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Accessibilty analysis of tsunami evacuation route to self supported shelter in sub-district Pasie Nan Tigo, Padang City

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Abstract. The city of Padang, the capital of West Sumatra, has 1 million populations and located on the west coast of Sumatra. The city situated at two earthquake sources that are subduction zone in the Indian Ocean and Sumatra fault inland of Sumatra. Since the year 2006, Padang city is often experiencing an earthquake from both sources. In Mentawai island, about 200 km from Padang City westward, there is still what so-called seismic gap that very potential to generate big earthquake followed by a tsunami. To anticipate this, the mitigation measurements are needed to prepare the people on the west coast of Sumatra, especially in Padang city. One of the activities is to prepare the shelter that can cover around 600,000 people prone to tsunami near the beach. The infrastructures for shelter are very limited. There are only 4 shelters that have been built that have capacity about 2000-3000 people. To anticipate this condition, it needs to build what so-called self-supported shelter. The self-supported shelter is an idea or concept of utilizing a mosque or musholla to be a shelter by participating in the community surrounding its construction and management. The shelter will have a function as the ritual of religion and the tsunami evacuation place. Mosque or musholla is selected to shelter since it does not need to buy land, available in the near residence area, and easy to get funds in its construction. There are some aspects need to be prepared in order to function a shelter well, that is, the selection of location, the evacuation system, the construction method, the accessibility, and the structural design. This paper focus on analysis of the accessibility of evacuation routes to self-supported shelter in terms of time estimation, road facilities, and barrier during evacuation. The case study is chosen as the sub-district of Pasie Nan Tigo that has about 12,000 populations. The result can be a model in designing accessibility to self-supported shelters in the other area.

1 Introduction

The capital city of West Sumatra, the city of Padang, often experiences earthquakes and has the potential of an incoming tsunami. Since 2006 until now, the city of Padang has experienced hundreds of small and large earthquakes. Tsunami Aceh in 2004 has stirred up the people in West Sumatra how the impact of a tsunami on human life. This trigger serious attention among the community, especially those who live around the coast or in areas along the sea coast. Some measurements need to be taken to reduce the impact of disasters. One of them is to prepare the shelters that can save their life in case of a tsunami coming. However, to build a shelter is not easy since it needs a lot of money. The government with a limited budget is lacking the capacity to provide the shelters to the community. Instead, it needs a breakthrough to provide shelters. One of the ideas is to optimize the mosques or musholla as shelters. It is called self-supported shelter.

There are some advantages to use a Mosque as a shelter. First, in terms of land availability, there is no need to buy land. Second, the mosque that will be used as a shelter can accommodate the surrounding communities, especially those who live only a few meters from the coastline. Third, building a shelter requires large funds, therefore, if the concept of building a shelter as building the mosque, it will be easier to get funding from the surrounding Muslim community. Although it takes a quite long time such as 7 (seven) or 8 (eight) years in the future, the construction can still be done by using step by step construction methods depending on how much donations or alms collected from residents in the mosque area.

Things that need to be considered as a reference to save residents who already have permanent residences around the coast are in terms of accessibility to Self-Supported Shelters. The effectiveness of accessibility can be seen from the estimated time to go to the shelter, both the horizontal evacuation time, as well as the estimated vertical planning time, road facilities, and obstacles that might occur during an earthquake or tsunami.

The estimated time for tsunami evacuation is assumed to be 30 minutes [1].

2 Methodology

In general, the methodology of the accessibility of tsunami evacuation routes in Pasie Nan Tigo Village,

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Padang City can explained as data collection, survey and do some data analysis.

3 Analysis and results

From the results of observational data in the field, obtained data to identify mosques. While the distribution of the locations of the 21 mosques can be seen in Figure 2. After being identified for the next cluster determination step is checking criteria. From checking the mosque criteria it produces 10 mosques that meet the criteria, which is seen from a score of > 10 points, or 10 mosques and with the highest value. The recapitulation of the mosque and values can be seen in Table 1.

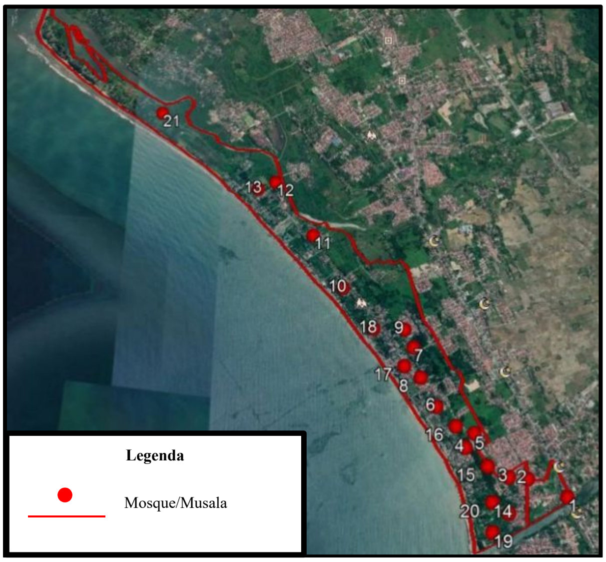

Fig. 1. Mosques and mushalla position

Table 1. Rank of Mosque recapitulation

No.	Mosque/Musalla Code	Population Distribution			Building Area > 300 m2		Area of Land > 600 m2		Distance from beach> 200 m		Accesibilty		Organization		Score Total	Rank
		Large	Medium	Small	Yes	No	Yes	No	Yes	No	High	Low	Yes	No		
		4	3	2	3	0	3	0	2	0	2	0	2	0		
1	M. Al Furqan		3		3		3		2		2		2		15	2
2	M. Nurul Falah	4				0	3		2		2		2		13	6
3	M. Baiturrahman	4				0		0	2		2		2		10	13
4	M. Darul Islah		3		3			0	2		2		2		12	8
5	M. Cahaya Rohani UMSB	4			3		3		2		2		2		16	1
6	M. Tabiyatul 'Ulum		3		3		3		2		2		2		15	2
7	Ms. Darussalam		3			0		0	2		2		2		9	15
8	M. Darul Muttaqin		3			0		0	2		2		2		9	15
9	M. Iqra'		3			0		0	2		2		2		9	15
10	Ms. Al Muqqarabin			2		0		0		0	2		2		6	21
11	Ms. Al Ikhlas Pasir Jambak		3			0	3		2		2		2		12	8
12	M. Asra			2	3		3		2		2		2		14	5
13	Ms. Ihdinasshiratol Mustaqim		3			0	3		2		2		2		12	8
14	M. Al Mannar	4				0	3		2		2		2		13	6
15	Ms. Nurul Ikhlas		3			0		0	2		2		2		9	15
16	Ms. Darul Iman		3			0		0	2			0	2		7	20
17	Ms. Nurul Ikhlas	4				0		0		1	2		2		8	19
18	Ms. Muslimin			2	3		3			1	2		2		12	8
19	Ms. As Salam			2	3		3		2			0		0	10	13
20	Ms. Al Falah		3		3		3		2		2		2		15	2
21	M. At Taubah			2		0	3		2		2		2		11	12

Furthermore, interviews were conducted with the management of the mosque for the approval to be a shelter. However, out of the 10 mosques, 4 mosques did not get management's approval. The reasons vary from the uncertain of funding, the seriousness of the program and the need meeting among stakeholders. So that only 6 (six) names of mosques have been supported by the management.

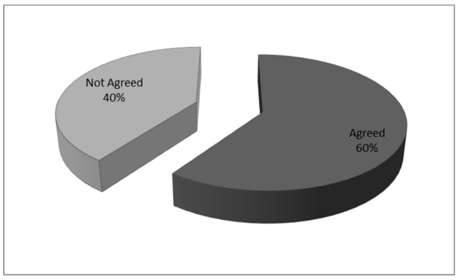

Fig. 2. Management approval

The names of the mosques are as follows.

1. Masjid Al Furqan
2. Masjid Cahaya Rohani UMSB
3. Musala Al Ikhlas
4. Masjid Asra
5. Mushala Ihdinasshiratol Mustaqim
6. Masjid Tarbiyatul 'Ulum

Base on the location of the mosque, it can be seen that there are several mosques that are located close together, such as Figure 3.

Fig. 3. Distance of the mosque and musalla

The next step is to compare the mosque based on the capacity to take each one of the two mosques. Obtained 4 mosques which will be divided into four clusters. Those are: cluster 1 is Al Furqan mosque, cluster 2 is Cahaya Rohani Mosque is UMSB, cluster 3 is Musala Al Ikhlas, and cluster 4 is Asra Mosque. The data for those four mosques/musalla are:

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1. Al Furqan Mosque (Land Size: 1345 m^2)
2. Masjid Cahaya Rohani UMSB (Land area: 3465m^2)
3. Musala Al Ikhlas (Land area: 945 m^2)
4. Asra Mosque (Land area: 1355 m^2)

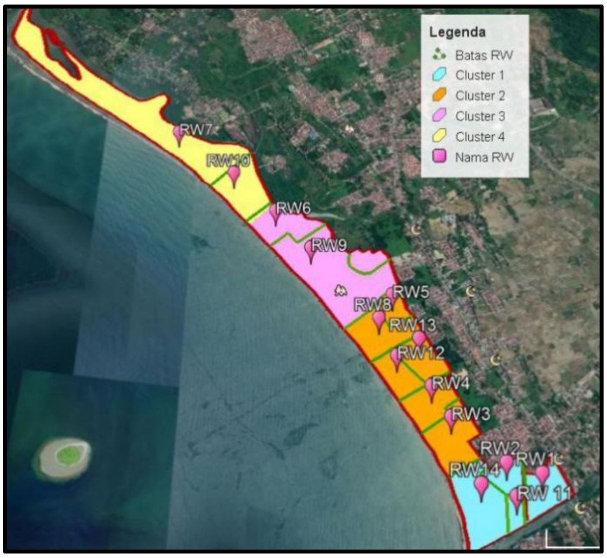

Fig. 4. Clusters position

Ten review points were determined to represent each corner of the cluster region. These points can be variants in the calculation of the estimated evacuation time for each cluster, also to find out the remaining time. The remaining time is golden time (20 minutes) [2] reduced by the estimated evacuation time.

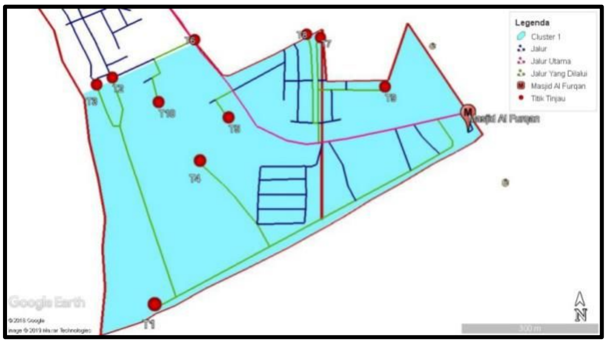

Fig. 5. Distribution of point at Custer 1

For the calculation of estimated time in cluster 1, data is needed in the form of distance from the point of view to the shelter building and the speed of human movement. The average human velocity at the time of evacuation on foot is 1,419 m/s.

From the results of the calculation of the estimated time in cluster 1, the longest evacuation time estimate is at point T2, which is 18.48 minutes. Where T2 has the farthest distance on cluster 1, it is 1573.6 m or equal to 1.576 km. This estimated time is obtained from distance (road length) divided by speed (v).

Distribution of the location of the point of view can be seen on Figure 4-7.

Fig. 6. Distribution of point at Custer 2

The calculation of the longest estimated time in cluster 2 is at the T2 review point, because at the T2 review point it has the farthest distance with the number 1679.77 m.

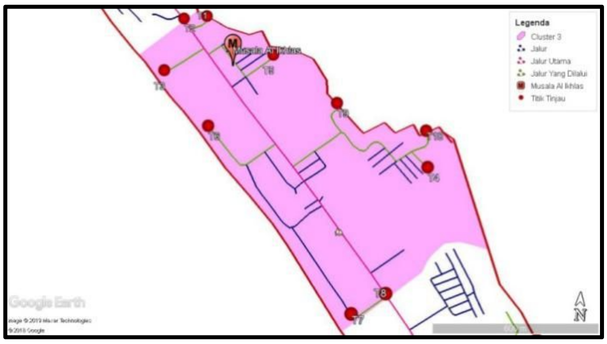

Fig. 7. Distribution of point at Custer 3

From ten points, the small estimated time is at point T5, with an estimated time is 2.70 minutes. It is due to the distance that only 229.5 m from point T5 to the shelter building, or equivalent to 0.229 km. The estimated evacuation time for other points can be seen in Table 2 below.

Table 2. The detail of shelter design

No	Cluster	Access Point	Floor	Door Distance	On foot veloci (m/s)	Evacuatio Time Estimation (Minute)	Accessibility	Design Area of t Shelter (m2)
1	Cluster I	Door A	1	47,75	0,586	1,36	High	30X28=840
			2	54,75	0,586	1,56	High	
			3	61,75	0,586	1,76	High	
			4	68,75	0,586	1,96	High	
			5	74,75	0,586	2,13	High	
		Door B	1	46,75	0,586	1,33	High	
			2	53,75	0,586	1,53	High	
			3	60,75	0,586	1,73	High	
			4	67,75	0,586	1,93	High	
			5	73,75	0,586	2,10	High	
		Door C	1	20,25	0,586	0,58	High	
			2	27,25	0,586	0,78	High	
			3	34,25	0,586	0,97	High	
			4	41,25	0,586	1,17	High	
			5	47,25	0,586	1,34	High	

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			1	63,75	0,586	1,81	High	
			2	70,75	0,586	2,01	High	
		Door A	3	77,75	0,586	2,21	High	
			4	84,75	0,586	2,41	High	
			5	90,75	0,586	2,58	High	
			1	56,25	0,586	1,60	High	
			2	63,25	0,586	1,80	High	
2	Cluster II	Door B	3	70,25	0,586	2,00	High	45X30=1350
			4	77,25	0,586	2,20	High	
			5	83,25	0,586	2,37	High	
			1	21,25	0,586	0,60	High	
			2	28,25	0,586	0,80	High	
		Door C	3	35,25	0,586	1,00	High	
			4	42,25	0,586	1,20	High	
			5	48,25	0,586	1,37	High	
			1	41,25	0,586	1,17	High	
			2	48,25	0,586	1,37	High	
		Door A	3	55,25	0,586	1,57	High	
			4	62,25	0,586	1,77	High	
			5	68,25	0,586	1,94	High	
			1	41,25	0,586	1,17	High	
			2	48,25	0,586	1,37	High	
3	Cluster III	Door B	3	55,25	0,586	1,57	High	25X25=625
			4	62,25	0,586	1,77	High	
			5	68,25	0,586	1,94	High	
			1	18,75	0,586	0,53	High	
			2	25,75	0,586	0,73	High	
		Door C	3	32,75	0,586	0,93	High	
			4	39,75	0,586	1,13	High	
			5	45,75	0,586	1,30	High	
			1	49,75	0,586	1,41	High	
		Door A	2	56,75	0,586	1,61	High	
			3	57,75	0,586	1,64	High	
			1	43,25	0,586	1,23	High	
4	Cluster IV	Door B	2	50,25	0,586	1,43	High	22X35=770
			3	51,25	0,586	1,46	High	
			1	17,25	0,586	0,49	High	
		Door C	2	24,25	0,586	0,69	High	
			3	25,25	0,586	0,72	High	

From the above table, the estimated vertical evacuation time above can be seen that the average vertical evacuation accessibility is high, where the estimated evacuation time ranges from 0.49 - 2.58 minutes.

The purpose of organizing signs [7] is as standardization of guidelines, for information on instructions, warnings, and prohibitions as an increase in community awareness of disaster risk in disaster-prone areas. But in the Pasie Nan Tigo area of Padang city, road facilities for evacuation routes such as signs and disaster boards can be said to be minimal. Because there are only evacuation signs at some point. There are also no street lights in the Pasie Nan Tigo district. Even though the installation of street lights is also needed to anticipate disaster risk in the event of a disaster at night.

At the time of observation, data was obtained that in Pasie Nan Tigo village, Padang city had 2 bridges, the first of which was a 62 m bridge with a width of 8 meters, which was located between the boundary area of cluster 3 and the boundary area of cluster 4.

Secondly, the bridge is 35 m long with a width of 7.5 m which is located between the boundary of cluster 4 and the sub-district boundary. If a large earthquake occurs and the worst condition is that the bridge collapses, then access to evacuation is interrupted. The first bridge that collapsed separates cluster 3 and cluster 4. And the second bridge separates cluster 4 with other sub-district boundaries. In cluster 4 there is no other access except for the 2 bridges. However, due to the existence of Self-Supported Shelter planning in the sub-district, the interrupted road did not affect the residents' evacuation. The location of the two bridges can be seen in Figure 8.

Fig. 8. The position of brige in District Pasie Nan Tigo

From Figure 8 it can be proven that cluster 4 has no other access when the two bridges collapse. However, even if the bridge collapses, this does not affect the evacuation of the population because cluster 4 is planned to have its shelter building.

4 Conclusions

From the results of research conducted in the village of Pasie Nan Tigo, Padang, the following conclusions are obtained:

1. Estimated time in cluster 1 is 18.48 minutes, cluster 2 is 19.73 minutes, cluster 3 is 15.27 minutes, and cluster 4 is 29.415 minutes. Where the lowest accessibility is in cluster 4, it has the longest estimation time which is affected by distance and speed of movement.

2. Road facilities in the village of Pasie Nan Tigo are very minimal so that it can affect the accessibility process at the time of evacuation.

3. The worst obstacle in the form of a collapsed bridge does not affect accessibility in the evacuation process, because each cluster is planned to have a Self-Supported Shelter building in the Pasie Nan Tigo sub-district area.

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