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DEVELOPING RESILIENT DESIGN CRITERIA FOR EVACUATION CENTRE

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ABSTRACT

Schools and community halls are frequently chosen as disaster evacuation centres during difficult flood incidences. However, the buildings' existing designs and facilities are designed for their respective uses and are inefficient for disaster relief. Thus, the buildings' suitability as disaster evacuation centres is in doubt. It is therefore recommended to apply the Multidisciplinary Centre for Earthquake Engineering Research, or MCEER 4R's Resilience Framework, to investigate the centres' resilience. It integrates four primary qualities to make a more disaster-resilient centre. These are robustness, redundancy, resourcefulness, and rapidity. The research method for the development of criteria is document analysis, which is used to collect qualitative data, which includes shelter design considerations, space provisions in a disaster evacuation centre, and resilience properties. Various official documents on disaster management, shelter guidelines, and resilience frameworks were used to compile this research. These documents attribute the current design standards used in a disaster evacuation centre and inform researchers that each design standard includes embedded resilience features. The findings of the document analysis approach will be used to understand key design issues and resilience ideas. Before identifying the essential design standards through the content validation process, this

becomes an initial list of shelter design standards acquired from official shelter guidelines. The findings will be presented in a disaster evacuation centre context, emphasising the four design domains with built-in resilience: site planning, spatial layout, existing design, and existing construction. The investigation continued with transforming the design variables into resilient design measures, synthesising the resilience ideas gathered from the shelter guidelines. A tabulation of four resilience categories was put together to see the overall resilience design pattern in disaster evacuation centres. This study aimed to develop a practical design framework that included design guidelines and resilience indicators for improving the existing design and space planning of the disaster evacuation centre buildings. As a result, the facilities can be enhanced to provide a resilient, more secure, comfortable, and practical environment for flood victims and rescuers.

Keywords: *"design criteria", "evacuation centre", "resilience"*

INTRODUCTION

The terms "sheltering" and "settlement," whether for temporary or permanent purposes, are frequently interchanged without being properly defined. This will cause conceptual uncertainty, resulting in inadequate shelter solutions that may be inappropriate for local conditions (Boano & Hunter, 2012). Although different interpretations of the definition have been made over time, a shelter acts as a multiphase or an incremental process that provides the potential to build humanitarian design thinking (Brogden & Kennedy, 2021). Making a shelter space is crucial to good design practice (Quarantelli 1982), but it should also address more complex challenges of sheltering and changing social expectations towards disaster relief. As the cost of disasters is rising, it is increasingly important that all related organisations prepare for and mitigate the risks posed by disaster events. With the results of the current disaster framework named The Sendai Framework for Disaster Risk Reduction 2015-2030 or SFDRR 2015-2040, the world challenges four priorities (UNDRR, 2015). Firstly, we need to contribute to the knowledge of disaster risks. Secondly, we need to contribute to strengthening disaster risk governance to reduce disaster risks. Thirdly, we need to encourage

investment in disaster risk reduction for resilience. And fourthly, we need to promote "Build Back Better" in recovery, rehabilitation and reconstruction. (UNDRR, 2015).

Disaster Evacuation Centre as Emergency Sheltering

The sheltering process is important in this research because they are treated like a process, not a building (United Nations, 2010). It is conducted during the phases of before and after the occurrence of a disaster. This process comprises the preparation of a shelter, the acts of mitigation and how sheltering response effectively to a disaster (The Sphere Project, 2015). The term "emergency shelter" is used in this study to refer to a short-term shelter that provides life-saving assistance and is the most basic shelter support that can be offered immediately after a disaster, according to the International Federation of Red Cross and Red Crescent Societies definition. (IFRC, 2013). 'Disaster evacuation centre' is a common term used in Asia to explain public buildings selected as emergency shelters. The two most common buildings used for emergency sheltering are public schools and community halls. In addition to the criteria for identifying acceptable sites for the centres, the design of the buildings must consider the resilience aspects (UNDRR, 2015), with the short- and long-term benefits and drawbacks carefully weighed (IOM & UNHCR, 2010).

Generally, these buildings offer protection from the risk of disasters, with adequate water and sanitation facilities, classrooms and assembly areas, and are also recognised as child-friendly spaces (Anderson & Mcfarlane, 2017). Unfortunately, users frequently disrupt the conditions of public schools and community halls, causing damage to educational facilities and equipment, primarily due to relief management misconduct (Khalid & Shafiai, 2016; Mohd. Subri & Wan Razali, 2016; Pertubuhan Arkitek Malaysia, 2015) and the unsuitability of the buildings for relief purposes (Corsellis, Vitale, & OXFAM, 2005; HM Government, 2014). This has prompted policymakers and other authorities to seek assistance to safeguard the structures. According to local publications, a structure not designed to assist disaster relief puts the sheltering population at risk. As a result, some of the buildings are not suitable to be selected as evacuation centres (Anderson et al., 2017; Wang, 2016). On the other hand, this means that when schools or other buildings are designated as safe and disaster-resistant, they can

provide protection, but only if conditions are met in advance.

Disaster Shelter Design Guidelines

The idea of risks in buildings across all scales has always been a part of design process, implementation, and maintenance. As many common practices in this field have shown, building standards, by-laws and regulations often complement climate change and its impacts on urban and rural environments. Chmutina, Jigyasu & Lee (2016) claimed that building regulations and codes are constantly revised and improved. The evidence in their research shows that in those countries where building codes have been effectively applied, there is an improvement in the performance of new construction, which considers various hazards and threats.

The focus of this research is the resilience of the disaster evacuation centre and, subsequently the sheltering needs in the centre. For a building to function as a disaster evacuation centre, it needs to implement a certain set of criteria gathered from various shelter guidelines that are used globally. These guidelines represent a combination of both technical and social considerations. Among the shelter guidelines that are being referred to in this research are the Transitional Settlement (Corsellis, Vitale, & OXFAM, 2005), Collective Centre Guideline (IOM & UNHCR, 2010), The Sphere Project (The Sphere Project, 2015) and Post-disaster Shelter:10 Designs (IFRC, 2013).

However, most of the building guidelines in this research do not address the design aspects in detail for a building to be resilient towards disaster events. For example, detailed procedures such as providing 1x100 litre refuse bin for every 50 people or one communal refuse pit of 2m x 5m x 2m for every 500 people (UNHCR, 2007; IOM & UNHCR, 2010 and The Sphere Project, 2015) are common shelter design standards to guide on the number of waste management resources. At the same time, the waste collection system is also essential to ensure that the waste is not accumulated during the event. This may require frequent refuse collection or recycling of certain items for other usages in the centre (The Sphere Project, 2015).

Therefore, every government needs to determine the shelter design standards appropriate to the country's context. The official shelter guidelines

gathered and studied in this research have suggested general design considerations in an emergency shelter. Each standard must reflect the specific needs of the disaster evacuation centre (UNHCR, 2007). Ksenia, Jigyasu & Lee (2016) explained the importance of revisiting existing building standards and incorporating the codes with elements to withstand disasters. The findings of this research have identified a need to establish properties of resilience in the design guideline to fit the purpose of a disaster evacuation centre. Buildings that are fit to provide safe shelter for the affected population can be effectively used during a disaster and in non-disaster situations.

Defining the Resilience of a Disaster Evacuation Centre

Based on the Sendai Framework of Disaster Risk Reduction 2015-2030, resilience is defined as the ability of people and the environment to withstand external shocks and return to their original state (UNDRR, 2015). In this research, the resilience of a disaster evacuation centre is measured through the functionality of the building to serve disaster relief. This function should be relative to the number of affected populations a centre can assess and treat. This research is influenced by the study of resilience developed by the Multidisciplinary Centre for Earthquake Engineering Research or MCEER 4R's resilience framework (Bruneau, 2004). The evacuation centre's resilience is determined mainly by site selection criteria, the compliance of design standards of an emergency shelter and the application of the resilience measures when needed. Over time, the centre will be restored to its original functionality and during this process, the resilience framework has captured the four properties of resilience; robustness, redundancy, resourcefulness and rapidity (Bruneau, 2004). These opportunities represent the fundamental properties of a resilience design framework for a disaster evacuation centre.

OBJECTIVES

The objectives of this research are:
•To identify the minimum design standards of a disaster evacuation centre
•To analyse the resilience properties in a disaster evacuation centre

METHODOLOGY

The first method used is in relation to the first research objective. Qualitative data comprising of shelter design considerations from shelter guidelines were extracted using the method of document analysis (Bowen, 2009). This analysis came from official documents on disaster management and shelter requirements. These documents attributed the current design standards used in a disaster evacuation centre and informed the research that there have been properties of resilience embedded in each design standard.

Table 1. Documents used for Document Analysis

Document	Year	Region
Malaysia National Security Council Directive 20 (MNSC 20)	1997 (revised in 2015)	Malaysia
OXFAM transitional settlement	2005	UK
FEMA design guidance for shelters	2006	USA
UNHCR handbook for emergencies	2007	United Nations
IOM & UNHCR collective centre guideline	2010	United Nations
UN shelter after disaster	2010	United Nations
The sphere project	2011	Sphere Assoc. & Red Cross
IFRC post-disaster shelter- 10 designs	2013	Red Cross
Australian Red Cross Queensland Evacuation Centre Planning Toolkit (2013)	2013	Australia Red Cross
HM Government evacuation & shelter Guideline	2014	UK

Source: Author

The four design domains that were identified during the document analysis comprised site planning, spatial layout, existing design and existing construction and in this research, the domains were coded respectively as P, L, D and C. These design domains were adapted from the readings of 'Handbook for Emergencies' (UNHCR, 2007) and 'The Sphere Project' (The Sphere Project, 2015). The objective of utilising these design domains was to apply the standards to buildings responding to disaster relief and humanitarian purposes. Due to the similarity in the terms used in the guidelines, therefore these design standards can be applied for future shelter assessment, monitoring and evaluation, and the management of relief

operations (The Sphere Project, 2015).

The second method used is concerning the second research objective. Since the document analysis method (Bowen, 2009) only aimed to select relevant design standards applied to a disaster evacuation centre, the list of design criterion has gone through a validation process to seek the criteria's reliability. A content validation process as suggested by Yusoff (2019) was applied for the refinement of the shelter design criterion list. During the validation, relevant design considerations were discussed and confirmed on their importance towards the resilience of a disaster evacuation centre. These recommendations were based on international and local experts in disaster, education, architecture and the humanitarian sector. This research also concluded that bringing in experts from various areas other than disaster would benefit the study (Yusoff, 2019).

Table 2. Profiles of Respondents of the Content Validation

No.	Profession of Respondents	Country of Origin
1	Disaster expert & academician	Malaysia
2	Disaster expert & academician	Japan
3	Humanitarian agent & architect	Malaysia
4	Disaster expert	India
5	Humanitarian agent, academician & architect	Malaysia
6	Humanitarian agent, academician & architect	Malaysia
7	Government relief agent	Malaysia
8	Academician	Malaysia

Source: Author

FINDINGS

The document reviews identified eight site planning variables, six spatial layout variables, six existing design variables and five existing construction variables.

Table 3. Design Variables of Shelter Design Standards that have been Extracted from 10 Shelter Guidelines and Validated by Disaster Experts through a Content Validation Process

Shelter Design Domain	Code	Shelter Design Standard

Site planning	P1	Ease of access to services and facilities; 1. Water supply, 2. Sanitation & hygiene, 3. Energy supply, 4. Waste management
	P2	Ease of access to alternative areas of safety
	P3	Extension to surface areas (in case if there is growth in the population)
	P4	Provision of administrative facilities and quarantined areas
	P5	Provision of stockpiling warehouse
	P6	Ease of access to emergency exits
	P7	Ease of access to mobility (roads and infrastructure)
	P8	Comply with site selection criteria
Spatial layout	L1	Provision of spaces of safety & privacy for women & children (e.g.: breastfeeding area)
	L2	Provision of space division through partitioning of a wall (for communal circulation and activities)
	L3	Provision of space for male and female praying area
	L4	Covered living space for household activities (sleeping, dressing, washing etc.)
	L5	Provision of space for medical assistance and counselling
	L6	Comply with cultural needs and religious beliefs
Existing design	D1	Provision of inhabitable designs of structures
	D2	Climatic responsive design (ventilation and thermal comfort)
	D3	Participatory design involvement (with local people)
	D4	Vector risk identification
	D5	Fits the capacity of evacuees and duration of stay after evacuation
	D6	Comply with minimum standards of shelter design
Existing construction	C1	Good procurement and construction management
	C2	Upgrading & maintenance involvement
	C3	Allows for materials that are locally available and easily accessible
	C4	Involvement of ease and speed of construction
	C5	Comply with local building practices and construction standards

Source: Author

DISCUSSIONS

During the document reviews, most criteria that are extracted from official documents are descriptive (Bowen, 2009). Having several criteria makes

decision-making difficult. Reducing or adding the criteria and focusing on the more important ones would make the process easier (Soltani et al., 2015). The following sections conclude each design domain by giving evidence and discussion by the disaster experts.

Site planning

The site planning variables were originally gathered from past research, which identified various lists of criteria or guidelines for site selection of an evacuation centre (The Sphere Project, 2015; Soltani et al., 2015 and Melgarejo & Lakes, 2014). The site planning design characteristics certainly assemble physical planning strategies which consider the site location, size and density of the selected site or building (UNHCR, 2007 and IFRC, 2103). Four criteria for site planning were defined in the document analysis. Based on proposed comments from the validation process (Yusoff, 2019), there was some overlaps between some criteria, such as 'adaptability to local conditions' (The Sphere Project, 2015), which may have similar ideas with the variable of 'climatic responsive design' (OXFAM, 2005; IFRC, 2013; HM Government, 2014; The Sphere Project, 2015). Some others could also be considered after proposing suitable sites based on other criteria, for instance, 'restoring dignity and rights of affected families' (UNHCR, 2007). This design consideration may be included in the measures for spatial layout that distinguish privacy among the affected population (IOM & UNHCR, 2010). Four criteria were more appropriate for disaster evacuation centre and are further explained in the table below.

Table 4. Additional Site Planning (P) Variables of Shelter Design Standard Suggested by Experts through Content Validation

Code	Suggestions or comments from experts	Supporting arguments
P2	Ease of access to alternative areas of safety	Access to alternate areas of safety or refuge is just as critical as the available areas (Samah, 2018) If contingency arrangements are not available or emergencies occur unexpectedly, the centre's main objective is to obtain a fast, concise overview of the displacement situation (IOM, 2010)

P5	Provision of stockpiling warehouse	Ensure organisation of maintenance for the warehouses, efficient stock control and well-negotiated contracts (UNHCR, 2007) If suitable storage facilities do not exist, it may be necessary to use prefabricated (tent) warehouses as a temporary measure and for rapid construction (UNHCR, 2007) Stockpiling warehouse's functionality must always be maintained (UNHCR, 2007)
P7	Ease of access to mobility (roads and infrastructure)	Continued ability to be easily accessible and also easy access to roads and other infrastructure (adapted from Sphere, 2015) Optimum routes for mass evacuation outside flood areas have now been identified, and research has been carried out into active traffic management, potential congestion points and the best location to deploy support services. (HM Government, 2010)
P8	Comply to site selection criteria	Site selection is important in the physical planning of an evacuation centre (adapted from Sphere, 2015)

Source: Author

Spatial Layout

The spatial characteristics apply best to the problem statement of this research, which is the question of spatial quality. The problem of space proxemics (Lawson, 2001) in a disaster evacuation centre means that the closed physical area often loses the opportunity for interaction because victims often choose to keep some space for themselves. Privacy and the opportunity to communicate are relational terms but demand some separation. For example, UNHCR (2007) mentions maintaining a presence in areas where people are vulnerable to ensure that they are safeguarded in an emergency. Another example Lawson (2001) views Malaysia as a nation with a strong religious beliefs by giving the example of Muslims who chose to avoid proximity between people of the opposite gender. Based on proposed comments from the validation process, only one criterion was added to the list of shelter design standards and is further explained in the table below.

Table 5. Additional Spatial Layout (L) Variables of Shelter Design Standard Suggested by experts through Content Validation

Code	Suggestions or comments from experts	Supporting arguments
L3	Provision of space for male and female praying area	Concept and design measures must allow proper separation/privacy of living units and communal areas, considering cultural, religious or traditional concerns regarding the appropriateness of spaces. (IOM, 2010)

Source: Author

Existing Design

Existing buildings have to be used as active or functioning buildings, such as schools and halls (Mcallister, 2013). The design impacts on current use for a disaster evacuation centre should be considered as critical, due to the reasons of disruption of use and services (Anderson et al., 2017). The participation of every user of the buildings is important to avoid such problems. For example, in a public school, the dual use of educational facilities can cause serious protection risks among children and elderly (IOM & UNHCR, 2010). For example, the staircases in a school can cause fall hazards during evacuation (UNHCR, 2007). Apart from this, the use of passive buildings, for example, warehouses and hotels, may have low design impact from the usage of relief purpose. Building design of multipurpose usage, such as a hall, is sustained better as a disaster evacuation centre (IOM & UNHCR, 2010). Based on proposed comments from the validation process, only one criterion was considered to be added to the list of shelter design standards and is further explained in the table below.

Table 6. Additional Existing Design (D) Variables of Shelter Design Standard suggested by Experts through Content Validation

Code	Suggestions or comments from experts	Supporting arguments
D5	Fits the capacity of evacuees and duration of stay after evacuation	Special conditions like bigger capacity or a 24-hour usage of buildings may need further reviews of the building requirements and planning. (Adapted from Sphere, 2015)

Source: Author

Existing Construction

One of the major concerns in selecting buildings to serve as disaster evacuation centres is whether the facility's structure is appropriate for the task. It may not be feasible to build a new structure in an area that requires a disaster evacuation centre (FEMA, 2012). Although retrofitting these existing buildings may be expensive and often disruptive to current users of the facilities, however, this retrofitting process may be the most viable option available (Main & Mcallister, 2011). These buildings should possess the structural attributes, for example, flood-resistant structures, and should go through expert assessment when needed (FEMA P646, 2008). Due to some characteristics such as duration and type of response and recovery phases, disaster evacuation centres in Malaysia differ from other contextual conditions and disaster situations. The research findings reveal that our disaster situation requires short-term reconstruction. Therefore, the ease of getting local materials and local construction skills (The Sphere Project, 2015) are sufficient to withstand the flood. However, disaster experts suggested revisiting buildings used for the emergency purpose in flood-prone areas. Design and retrofit strategies can be proposed to achieve resilience in these buildings Main & Mcallister, 2011). Based on proposed comments from the validation process, two criteria were considered to be added to the list of shelter design standards and is further explained in the table below.

Table 7. Additional Existing Construction (C) Variables of Shelter Design Standard suggested by Experts through Content Validation

Code	Suggestions or comments from experts	Supporting arguments
C3	Allows for materials that are locally available and easily accessible	The rapid provision of shelter solutions or local materials and tools, either separately or in the form of a predefined kit, can enable the affected population to erect or construct shelters themselves. (UNHCR, 2007)
C5	Involvement of ease and speed of construction	If suitable storage facilities do not exist, it may be necessary to use prefabricated (tent) warehouses as a temporary measure. and for rapid construction. (UNHCR, 2007)

Source: Author

CONCLUSION

The research has synthesised a selected number of design standards to make it more appropriate to the context of the Asia region. However, the research has also shown that current disaster evacuation centres lack in emphasising the elements of resistance or resilience towards disaster. The integrative aspect of design standards and resilience properties became the basis of this research. The document analysis (Bowen, 2009) delivered a refined set of relevant design variables, whereas the redundant variables were eliminated during the validation process. This method has signified that the variables contained in the domains of Site Planning, Spatial Layout, Existing Design and Existing Construction (The Sphere Project, 2015) were the key variables in forming the design framework of a disaster evacuation centre.

Furthermore, disaster experts debated whether the research's integration of design measures and resilience elements made sense. The findings demonstrated that the refined design measures supported all other shelter standards and strengthened the building's resilience. Experts have suggested that implementing these measures during the early design stage would be the most appropriate time.

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The corresponding author writes the paper under the guidance of both supervisors, which are the two co-authors.

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