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"Sustaining the Resilient, Beautiful and Safe Cities for a Better Quality of Life"

ORGANISED BY

Gresafe_Cities RIG
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ARCHITECTS' PERCEPTION OF RESILIENT DESIGN FOR BUILDING IN MALAYSIA

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Abstract

The 'resilience' approach has become increasingly prominent in architecture in recent years. Their significant effects on national and global economies have prompted action to improve building resilience. These challenges are overcome only by making buildings better, innovative, and resilient. Despite its current influence, the literature lacks studies that comprehensively understand architect perception related to resilient design in a built environment. In this context, this study examines the perception of Malaysian architects on the application of resilient design strategies to buildings in Malaysia. The focus on architects' disaster resilience knowledge originates from the inadequacy of conventional building design in dealing with natural disasters. This study employed a quantitative method using structured questionnaires to identify the respondents' views. The selected respondents are architects due to their direct involvement in conceptualizing, planning, designing, and constructing a built environment project. The research first identified the risks facing buildings in Malaysia and built resilience indicators through a literature review of available resilient strategies from journals, articles, and thesis to interpret the key resilience strategies used as variables measurement in this study. The findings revealed that there is a positive perception by the architects regarding the application of resilient design in Malaysia. Identifying the perception of architects within the context of resilient design can lead to a basis for developing a practical scheme for the improvement of building resiliency in Malaysia.

Keywords: *Architects' Perception, Built Environment, Climate Change, Disaster, Resilient Design*

INTRODUCTION

Over the last few decades, the global effect of severe weather events such as floods, landslides, and earthquakes has increased significantly. With half of the world's population now living in metropolitan regions, especially cities, cities' vulnerability has risen owing to the incredible complexity of difficulties they face on all levels: physically, economically, socially, and environmentally (Shamout et al., 2020). Natural and man-made hazardous occurrences are unpredictable, but they may be mitigated by improving and adapting building resilience strategies. The resilient design ensures a structure is more robust to destruction from natural hazards (Bejtullahu, 2017).

According to Bosher & Dainty (2011), professionals responsible for planning, designing, and constructing the built environment are expected to face a wide range of hazards in the coming years, and they must implement resilient strategies that take into account future climate change in their location (E.l. Basyouni, 2017). Resilient climate strategies should be incorporated at the architectural design level instead of requiring specialist expertise (Leone & Raven, 2018); where during the design process, architecture can help avoid risk in the first place by choosing the right site or building configuration. (Laboy & Fannon, 2016). To do so, they will require a framework and tools for implementing climate adaptation techniques into their projects (E.l. Basyouni, 2017).

Recent natural disasters around the world have highlighted the vulnerability of our built environment and the frequently severe effects of disasters. According to Bader et al. (2021), the 2019 statistics showed that the total economic losses accumulated to around 140 Billion USD, whereas natural disasters accounted for 133 billion USD. The significant natural disasters and their effects on national and global economies have raised awareness and sparked action to improve building resilience (Szoke, 2014). Building resiliency is becoming increasingly vital on a national and global scale, and it is a critical component of economic, societal, and environmental viability (E.l. Basyouni, 2017).

Although many cities that have persisted for centuries have shown resilience in the face of various challenges such as natural catastrophes and conflicts, improving city resilience should become a priority since many new global issues, including climate change, have developed (Da Silva & Morera, 2014). The built environment is crucial in any city and must be functional and operable in the event of a disaster to protect people and other infrastructure (Malalgoda et al., 2014). These challenges can only be solved by doing things better, smarter, and more resilient (Bejtullahu, 2017). Adaptation in the buildings and construction sector is still in its early phases, and efforts must be ramped up quickly to cope with more severe climate change impacts (United Nations Environment Programme (UNEP), 2021).

The focus on architects' disaster resilience knowledge originates from the inadequacy of conventional building design in dealing with natural disasters. Architects were chosen as the respondents due to their direct involvement in the conceptualisation, planning, design, and construction of a built environment project. Architects are responsible for evaluating, designing, and maintaining resilient building environments that can better adapt to natural circumstances and absorb and recover cities from various disasters (Bejtullahu, 2017). Few surveys involve the distribution of questionnaires to architects to determine their knowledge levels on particular topics or their perceptions of issues (Brisibe, 2018). However, there is less research involving surveys of architects on disaster resilience strategies. To date, the literature is lacking studies that specifically provide a comprehensive understanding of conducted to examine the perception of Malaysian architects on the application of resilient design strategies to buildings in Malaysia. As such, architects in Malaysia are selected as the target group for this research effort, as they are key decision-makers in the development process. The objectives of the research are to understand the disaster risk that facing buildings in Malaysia, to identify resilience key variables and to determine the perception of Malaysian architects of the implementation of Resilient design for building in Malaysia.

LITERATURE REVIEW

Building Vulnerability towards Disaster in Malaysia

When a natural or man-made disaster of any type takes place, it almost always results in a high number of fatalities, the destruction of property, a decline in people's ability to make a living, the loss of habitat, and a great variety of other negative outcomes (Akter et al., 2019). Each year, Malaysia is struck by a variety of disasters. According to the United Nations (2015), Malaysia experienced drought (4.2%), earthquake (2.1%), flood (62.5%), landslide (8.3%), mass movement (2.1%), storm (12.5%), and wildfire (8.3%) between 1990 and 2014.

Floods

With the majority of the natural disasters that occurred in the last twenty years being floods, their impact on Malaysia's built environment is significant. About 2.5 million Malaysians are at risk of flooding since their dwellings are located in the flood plain (Noorazuan et al., 2003). Floods can cause slab and floor systems to rise as a result of hydrostatic loads; due to the difference in elevation between the water within and outside the structure (Munach, 2010).

Landslide and Mass Movement

Massive landslides are typically associated with prolonged rainfalls in Malaysia, which are frequently associated with monsoons (Yeong, 2012). Malaysia has an annual monsoon season, which is associated with landslides. Landslides are difficult to foresee or prevent due to the considerable rainfall each year. While landslides seldom exceed 500 meters in length or breadth in Malaysia, the rate of damage caused by landslide disasters is staggeringly high (Majid et al., 2020). The risk to a building is that racking will develop as a result of the overall pressure of the ground on the structure if subsidence occurs (Munach, 2010). If the foundations shift as a result of movement, the structure may potentially collapse (Alfraidi, 2015). In the face of climate change, architects and designers must come up with new ways to make their structures more resilient (Alfraidi, 2015).

Storm

Although Malaysia seldom encounters tropical cyclones, it is estimated that the frequency of storm surges would rise as the severity of tropical storms in the Southeast Asia area increases due to climate change (The World Bank Group & Asian Development Bank, 2021). IPCC (2022) raises this issue further, predicting that monsoon precipitation would rise globally soon, with the greatest increase occurring in South and Southeast Asia. High-rise structures, which are susceptible to a range of powerful linear, shear, and twisting pressures, are particularly vulnerable to the effects of storm winds, damaging the façade and external walls (Alfraidi, 2015). In the face of climate change, architects and designers must come up with new ways to make their structures more resilient (Alfraidi, 2015).

Resilience in Architecture

Resilience is a broad concept with various definitions and applications across several academic fields. There are several definitions and interpretations of resilience across diverse disciplines, making it a challenging topic to quantify, analyse, and understand what it means and how it pertains to various disciplines (Hassler & Kohler, 2014). The idea of resilience originates from the physical and mathematical disciplines: the phrase initially referred to the ability of a substance or system to return to equilibrium following a shift (Norris et al., 2007). In a broader context, resilience is known as a system's ability to recover and reconfigure itself in the wake of adversity (Losasso, 2018). At the same time, resilience in the construction industry with an influence on disaster response highlights the maintenance and quick restoration of the regular operation of the physical environment in the face of immediate shocks and disruptions (Laboy & Fannon, 2016). Table 1 shows several definitions from relevant works of literature on resilience in architecture.

Table 1
Different definitions of resilience in architecture.

Reference	Context	Definition
United Nations Environment Programme (UNEP), (2021)	Building	The capacity of a building to fulfill the needs of its occupants and offer a safe, consistent, and comfortable environment in reaction to changing outside circumstances.
Samadian et al., (2019)	Building & Infrastructure	The ability to withstand the impact of extraordinary events while swiftly recovering critical performance and functioning.
Tyler & Moench, (2012)	Urban	A resilience-based approach pushes practitioners to explore innovation and change to facilitate recovery from unpredictable stressors and shocks.
Asian Development Bank (2019)	Building & Infrastructure	The ability to resist, respond to, or recover from natural disasters and keep the vital infrastructure working, both now and in the short, medium, and long term. Geophysical and weather-related hazards are among these. Changes in weather extremes and climate trends show how the Earth's climate changes and how exposed and vulnerable people are to these events and trends.
Peters (2021)	Building	Buildings have a responsibility to supply the fundamental essentials of functioning and shelter continuously.
El Basyouni (2017)	Building	Building resilience refers to a building's ability to function in such a way that it is robust, durable, long-lasting, disaster-resistant, safe, and secure regardless of the stressors or shocks it faces.

Measurement of Resiliency in Architecture

The resilience concept has attracted growing interest as a response to many emerging disaster risks. There is a relatively new and growing body of literature defining resilience in a built environment and how to measure it (Tierney, 2003). Despite various kinds of literature addressing different levels of assessment frameworks for resilience, little is known about resilience design and assessment criteria for the built environment (MacAllister, 2013). There is no consensus exist currently that is devised on how to measure resilience in architecture. Therefore, it is essential to understand what resilience can mean and how to measure it when it comes to the built environment. To find the key variables used in this analysis, works of literature on resilience from previous researchers have been analysed and summarised. Table 2 shows the summary of examples of key resilience indicators from previous literature outlining its defined metrics. It is important to understand a holistic approach to resilience that combine a different point of view from current literature and practice to be able to define what is that we are trying to achieve in building resilience (Shamout et. al, 2020).

Table 2
Characterisation of resilience in international references addressing the key variables.

Reference	Level	Objective	Key Variables
Da Silva & Morera (2014)	City	City Resilience Index as the outcome of a City Resilience Framework. Comprises 4 categories, 12 goals, 52 indicators, 156 variables	Reflective, **Robust, Redundant,** Flexible, Resourceful, Inclusive, Integrated
Zhao et al. (2016)	Infrastructures	Use of Non-homogenous Hidden Markov Models for computation of resilience	**Absorptive capacity, Adaptive capacity, Recovery capacity**
Wholey (2015)	Building	Identifies potential cost/benefits of designing for resilience	**Adaptability, Redundancy**, Diversity, Design for Resiliency, Traumatic Changes
Burroughs (2017)	Building	Defines a rating system based on 6 resilience dimensions, for commercial buildings and owners	Physical, Infrastructural, **Environmental**, Economic-social, Political-regulatory, Organisational
Francis & Bekera (2014)	Building Systems	Propose a quantitative model for measuring the resilience of systems	**Adaptive Capacity, Absorptive Capacity, Restorative Capacity**, Speed Recovery
Cerè et al. (2017)	Building	Propose resilience of the built environment framework	Vulnerability, Recoverability (or **Restorative Capacity), Adaptive Capacity**
El Basyouni (2017)	Building	Propose a framework for the design and interventions for climate-adaptable buildings in terms of resilience	**Adaptability**
Winderl (2014)	Building	Identifies measurement frameworks for disaster resilience through mapping and a literature review	**Adaptive Capacity, Absorptive Capacity**, Transformative Capacity
Alfraidi (2015)	Building	Developed a resilient building design evaluation tool to help architects prepare designs for climate change problems.	**Robustness, Redundancy, Capacity for Adaption, Environmental Responsiveness**
National Institute of Building Sciences (2018)	Building	Presents four key features called 4Rs by U.S National Infrastructure Advisory Council as guidance for building designers in the Whole Building Design Guide	**Robustness**, Resourcefulness, **Rapid Recovery, Redundancy**

For this study, four key variables are identified following various key variables found in previous resilience literature (Table 2). The four key variables are robustness, redundancy, capacity for adaptation, and environmental responsiveness. These key variables are selected for their striking similarity across the reviewed literature, and they cover all of the relevant aspects of resilience and significance to buildings in the context of climate change. Each of the key variables is further identified by its definitions and characteristics.

Resilience Key Variables

Robustness (RO)

Robustness as identified by Bruneau et al. (2003) is the ability to tolerate a certain amount of stress or demand without degradation or loss of functionality. Robustness in architecture refers to well-designed buildings that can resist the effects of a natural disaster without suffering major damage.

Redundancy (R)

Redundancy can be defined as using more components than necessary for the system's functionality; recovering lost functionality by simply swapping out a defective component is made possible through redundancy (Liu et al., 2010). Redundancy makes things more resilient by acting as a buffer against outside shocks, but it also makes things more expensive and less efficient (Longstaff et al., 2010; Alfraidi, 2015).

Capacity for Adaptation (CA)

Capacity for Adaptation can be referred to as the ability to adapt. Adaptability in architecture is not a new concept; in the context of climate change, it is commonly used to refer to adjustments that can be made to the design or construction of structures to mitigate the effects of one or more climate change impacts (El Basyouni, 2017).

Environmental Responsiveness (ER)

Environmental responsiveness refers to the degree to which a building's systems and functions are responsive to and integrated with the building's internal and external environments (Alfraidi, 2015). To adapt to its user, a responsive environment combines several adaptive components such as light, temperature, or sound, effectively contributing to the minimisation of energy consumption. (Alves et al., 2010).

METHODOLOGY

There were limitations in the literature that conduct research on the perception of resilient design for buildings in Malaysia. However, various works of literature were identified from abroad that included built environment professionals and practitioners in their study. This methodology and its findings have been summarised in Table 3 and Table 4.

Table 3
Past Researches Method and Findings on Architecture Perception.

Reference	Method(s)	Target Sample(s)	Findings
Landeros-Mugica et al. (2015)	Questionnaire Survey	Pilot Study: 206 Local people Main Study: 600 Local people	Perceived risk is shaped as a function of preceding knowledge and the consequences of a given disaster event, on an individual, household, or neighborhood basis; the higher the knowledge and experience, the better level of awareness.
Adewale et al. (2020)	Questionnaire Survey	137 architects	The findings revealed a high level of awareness of acid rain among the architects but a low response to the adaptation and mitigation of the phenomenon. Architecture design values as the main contributors to this behaviour.
Rajali & Bakri (2016)	Questionnaire Survey	50 Construction Practitioners consisting of architects, engineers, building surveyors, quantity surveyors, contractors, consultants, and developers	30 completed questionnaires formed a database for descriptive analysis. The highest degree of influence contributing to the safety and health performance of building design was the architecture approach.
Hemström et al. (2017)	Questionnaire Survey	412 architects	Architects perceive a low level of innovativeness in the Swedish building construction industry because of several barriers of varying relevance

Table 4
Past Researches Method and Findings on Resilient Design in Architecture.

Reference	Method(s)	Target Sample(s)	Findings
Bejtullahu (2017)	Literature Review, Participant Observation	Architects	The main role of architects is to design and plan always locally specific resilient architecture by using all social-spatial and environmental resources.

Laboy & Fannon (2016)	Literature Review	-	Presented competing conceptual frameworks from various literature on resilience. Suggested that a framework for social-ecological resilience is critical to transforming architectural education and practice.
Peters (2021)	Literature Review, Case Studies	-	There is an urgent need for deeper studies and analysis of built examples of resilient architecture.
Wijaksono et al. (2020)	Questionnaire Survey	753 Local People	The results showed that architects were judged by the community to be quite adaptive to disaster risk mitigation. However, architects need to improve their understanding of various threats that exist and how to mitigate them in the event of a disaster.
Benfarhat et al. (2020)	Literature Review	Professionals consisting of architects and engineers	90% of architect respondents feel that they are not well versed in seismic design.
Malalgoda et al. (2014)	Literature Review	-	Proposed paper. Proposed a set of recommendations to address threats posed by natural hazards and to build a more resilient built environment.
Cerè et al. (2017)	Literature Review	-	Identified the built environment resilient framework and systemic approach to conceptualise resilience
Bader et al. (2021)	Literature Review, Questionnaire Survey, Structured Interviews	80 Professionals consisting of structural engineers, architects, and ecologists	Most responses from the professionals generally believed that the existing building resiliency in comparison to potential hazards was 'Good but not enough.
Brisibe (2018)	Semi-Structured Interview	20 Architects	The result reveals that the majority of architects interviewed are acquainted with the effects of flood waters on buildings and have the opportunity to design or supervise the construction of buildings in flood-prone areas.

			However for most, the extent of their professional knowledge is still limited to the basic precautionary measure and there are little to no innovative, efficient, and adaptable designs being employed.
Alfraidi (2015)	Literature Review, Questionnaire Survey	270 Architects	77 out of 270 respondents completed the survey. 85 Design resilient strategies were identified from a literature review of six design aspects. 28 of the design resilient strategies are included in the building design resilient assessment tool.

Based on the methodologies adopted by past research, the study employed a quantitative method using structured questionnaires to measure the perception of local architects registered with the Board of Architects, Malaysia (LAM), and with a balanced distribution of graduate and professional architects. Architects were chosen as the only respondents due to their direct involvement in the conceptualisation, planning, design, and construction of a built environment project. 50 respondents completed the survey. This was a satisfactory number as a sample size larger than 30 and less than 500 is appropriate for most behavioural research (Hashim, 2010; Memon et al., 2020; Roscoe, 1975; Sekaran & Bougie, 2016).

The research questionnaires developed had two sections. The first section included demographic information such as name, gender, working experience, and academic and professional background. The second section of the questionnaire assesses their opinions on the implementation of resilient strategies by using a set of variable measurements that is based on a previous study by Alfraidi (2015). The respondents were asked to rate their level of implementation or considerations of resilient factors in design (1 = Very Low, 5 = Very High) on a five-point Likert-type scale. Such scales are commonly used in social science research to elicit attitudinal information (Rea & Parker, 2005).

Statistical Package for Social Science (SPSS) is used to analyse the data concerning the respondents' level of experience (0-5 years' experience, 5-10 years' experience, and more than 10 years' experience) and their professional capacity (academic, practicing, or both).

RESULTS AND DISCUSSION

Reliability of Measurement

The architecture perception of resilient design for building in Malaysia construct is based on four variables; (a) Robustness (RO), (b) Redundancy (R), (c) Capacity of Adaptation (CA), and (d) Environmental Responsiveness (ER). The variables were measured using a 5-point Likert Scale; (1) Very low, (2) Low, (3) Average, (4) High, and (5) Very High. Cronbach's alpha is used to examine the reliability of the four resilience key variables to verify that the scale's items are composed of reliable factors. As indicated in Table 5, the reliability scores obtained are: Robustness ($\alpha = 0.87$), Redundancy ($\alpha = 0.79$), Capacity for Adaptation ($\alpha = 0.71$), Environmental Responsiveness ($\alpha = 0.94$). Based on the result obtained, all the Cronbach's Alpha values are above 0.7 which indicates the reliability of measurement. These four resilience key variables correspond to Nunnally & Bernstein's (1994) recommendations for acceptable reliability levels.

Table 5
Cronbach's alpha value for all resilience key variables.

Resilience Key Variables	Items	Description of Items	Corrected item-total correlation	Reliability (Cronbach's Alpha, α)
Robustness (RO)	Item 1	Specify windows, doors, or openings to withstand wind loads and windblown debris	0.48	**0.87**
	Item 2	Oversize roof covering fixings to reduce windblown debris	0.46	
	Item 3	Build a permanent water-resistant barrier around HVAC equipment to protect from flooding	0.63	
	Item 4	Provide anchorage between superstructure and substructure to increase resistance to high winds	0.77	
	Item 5	Oversize framing system to increase redundancy	0.80	
	Item 6	Oversize bracing system to increase redundancy	0.77	
	Item 7	Provide protection for the main electrical system from flooding	0.64	
Redundancy (R)	Item 1	Direct runoff of water to a catch basin or holding area to reduce erosion	0.36	**0.79**
	Item 2	Increase structure bracing to create strength redundancy to wind loads	0.61	
	Item 3	Specify cogeneration to run during blackouts	0.68	
	Item 4	Specify solar power to run during blackouts	0.64	
	Item 5	Size drainage system to vulnerability to the high level of rain	0.55	
Capacity for Adaptation	Item 1	Use of permeable surfaces in landscaping against vulnerability to flooding	0.69	**0.71**
	Item 2	Provide expansion joints within the materials on vulnerability to expansion	0.84	
	Item 3	Use appropriate floor height to allow for future modification	0.90	
	Item 4	Use optimum building orientation to improve resilience to high/low temperature	0.74	
	Item 5	Use appropriate floor height to enhance and optimise ventilation processes	0.80	
	Item 6	Use structure materials that are more resistant to pest	0.72	
	Item 1	Use secure cross-ventilation for passive cooling for occupants' comfort	0.77	**0.94**

	Item 2	Specify the layout of rooms, corridors, stairwells, etc. in a way that upholds a low-resistance airflow path through the building for thermal comfort	0.76
	Item 3	Use appropriate exterior shading to reduce vulnerability to overheating	0.73
	Item 4	Use energy-efficient windows to reduce energy use	0.77
	Item 5	Use energy-efficient shading devices to reduce energy use	0.76
	Item 6	Use of appropriate insulation systems to reduce conduction through the thermal envelope	0.76
Environmental Responsiveness (ER)	Item 7	Use a high solar reflectance material to reflect heat from the sun away from the building	0.72
	Item 8	Use advanced wall techniques to reduce energy loss	0.65
	Item 9	Plant mature trees to assist in the dissipation of the wind force	0.67
	Item 10	Prepare the site landscape for high wind conditions as well as reduce the noise, pollution, energy consumption, temperature degree, and relative humidity	0.73
	Item 11	Use an appropriate roof form to optimise ventilation and thermal comfort, as well as to resist storm	0.71
	Item 12	Use an appropriate roof angle to optimise ventilation and thermal comfort, as well as to resist storm	0.72

In several studies, the corrected item-to-total correlation serves as a criterion for initial assessment and purification. Based on Cristobal et al. (2007) and Field (2018), above the cut point of 0.30 for corrected item-to-total correlation, is acceptable. For RO, all the seven items of corrected item-to-total correlation are above 0.3; with the lowest value of 0.46 and the highest value of 0.80. This finding indicates that all the items in RO are acceptable to be measured. All the five items of R score above 0.30 with item 3 being the highest value of 0.68, making all the items in R acceptable for measurement.

Meanwhile, the variable of capacity for adaptation (CA) contains six items. Analysis findings have illustrated that the corrected item-to-total correlation is in between 0.69 to 0.90, making all the six items to be valid to be used in measuring CA. For the measurement of environmental responsiveness (ER), the value of corrected item-to-total correlation is in the range of 0.65 to 0.72. This indicates that all the 12 items for ER are good to be used for measurement of ER. Therefore based on the result in Table 5, establish that all the items in the four resilience key variables used in this study are reliable for measurement.

Demographic Characteristics of the Respondents

Table 6 shows the respondents' statistical analysis based on their gender, age, qualifications, and working experience. In respect of gender, male respondents represent 58%

while female respondents represent 42%. Of a total of 50 respondents, 16 were 25 years old and below, 11 are in between 26 to 35 years of age while 23 of the respondents are at the age 36 and above.18 of the respondents were graduate architects with LAM part 2 qualifications, followed by 32 were architects with LAM part 3 qualifications. About 22% of the respondents had less than five years of working experience, while 20 % had worked between six to ten years. More than half of the respondents had more than ten years of experience in architecture. With this balance distribution of level of gender, age, qualification, and working experience, the respondents could be said to represent diverse experiences in the architecture profession, which gives credibility to the data collected.

Table 6
Demographic Characteristics of the Respondents.

Categories	Attributes	Frequency	Percentage (%)
Gender	Male	29	58.0
	Female	21	42.0
Age Range	25 years and below	16	32.0
	26-35 Years old	11	22.0
	36 Years and above	23	46.0
Qualification	LAM Part 2	18	36.0
	LAM Part 3	32	64.0
Years of Experience	0-5 Years	11	22.0
	6-10 Years	10	20.0
	10 Years and above	29	58.0

Architect's Awareness of the Application of Resilient Design

The respondent's response to the level of awareness on the application of resilient design is encouraging. As can be seen in table 7, the grand mean is high, with both of the items having a mean score that is above 3.70. The result reflects that more than half of the respondents have an average to an exceptionally high level of awareness and consideration of climate change and resilient design application in their projects.

Table 7
Architect's Awareness on the Application of Resilient Design.

Categories	Level of Awareness					Mean
	Very Low	Low	Average	High	Very High	
Level of resilience needed in the current or past project(s)	0 (0%)	5 (10%)	13 (26%)	23 (46%)	9 (18%)	3.72 (High)
Level of consideration on climate change in the decision-making process	1 (2%)	2 (4%)	17 (34%)	18 (36%)	12 (24%)	3.76 (High)
Grand Mean						3.74 (High)

Architect's Implantation or Considerations of Resilient Design Strategies
Robustness (RO)

Table 8 depicts the architect's level of implantation or considerations of the robustness and resilient design strategies. According to the table, the majority of the respondents scored the average level of implantation or considerations of the robustness resilient design strategies with a grand mean of 3.40. Out of the seven items, one strategy is highly applied to the building design: the consideration of specifying windows, doors, or openings to withstand wind loads and windblown debris. This high level of consideration can be further justified considering that storm was the second-highest frequency of disaster occurrence in Malaysia, with an estimated 12.5% after the flood (United Nations, 2015).

Table 8
Architect's Implantation or Considerations of Robustness Resilient Design Strategies.

Resilient Design Strategies	Level of Implantation or Considerations					Mean
	Very Low	Low	Average	High	Very High	
Specify windows, doors, or openings to withstand wind loads and windblown debris	1 (2%)	4 (8%)	11 (22%)	25 (50%)	9 (18%)	3.74 (High)
Oversize roof covering fixings to reduce windblown debris	1 (2%)	7 (14%)	11 (22%)	23 (46%)	8 (16%)	3.60 (High)
Build a permanent water-resistant barrier around HVAC equipment to protect from flooding	3 (6%)	7 (14%)	21 (42%)	15 (30%)	4 (8%)	3.20 (Average)
Provide anchorage between superstructure and substructure to increase resistance to high winds	2 (4%)	6 (12%)	20 (40%)	16 (32%)	6 (12%)	3.36 (Average)
Oversize framing system to increase redundancy	3 (6%)	8 (16%)	18 (36%)	16 (32%)	5 (10%)	3.24 (Average)
Oversize bracing system to increase redundancy	3 (6%)	7 (14%)	19 (38%)	16 (32%)	5 (10%)	3.26 (Average)
Provide protection for the main electrical system from flooding	2 (4%)	7 (14%)	14 (28%)	21 (42%)	6 (12%)	3.44 (High)
Grand Mean						3.40 (High)

Redundancy (R)

The architect's level of implantation or considerations of the redundancy resilient design strategies are presented in Table 9. The result indicates that most of them highly consider the resilient design strategies in their design, especially the drainage system. One possible explanation for this is Malaysia's year-round rainy seasons and two annual monsoon seasons;

the country is highly susceptible to floods due to the high amount of precipitation. Therefore it is expected that the architects would consider the process for mitigating flood impact to avert the consequences.

Table 9
Architect's Implantation or Considerations of Redundancy Resilient Design Strategies.

Resilient Design Strategies	Level of Implantation or Considerations					Mean
	Very Low	Low	Average	High	Very High	
Direct runoff of water to a catch basin or holding area to reduce erosion	1 (2%)	2 (4%)	10 (20%)	29 (58%)	8 (16%)	3.82 (High)
Increase structure bracing to create strength redundancy to wind loads	2 (4%)	4 (8%)	13 (26%)	25 (50%)	6 (12%)	3.58 (Average)
Specify cogeneration to run during blackouts	4 (8%)	9 (18%)	17 (34%)	19 (38%)	1 (2%)	3.08 (Average)
Specify solar power to run during blackouts	5 (10%)	10 (20%)	16 (32%)	17 (34%)	2 (4%)	3.02 (Average)
Size drainage system to vulnerability to the high level of rain	0 (0%)	2 (4%)	10 (20%)	27 (54%)	11 (22%)	3.94 (High)
Grand Mean						3.49 (High)

Capacity for Adaptation (CA)

Table 10 depicts the implantation or considerations of capacity for adaptation resilient design strategies. According to the table, the majority of the respondents show a significant level of consideration for resilient design strategies in their projects. The mean score for each item was above the median score of 3.50, which indicates the score is at a high level. Out of all the strategies, the most considered by the respondents is the optimisation of building orientation to improve resilience to high or low temperatures.

Table 10
Architect's Implantation or Considerations of Capacity for Adaptation Resilient Design Strategies.

Resilient Design Strategies	Level of Implantation or Considerations					Mean
	Very Low	Low	Average	High	Very High	
Use of permeable surfaces in landscaping against vulnerability to flooding	0 (0%)	1 (2%)	14 (28%)	28 (56%)	7 (14%)	3.82 (High)
Provide expansion joints within the materials on vulnerability to expansion	0 (0%)	7 (14%)	15 (30%)	24 (48%)	4 (8%)	3.50 (High)
Use appropriate floor height to allow for future modification	1 (2%)	4 (8%)	14 (28%)	24 (48%)	7 (14%)	3.64 (High)
Use optimum building	0	1	9	26	14	4.06

orientation to improve resilience to high/low temperature	(0%)	(2%)	(18%)	(52%)	(28%)	(High)
Use appropriate floor height to enhance and optimise ventilation processes	1 (2%)	1 (2%)	6 (12%)	30 (60%)	12 (24%)	4.02 (High)
Use structure materials that are more resistant to pest	0 (0%)	2 (4%)	12 (24%)	29 (58%)	7 (14%)	3.82 (High)
Grand Mean						3.81 (High)

Environmental Responsiveness (ER)

Respondent's response to the implantation and considerations of environmental responsiveness and resilient design strategies showed a positive design response. As can be seen in Table 11, the grand mean is above average, with a score of 3.89. Just 6% of the respondents give very little consideration to using advanced wall techniques to reduce energy loss. This result could be due to economic factors when the construction cost is an issue in a project.

Table 11

Architect's Implantation or Considerations of Environmental Responsiveness Resilient Design Strategies.

Resilient Design Strategies	Level of Implantation or Considerations					Mean
	Very Low	Low	Average	High	Very High	
Use secure cross-ventilation for passive cooling for occupants' comfort	0 (0%)	2 (4%)	8 (16%)	22 (44%)	18 (36%)	4.12 (High)
Specify the layout of rooms, corridors, stairwells, etc. in a way that upholds a low-resistance airflow path through the building for thermal comfort	0 (0%)	1 (2%)	11 (22%)	20 (40%)	18 (36%)	4.10 (High)
Use appropriate exterior shading to reduce vulnerability to overheating	0 (0%)	1 (2%)	7 (14%)	21 (42%)	21 (42%)	4.24 (Very High)
Use energy-efficient windows to reduce energy use	2 (4%)	1 (2%)	15 (30%)	18 (36%)	14 (28%)	3.82 (High)
Use energy-efficient shading devices to reduce energy use	2 (4%)	1 (2%)	14 (28%)	21 (42%)	12 (24%)	3.80 (High)
Use of appropriate	0	0	8	26	16	4.16

insulation systems to reduce conduction through the thermal envelope	(0%)	(0%)	(16%)	(52%)	(32%)	(High)
Use a high solar reflectance material to reflect heat from the sun away from the building	1 (2%)	5 (10%)	15 (30%)	18 (36%)	11 (22%)	3.66 (High)
Use advanced wall techniques to reduce energy loss	3 (6%)	4 (8%)	19 (38%)	17 (34%)	7 (14%)	3.42 (High)
Plant mature trees to assist in the dissipation of the wind force	2 (4%)	5 (10%)	10 (20%)	22 (44%)	11 (22%)	3.70 (High)
Prepare the site landscape for high wind conditions as well as reduce the noise, pollution, energy consumption, temperature degree, and relative humidity	2 (4%)	7 (14%)	9 (18%)	20 (40%)	12 (24%)	3.66 (High)
Use an appropriate roof form to optimise ventilation and thermal comfort, as well as to resist storm	0 (0%)	1 (2%)	10 (20%)	27 (54%)	12 (24%)	4.00 (High)
Use an appropriate roof angle to optimise ventilation and thermal comfort, as well as to resist storm	0 (0%)	1 (2%)	9 (18%)	28 (56%)	12 (24%)	4.02 (High)
Grand Mean						3.89 (High)

Architect's Perception of the Application of Resilient Design in Malaysia

Current Level of Existing Built Structures' Resiliency

According to Table 12, 26% of respondents consider the level of existing built structures' resiliency is good enough compared to Malaysia's potential hazards. About 30% believed it was good, while 38% of respondents viewed it as reasonable but not adequate. Only 3% consider the current building structure level is bad compared to Malaysia's potential hazard. From these findings, it is evident that the respondents viewed that Malaysia is still not good enough in mitigating buildings from potential hazards.

Table 12
Architect's Perception on the Current Level of Existing Built Structures' Resiliency in Comparison to the Potential Hazards in Malaysia.

Perception	Level of Perception					Mean
	Bad	Average	Good	Good But Not Enough	Very Good	
The level of existing built structures' resiliency in comparison to the potential hazards in Malaysia	3 (6%)	19 (38%)	15 (30%)	13 (26%)	0 (0%)	2.76 (Good)

Incorporation of Resilient Design Strategies in New Building's Design

The perception of the incorporation of Resilient Design Strategies in a new building's design was presented in Table 13. The result indicates that the majority of them held a view that resilient design strategies should be incorporated into a new building's design. Only a total of 12% of the respondents viewed that it is not necessary to consider resilient design strategies. It is evident from this finding that resilient design strategies constitute an important part when architects make their design decisions in projects.

Table 13
Architect's Perception on the Incorporation of Resilient Design Strategies in New Building's Design.

Perception	Level of Perception			Mean
	Should Not	Not Necessary	Yes Definitely	
Incorporation of resilient design strategies in a new building's design	1 (2%)	5 (10%)	44 (88%)	2.86 (Yes Definitely)

CONCLUSION

Natural disasters have posed a significant challenge to the integrity of buildings, requiring architects and designers to devise new ways of making the built environment more resilient. This research has examined architects' response to resilient design for building in Malaysia. In this research, the method used is the questionnaire and analysed using Statistical Package for Social Science. The three objectives of this research are to understand the disaster risk facing a building in Malaysia, to identify resilience key variables, and to determine the perception of Malaysian architects of the implementation of resilient design for building in Malaysia.

After the data was analysed, the objectives of this study were already fulfilled. The first objective is fulfilled by studying the risk posed to buildings in Malaysia by three major natural disasters: flood, landslide and mass movements, and storm. The second objective is fulfilled by identifying four resilience key variables following various key variables found in previous resilience literature. The four key variables are robustness (RO), redundancy (R), capacity for adaptation (CA), and environmental responsiveness (ER). These four key variables are then used to determine the perception of Malaysian architects of the implementation of resilient design for building in Malaysia, fulfilling the third objective of this study.

Results suggest that, in general, there is a positive perception regarding the application of resilient design in Malaysia. From the responses, the majority of the respondents had good knowledge and awareness and the implantation and consideration of resilient design strategies in their projects. The results alert us to the architects' recognition of the importance of resilient design applications. According to Adewale et al. (2020), this could be attributed to the hypothesis made by Schultz (2002) that a person with an awareness of the impact and method for minimising such impact would be able to utilise the knowledge to prevent the consequences.

Although there is a reasonable consideration of the application of resilient designs by the respondents in their projects, it is evident that the respondents viewed that Malaysia is still not good enough in mitigating buildings from potential hazards. 88% of the respondents agreed that resilient design strategies should be incorporated into a new building's design. Therefore, various stakeholders in the built environment, including local authorities, must develop a resilient framework and practical scheme for improving resiliency in Malaysia.

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