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A study on Mega-Shelter Layout Planning

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ABSTRACT

The objective of this research is to provide a mega-shelter planning guideline based on user's behavior by examining spatial hierarchy characteristics and conducting a spatial configuration analysis of the mega-shelters' spatial layouts. The study is performed as follows: first, mega-shelter guidelines and spatial plans prepared by the U.S. and Australian agencies are reviewed. Second, Axial analysis and VGA on two mega-shelter cases is used for analysing the spatial hierarchy. Finally, the mega-shelter planning guideline based on human behaviour is presented. Analyses of spatial hierarchy show that there are some distinct differences in the core space with integration values in the top 0-19% percentile. In the U.S. facility, logistics (at 0%) and management (at 14.3%) have the highest accessibility, whereas in the Australian facility, the community space has the highest accessibility at 5%. The fact that the logistics and management spaces are in the core space in the U.S. facility show that its spatial plan emphasizes distribution of supplies and management functions. On the other hand, the fact that the community space ranks the highest in the Australian facility shows that while this shelter is a temporary facility, its spatial plan emphasizes the community of the residents. Based on the analyses, the following conclusions are presented: in a mega-shelter design based on user behaviour, planning of the spatial hierarchy needs to ensure that the community space is given top priority. Community space such as feeding, recreation area, and childcare should be located in areas with highest accessibility. This study raised the issue that the current mega-shelter guidelines were fundamentally written from a management perspective.

KEYWORDS

Disaster, Mega shelter, Spatial behavior, Planning guideline, Space Syntax, VGA

1 INTRODUCTION

The world faces natural disasters such as typhoons, earthquakes, and floods, and social disasters such as terrorism, wars, and fires every day. To protect these refugees, mega-shelters are built. These are temporary public facility set up in large space such as schools and stadiums to assist the refugees until the disaster ends. These facilities usually operate for less than a year but contains all functions necessary for everyday life. A mini social environment emerges, one that contains residential space, meal space, community space, sanitary space (laundry room, bathrooms, showers), childcare, and other uses.

Mega-shelter guidelines issued by FEMA (Federal Emergency Management Agency) of the U.S. or agencies in Australia or Japan provide detailed information on space size, space functions, as well as operation and management procedures. But very little information is provided about the spatial behavior of the refugees, or how they use the space. A review of previous literature also revealed that while there is a large body of research about functions of mega-shelters, post-disaster psychology of the refugees, and user demands, there are very few studies on mega-shelter planning from a user's behavior perspective. In particular, the few studies that examine spatial planning of mega-shelters do not include user-centric spatial analysis methods.

Mega-shelter planning needs to not only focus on providing physical space to temporarily accommodating and managing refugees, but with a perspective that a mini social group is in operation, with a very diverse array of acts by its members. The plan needs to incorporate psychological state of the refugees and be based on spatial form under special circumstances.
In this context, the aim of this research is to propose a mega-shelter planning guideline based on user's behavior by examining the characteristics of spatial hierarchy in mega-shelter planning guidelines and conducting a spatial configuration analysis of the mega-shelters' spatial layouts.

2 THEORY

2.1 LITERATURE REVIEW

Many people who experience disaster display symptoms of PTSD. Previous research on symptoms of post-disaster PTSD report chronic tiredness, loss of interest in everyday life, anxiety, depression, and anger (Ruzek et al. 2008, Pearl S. 2005). Many studies point out community support as an important force that help the refugees return to their normal lives (Frueh et al. 2012, Armstrong et al. 2013).
The spatial cognition capability of refugees is often degraded by stress. As a result, use of shortcuts decreases, and dependence on familiar route increases (Brown et al. 2020).

The few studies that addressed spatial planning of mega-shelters include Nappi and Souza (2017), Zhang and Dong (2009), Biswas (2019), and also Choi and Kim (2017). However, there are almost no study conducted on post-disaster use of space, spatial connectivity, or focus on user-centric analysis using space syntax methodology.

2.2 Research Method

This study addresses spatial planning of mega-shelters. The study sites are two temporary mega-shelters established in large gyms. These temporary facilities were prepared based on Mega-shelter Planning Guideline (American Red Cross, 2010) and Emergency Relief Handbook (Department of Human Services, Victoria State Government, Australia, 2013). The reasons for selecting mega-shelters in the U.S. and Australia are as follows: both facilities utilize indoor gym or school ground as mega-shelter, and are exemplary cases adhering to facility design guidelines provided by public institutions.

Research steps were as follows. First, previous studies on human psychology and spatial behavior during disaster were reviewed. Second, axial maps and visibility graphs were analyzed for two mega-shelter case studies. This study analyzed spatial accessibility using Space Syntax theory and determined the hierarchy among shelter spaces such as management, residential, community, and storage. Finally, a mega-shelter planning guideline based on human behavior was presented.

3 DATASET AND METHODS

Study methods are as follows. First, the two mega-shelter guidelines were reviewed, from which the programs relevant to spatial planning were categorized into nine functions: entrance, registration, management, medical, dormitory, sanitary, feeding, community, and logistics.

Second, axial analysis and VGA were conducted for the two mega-shelters from which the global integration values were calculated from axial map and visibility graph. Spatial relationships in the shelters were analyzed from global integration values. While an axial map shows movement from one space to another in a graph format, accessibility to a space can be analyzed quantitatively through visibility graph. Visual integration is used to analyze the level of communication among the users in the shelters.

Third, the hierarchy of space is categorized into three groups - high, middle, low – depending on level of integration. The high group ranges from 0-19%; the medium group 20-59%; and the low group 60-100%. The high group is defined as space with highest integration value. This is called the *integration-core*, which values of space within the facility has a highest level of accessibility. The middle group has lower integration values, but still relatively good accessibility. The low group has lowest level of accessibility.

In the final step, a comprehensive review of two case studies is conducted to present a mega-shelter planning guideline based on user behavior.

4 RESULTS

4.1 Mega-shelter Axial Map Analysis and Visibility Graph Analysis

Mega-shelter (US)

The spatial hierarchy of this facility can be calculated as follows (Table 1). The facility with highest integration value is logistics (1.3112 at 0% percentile). The facilities in the middle integration group are as follows: sanitary space (21.5%), registration (28.6%), dormitory (35.8%). The facilities in the low integration group include mental health services (64.3%), community space for children and family (85.8%).

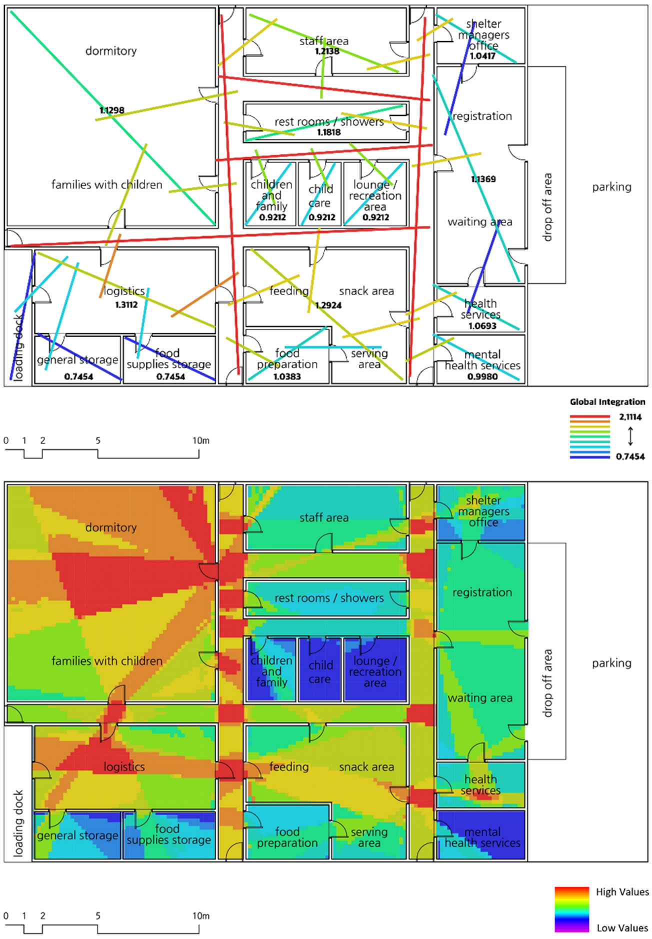

Figure 1: Axial Map Analysis (Top) & VGA (Bottom) – Mega-shelter Plan (US). Adapted from Shelter Field Guide by the Department of Homeland Security, FEMA, 2015, Washington D.C., US Press.

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Hierarchy		Function	Program	Global Integration	Ratio (%)
High	1	Logistics	Logistics	1.3112	0
	2	Feeding	Feeding, Snack area	1.2924	7.2
	3	Management	Staff Area	1.2138	14.3
Medium	4	Sanitary	Restrooms, Showers	1.1818	21.5
	5	Registration	Registration, Waiting Area	1.1369	28.6
	6	Residential	Dormitory, Families with Children	1.1298	35.8
	7	Medical	Health Services	1.0693	42.9
	8	Staffing (Management)	Shelter Manager's Office	1.0417	50
	9	Feeding	Food Preparation	1.0383	57.2
Low	10	Medical	Mental Health Services	0.9980	64.3
	11	Community	Child Care	0.9212	85.8
	12		Lounge/ Recreation Area		
	13		Children and Family		
	14	Logistics	Food Supplies Storage	0.7454	100
	15		General Storage		

Table 1: Global Integration Ranking in Mega-shelter (US)

The logistics and staff areas are located in the integration-core with the best accessibility in the entire facility. The facilities with lowest integration level are community space and storage, indicating they have the lowest level of accessibility. The feeding facility which is used by many users has high integration value, while the community facility which also attracts people has low integration value. Analysis of axial map and visibility graph indicate that all other facilities except residential space showed similar rank in spatial hierarchy. Analysis of axial map showed that residential space belonged in the medium group but showed highest integration value in the VGA. This stems from the location of residential space at the facility's periphery – while its connectivity to all other spaces is low, it has high accessibility to functions within residential space.

Mega-shelter (Australia)

As with the previous US facility, the integration values were calculated in three categories to assess spatial hierarchy. The integration core (top 0-19% percentile) included main entrance and recreation area/childcare (1.4946 at top 5% percentile). The middle integration group (20-59%) included dormitory, management, and sanitary facilities. The low integration group (60-100%) included sanitary and storage.

In this facility, spaces with highest integration values were entrance and community space(recreation area, feeding area, and general area). They have the highest level of accessibility in the integration-core. Based on the axial map and VGA, the integration values were relatively uniform in general. However, the entrance was classified as integration core in the axial analysis while it showed medium-level hierarchy in VGA. This stems from the fact that axial analysis takes connections to outside space into consideration while VGA only analyzes visibility within the mega-shelter.

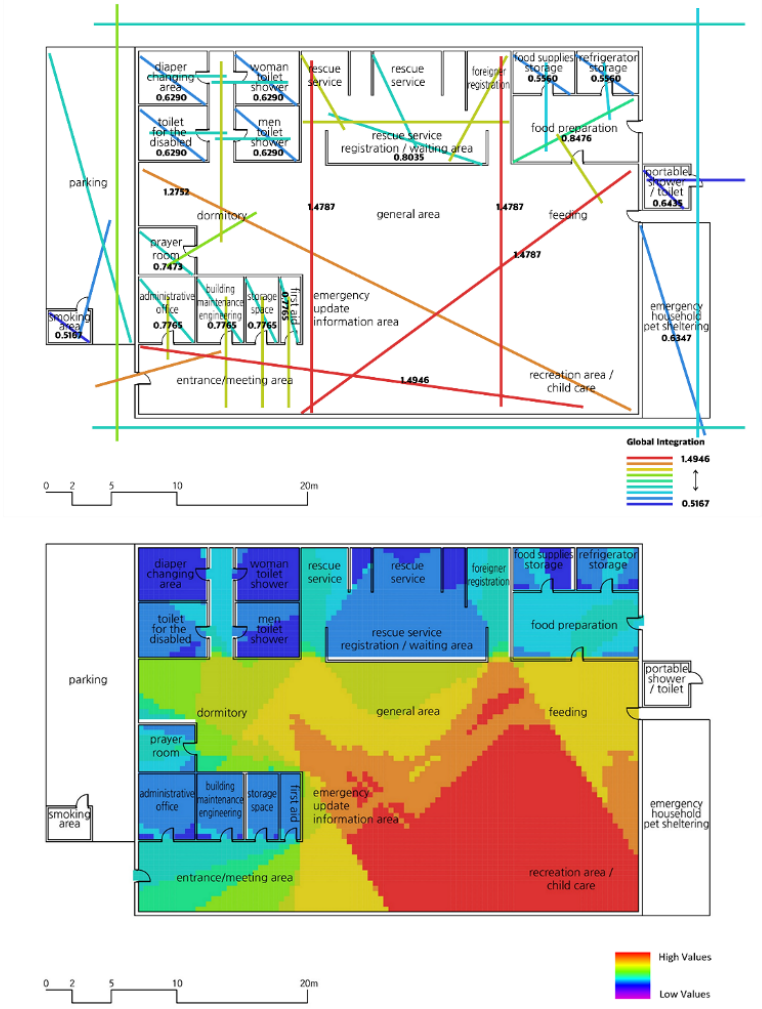

Figure 2: Axial Map Analysis (Top) & VGA (Bottom) – Mega-shelter Plan (AU). Adapted from Emergency Relief Handbook by the Department of Human Services, 2013, State Government Victoria Press.

Hierarchy		Function	Program	Global Integration	Ratio (%)
High	1	Entrance	main entrance / meeting area	1.4946	5
	2	Community	recreation area / child care	1.4946	
	3	Feeding	feeding	1.4787	10
	4	Community	general area	1.4330	15
Medium	5	Residential	dormitory	1.2752	20
	6	Feeding	food preparing	0.8476	25
	7	Registration	rescue service / registration / waiting area	0.8035	30
	8	Staffing	administrative office	0.7765	50
	9		building maintenance and engineering	0.7765	
	10		storage space	0.7765	
	11	Medical	first aid station	0.7765	
	12	Residential	prayer room	0.7473	55
Low	13	Sanitary	portable shower / toilet	0.6435	60
	14	Staffing	emergency household pet sheltering	0.6347	65
	15	Sanitary	diaper changing room	0.6290	85
	16		women toilet, shower	0.6290	
	17		men toilet, shower	0.6290	

	18		toilet for the disabled	0.6290	
	19	Feeding	food supplies storage	0.5560	95
	20		refrigerated food supplies storage	0.5560	
	21	Smoking	smoking area	0.5167	100

Table 2: Global Integration Ranking in Mega-shelter (AU)

5 CONCLUSIONS

This study conducted spatial configuration analyses for two mega-shelters using axial maps and visibility graph to calculate spatial hierarchy, with the goal of presenting a mega-shelter planning guideline based on user behaviour.

Analysis of the two floor plans show connections between functions. But analyses of spatial hierarchy show that there are some distinct differences in the core with integration core (top 0-19% percentile). In the U.S. facility, logistics (1.3312 at 0%) and management (1.2138 at 14.3%) have the highest accessibility, whereas in the Australian facility, the community space has the highest accessibility at top 5% percentile. The fact that the logistics and management spaces are in the integration-core in the U.S. facility show that its spatial plan emphasizes distribution of supplies and management functions. On the other hand, the fact that the community space(1.4946 at 5% percentile) ranks the highest in the Australian facility shows that while this shelter is a temporary facility, its spatial plan emphasizes to enhance the community of the residents.

The comparison of two cases shows that even for facilities with same purpose, spatial hierarchy can be constructed differently in the planning process, depending on which functions were emphasized. Based on the analyses, the following conclusions are presented. In a mega-shelter design based on user behaviour, planning of the spatial hierarchy needs to ensure that the community space is given top priority. To achieve this goal, community space such as feeding, recreation area, and childcare should be located in areas with highest accessibility. Second, management spaces including registration, management, and medical services also need good accessibility. This allows the users to request for help easily, and can support their community life. Third, the dormitory must be planned to have good connections and easy access to other functions. But given the importance of protecting privacy, it needs to be separated from other uses and also have visual blockage. Finally, logistics must be located adjacent to management while sanitary facility must be located adjacent to dormitory.

This study raised the issue that the current mega-shelter guidelines were fundamentally written from a management perspective. In the occurrence of a disaster, the victims live in a dense environment in a large evacuation facility. Because of the psychological shock, spatial awareness and learning ability are significantly lower than usual, so more appropriate planning is required. This study is meaningful not only academically but also practically by providing new knowledge of spatial layout criteria in shelter planning in consideration of spatial behavior in disaster situation.

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