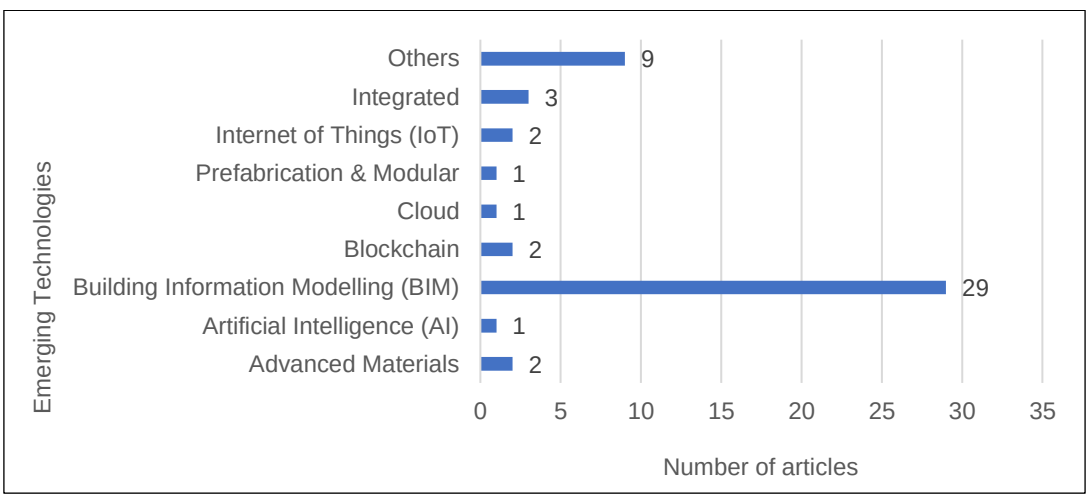

Figure 3. Emerging Technologies Identified from The Reviewed Articles

Advanced Materials

Two articles are related to Advanced Materials. The construction industry is facing a surge in developing new and advanced building materials. These materials offer numerous benefits to contractors, architects, and property owners, ranging from improved sustainability and durability to enhanced aesthetics and reduced construction costs (Abyzov et al., 2020). One of the key trends in advanced building materials is sustainable materials (Ortiz et al., 2009). This includes using recycled materials (e.g., steel, concrete, and plastic) as well as developing environmentally friendly materials (e.g., bamboo, straw, and engineered wood products) (Bredenoord, 2017). Using sustainable materials helps reduce construction's carbon footprint and promotes a more sustainable future for the industry (Chan et al., 2022).

Regardless of the surge in the significance of advanced materials in the construction industry, thorough research within the context of Malaysia remains scarce. Research by Nawi et al. (2018) explored the implementation of load-bearing masonry (LBM) in the Malaysian construction industry to identify key success criteria and challenges. These included organisational preparedness, effective collaboration, ease of installation, skilled labour, continuous knowledge improvement, efficient work coordination, enhanced construction efficiency, and sustainable practices. Furthermore, Gungat et al. (2022) investigated different aspects of crumb rubber usage in road construction in Sabah, such as awareness, benefits, challenges, strategies, and personal opinions. The research highlighted environmental sustainability as a primary benefit, but financial constraints posed a significant challenge. Despite these valuable contributions, there remains a pressing need for further exploration into the adoption of advanced materials in the Malaysian construction industry.

Artificial Intelligence

Only a single article on AI was identified in the review. AI encompasses the development of machines capable of executing tasks typically necessitating human intellect, such as perception, learning, and decision-making (Helm et al., 2020). Within the construction industry, AI enhances multiple components of the construction process, from conception to completion. A significant benefit of AI in construction is its ability to optimize project timelines, minimize waste, and bolster safety (Abioye et al., 2021). For instance, AI algorithms can estimate the material quantity needed for a project and determine the most effective construction order, lowering the likelihood of expensive errors and delays (Regona, 2022). Moreover, AI can be employed for real-time surveillance of construction sites, offering immediate insights into potential safety hazards, and facilitating pre-emptive actions to reduce risks (Pan et al., 2021; Abioye et al., 2021).

Research on AI applications within the Malaysian construction industry remains scarce. In 2020, Basaif et al. (2020) explored the awareness of Malaysian construction professionals regarding AI usage for risk analysis. The research revealed that numerous participants possessed a limited grasp of AI and had not integrated it into the risk assessment procedures. Furthermore, most had not participated in any training or attended university courses on AI. The research also discovered that most Malaysian construction organisations provided minimal, if any, formal AI training and lacked subsequent programs for reinforcement. These findings suggest the existence of a knowledge and education gap concerning AI in the Malaysian construction industry, underscoring the necessity for additional research and training efforts in this domain.

Building Information Modelling

From the review, 29 articles are associated with BIM, an ET that can revolutionise the construction industry (Abubakar et al., 2014). It involves a process using 3D computer-aided design (CAD) to develop a virtual representation of a structure, including details about its design, construction, and operation (Rogers et al., 2015). BIM allows all project stakeholders involved in construction projects to collaborate within a unified digital space, minimizing the chances of mistakes and miscommunications, as well as enhancing team member interactions (Doumbouya et al., 2016). The Malaysian construction industry is having increased interest in BIM, with researchers concentrating on promoting awareness and assessing its adoption status. Research by Ting & Taib (2018) and Hanafi et al. (2016) underscored BIM's potential to boost productivity and tackle industry issues and, drawing attention to the low adoption rate among architectural organisations.

Despite recognizing its benefits, BIM adoption in Malaysia remains low, as demonstrated by research carried out by Musa et al. (2019), Roslan et al. (2019), and Jamal et al. (2019). Rogers et al. (2015) found that engineering consultancy organisations are prepared to adopt BIM in line with industry requirements. In terms of benefits, Ismail et al. (2020) identified visualization and simulation for safety as key BIM capabilities for improving safety climate, while Al-Ashmori et al. (2020) and Ern et al. (2019) emphasized the significance of productivity, time, cost, clashes, and communication. Prior research also explored the challenges, success criteria, and drivers behind BIM adoption in the local construction industry. Key challenges include time and financial appraisal, resistance to change, hardware

upgrades, lack of clear guidelines, and intellectual property rights issues (Munianday et al., 2021; Ismail et al., 2021; Baharom et al., 2020). Despite these obstacles, management support, staff capabilities, competencies, and IT skills have emerged as critical success factors for BIM adoption (Aziz et al., 2022; Harris et al., 2015; Ying et al., 2021). Different factors, such as benefits, support from top management, and the government, can facilitate BIM adoption, but financial constraints and interoperability issues hinder progress (Ahmed et al., 2022; Shehzad et al., 2022). To foster quicker adoption of BIM, research points to the crucial role of digital evolution, sustainable approaches, BIM-centric education, unambiguous guidelines, and all-encompassing training initiatives (Hussain et al., 2020; Zulkefli et al., 2020; Ibrahim et al., 2019; Jamal et al., 2019).

Blockchain

In the reviewer literature, only two articles are on blockchain. Blockchain employs encryption to safeguard and authenticate transactions as a decentralized digital register (Javaid et al., 2021). Initially developed as the underlying technology for cryptocurrency, blockchain is currently adopted across industries (Habib et al., 2022). Within the construction industry, blockchain oversees and monitors the exchange of information and data among different project stakeholders (Wang et al., 2017). Such information and data encompass contracts, invoices, payments, and more. By offering all project stakeholders a secure and transparent record of every transaction, blockchain reduces the chances of errors, fraudulent activities, and disputes (Habib et al., 2022).

Several research examined the prospect of blockchain tackle issues within the Malaysian construction industry. Amaludin et al. (2018) analysed possible blockchain applications in the Malaysian construction industry and concluded that its prospects are promising but remain in the early adoption stages. Bolhassan et al. (2022) investigated the integration of blockchain and smart contracts in the Malaysian construction industry. The research discovered that such contracts could promote a more equitable allocation of risks, diminish the likelihood of disputes, and enhance transparency and accountability. However, although prior research offers encouraging insights, evidence to ascertain whether blockchain adoption in the local construction industry is adequate is still lacking. Therefore, evaluating the benefits of blockchain adoption within the construction industry and researching real-world applications are necessary.

Cloud

One article related to cloud was discovered within the reviewed literature. Cloud involves providing computing services via the internet (Albini et al., 2019; Leymann, 2011). It offers a secure and adaptable platform for sharing and accessing vast amounts of data and information (Bello et al., 2020). These features enable construction professionals to collaborate and work on projects remotely, using different tools such as smartphones, tablets, and laptops. Notably, although cloud adoption is growing in numerous industries globally, research on its adoption in the Malaysian construction industry remains scarce. The investigation by Goh et al. (2020) offers glimpses into the present awareness and usage of cloud in the local construction industry. The research indicates that much work remains to incorporate cloud into the local construction industry. Additional R&D is required to examine the potential benefits of cloud, including enhanced efficiency, collaboration, and cost savings.

Finally, industry experts and policymakers need to acknowledge the significance of cloud and prioritize its adoption to stay competitive in a rapidly changing global market.

Prefabrication & Modular Construction

Only one article focused on Prefabrication & Modular Construction was identified in this study. Prefabrication and modular construction refer to constructing components in a factory setting and then delivering and assembling on-site (Neelamkavil, 2009). In the construction industry, prefabrication and modular construction are used as an alternative to traditional construction methods, providing a faster, more efficient, and cost-effective solution (Razkenari et al., 2019). The available literature suggests limited research on prefabrication and modular construction in Malaysia. This sole research focuses specifically on Industrialized Building Systems (IBS), a type of prefabrication and modular construction system involving standardized building components and systems.

In 2017, Zakaria et al. (2017) published an article aiming to identify the criteria that affect the decision to use IBS in construction projects. The research revealed that the affecting factors could be classified into three themes: ‘structural,’ ‘contextual,’ and ‘behavioural.’ The ‘structural’ and ‘contextual’ themes contained five factors affecting the decision to adopt IBS. In comparison, the ‘behavioural' theme consisted of four factors. The 'contextual' theme presents five factors: economic circumstances, technology development, government engagement, environmental sustainability attributes, and involvement of stakeholders. The 'behavioural' theme encompassed four factors: experience, limited rationality, awareness, and attitude. Although the research offers valuable insights into the decision-making process regarding IBS adoption in the local construction industry, it is worth noting that the results may not be entirely representative of other prefabrication and modular construction approaches. Further research is necessary to investigate the broader benefits and opportunities of prefabrication & modular construction in the Malaysian construction industry, as well as assess the solutions for addressing the adoption challenges.

Internet of Things

Within the literature focused on ET, only two articles delve into IoT. IoT entails a network or a system of interconnected physical tools, appliances, automobiles, and other objects equipped with electronics, software, sensors, and network connectivity to facilitate the exchange of information (Bhosale et al., 2020). In the construction industry, IoT holds high prospects for transforming how buildings are designed, constructed, and managed. Improved safety is one benefit of IoT in construction. IoT devices can monitor the environment for possible hazards, such as changes in temperature, noise levels, and air quality (Nandanwar & Chauhan, 2021). The gathered data can be used to take proactive measures to prevent accidents and safeguard workers.

Mahmud et al. (2018) outlined the different IoT applications that are used in the Malaysian construction industry. The research discovered that the local construction industry employs different forms of IoT applications, including social media applications for communication and discussion, emails for exchanging information, and websites as a source of reference for data on organisation profiles, laws and policies, and price quotes. Subsequently, Ibrahim et al. (2021) conducted another research regarding IoT in the industry

in response to the rise of Construction 4.0 in Malaysia. The research observed that using IoT with other ET, including BIM, smart communication, sensors, big data, augmented reality, location services, and remote operation, during the construction process contributed significantly to monitoring the construction process. In other words, IoT helped reduce the risk of construction errors and defects and prevented construction delays.

Integration

Three articles related to integrating ET were found. This research revealed that ET are integrated with each other in the Malaysian construction industry. Lee et al. (2022) developed an acceptance model for BIM-based Virtual Reality (BIM-VR) in cost estimation. The research showed that the most significant factors in BIM acceptance are cost and resource-saving. In contrast, the primary challenge to BIM-based VR adoption in cost estimation is the scarcity of necessary skills. In another research, Nursal et al. (2016) explored the adoption of cloud-based decision support systems for BIM software selection, which aimed to provide an analytical tool for evaluating and identifying the most eligible BIM software in a fuzzy environment. Lastly, Mugumya et al. (2019) investigated the function of Linked Building Data (LBD) in synching augmented reality with construction sustainability. The research explored the performance gap in the Malaysian construction industry concerning using LBD with augmented reality to improve sustainability throughout a building's lifecycle. The research suggests that current industry practices do not favor the usage of augmented reality. However, stakeholders positively perceive adopting workflows that connect heterogeneous building data to integrate augmented reality with sustainable building design and construction.

Others

There are nine articles categorised under this cluster. Within the scope of safety and health in the construction industry, several research has focused on ET and its potential benefits. According to Yap et al. (2021), BIM, wearable safety technologies, and automation & robotics are the most effective ET for improving safety management in the construction industry. Similarly, Musarat et al. (2022) identified BIM and wireless monitoring and sensors as critical in improving safety and health via the Industrial Revolution 4.0 (IR 4.0). Another research by Yap et al. (2022) uncovered critical challenges in adopting ET to improve construction safety. Kasim et al. (2021) highlighted the drivers and challenges of adopting IR 4.0 to improve safety management practices. The research highlights the benefits and challenges of ET adoption for enhancing safety and health in the local construction industry.

In terms of IT, Zainon et al. (2022) identified eighteen critical success criteria for delivering IT infrastructure flexibility (ITIF) in the Malaysian construction industry. The research highlighted hybrid skills and willingness toward changes as distinctive criteria. On the contrary, Yaakob et al. (2021) found that telecommuting acceptance in the construction industry is positively affected by one's attitude, the balance between work and personal life, the type of work being performed, work efficiency, the feeling of empowerment, and the use of IT. According to the research, empowerment and the nature of the work being performed were the most significant factors in driving acceptance of telecommuting. In contrast, Hashim et al. (2021) assessed construction organizations' readiness for ET; most are moderately prepared. Meanwhile, Nawi et al. (2017) emphasized the benefits of e-procurement, such as

cost reduction and improved efficiency in government business. Lastly, Waris et al. (2015) investigated on-site mechanisation in the Malaysian construction industry. The research suggests that local IBS contractors exhibit an excellent comprehension and execution of automated practices. However, budget constraints still hinder its adoption among SMEs.

Limitations and Future Directions

Research on any topic is never complete; there is always room for further exploration and refinement. The same can be said for the research on this subject matter. Nevertheless, this study significantly contributes to the body of knowledge on ET in the Malaysian construction industry by assessing the existing body of knowledge. Furthermore, this study examines the current research limitations and potential future research initiatives.

The methodology of several previous research is constrained by adopting a single method, either qualitative or quantitative (Munianday et al., 2022; Nawi et al., 2018). Therefore, using multiple methods to strengthen the findings by providing a more nuanced and comprehensive understanding of a topic (Mertens & Hesse-Biber, 2012; Creswell & Zhang, 2009; Greene et al., 2005). This research strategy can help address a single method's limitations and provide a more robust understanding of the complex relationships between factors (Golicic & Davis, 2012; Abowitz & Toole, 2010).

On top of that, bias in sample selection can occur if research involves a sample limited to one profession rather than including individuals from different professions (Ismail et al., 2021; Ying et al., 2021; Basaif et al., 2020). Hence, future research should involve a wider sampling and interdisciplinary approaches to bring together experts from different fields, such as engineering, architecture, and environmental science. This involvement can provide a more comprehensive understanding of the potential and limitations of ET (Butt & Dimitrijević, 2022).

Another limitation of current research regarding ET is that data gathering is often limited to developed or large cities (Ahmed et al., 2022; Shehzad et al., 2022; Gungat et al., 2022; Othman et al., 2021). This limitation occurred as developed states and major cities have more infrastructure and resources to facilitate data collection. However, the lack of data from rural or less developed areas can lead to a biased understanding of the local construction industry (Abrams, 2010). The experiences and needs of people may be significantly different from one place to another. Additionally, this bias in data collection can result in unequal distribution of resources and services, as the needs of less represented populations may not be fully understood or addressed (Lipton, 1977). Thus, limiting data collection to developed or large cities can result in difficulties in drawing accurate conclusions or making informed decisions.

Another limitation is that ET adoption involves high costs and training programs (Ismail et al., 2021). The cost of acquiring the necessary equipment, software, and skilled workers can be substantial, particularly for SMEs (Nnaji & Karakhan, 2020; Awwad et al., 2020; Ahmad et al., 2018). Future research should be carried out to determine how ET can be implemented cost-effectively. By reducing the adoption cost, SMEs are more likely to embrace ET, which can help organisations stay competitive in the rapidly evolving industry landscape (Ameen et al., 2022).

Prior research also suggests that research on factors affecting ET adoption is still limited and fragmented (Zamani, 2022; Mccoy & Yeganeh, 2021). Specifically, out of the twelve ET in CIDB's Construction 4.0 Strategic Plan (2021-2025), only several ET are covered by the body of knowledge. Additionally, all research was specific to a certain ET. The limited research coverage highlights the need for further research to uncover factors affecting ET adoption. Identifying the factors can provide a comprehensive understanding and create a unified approach toward ET adoption in the Malaysian construction industry (Basaif et al., 2020; Al-Ashmori et al., 2020).

CONCLUSION

In summary, this study contributes to the existing body of knowledge by providing an SLR analysis of current research on ET adoption in the Malaysian construction industry. ET holds the capacity to revolutionise the industry by improving efficiency, accuracy, safety, and sustainability. CIDB has initiated the Construction 4.0 Strategic Plan (2021-2025) to modernize the construction industry and make it smarter for the benefit of society. Although the body of literature on ET adoption in the Malaysian construction industry is expanding, certain areas still have knowledge gaps that require further exploration.

This study extensively reviews existing literature on ET adoption in the Malaysian construction industry. By systematically examining articles published between 2015 and 2023, this study presents a thorough overview and insights for industry professionals and academics. A total of fifty articles were meticulously scrutinized and then grouped into nine categories of ET: Advanced Materials, AI, BIM, Blockchain, Cloud, Prefabrication & Modular, IoT, Integrated, and Others. The study also identifies several aspects that call for more in-depth research to leverage the potential of ET in the construction industry. Industry professionals and policymakers must recognize the importance of ET and prioritise adoption. This prioritisation may involve investing in R&D, providing employee training and development programs, and developing partnerships with ET providers and academic institutions. By embracing a culture of innovation and constant improvement, the Malaysian construction industry can stay ahead of the curve and remain competitive in a rapidly evolving global market.

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NUMERICAL STUDY OF FOOTBALL TRAINING CENTER THERMAL COMFORT CHARACTERISTICS IMPROVEMENTS BY TRANSPARENT ROOFS APPLICATION

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Abstract
The temperature of the air and football field are estimated very high at noon in Asian countries. The passive method of thermal comfort including a transparent roof is preferable during no-match and no-training times especially at noon, in order to save energy and go green. Therefore, the present work predicts the football field temperature and air temperature inside a football training center with a transparent roof in order to reduce turf and air temperatures, hence, improving the quality of thermal comfort at noon. FLUENT CFD code was utilized in the present work. The study covers the effect of a single-layer transparent roof and a double-layer transparent roof on the football training field temperature and the temperature of the air inside the building. The ambient temperature was set at 34°C, and solar irradiance and natural convection effects were included in the computational. The materials of the roof, building wall, office wall, and football field are set as ETFE, ACP, glass, and artificial roof, respectively. According to the results, the average temperature of a football training field for the double-layer transparent roof is 6.3°C lower than that for the single-layer transparent roof. Moreover, the average air temperature for the double-layer transparent roof is 0.96°C lower than that for the single-layer transparent roof. In conclusion, the double-layer transparent roof enhances the thermal comfort of the football training center.

Keywords: *Thermal Comfort; Computational Fluid Dynamic; Football Field; Transparent Roof*

INTRODUCTION

Thermal comfort is one of the comfortable characteristics in designing buildings. Heat transfer is the key element of the building's thermal comfort. The heat transfer mechanism is divided into three including conduction (Choong, Hasan, Shuib, Yusoff, & Xin, 2021), convection (Nasir, Abdullah, & Ismail, 2019), and radiation (Liu, Wang, & Yang, 2023). Therefore, all heat transfer mechanisms affect the building's room temperature. Moreover, relative humidity (RH) and air velocity are the other elements of thermal comfort (Azmi, Abdul Tharim, & Yusof, 2022). In Malaysia, the ideal indoor temperature in residency is between 23°C and 26°C. However, the mean daily average maximum temperature is 34°C (Jamaludin & Mohammed, 2015). Therefore, the air conditioning system is employed to maintain comfortable indoor temperatures.

In 2023, the total population around the world exceeds 8 billion people. This number is expected to increase in the future. Thus, the number of buildings especially in big cities increases and it is unavoidable. As a result, the number of air conditioning increases in order to achieve proper thermal comfort in the building. As a consequence, the demand for energy increases. If the situation is not properly managed, an energy crisis is expected to happen in the future. The overall energy demand in Malaysia increased by 6.3%. Meanwhile, 48% of electrical energy goes to building operations (Mohamad Nasir, Lop, Mohd Kamar, & Mat

Salleh, 2022). Thus, a smart energy system is necessary to flatten the percentage of air conditioner appliances and energy demand.

Relative humidity (RH) is another factor of thermal comfort. In fact, RH in Malaysia is quite high, between 74% and 86% (Jamaludin & Mohammed, 2015). However, the ideal RH is between 50% and 60%. In addition, very high RH degrades air conditioning and thermal comfort effectiveness. Thus, the researchers approach many methodologies to reduce RH including the application of solid desiccant. Silica gel is a popular material that has been used as a passive dehumidifier (Balthazar, et al., 2021). The other passive method enhances the effectiveness of building orientation selection. Proper building orientation reduces solar heat irradiance gain from the sun and enhances comfort (Shamsu Kamal Bahrin, Abdul Tharim, & Abdul Aziz, 2022). Thus, the rule of thumb for thermal comfort now is obsolete and inaccurate.

It is well known that the temperature in Middle East and Asian countries is warm. At noon, the ambient temperature is very high, and the football field temperature is expected around 48°C (Losi, Bonzanini, A., & Poesio, 2021). The active HVAC system is used during football matches and training only, as it requires a lot of energy and electric power consumption. Then, the passive cooling system, the transparent roof, is very useful to use during idling time, especially at noon. The transparent roof reflected some IR radiation from the sun back to the sky or surroundings, hence the football field absorb less IR radiation from the sun. As a result, the temperature of the football field decreases by applying a transparent roof in the design. In addition, the ETFE transparent roof allows light transmission through it. Thus, it reduces the lighting cost during the daytime.

The sophisticated method available the predict the thermal comfort characteristic and design is computational fluid dynamic (CFD) code. However, the CFD is not suitable at the level where it can be blindly used by designers with no basic knowledge of numerical methods, heat transfer, and fluid mechanics. In thermal comfort CFD application, experience and CFD knowledge are required by the designers to analyse the data and avoid wrong interpretation of the data. Therefore, as a preliminary HVAC design of the football training center, the CFD has been employed to estimate the temperature of the air and football field.

The history of CFD dates back over 40 years ago. Since the commercial CFD code was introduced in early 1980, it has become popular in real engineering applications including electronic cooling (Azmi, Abdullah, & Ismail, 2019), aeronautic (Ismail & Wang, 2018), anti-icing systems (Munas, Yu, Yusoff, Muzathik, & Ismail, 2023) water dams (Issakhov & Imanberdiyeva, 2019), water treatment (Rosli, Murshed, & Adlan, 2016), HVAC and thermal comfort (Ismail & Che Jamil, CFD HVAC Study of Modular Badminton Hall, 2020), and fire safety (Bernardi, Michelini, Sirico, Rainieri, & Corradi, 2020), etc. CFD was proposed for building energy consumption back in 1985 by Clark et al. (Zhang, Deng, Shan, Kang, & Ren, 2023). Since then, CFD has proven it be an excellent methodology for designing building thermal comfort. As a result, CFD becoming very popular among researchers in thermal comfort studies. For instance, Catalina, Virgone & Kuznik (2009) employed CFD in a study of chilled cooling ceiling panels as alternatives to traditional air conditioning systems. They claimed that thermal comfort is achieved by cooling ceiling panels even for the high rate of metabolism. Moreover, they also stated that the cooling ceiling has advantages over traditional air conditioning including low vertical air gradient.

Three years later, the natural ventilation and thermal comfort study in an atrium was conducted by CFD code FLUENT (Hussain & Oosthuizen, 2012). The author utilized steady-state conditions with k-omega shear stress transport as a turbulent airflow model. According to the results, a higher chimney height produces a better performance of natural ventilation performance. In addition, solar is one of the important parameters for inducing the ventilation airflow in the atrium building. Subsequently, the thermal comfort and temperature distribution inside the theatre building using high-rise ceiling theatre air-conditioned with underfloor air distribution has been studied by Nada, et al. (2016). They also use CFD code FLUENT to understand the air temperature, air velocity, space height, and number of diffusers inside the building. The predicted results then have been validated with available experimental data. According to the authors, their predicted results show good agreement with experimental data.

Recently, with advancements in CFD application and computer performance, the thermal comfort parameters of sports venues have been predicted by the CFD code. The thermal comfort of Galatsi Arena has been evaluated by Stamou, Katsiris & Schaelin (2008). According to the CFD results, the predicted mean vote and predicted percentage of dissatisfied values reveal the thermal condition of the arena was in excellent condition. Next, Rajagopalan and Luther conducted a CFD study to evaluate the thermal performance of natural ventilation within an aquatic center in Victoria, Australia (Rajagopalan & Luther, 2013). During warm weather with high solar radiation, a high thermal comfort design is required to overcome a high level of thermal discomfort in this space. The author also suggests that low-level wall exhaust fans produce better comfort conditions for occupants than roof exhaust fans. Then, Ismail & Che Jamil (2020) utilized CFD code to predict the temperature and velocity of air in modular badminton halls. They employ wall exhaust fans to enhance thermal comfort in the hall. The exhaust fan arrangement needs to be designed properly to make sure indoor air velocity is less than 0.2m/s. With the aid of CFD, they managed to design proper exhaust fan numbers and arrangements in the modular badminton hall.

Afterward, Limane, Fellouah, & Galanis (2018) used OpenFOAM to conduct a 3D prediction of thermal comfort inside an indoor swimming pool. They study the thermal comfort characteristics including velocity, temperature, and relative humidity of air. For further improvement, they suggested modifying air-blowing conditions to enhance indoor air quality and the thermal comfort of occupants. The combination of building energy modelling and CFD has been studied by Guo et al. (2022) in order to evaluate the natural ventilation of a gymnasium in a subtropical country. Based on the result, thermal buoyancy affects air change rate and wind velocity conditions. In addition, the indoor temperature has a slightly higher temperature than the outdoor ambient temperature. Losi, Bonzanini & Poesio (2021) present of CFD analysis of thermal comfort in a football stadium for the International World Cup 2022 in Doha, Qatar. According to the analysis, the present air conditioning system indicates significant thermal comfort for spectators and occupants in the stadium.

This paper presents the thermal comfort analysis of a football training center at noon. In Malaysia, football matches are normally at night, and training has been scheduled in the early evening and evening. Besides, the active HVAC system may be activated during football matches and training times to fulfill authority guidelines. In the idling time, at noon especially there is no guideline HVAC requirement about it. Therefore, at noon, active HVAC systems are turned off. If the temperature is too high at noon, it may reduce the lifespan of the football field and equipment, for example, artificial turf. Thus, the study emphasizes temperature

distribution on the football training field at the peak solar irradiation condition. The passive HVAC system, which is the transparent ETFE roof, is used as the football training center roof in order to save light energy in the daytime. Besides ETFE transparent roofs reduce wall air temperature in the football field and equipment by reflecting IR heat from the sun. CFD has been used to estimate the effectiveness of the EFTE as a transparent roof in reducing air and football field temperatures at noon. Afterward, by using CFD, the design improvement has been made to reduce the temperature on the football field and enhance the lifespan of the football training facility.

METHODOLOGY

The geometric modelling, dimension, meshing, boundary conditions, and computational setup are discussed in the methodology section.

Assumption of the Study

In the present simulation work, there is some assumptions have been made and listed below:

- The heat is supplied by solar radiation only, not by humans, spectators, or players.
- No external wind has been assumed. Therefore, the simulation is 100% natural convection. The air density is assumed as ideal gas to turn on air buoyancy force.
- The wall of the office (glass wall) is assumed isothermal and set at 24°C, due to office thermal comfort being 24°C.
- The thermal properties of all wall materials including the coefficient of reflectivity, transmittivity, and absorbability of all materials are constant again time and temperature.

Geometric Modelling and Dimension

The design of the football training center is proposed by NHK Ultimate Consultant. The building has dimensions of 160m in length, 103m in width, and 25.8m in height as illustrated in Figure 1. The building consists of an office and gym, a football training field, a building wall, and a transparent roof. In the present study, the Gambit pre-processor was used to develop 3D modelling. The material of the roof, building wall, office and gym wall, and football field are ETFE, ACP, glass, and artificial turf, respectively. The details of the materials are summarised in Table 1.

Table 1. Detail Material Information

Design Type	Materials
Roof	ETFE
Building Wall	ACP
Office-Gym wall	Glass
Football field	Artificial Turf

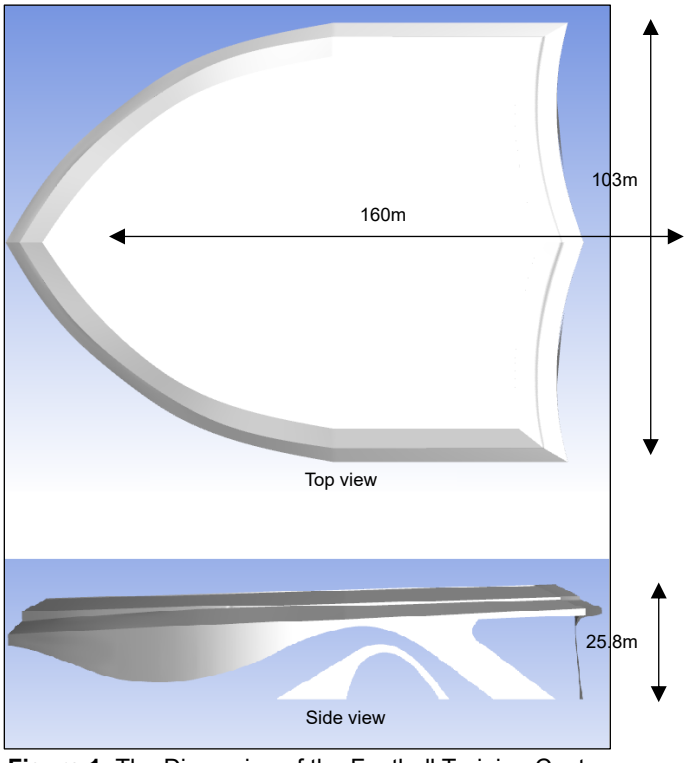

Figure 1. The Dimension of the Football Training Center

Meshing and Boundary Conditions

The first step, the hybrid tetrahedral and hexagonal meshing was developed using Gambit. However, according to mesh assessment, the quality of hybrid tetrahedral and hexagonal meshes in the present work was poor, with a few skewed meshes detected in the FLUENT CFD code. Therefore, using FLUENT software, all meshes have been converted to Polyhedral type. This type of meshing has several advantages including i. high quality of meshes, ii. less distortion and skew element, and iii. Less a number of meshing especially in complex geometric modelling. Thus, the present work employed a polyhedral type of meshing. Figure 2 shows the meshes of the present CFD modelling.

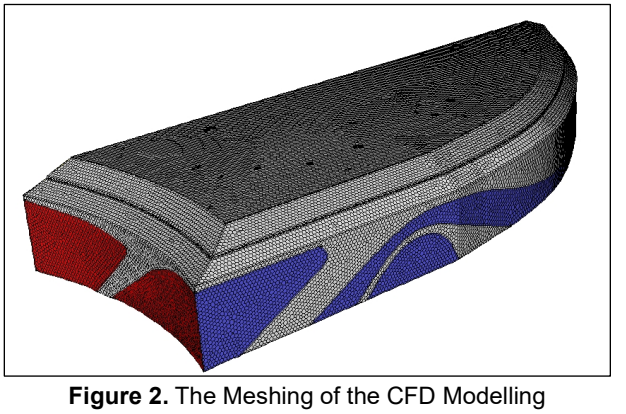

Figure 2. The Meshing of the CFD Modelling

Boundary Conditions

Figure 2 also indicates red and blue surface colour. The red colour represents the pressure outlet, and the blue colour is the pressure inlet. Symmetry boundary condition was applied in the middle of the training center, in order to reduce the number of meshing in the present work. The rest of the surfaces, including the roof, wall, floor, gym, and office, were set as wall boundary conditions, as illustrated in Figure 3.

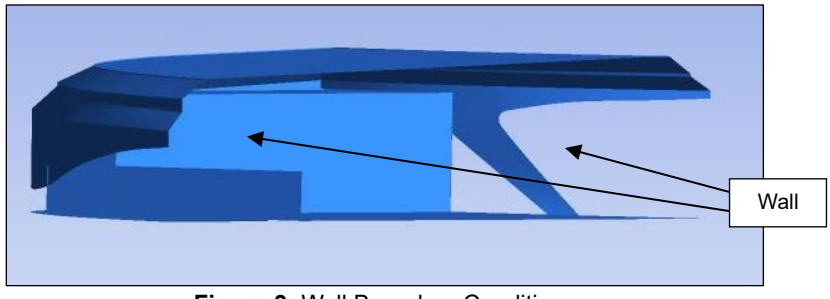

Figure 3. Wall Boundary Conditions

Several materials have been applied to wall boundary conditions. The office and gym wall surfaces were set as glass. The football training field was set as artificial turf. The special materials, ETFE and ACP, were set for the transparent roof and training center wall, respectively. Lastly, the floor, other than the football training field was set as artificial turf. The details of the materials setup and material thermal properties are summarized in Table 1 and Table 2, respectively.

Table 2. The Thermal Properties of ETFE, ACP, Glass, and Artificial Turf

Material	Thermal Conductivity	Heat Capacity	Density
ETFE	0.238 W/m.K	2 kJ/kg.K	1700 kg/m^3
ACP	0.221 W/m.K	875 J/kg.K	1510 kg/m^3
Glass	0.8 W/m.K	800 J/kg.K	2500 kg/m^3
Artificial Turf	0.42 W/m.K	0.551 kJ/kg.K	1150 kg/m^3

For operating conditions, the air pressure of 0 Pa was applied on both pressure inlet and pressure outlet boundary conditions, to allow natural convection in the building. The density of the air was changed from constant to ideal gas. The ideal gas of air density was used to activate the buoyancy phenomenon. The heat from the football field transfers to the adjacent air. As a result, the air experiences higher temperatures. According to the ideal gas law, the density of air decreases as the temperature increases. As the surrounding has a lower temperature and higher density, the phenomenon of buoyancy force happens. The air with less density moves upwards against gravity and flows out through a pressure outlet.

The present work assumes no external flow across the building. The air temperature of the operating condition and both pressure inlet and outlet were set as 34°C, which is the average maximum temperature in Malaysia. The office and gym temperature were set at 24°C as the ideal building temperature in Malaysia (Jamaludin & Mohammed, 2015). The average heat transfer coefficient of wall natural convection of 3W/m^{2}K was applied to the other wall of the building (Jayamaha, Wijeysundera, & Chou, 1996). This value is considered as the present work assumes the worst convection condition for the building.

In the present work, the heat source of the building comes from solar irradiation. Thus, the mode of solar ray tracing and radiation heat transfer was activated. In the solar ray tracing setup, the location of the building was set at a longitude of 1.49° and a latitude of 103.74° in the solar calculation. The time and date were set for 1 pm and 21 June, as they are the peak of the summer in Malaysia. Meanwhile, for radiation heat transfer, the surface-to-surface mode was selected. This mode is suitable for the present work as the optical thickness of air is less than 0.1 and negligible. The k-epsilon turbulent flow was employed as the geometry of the building was quite complex, the dimensions very large and the Rayleigh number higher than 10^9.

The ETFE radiation properties are recorded and shown in Table 4. The emissivity of ACP and artificial turf were set as 0.3 and 0.95, respectively. The present study neglected the effect of solar radiation on the glass material as the glass is only used for offices and gyms because it is shadowed by the building wall and is not exposed to solar irradiation. Therefore, the gym and office walls were assumed as opaque wall conditions. In the solution methods, the pressure in spatial discretization was changed to PRESTO! scheme as it works better in solving swirl flow and natural convection. First-order upwind in both momentum and energy has been changed to second-order upwind in order to obtain high reliability of CFD results.

Table 4. ETFE Radiation Properties

	UV	Visible Light	Solar Light
Transmission	0.18	0.21	0.21
Reflectance	0.43	0.46	0.45
Absorption	0.39	0.33	0.33

In the residual monitor, the continuity, x-velocity, y-velocity, z-velocity, k, and epsilon equations were set as 0.001. Only the energy equation was set as 1×10^{-6}.

Grid Independent Test

Higher meshing predicts better and more reliable results than lower meshing. However, higher meshing needs a longer time to complete. Therefore, the grid-independent test was conducted in the present work. The present work employed a workstation with processor AMD Ryzen 9 9500X 12 core processor and random-access memory RAM of 64GB to run FLUENT CFD code for the present work.

Table 5. Meshing Element Number

Name	Number of Elements
Meshing A	162264
Meshing B	294667
Meshing C	704116
Meshing D	1131459
Meshing E	2109428

Therefore, five different numbers of meshing have been conducted in the present work. The finding of the grid independence test is illustrated in Figure 4. Table 5 shows the detailed number of meshing from 160 thousand to 2.1 million, which have been conducted in the present study. The maximum solar irradiation on the earth, 1423 W/m^2, is the grid

independence test. This is the default value using solar tracing ray in FLUENT CFD code The grid independence test study did not include accurate thermal properties data.

Figure 4 shows that Meshing A is 3.4°C higher than Meshing B. Meshing C shows the highest average temperature in Figure 4. The percentage difference result of Meshing C and Meshing E is 26.9%. Therefore, Meshing A and Meshing C are out of the choice. Meshing B, Meshing D, and Meshing E show similar average temperatures. Meshing B required 3 hours to converge, however, Meshing D and Meshing E needed more than 8 hours to complete. Therefore, meshing B is selected in the present simulation work due to it has a similar average temperature with higher element meshing (Meshing D and Meshing E).

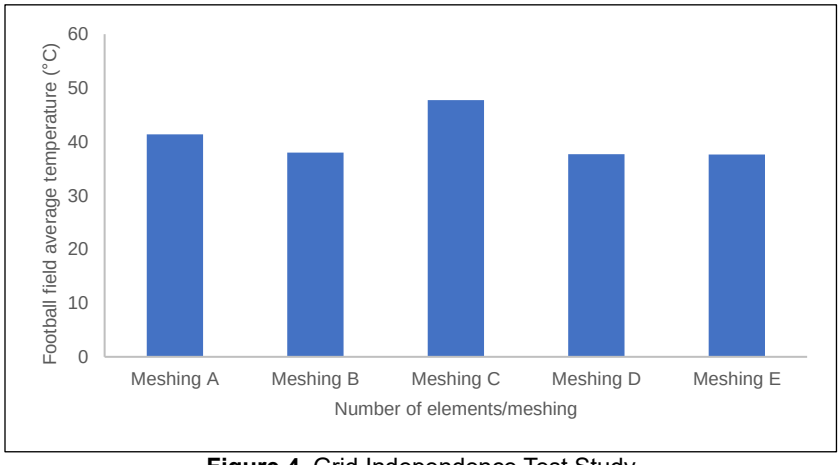

Figure 4. Grid Independence Test Study

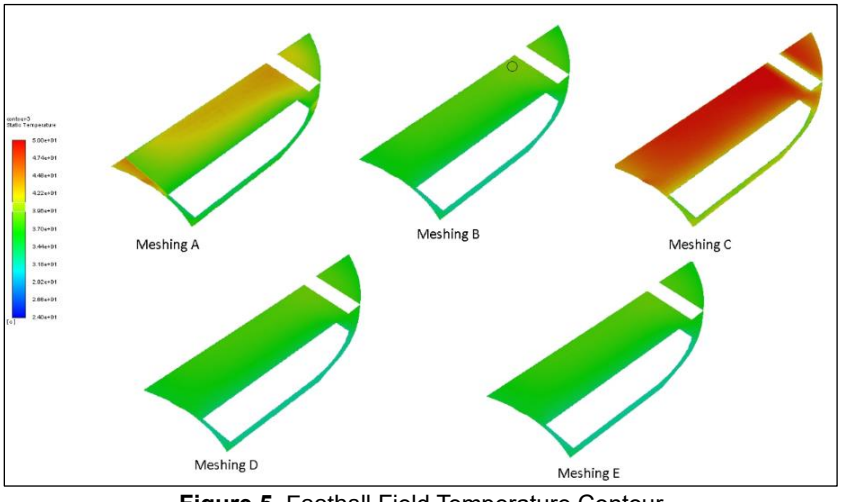

Figure 5. Football Field Temperature Contour

Figure 5 shows the temperature contour on the football field. From the figure, Meshing B, Meshing D, and Meshing E show similar temperature contours. However, Meshing A and Meshing C show higher temperature contours than Meshing B, Meshing D, and Meshing E. Meshing C shows higher temperatures due to a skewed element, which is a quality element less than 0.3. Meshing B is selected in the present simulation because it has a similar temperature contour to the highest element meshing (Meshing D and Meshing E). Besides

that, the simulation duration for Meshing B is much faster than for Meshing D and Meshing E.

RESULTS AND DISCUSSION

Figure 6 shows the temperature contour of the football field for the single-layer transparent roof. As shown in the figure, the highest temperature occurs at the center of the football field. However, the lower temperature at the football field outskirt is shown in the figure due to its border to the office and gym. The red dots are the graphical error.

Figure 6 also shows that the average temperature of the football training building is 39.8°C, while the maximum temperature is 42.1°C. Thus, at noon time, the temperature of the football field is higher than the human body temperature (37°C). Therefore, the design needs to be amended in order to obtain a lower football temperature field. The lowest temperature on the football field is 31°C as it is located close to the office and gym.

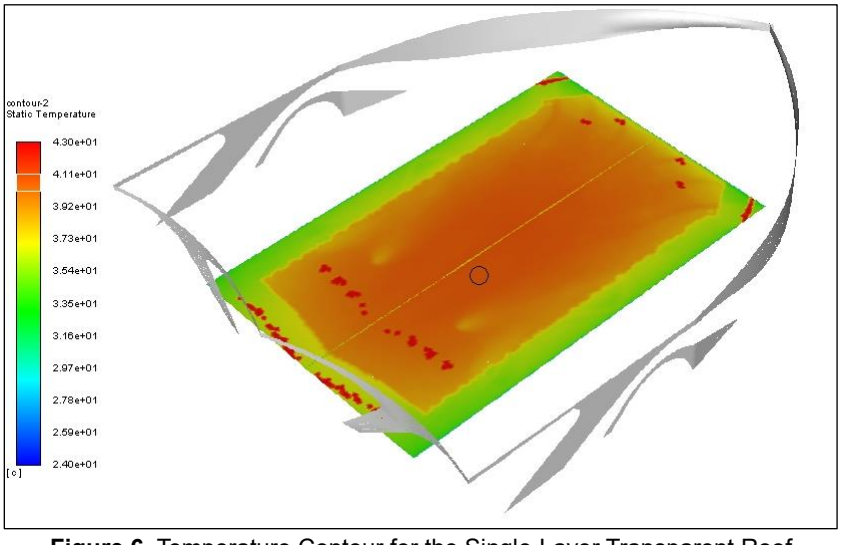

Figure 6. Temperature Contour for the Single-Layer Transparent Roof

There are three mechanisms of heat transfer radiation, which are Transmission, Reflectance, and absorption as illustrated in Figure 7. Higher transmitted solar radiation through transparent walls produces higher temperatures inside the building. On the contrary, higher reflected solar radiation produces lower temperatures inside the building. Therefore, the ETFE transparent roof needs to reflect higher solar radiation, thus, less amount of solar radiation is transmitted into the building. According to the results, it is expected that the single layer of the transparent roof reflects some solar radiation to the sky and less IR radiation heat transmitted into the building. However, it seems that the heat inside the training center is still high. As the wall temperature is still high, more solar radiation needs to be reflected in the sky in order to obtain a lower wall temperature. Thus, a double-layer transparent roof is suggested to the client, in order to obtain lower football field temperatures. Therefore, more solar radiation will be reflected to the sky.

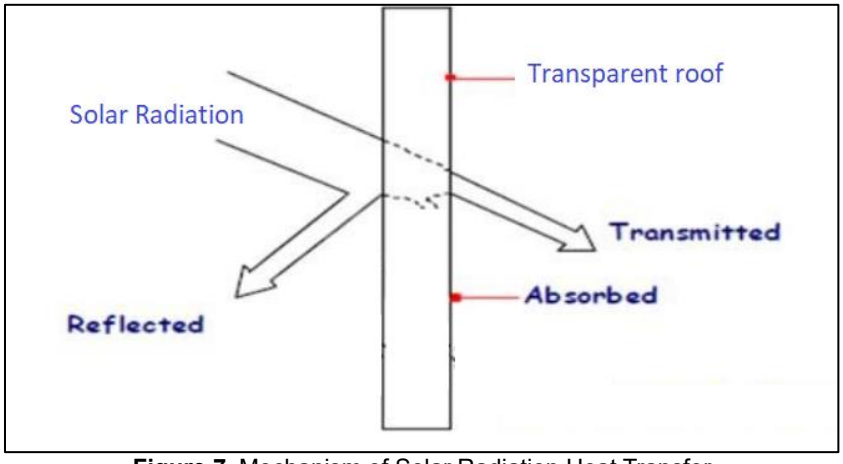

Figure 7. Mechanism of Solar Radiation Heat Transfer

As a consequence, the double-layer transparent roof is used instead of the single-layer transparent roof. As shown in Figure 8, the temperature of the average football field drops to 33.5°C, which is 6.3°C lower than that of a single-layer transparent roof. The maximum football temperature also drops 7°C or 16.6% as the transparent roof design changes from a single-layer layer to a double-layer layer. As a result, a double-layer transparent roof was selected for designing a football training center. The lowest temperature on the football field is 29°C.

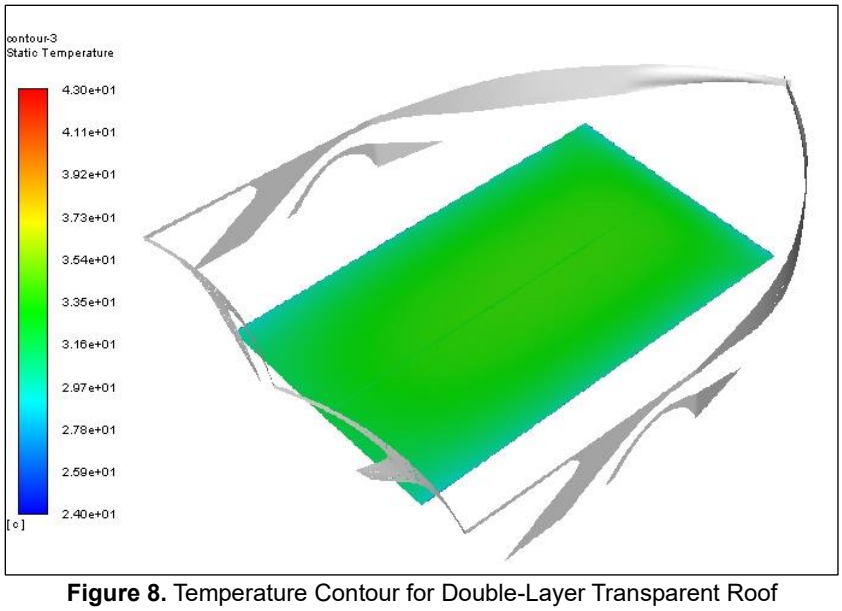

Figure 8. Temperature Contour for Double-Layer Transparent Roof

Figure 9 illustrates the mechanism of solar radiation for the double transparent roof. The solar radiation is absorbed, reflected, and transmitted by an outer layer of a transparent roof. A portion of transmitted solar radiation from the outer layer of the transparent roof will be reflected and absorbed by the inner layer of the transparent roof. Therefore, the amount of solar radiation transmitted into the building becomes less than the single transparent roof. This is the explanation of how the double-layer transparent roof provides lower football field

temperature than the single transparent roof as shown in Figures 6 and 8. Moreover, the air temperature between the outer layer and the inner layer is expected to become higher than ambient temperature. The reason is the heat solar radiation traps in space between the outer layer and the inner layer of the transparent roof, as illustrated in Figure 11.

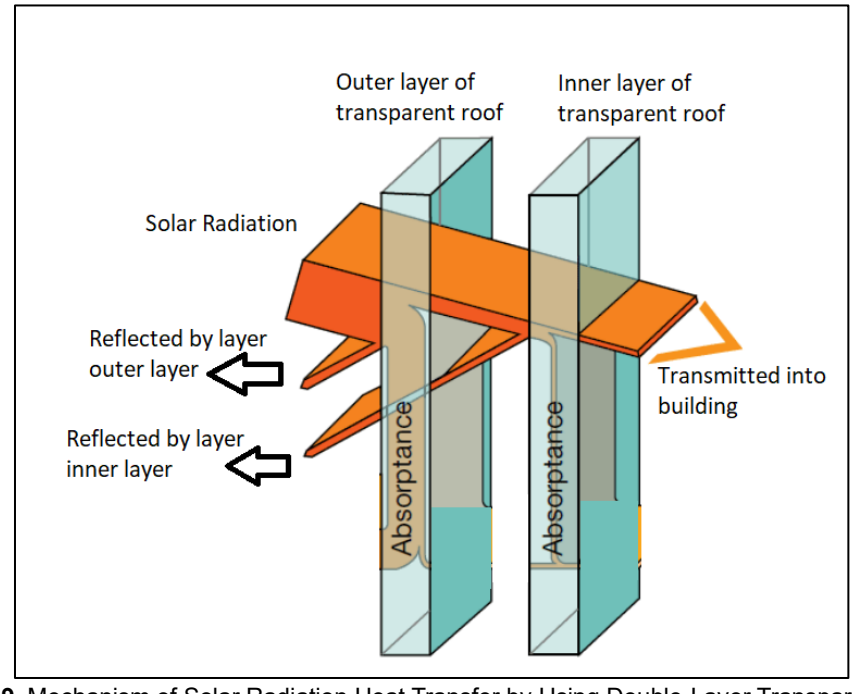

Figure 9. Mechanism of Solar Radiation Heat Transfer by Using Double-Layer Transparent Roof

The air temperature contour inside the football training center for the single-layer transparent roof is shown in Figure 10, and Figure 11 illustrates the air temperature contour for the training center with a double-layer transparent roof. In Figure 10, the temperature on the building floor (Rectangle A) seems slightly higher than in Figure 11. That indicates that the temperature of the football training field for the single-layer transparent roof is higher than that of the double-layer transparent layer. As illustrated in Figure 11, the temperature between the inner roof and outer roof (Rectangle B) seems higher than the temperature adjacent to a single-layer roof. That happens because of the hot air trapped in this confined space. According to the results, the average air temperature under the roof for the double-layer transparent roof is 31.11°C, which is 0.96°C lower than the average air temperature under the roof for the single-layer transparent roof. The detailed air temperature profile for both figures is summarised in Figure 12.

Figure 12 shows both air temperature profiles for a single-layer transparent roof and a double-layer transparent roof. The location of the profile is shown in Figure 10 at Line A. The figure shows the double-layer transparent roof has lower intercept temperatures in the Y-axis than the single-layer transparent roof, meaning a double-layer transparent roof produces lower football field temperature than the single-layer transparent roof. After Point i, the air temperature for both roofs are similar until the height of 10m. Then, the air temperature of the double-layer transparent layer fluctuates until Point ii. Afterward, the temperature increases to the maximum as the height reaches the roof.

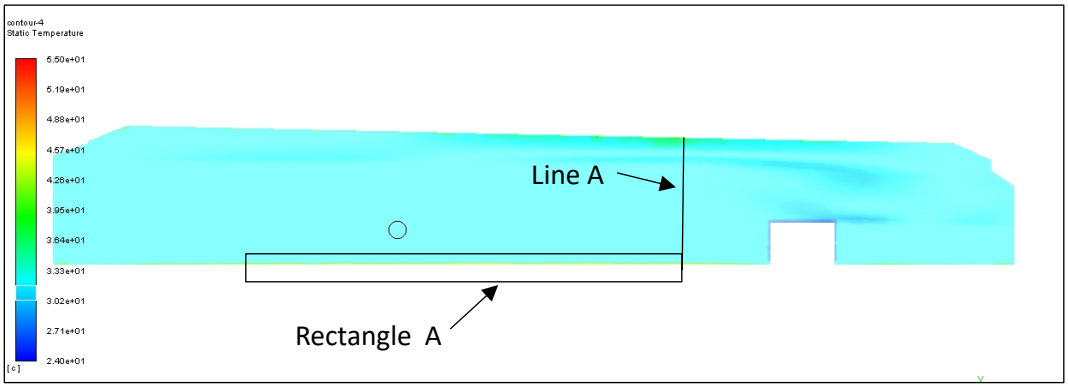

Figure 10. Air Temperature Contour Inside the Football Training Center with a Single-Layer Transparent Roof

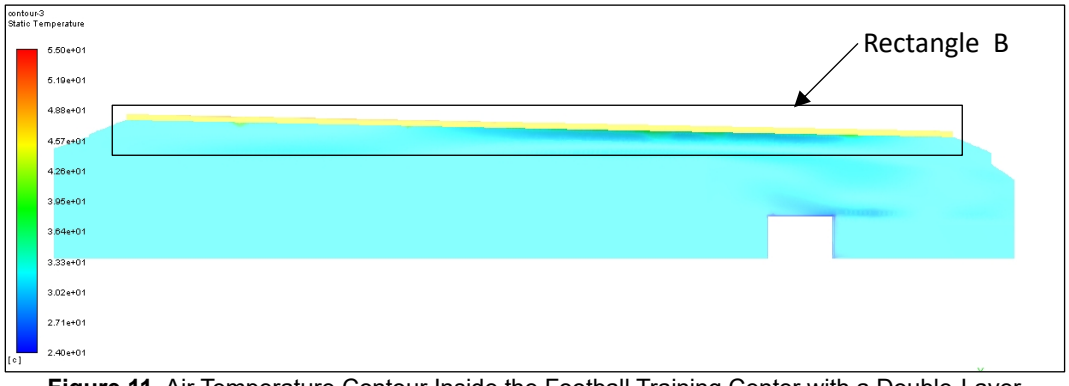

Figure 11. Air Temperature Contour Inside the Football Training Center with a Double-Layer Transparent Roof

Both Figures 10 and 11 show air average air temperatures of 32°C and 31°C, respectively, which is higher than the ideal temperature of thermal comfort. However, these air temperatures are less than the ambient or air operating temperature of 34°C. It is impossible to achieve an ideal temperature of thermal comfort, 24°C without an air conditioning system. It is possible to reduce average air temperature to less than 31°C using a forced convection system or active cooling method. The present work only focuses on the passive cooling method or natural convection heat transfer.

Based on the results, the double-layer transparent roof produces a lower football training field. That happens due to two potential reasons. First, the inner layer roof acts as the thermal radiation barrier. Thus, the heat received by the football field by radiation heat transfer for the double-layer transparent roof is lower than that of a single-layer transparent roof. Second, the inner layer has reflected the remaining solar irradiance that has been transmitted by the outer transparent roof, as shown in Figure 9. As a result, the football field of double-layer transparent roofs received lower heat solar irradiance than the football field of single-layer transparent roofs. In conclusion, a double-layer transparent roof is an effective passive method to reduce football field temperature and enhance the thermal comfort of the football training center.

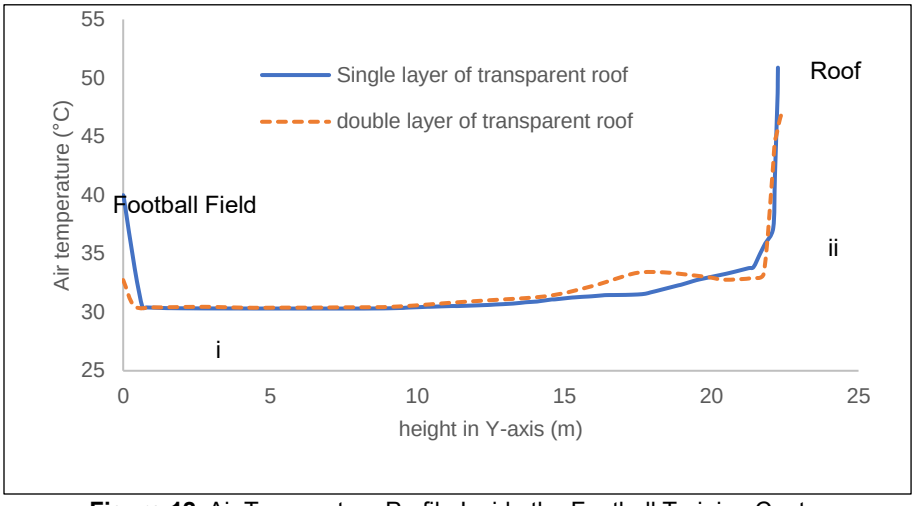

Figure 12. Air Temperature Profile Inside the Football Training Center

CONCLUSION

The present work predicted the football field temperature and air temperature of the football training center. FLUENT CFD code has been employed in the present work. The study covers two types of roofs including single-layer transparent roof and double-layer transparent roof. For a single-layer transparent roof, the present study predicted that the average football training field temperature is 39.8°C. The air average temperature for a single-layer transparent roof is 32.07°C. Then, the single-layer transparent roof was replaced by a double-layer transparent roof in order to reduce the temperature of the football training field and air temperature. According to the prediction data, the average temperature of the football training field reduced to 33.5°C, as the roof changed from single-layer transparent to double-layer transparent. In addition, the average air temperature to 31.11°C. In conclusion, the double-layer transparent roof enhances the quality of the training center's thermal comfort by reducing both football field and air temperatures.

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GUIDE TO AUTHORS

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The Malaysian Construction Research Journal (MCRJ) is the journal dedicated to the documentation of R&D achievements and technological development relevant to the construction industry within Malaysia and elsewhere in the world. It is a collation of research papers and other academic publications produced by researchers, practitioners, industrialists, academicians, and all those involved in the construction industry. The papers cover a wide spectrum encompassing building technology, materials science, information technology, environment, quality, economics and many relevant disciplines that can contribute to the enhancement of knowledge in the construction field. The MCRJ aspire to become the premier communication media amongst knowledge professionals in the construction industry and shall hopefully, breach the knowledge gap currently prevalent between and amongst the knowledge producers and the construction practitioners.

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CODIFICATION AND APPLICATION OF SEMI-LOOF ELEMENTS FOR COMPLEX STRUCTURES

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[1]Department of Quantity Surveying, Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Sarawak, Malaysia
[2]Institute 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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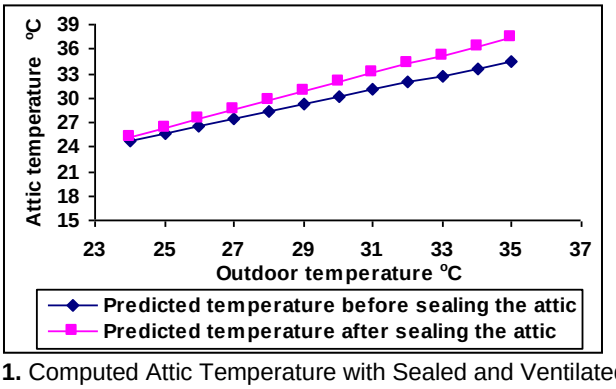

Figure 1. Computed Attic Temperature with Sealed and Ventilated Attic

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Table caption: Arial Bold + Arial, 9pt. + Capitalize Each Word. Captions should be written above the table.

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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
pH	5.5-9.0	6.5-9.0

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

Units: All units and abbreviations of dimensions should conform to **SI standards.**

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One author	Walker (2007)	(Walker, 2007)	(Walker, 2007)	(Walker, 2007)
Two authors	Walker and Allen (2004)	Walker and Allen (2004)	(Walker & Allen, 2004)	(Walker & Allen, 2004)
Three authors	Bradley, Ramirez, and Soo (1999)	Bradley et al. (1999)	(Bradley, Ramirez, & Soo, 1999)	(Bradley et al., 1999)
Four authors	Bradley, Ramirez, Soo, and Walsh (2006)	Bradley et al. (2006)	(Bradley, Ramirez, Soo, & Walsh, 2006)	(Bradley et al., 2006)
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