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The Sustainable Aspect of Safety in Architectural Early Design: An Introduction to Prevention through Design (PtD) Concept

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Abstract: Architects must have an adequate and relevant understanding of Prevention through Design (PtD) to execute essential design decisions during the early design stage. The understanding of PtD as a proactive safety intervention throughout the design process has been supported in various studies, but there has been little research incorporating PtD in design practices by the architect and provisional architectural safety design parameter on the Occupational Safety and Health (OSH) matters, thus, leading to the gap in this study. Considering thePtD concept as part of the sustainable strategy into the architectural early design stages may significantly enhance the building's life cycle and safety performance, particularly during the operational and maintenance phase of the building projects. Therefore, the systematic review was motivated by the belief that the early architectural design stage is one of the key factors improving safety performance in the practice of PtD. This review begins by analysing literature from 2011 to 2021 with relevant keywords related to the architectural design aspect that contributes to building safety performance, followed by characterising the safety aspect at the early architectural design stage. The findings were identified and clustered into the following five categories of the architectural design parameters: 1) Site planning, 2) Space Planning, 3) Building envelope, 4) Design for Visibility, and 5) Environmental Design Parameters. This finding is hope to be able to providean architectural frame of reference on Occupational Safety and Health (OSH) matters, allowing future researchers and practitioners to address sustainable aspect of safety in the early architectural design practices of PtD while optimising building safety performance across the building life cycle projects.

Keywords: Sustainable, Safety Aspect, Early Design Stages, Architectural Design, Prevention through Design,

1. Introduction

The architectural design stage plays a pivotal role in the construction industry towards achieving successful delivery of projects by guiding the project team and clients undertaking building projects (RIBA, 2020). It involves the most important decisions that affect the project performance and safety throughout its life cycle. For instance, decisions concerning end-users' participation, cost estimation, material selection, systems and design features (Al-Saggaf et al., 2020; Othman & Abdelwahab, 2018). While most parties generally believe that building-related accidents are most frequent to occur during construction, early design phases also contribute to accidents and injuries statistics. For instance, out of 224 construction fatality cases in the USA, 42% of the cases were linked to design (Manu et al., 2019).

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Regardless of this evidence, implementing safety guidelines through the adoption of Prevention through Design (PtD) in the early design stage has yet to be addressed.

The Ptd concept has been in Malaysia since 2017 to reduce the risk of accidents occurring throughout the life-cycle of a building (Che Ibrahim et al., 2020).PtD is defined as the inclusion of occupational safety and health considerations in the planning and design process to prevent or eliminate the work-related hazards and risks connected with the building and manufacturing of facilities and materials as well as during building operation and maintenance (Lingard et al., 2013; Mehany et al, 2016). In the architectural context, PtD emphasises the importance of preventing any potential hazards through architectural design. Traditionally the role of the architect in construction is to design a structure (building, facility, dwelling, etc.) that would comply with established engineering practices, rules, local building codes and would be safe for the occupants. The architect provides the solution to improve safety design at the early design stage (Samsudin et al., 2021). More often, designers and authorities have begun developing a building or construction-specific rules or legislation incorporating the PtD principles into project construction and design phases. (Che Ibrahim et al., 2019). For instance, Malaysia's Guidelines on Occupational Safety and Health in Construction Industry (Management), OSHCI(M), which adheres to the philosophy of "from the cradle to the grave," a belief that considers the entire life-cycle of a building or structure. – starting with the initial concept, followed by design, construction, building usage, and finally, demolition.

Even though the PtD practice has been implemented in the construction stage,a lack of safety matters has been discovered during the design and operation maintenance stages (Che Ibrahim et al., 2020). This is supported by Idham (2020) who reported that the safety factors related to the design of the building and occupant's safety are often considered after most architectural design aspects are readily completed. Hence, there is still an incomplete list of safety design aspects/variables to consider when evaluating building safety performance in the early design phase. As a result, this contributes to a less comprehensive building safety design.

Thus, this research aims to identify the sustainable aspect of safety in early architectural design stages concerning in relation to the safety performance of building design and take into account the practice of the PtD. This review adds knowledge to the significance of early design decisions in the PtD practice and its impact on building safety performance.

2. Literature Review

2.1 The Sustainable Aspect of Safety

Sustainability is gaining popularity in today's world as many governments incorporate it into their economic development policies. Sustainability is defined by the World Health Organization (WHO) as meeting current global population demands without adversely affecting health or the environment, and without depleting or endangering the global resource base, therefore compromising future generations' ability to fulfil their needs (Boileau, 2016; WHO, n.d.).After decades of broad attention to environmental stewardship and worker safety and health issues, the release of United Nations' (UN) Brundtland Commission report in 1987 has marked the beginning of sustainability's emergence on the Occupational Safety and Health (OSH) as an important topic of discussion and debate. According to the United Nations' (UN) Brundtland Commission (1987), sustainable development is defined as development that meets present needs without jeopardising the ability of future generations to meet their own needs (Occupational Safety and Health Administration, 2016). The term "Occupational Safety and Health" (OSH) refers to as the state of being safe or the lack of factors that could lead to accidents, injuries, or disruptions in the performance of work in the context of a "place of employment" or a "person at work" (Saad, 2011). In this context, OSH concern benefits from the implementation of the PtD in the early architectural design for the entire lifecycle's project.

Further discussion in United Nations' (UN) Brundtland Commission report, summarised the aspects of sustainability that fall within the social sphere are less understood and have received less attention. In response, people have separated sustainability into environmental and social sustainability, rather than an integrated vision for sustainable outcomes. It could cause unforeseen negative consequences (e.g., hazards to workers from enhancements to lessen environmental impacts) or create tension between agendas (e.g., labour and environment). By contrast, a prior study has found that the well-being of workers may be neglected during the construction of high-performance sustainable buildings (Karakhan & Gambatese, 2017b; Zuo & Zhao, 2014), and that if this is the case, the building will not be really sustainable. Though, it is agreeable that enhancing lifecycle safety is a vital aspect of sustainable development (Karakhan & Gambatese, 2017a). In this context, lifecycle safety is defined as a strategic concern to facilitate the safety and health, and well-being of occupational and public safety (Karakhan, 2016). On the other hand, in the early stages of designing a facility, lifecycle safety is considered holistically. This means that the safety and health, as well as the well-being of everyone engaged as construction workers, building users, and maintenance workers, are addressed throughout the project life-span.

However, the promotion of the PtD concept as part of the sustainable development to enhance the safety, health, and welfare of workers is still platable in the construction industries (Adaku, Ankrah, & Ndekugri, 2021; Che Khairil Izam Che Ibrahim et al., 2020). Sustainable development is guided by several concepts, many of which are directly applicable to OSH. These principles emphasise the importance of protecting people's health and well-being, preventing recognised hazards, and taking precautionary measures where there is a lack of certainty about the risks (Boileau, 2016). As a result, occupational health and safety (OHS) and injuries and prevention may be regarded as a significant concern in terms of sustainability.

2.2 Architectural Design Process

The architectural design process is a critical strategy for problem-solving in which architects and designers integrate arts and science to generate architectural solutions. Architects generally follow a pattern or sequence of processes to achieve their designs from conception to completion. In many countries, there is no prescribed approach in designing a building (Abowardah, 2016; RIBA, 2020). There is no written or published version of 'the way to do it.' Instead, informal knowledge is passed down from one generation of practitioners to the next (Mayssara A. Abo Hassanin, 2014; RIBA, 2020). Hence, scholars with architectural background, on the other hand, review, systemize, and rationally combine various techniques to generate effective design processes and solutions. As such, the design processes emphasised are significant in achieving an effective design solution by providing a road map for the project team to follow and assisting clients through their first or only building project (RIBA, 2020).

As there are no definite processes to architectural design, many scholars provide different approaches to the design process. Mayssara A. Abo Hassanin (2014) took an informal approach to architectural design, beginning with reading the programme or brief, defining and interpreting obstacles, engaging the client, and gathering information. The initial stages of design entail evaluating a site, visualising possibilities, and developing concepts. Occasionally, this design process is repeatable, consistent and intuitive (RIBA, 2020). In comparison, Abowardah (2016) and Makstutis (2018) stated that the design process is essentially executed through a gathering of information (research), testing and evaluation (revision) of the design decisions to the problem. In the UK, The Royal Institute of British Architects (RIBA) Plan of Work is the most often used framework tools in understanding the construction process (Ojo & Pye, 2020). Few papers refer to the RIBA Plan of Work which classifies the process in the following (refer to Table 1): Strategic Definition, Preparation and Brief, Concept Design, Developed Design, Technical Design, Construction, Handover and Close Out, to In Use stage. It follows a more complex structure, distinguishing between design at the early stage of the project (Concept Design), refinement ('Developed Design') and construction design ('Technical Design') . The RIBA Plan of Work was established in 1963, has served as a framework for architects as a guide when working on projects as well as offering greater clarity as to the essential results that the project team should attain at each step of the project's life cycle. It has evolved through time to reflect shifting approaches to projects and is now a widely used tool in the industry.As refer to the UK Government's Construction Strategy document, which recently came out with the RIBA Plan of Work 2020 (RIBA, 2020) and has since changed, was a leading factor in the development of the construction industry in the country toward sustainable prevention in OSH.

It recognises that tasks performed at any stage may have an effect on the building's performance and on the successful delivery of the requirements set out by the client. Apart from Occupational Safety and Health Acts (OSHA) regulations which are primarily responsible for this, various studies have highlighted elements that are useful for sustainable safety programmes. Similarly Findley research as cited in Dewlaney & Hallowell, (2012) explicicates that an effective safety programme includes several of components, including: a written, comprehensive safety and health programme; clearly established and implemented safety and health responsibility and accountability; employee involvement in the design and operation of the safety and health programme; and frequent inspections of the workplace. Those aspects must work together to promote the ecologically responsible construction, profitable, safe and healthy towards its entire life span.

Table 1 - Stages involved in building projects

RIBA Plan of Work	
Stage 0:	Strategic Definition
Stage 1:	Preparation and Briefing
Stage 2:	Concept Design
Stage 3:	Spatial Coordination
Stage 4:	Technical Design
Stage 5:	Manufacturing and Construction
Stage 6:	Handover
Stage 7:	Use

(Adopted from RIBA, 2020))

These stages differ in the outcome and fundamental tasks and may overlap in the project timeline. Accordingly, this paper will focus on the early stages of architectural design that are based on the RIBA Plan of Work, which gives a structured and comprehensive view of the architectural design process in building projects (RIBA, 2020), namely, concept design, developed design and technical design stages:, namely, concept design, developed design and technical design stages:

- **Concept design stage.**

This stage focuses on developing the concept design, which includes requirements such as preliminary proposals for structural design, building services systems, outline specifications and preliminary cost information, as well as pertinent project strategies in accordance with the Design Programme (Ko, 2017; O'Connor & Koo, 2020; Sacks et al., 2015). The requirements are iterated to fit the brief upon the response from project stakeholders and aligned to the architectural concept. This stage ensures the development of sustainability strategies, the preparation of maintenance and operation plans, handover strategies and risk assessment. Reviewing the project execution plan is important to ensure that all aspects are adequately performed and that construction strategies and health and safety concerns are expressed explicitly.

- **Developed design stage.**

This stage is responsible for preparing Developed Design, which includes coordinated and updated proposals for site planning, structural design, building services systems, outline specifications, cost information and project strategies that adhere to the Design Programme (Eilouti, 2018; Rafael Sacksa et al., 2015). In this stage, updated sustainability issues, maintenance and operational issues must be checked and resolved continuously, similar at each stage. It is critical to implement the change control procedures to ensure that any change is well-controlled. It is expressed in RIBA (2020) that this stage may be overlapped with other stages to well-bind the entire project cycle.

- **Technical design.**

This stage guarantees that all architectural, structural, and building service information and the designs and specifications for expert subcontractors are prepared in line with the Design Programme (Ismail, Che Ibrahim, Belayutham, & Mohammad, 2021; O'Connor, Koo, O'Connor, & Koo, 2020). At this point, the design team and the contractor's specialty subcontractors complete the design as well as solve issues presented on site. A client monitoring team may be created to review the information produced in certain types of procurement (Alabi & Fapohunda, 2021). While safety and health strategies are identified, documented, analysed, and eliminated at this stage, the design information is to be developed and prepared to seek planning permission and discharge of planning condition commencement.

2.3 Prevention through Design (PtD) concept in Architectural Design Process

Prevention through Design (PtD) is a comprehensive approach in addressing safety and health issues by "designing out" hazards and minimising residual risks at the early design stage (Tymvios & Gambatese, 2016). PtD emphasises the significance of preventing any potential hazards by architectural design in the context of the built environment (Samsudin et al., 2021). Besides that, prior scholars and recommendations to PtD practise as a proactive safety interventions to reduce OSH concern (Ho, Lee, & Gambatese, 2020; Tymvios et al., 2020), it is agreed by Renshaw (2019),the PtD principle advocates for OSH risk elimination through design. This supports the incorporation of PtD as part of preventative measures into architectural designs to enhance the fundamental dimension of sustainable development. Although previous research haves supported the application of the PtD as a risk prevention strategy throughout the design process to reduce workplace hazards. However, there is a limited number of studies examining the incorporation of the architectural safety design parameter and how it might provide an "architectural perspective" on OSH issues. While architects are more concerned with the final appearance, safety, cost, construction timeline, and aesthetic value of their work than worker safety and health (Guo et al., 2021). This means that the upstream design decision could be jeopardised by the architects' lack of education and training towards safety, their ignorance of worker safety, fear of liability, and their inadequate reliance on safety tools and safety resources.

Along with RIBA (2020), outlines that early in the project's development, the Health and Safety Strategy should be considered to assure safe construction, occupation, maintenance, and eventual re-use or demolition. This recommended for the architect to improve safer design at the early design stage (Samsudin et al., 2021). Similarly, Szymberski (1997) suggested that the ideal way to ensure safe working conditions for construction workers is to prioritise safety during the conceptual and design stages of a project, as this method has the potential to reduce accidents and injuries. Additionally, New Zealand's leading health and safety solutions provider, Site Safe, further expands this notion in their guideline by including the cost of incorporating health and safety strategies, as seen in Figure 2.

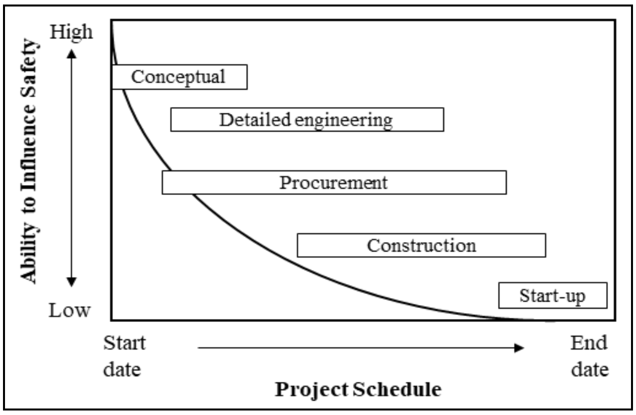

Fig. 1 - Time-safety influence curve (taken from Szymberski (1997)

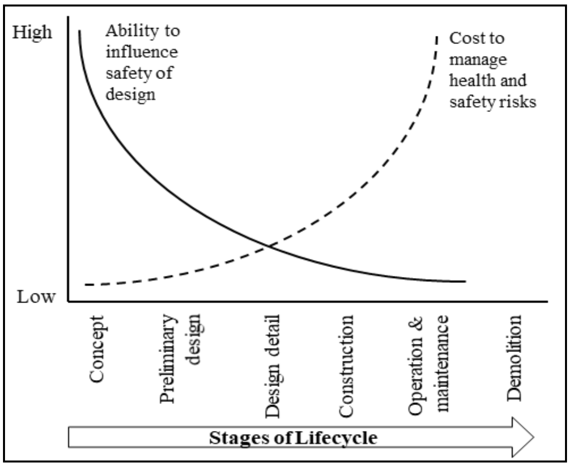

Fig. 2 - Time-safety-cost influence curve (adapted from Site Safe New Zealand (2019)).

From Syzmberski's time-safety influence curve (Figure 1), it is noted that as the life-cycle of a design project progresses, the ability to influence the design for health and safety decreases. Moreover, according to Site Safe by New Zealand (Figure 2), the cost of managing health and safety risks grows as the building lifespan continues towards the end-stage. This finding supports Szymberski's (1997) assertion that includs safety planning throughout the design phase permits the provision of inexpensive features to limit potential hazards. Ideally, from the studies, to prevent the increase occurences of accident and increase cost in the future, the implementation of PtD must be carried out earlier in the design phase by adopting safety measures. Therefore this paper explores the concept of PtD early design stages of architectural projects as part of the sustainable solutions.

3. Methodology

At the initial stage of this study, a systematic literature review (SLR) was conducted. It utilised a thematic review technique that was adapted from Mohd Zairul (2020) method. The snowballing technique was then utilised in the literature search.This technique anticipated a range of epistemological stances and utilised a paper's reference list or citations to identify more related publications (Wohlin, 2014). A three-stage search process was implemented to conduct a content analysis on the architectural design stage and its components involved in PtD practice. The stages include (1) literature search, also known as identification of journals through database search, (2) literature selection; in other words, screening of papers to select for review; and finally, (3) examination of selected papers for data extraction

3.1 Literature Search

A comprehensive literature study was conducted to determine the architectural design stage and its components involved in PtD practice. For the review, information was obtained from several sources such as journal articles, conference papers, review articles and relevant safety guidelines. Journals were extracted from three (3) leading databases: Scopus, ScienceDirect and Web of Science (WoS). The main keywords used in searching the articles were "early design stage", "architect", "prevention through design", "safety", and "sustainability". The keywords were then expanded accordingly to facilitate further search. The analysis of the architectural design stage and its components involved in the PtD practice was subsequently carried out by a critical review of the findings from the selected articles.

3.2 Literature Selection

Although the search resulted in 240 articles, some articles were deemed as not relevant to the research subject. It is likely to be included in search results as it corresponds to the research keywords or scheme. Subsequently, a screening procedure was implemented. The selection of articles was made through meticulous manual screening, paired with the assistance of a database, where the articles were selectively included or excluded. Hence, only articles that are deemed to be useful for the subject are selected from each database. These papers are preliminarily screened by reviewing their title and abstract to establish fit for review. As a result, after the first screening, only 65 articles were considered acceptable for this study. Next, to assess for eligibility, a further review was conducted on the remaining papers by reading the full text. Duplicates were expected due to adopting overlapping databases. The main criteria for eligibility were that the publication must provide an insight into a sustainable approach in an early architectural design. Three duplicates were also eliminated during this process, and 1 article without online availability was also excluded. After the screening process, unrelated papers were removed, and 23 papers were retained.

In addition, a technique adopted from the study of Che Ibrahim et al., (2020), the snowball method of identifying relevant articles that the three databases did not capture, has also been conducted in additional 10 articles. This exercise was conducted to enrich findings from the previous search stage to obtain comprehensive coverage of the papers that are worth reviewing. The snowball exercise suffices because it provides an opportunity to include the significant state-of-the-art works related to the study (Che Ibrahim et al., 2020; Yongkui Li et al., 2019). As a result of database searches and the snowballing method, 33 articles were used for this review.

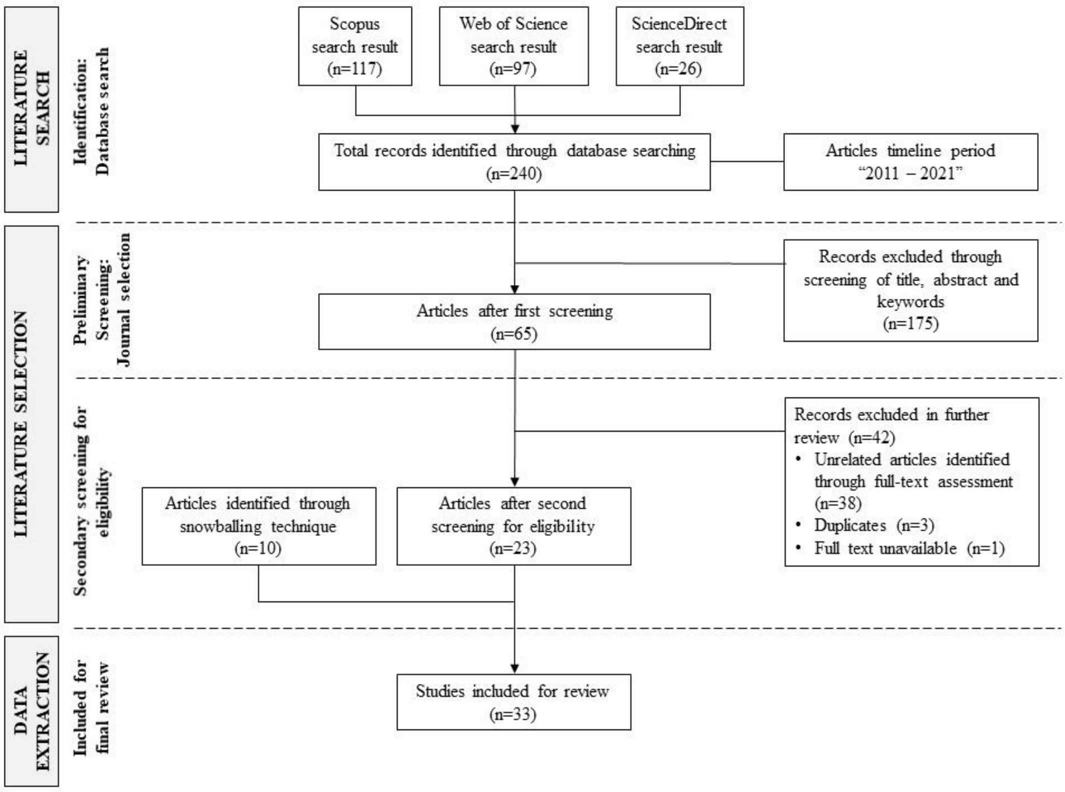

Fig. 3 - Flow diagram of research methodology for the review.

3.3 Data Extraction

Table 2 indicates the key source-journals of articles. The research strings used are either directly or indirectly referred to in the 33 identifies articles through several periodicals. The prospects of PtD were subsequently carried out by a critical review of the findings from the selected articles. The 33 research articles have been reviewed in an iterative process in which comparisons for similarities and differences have been made to achieve consistency in the resulting sub-categories. Furthermore, this includes the perspectives from which early architectural design processes in PtD have been researched so far have been identified.

A list of publications and their allocation into the frequency theme table can be seen in Table 3. The identified themes in the text were refined into code, which served as the foundation of the analysis. Codes or clusters are established to represent the identified themes and to correlate them to the raw data for further analysis (Fourie & de Vries, 2017). The initial coding was further categorised into 5 main themes which are site planning, space planning, building envelope, design for visibility, and environment design parameters (Table 3). Hence, all 33 of metadata were transferred into was analysed using the year of the study conducted (Table 4).

Table 2 - Publications found according to journal and year

Journal/Article	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Safety Science					1					1	1
Journal of Building Engineering										1	
Automation in Construction							1				
Sustainable Production and Consumption											1
Frontiers of Architectural Research					1						
IOP Conference Series: Materials Science and Engineering									1	1	
Green Design and Sustainable Architecture										1	
Journal of Engineering, Design and Technology								3			
Computers & Graphic										1	
Applied Mechanics and Materials		1	1								
Advances in Engineering Research										1	
Sustainability											1
International Journal of Occupational Safety and Ergonomics								1			
Construction Economics and Building										1	
Procedia Engineering							1				
Conference BSA		1									
Building Research & Information											1

Journal/Article	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
IOP Conference Series: Materials Science and Engineering											1
Proceedings of 2016 International Conference on Architecture & Civil Engineering						1					
E3S Web of Conferences				1							
Reliability Engineering and System Safety									1		
Architectural Engineering Conference (AEI)	1										
Conference on Construction Applications of Virtual Reality			1								
Journal of Construction Engineering and Management						1					
Conference Proceeding ICITSBE		1									
Open House International											1
Construction Management and Economics		1									
Journal of Prevention, Assessment and Rehabilitation							1				

Table 3: Articles to frequency theme table.

Authors of selected articles	Theme Code				
	Site Planning	Space Planning	Building Envelope	Design for Visibility	Environment Design Parameter
(Scope, Vogel, & Guenther, 2021a)	x	/	/	x	/
(Valitabar, Mahdavinejad, Skates, & Pilechiha, 2021)	x	/	/	x	/
(Samsudin et al., 2021)	/	x	x	x	x
(Kuliga, Berwig, & Roes, 2021)	x	/	x	/	/
(Guo et al., 2021)	/	x	-	x	x
(Abueisheh, Manu, Mahamadu, & Cheung, 2020)	/	/	/	x	/

Authors of selected articles	Theme Code				
	Site Planning	Space Planning	Building Envelope	Design for Visibility	Environment Design Parameter
(Al-Saggaf et al., 2020)	/	/	/	x	/
(Abas, Abd Rahman, Mohammad, & Rahmat, 2020)	/	/	/	x	x
(Bosova, 2020)	/	/	/	x	/
(Marisa & Yusof, 2020)	x	/	x	x	/
(Rohde, Jensen, Larsen, Jønsson, & Larsen, 2021)	x	/	/	x	/
(Idham, 2020)	/	/	/	/	/
(Dubey, Khoo, Morad, Hölscher, & Kapadia, 2020)	/	/	x	/	x
(C. K.I. Che Ibrahim et al., 2019)	/	x	x	x	/
(Dreany & Roncace, 2019)	x	x	/	x	/
(De Silva, Rathnayake, & Kulasekera, 2018)	/	x	x	x	x
(Othman & Abdelwahab, 2018)	x	x	/	x	/
(Manu et al., 2019)	x	x	/	x	x
(Poghosyan et al., 2018)	x	x	/	x	x
(D. Y. Kim & Kim, 2017)	x	/	/	x	/
(Naboni, Lee, & Fabbri, 2017)	x	/	/	x	/
(Toh, Goh, & Guo, 2017)	/	x	/	x	/
(López-arquillos, Rubio-romero, & Martinez-Aires, 2015)	x	x	/	x	x
(Stavridou, 2015)	/	/	/	x	/
(Weidman, Dickerson, & Koebel, 2015)	x	x	/	x	x
(Agus Salim, Mydin, & Ulang, 2014)	x	/	/	x	/
(Hosseinian, Torghabeh, & Ressang, 2013)	x	x	/	x	x
(Kamardeen, 2013)	/	/	/	/	/
(Rezaallah & Khoraskani, 2012)	/	/	/	x	/
(Dewlaney & Hallowell, 2012)	/	/	/	/	/
(Yusop, Dahlan, & Che Ahmad, 2012)	/	/	/	/	/
(Zhou, Liang, & Dong, 2012)	x	x	/	x	/
(Ghaderi & Kasirossafar, 2011)	x	x	/	x	x

/ : indicating the variable is present in the reviewed articles.

x : indicating the variable is not specified in the reviewed articles.

The pattern was analysed using the year of the study conducted (Table 4). The pattern on early consideration of site planning and building envelope in PtD is widely discussed, beginning from 2012. Similarly, the category of building envelope criteria was one of the first aspects to be discussed, in 2011. Though there were few publications devoted entirely to the theme, it remains an important one, as the PtD concept led to safety in early architectural design practices. The trend on environmental design parameters is one of the most frequently discussed and this contributes to more recent publications, since more publications emphasise on sustainable design and indoor environmental quality which corresponds to safety and health as its core program. Besides that, the year 2020 and 2021 show a big difference in the number of publications from the previous years on safety design criteria for occupational safety. Other than that, the paper also found the trends on design for visibility was not given focus, as there has been decline in the number of publications contributing to the subject. However, recent years have shown an increase albeit in small number suggesting the criteria is encouraging PtD in projects.

Table 4: Themes of articles according to year published (after screening process)

Theme	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Site Planning	-	2	1	-	1	-	1	1	1	5	2
Space Planning	-	3	1	-	1	-	2	-	-	5	4
Building Envelope	1	3	2	-	3	-	2	2	2	6	2
Design for Visibility	-	2	1	-	-	-	-	-	-	2	1
Environmental Design Parameter	-	4	1	-	1	-	3	1	2	6	3

The articles reviewed were published from many different countries (Table 5). The trends of the early architectural design process in PtD was seen as rather popular in Malaysia. There are also PtD publications reported from other countries such as Germany, Egypt, Greece, Indonesia, Saudi Arabia, Spain, United Kingdom, Singapore, China, Palestine and Nigeria. Other than that, many articles were published as a collaborative effort between research of different universities from different countries as shown in Table 6.

Table 5: The distribution of articles according to countries

Countries	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Palestine										1		1
Saudia Arabia										1		1
New Zealand											1	1
Korea							1					1
Spain					1							1
Germany											2	2
Greece					1					1		2
Malaysia		1	1						1		1	4
Czech Republic										1		1
Sri Lanka								1				1
Indonesia									1	1		2
Nigeria									1			1
Egypt								1				1
Italy		1										1
Denmark										1		1
USA		1							1			2
Iran	1											1
Australia			1									1
Singapore						1						1
China		1										1
Collaborative						1	1	2		1	1	6

Table 6 - Articles of collaborative effort according to year published

Year	Number of Article	Countries
2011	-	-
2012	-	-
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	1	Denmark, Italy
2018	2	Nigeria, United Kingdom United Kingdom, United States
2019	-	-
2020	3	Saudi Arabia, Pakistan, Canada Singapore, United States Malaysia, Indonesia

2021	2	New Zealand, Singapore Iran, Australia

4. Result and Discussion

The review results show that the selected articles related to early architectural design stages are directly involved with the PtD practice. Besides that, the researcher analysed the articles that discuss the components in the architectural design stage regarding PtD. By analysing the sources, Szymberski's (1997) suggested that a safety prevention strategy consideration in the early design stages may significantly enhance the building's whole life cycle and safety performance in the PtD practices. Therefore, when it comes to the subject of the architectural design parameter and its implementation of the PtD in its early stage, 5 main components were discovered, which are: (1) Site planning, (2) Space Planning, (3) Building envelope, (4) Design for Visibility and (5) Physical Environmental Parameters.

4.1 Site Planning

Site planning-related safety could significantly improve buildings’ safety performance during the early design stage by mitigating any potential hazard and occupational safety and health risk during the facility's construction, operational, and maintenance stages. According to Che Ibrahim et al. (2020), this can be accomplished by taking into account facility planning within the site and its surroundings. In terms of the surrounding context, Che Ibrahim et al. (2020) noted that it is critical to identify the site characteristics to avoid climate risk. During building construction, the necessity of site planning is also highlighted, with the worksite entirely fully enclosed by protective hoarding and a defined allotment of space for temporary structures (DOSH, 2019), suggesting the critical need for planning and placement considerations to mitigate hazards. Furthermore, building orientation consideration in early site planning can improve the passive design approach and safe operation for workers by avoiding sun exposure and extreme climate conditions (Department of Malaysian Standard, 2014). Therefore, several scholars' discussion supports the belief that site planning as a critical component in early PtD practice.

4.2 Space Planning

Space planning is one of the primary goals of building design. As stated by Scope et al. (2021), good building space planning should not jeopardise the safety and health of workers and occupants. This idea is accomplished by the division of appropriate spatial layouts that eliminates hazardous conditions and accidents early in the design stage (Dewlaney & Hallowell, 2012). For instance, ensuring that each room has adequate airflow openings can reduce indoor chemical and pollution hazards, thus decreasing safety risks to occupants as well as maintenance workers. Furthermore, functional spaces and circulation areas are appropriately distinguished during space design to suggest better layouts and lengthen the building life-cycle (DOSH, 2019). According to Al-Saggaf et al. (2020), building space functionality is effective by structural element dimensions and floor area consideration and depreciation of the circulation area. Considering both components could therefore increase building safety performance throughout its entire life-cycle. In addition, according to Act 341 Bomba service Act for Occupational Safety and Health in construction workers and occupants, emergency escape and services should be allocated with designing the fastest and safest escape routes immediately after the detection of fire (DOSH, 2019). This is reinforced by UBBL (2006) by providing sanitary, water, and power systems, as well as fire lifts and fire extinguishment systems during fire escape planning. By reinforcing its importance, it demonstrates that space planning strategies are integral to mitigating hazards in the early design stage in the PtD practice.

4.3 Building Envelope

Building envelope mainly includes elements that define a building's form and facades, such as windows and openings, height, and materials. Material safety and component technology are also considered in this context. The building's exterior facade allows for indoor climate control and protects occupants from weathering (Valitabar et al., 2021). However, failure of the building envelope design could pose further internal issues in the future, impacting maintenance planning, operations, and costs negatively (Agus Salim et al., 2014). More often, safety hazards occur during the installation and material of cladding on facades creating injuries such as objects falling due to collapse, slipping of cladding components or being highly combustible (Mohamed et al., 2020; DOSH, 2019). Thus, design intervention is necessary by utilising brick guards, façade nets, sheeting, or fans to support maintenance and operational activity (DOSH, 2019). In addition, an integrated fall protection method for workers working on the roof should also be provided, as it would be less hazardous and more economical (DOSH, 2007).

According to the RIBA Plan of Work 2013 (Bailey, 2015), building maintenance strategy should be discussed early on in the concept design stage. To strategise maintenance operations in the building, the optimum location and ergonomically designed service risers, cleaners' equipment, and general storage will have to be identified and resolved as it could potentially mitigate workers' safety hazards (Bailey, 2015). UBBL (2006) stated that this could also be accomplished by providing access to the roof for maintenance and repair. The same goes for window maintenance, where permanent access equipment such as anchorages, rails, trolleys, and travelling ladders should be designed to reduce danger risk and ease of maintenance (DOSH, 2007). Additionally, early material selection can assistin reducing the risk of injury during construction and maintenance (Abas et al., 2020; Weidman et al., 2015). For example, it utilises lighter, more fire-resistant construction materials to prevent fire spread (DOSH, 2020; UBBL, 2006). Additionally, it is vital to keep in mind that having less frequent maintenance and replacement, easier handling (e.g., lightweight block), and fewerhazardous chemicals can help keep design risk to be minimal (Abueisheh et al., 2020). These considerations have substantial impacts on the overall performance of the building in terms of worker safety and health, as well as on building maintenance and use.

4.4 Design for Visibility

Findings from prior studies on the PtD seemed to agree that design for visibility should be part of architects' repertoire in the early stages of design to enhance building life-cycle, safety performance and occupants safety as proven by(CIDB, 2018; Eilouti, 2021; Hamzah, 2006; Kowaltowski et al., 2013; Kuliga et al., 2021). The topic addresses universal design consideration through adequate building signage, a design for people with disabilities, ergonomic safety building facilities, especially for maintenance work, fire prevention, and emergency escape. Accordingly, this is achieved by providing adequate building signage for smooth accessibility, maneuverability, and way-finding in and around buildings (Eilouti, 2021). In addition, including 'display of signage according to colour', could draw attention to objects and situations affected by safety or health (CIDB Malaysia, 2018; DOSH, 2019).

Accessibility and inclusion for people with disabilities must be prioritised early in the design process by establishing barrier-free accessibility, security, privacy, orientation, and safety principles (Kuliga et al., 2021; RIBA, 2020). Building facilities for ergonomic safety, particularly for maintenance operations, should be designed with visibility and comfort in mind. Identifying the type of manual handling risk factor by walkthrough survey, interview and document review could prevent and control ergonomic diseases in workers (DOSH, 2019). Similarly, good building designs require adequate clear fire safety prevention (Hamzah, 2006). This is supported by UBBL (2006). The storey exits, access, and fire extinguishment system are marked by clearly visible signs and not obscured by decorations, furnishings, or other equipment to facilitate an emergency evacuation. With the emphasis on design for visibility, designers should plan emergency routes to be concise and straightforward, with firefighting equipments being stored properly with signage, allowing no room for possible vandalism. Therefore, through these visible interventions early on in the design stage, hazards and risk related to the built environment may be minimised or eliminated.

4.5 Environmental Design Parameter

Several scholars have highlighted the building's impact on its surrounding environment in the early design stage(Altomonte et al., 2020; Wang et al.,, 2020). Hence, physical environmental parameters address these environmental sustainability issues such as environmental footprint, ease of maintenance, waste minimisation, environmental protection, energy demand, and acoustic and thermal comfort at the early design stage in order to minimise the environmental impact of building construction.

Eilouti (2021) suggested that material efficiency and selection of building systems significantly reduce the buildings' environmental footprint without compromising safety. At the same time, Sutrisna & Goulding (2019) agreed that the offsite construction method couldreduce safety hazards, carbon footprints, and waste. In addition, consideration of designing for maintenance ease for workers could reduce operational issues in construction. These sustainable aspects should be checked and reviewed early on in the design stage (Othman & Abdelwahab, 2018). This is reinforced by INDEX (2009) in which sustainable maintenance could ensure the building's energy-related systems will continue to operate as intended after the Defects & Liability Period of 12 months has passed. Meanwhile, waste management has the greatest impact on construction worker safety (Dewlaney & Hallowell, 2012). Thus, tackling the issue first-hand during the design stage could potentially reduce safety hazards. Recycling material waste and lowering material amounts could divert this waste from landfills and incineration facilities. A domestic effort such as clearly labelled dumpsters with bilingual text encourages proper recycling waste sorting. This endeavour is supported by (DOSH, 2019) in which waste materials should be collected and sorted for recycling or disposal.

Recent studies show that lighting, noise, temperature, and risks are significant drivers of optimal physical working conditions (Marisa & Yusof, 2020). Additionally, light pollution in the built environment can be intrusive to occupants and workers (Zielińska-Dabkowska et al, 2020). Hence, Kim & Yi (2019) suggested that site planning should include solar design to address light pollution early on in the design stage. Plan the distance between separate structures, setbacks, and the road should apriorotised during the planning stage. UBBL (2006) also reinforces this issue by stating that at least 10% of a room's unobstructed floor space is lit by natural light.

Meanwhile, studies have shown that workers in the construction sector are more exposed to noise hazards (Abueisheh et al., 2020). Similarly, Che Ibrahim et al. (2019) categorised loud noise as the second-highest common hazard found on site. Hence, DOSH (2019) suggested that these hazards can be avoided by planning construction sites in a secure location with no potential noise hazards. In addition, acoustic comfort can be improved through sound insulation of partition walls, ceiling panels and floor separation during the design phase (Rohde et al., 2021). According to Stavridou (2015), thermal comfort can contribute to an individual's health and well-being by creating a pleasant living environment. UBBL (2006) stated that each room must have natural lighting and ventilation provided by windows and unobstructed air flow to assist in accomplishing this. Rohde et al. (2021) also suggested that exterior sun shading, suspended ceilings, load-bearing construction, and mechanical ventilation could also improve thermal comfort and reduce heat loss.

Besides that, poor hygiene practices often contribute to incidents, as stated by DOSH (2019). A comprehensive cleanliness strategy should be developed early on to improve the work environment's conduciveness, hygiene, and safety. According to the Department of Occupational Safety and Health (DOSH, 2019), this can be accomplished by routine housekeeping, timely disposal, or removal of infrequency use on construction sites. Therefore, based on these studies, it is agreeable that the environmental aspect of building design should be prioritised in the early design stage to build a more conducive and safe building condition for occupants and workers.

5. Conclusion

Recently, much research has underlined the responsibilities held by designers towards PtD practices in the construction industry. This research focused specifically on the architectural design safety aspect while incorporating the PtD concept in the early design stage.

Findings of this study have identified the main themes commonly associated with PtD on the sustainable aspect of safety in the early architectural design, which are (1) Site planning, (2) Space Planning, (3) Building envelope, (4) Design for Visibility and (5) Environmental Design Parameters. The results from the findings also specify the design safety attributes in the design stage in order to improve safety building performance at an early stage. These attributes were elaborate and concluded to be significant in the PtD practices. Although generally it is suggested that the sustainable aspect of safety in the early design stage contributes to the PtD and safety performance of the building, a continuous improvement of the level of understanding, research, and provision of early design framework are required, as current technologies keep leapfrogging past designs. These findings are elaborated on below.

During the early design stage, site planning is accomplished by taking into account site location planning and its surroundings. It is noted that it is critical to consider planning and location for temporary works and structures. During building construction, at the planning stage of any proposed building works, specific consideration should be given by those who are responsible for the design and the construction, to the safety of the workers and the public who will subsequently be affected by the process of the erection of such structures. Moreover, planning of entrance and on-site exit plans should considerably improve the safety performance of the building.

By devising appropriate spatial layouts, effective space planning could eliminate hazardous conditions and accidents early in the design stage.Along with the practicality of building design to its function, aesthetics, and cost consideration, the factor of safety must be considered as one of the primary design objectives. Additionally, components such as the building layout and complexity, functional space, circulation area, emergency escape, and services must be taken into consideration. All of these objectives must be prioritised in a way that does not jeopardise the safety and health of those who work on or use the building during its entire life cycle. .

Building envelope allows indoor climate control and shelters occupants from weathering. Better interventions must be incorporated into the design of building envelopes to prevent accidents. Ignorance of this aspect could impact maintenance planning, operations, and costs negatively. This includes elements that define a building's form and facades, such as windows and openings, height, andaterials safety as well as technological components which are also considered in this context.

Design for visibility addresses topics on universal design consideration through adequate building signage, design for people with disabilities, ergonomic safety building facilities, especially for maintenance work, fire prevention, and emergency escape. This should be emphasised in the early design stages to enhance building life-cycle, safety performance and occupants' safety.

Environmental design parameters should address environmental sustainability issues such as environmental footprint, ease of maintenance, waste minimisation, environmental protection, energy demand, and acoustic and thermal comfort at the early design stage in order to minimise the environmental impact of building construction. However, the environmental sustainable designs may have unforeseen implications that go beyond merely improving occupant comfort; they may also put the safety of maintenance workers at risk.

Furthermore,this paper possesses a few limitations. First, this study was limited mainly to a sustainable aspect of safety in the architectural early design stage towards the PtD concept. Secondly, as several of articles were reviewed, the study occasionally had to remain at a general level to provide a broad overview of the subject instead of a meticulous account of extremely detailed findings. Still, the outcome could serve as a point of reference for architects and their respective firms or organisations for them to self-examine their PtD proficiencies, which will then spark a movement to enhance the abilities of designers regarding the concept continuously. Consequently, with adequate knowledge, capabilities, and experience, architects can work cohesively and efficiently in line with the implementation of the PtD concept and enhance safety aspects in early architectural design.

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