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# Accessibility Analysis of Potential Vertical Evacuation Site (PVES) from Tsunami of West Sumatra Governor's Office Escape Building in Padang.

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**Abstract.** Potential Vertical Evacuation Site (PVES) from tsunamis, namely as shelter, is an alternative evacuation solution for the coastal communities in Padang City to people from tsunami despite off to using horizontal evacuation routes. PVES building as evacuation shelter is not identified yet as a proper shelter regarding as structural, management and social impact for safety and it needs recommendation and technical data for better routes and evacuation. The accessibility of PVES's does not technically measure from the community who will evacuate to it. They just acclaimed as shelter just designed resistant from the earthquake and the location just based on the Tsunami Evacuation Map in 2011 and Stanford University research evaluation for vertical evacuation buildings. The adequacy of evacuation routes to PVES need to be confirmed and have a prior recommendation for surround community how to get there safely. Based on traffic Google Map data create a real-time simulation for people act with their activity and it will project the how they reaction if they need to evacuation to PVES promptly. This study will obtain level of travel time vulnerability, capacity and evacuation ratio for West Sumatra Governors Escape Building as a first building had been built as PVES in Padang City, West Sumatra.

## 1. Introduction

Padang as the the most populous population in the province of West Sumatra is known as one of the cities that has predicted as the highest risk of tsunami impact in the world. The city of Padang has two tsunami vulnerabilities namely its proximity to the Sunda fault and in particular the high level of vulnerability in this place [1]. In 2004, the Indian Ocean destroyed northern Sumatra and specifically the northernmost city, Banda Aceh. Padang faced a similar danger to the fault that caused the 2004 Tsunami. Tsunamis will change their geographical shape [2]. Padang had four times the population of Aceh before the tsunami. PVES as an alternative solution will give significant impact for people evacuation fro tsunami. It will change the paradigm and utilize Padang's people evacuation behavior during emergency response. Many tremors is generate people evacuate massively to inland but it is not effective beacuse traffic jam and bottle neck in intersection will increase remaining time for evacuation horizontally [3]. Lack of routes as main factor cause this problem and drive vehicle during evacuation. PVES have been built in Padang to counter this problem but it is not give big contribution to community [4]. This reasearch will seek the condition on the acessibiltyof it. So, the scope of this research is



- a. Number of Potential Vertical Evacuation Sites (PVES) that have been built in the city of Padang
- b. The VES building is still potential in nature, yet a comprehensive study of the feasibility of access, function and strength of the structure has not been conducted
- c. Many of these VES's are overlapped by not thinking about the optimum capacity to evacuate to tsunamis.
- d. Utilization of real time traffic data technology by using Google Map on the traffic lane in Padang City and the path to potential VES.
- e. There is no clear path and travel time for evacuation to nearby VES.

The basic contribution of this research is that it is part of a series of road maps of research on the Vertical Evacuation Infrastructure from Tsunami [5]. The results are expected to be able to assess and justify the role of potential buildings as vertical evacuation sites in Padang, both for the ratio of evacuation contributions to tsunamis, access, capacity and feasibility of the evacuation buildings themselves. This will synchronize with schemes related to disaster management technology and management.

## 2. Methodology

This research is a part of research road maps on Vertical Evacuation of Tsunamis. Previous studies have reviewed preliminary evacuation studies for tsunamis which have resulted in several existing buildings that can be used as evacuation sites. To measure how feasible, the evacuation route is, it is necessary to conduct a parametric study of this evacuation which then decides whether the evacuation infrastructure development uses horizontal or vertical lines. Vertical evacuation options that can be used can be in the form of TEREPA (Tsunami Evacuation Raised Earth Park) in the form of artificial hills, then Evacuation Buildings (Escape Building) or better known as shelters and POBET (Pedestrian Overpasses Bridge for Evacuation from Tsunami), namely by utilizing pedestrian crossings in such a way. By designing concepts that adapt to the abilities and needs of the community and proceed into the detailed planning stages of construction and budgeting.

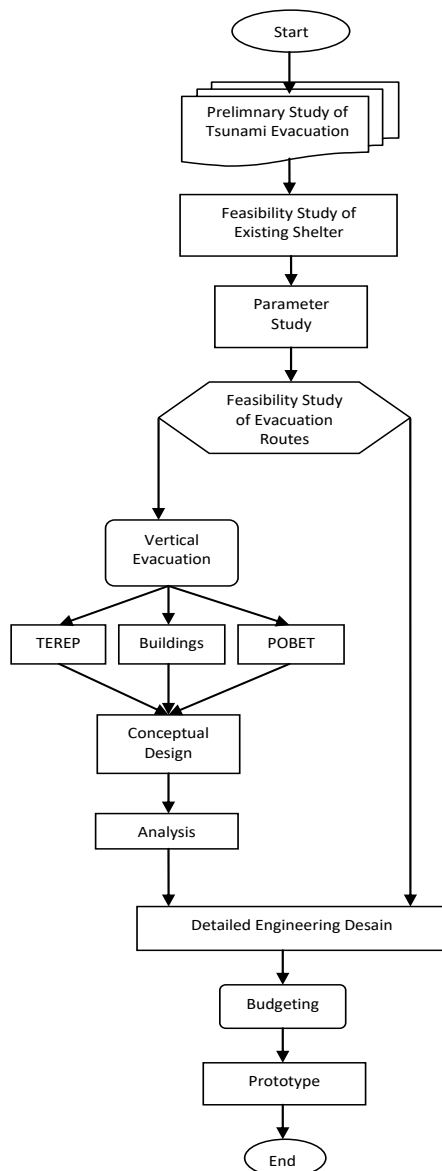
The proposed research stage is still in the stages of the parametric study of the study of evacuation sites in the city of Padang. Two types of evacuations, namely horizontal and vertical in the city of Padang, need to be assessed for the vulnerability and effectiveness and safety of their use. Vertical Evacuation of Tsunamis is an effective and safe alternative for communities where horizontal evacuation routes are not sufficient to evacuate to a place higher than sea level. To measure the effectiveness and safety of potential vertical evacuation sites (VES) in Padang, a feasibility analysis of the accessibility needs of potential vertical evacuations in Padang City, West Sumatra is needed. The research method for analyzing the accessibility of potential vertical evacuation sites for tsunamis is,

- a. Conduct a feasibility study of all VESs in Padang based on function, ergonomics and building accessibility.
- b. Sampling community data around the PVES environment to prepare community movement patterns.
- c. Record data of Padang City real time traffic conditions using Google map data traffic.
- d. Overlaying the feasibility of evacuation site data, community movement patterns and traffic data.
- e. Conduct analysis, capacity, evacuation routes and evacuation scenarios of VES in Padang City

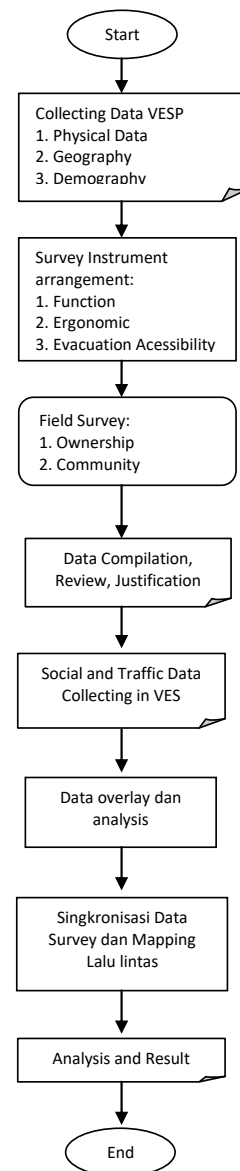
In this study is an analysis of potential vertical evacuation sites in the city of Padang. The sub districts covered by the study area that have vulnerability to tsunami evacuation [5] are seven districts out of 11 in Padang, including:

- a. Kecamatan Koto Tengah
- b. Kecamatan Nanggalo
- c. Kecamatan Padang Utara
- d. Kecamatan Padang Barat
- e. Kecamatan Padang Selatan
- f. Kecamatan Lubuk Begalung
- g. Kecamatan Bungus Teluk Kabung

In the northern region is an area that has a fairly flat topography and has not enough buildings. In contrast to the city center which has many tall buildings and evacuation center and in the southern area already has a hill as a place to evacuate naturally from tsunamis. The study area has a population density of 127 inhabitants / km<sup>2</sup> to 34072 inhabitants / km<sup>2</sup> with a population impacting tsunami hazard 345906 inhabitants out of 927,168 inhabitants of the entire city of Padang or about 37% of the population will have an impact on the tsunami hazard as shown in the following table



**Figure 1.** Reasearch Road Map of Vertical Evacuation



**Figure 2.** VES Accessibilty research flow diagram

**Table 1.** Potential Vertical Evacuation Site (PVES) in Padang

No.	PVES	Address	Distance from shoreline (meter)	Capacity (peoples)
1.	Escape Building Ktr. Gubernur	Jl. Jend. Sudirman No.51 Padang	600	3500
2.	Mesjid Raya Sumbar	Jl. Khatib Sulaiman	750	4000
3.	Pasar Inpres	Jl. M.Yamin, Pasar Raya	500	3750
4.	SMPN 4 Padang	Jl. Pulau Karam No.82 Padang	700	1200
5.	SMPN 25 Padang	Jl. Beringin, Belanti Timur,	800	2300
6.	Sekolah Al Azhar 32 Padang	Jl. Khatib Sulaiman	750	1000
			Total	30.550

Source: Mercy Corp Indonesia (NGO-2014)

Vertical evacuation is a function to save themselves in higher area [6]. It is not only hills (natural shelters) or multi-story buildings. Because of the study area, there are no hilly or very sloping areas then the choice is to use several buildings that have more than three story's floors or use the existing multi-story building as a vertical evacuation building. In order to reach a safe area to evacuate, the speed of people evacuating is a key factor before the tsunami comes. The Japan Institute for Fire Safety and Disaster Preparedness (1987) [7] provides an explanation that the running conditions and average walking speed in disaster evacuations are shown in the table

**Table 2.** Average Evacuation for Walking

Walking Condition	Average Velocity (m/s)
Accompanying Baby	1.07
Accompanying Children	1.02
Single Resident	0.948
Amount of Resident	0.751

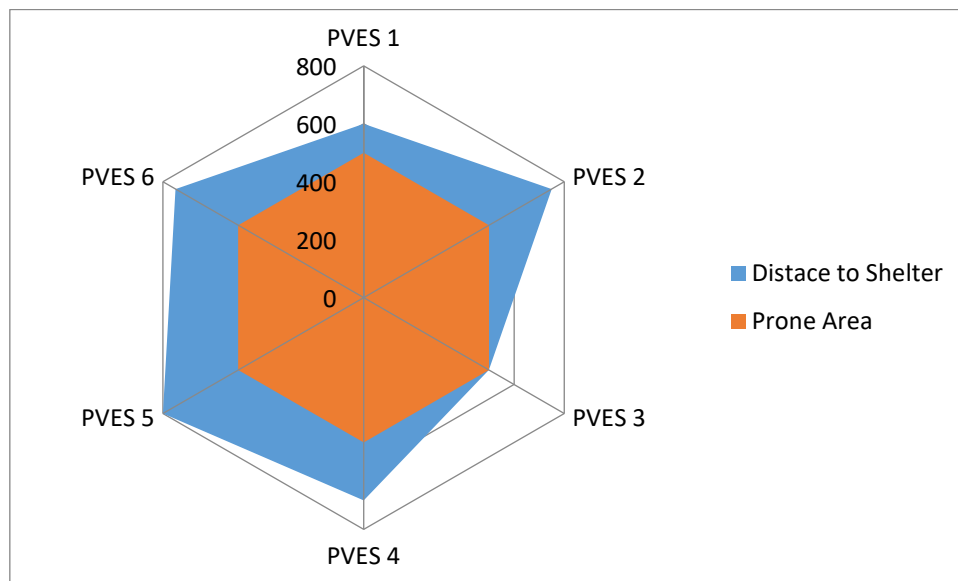
Source: Institute for fire and average and Disaster Preparedness, 1987

To analyze the distance of refugees in this study area, use the lowest value from the table above, which has a speed of 0.751 m / s. According to Sing et al, 2010, the tsunami in the city of Padang came within 20-30 minutes and also in refugees could evacuate for 10 minutes. Then, there are three long groups of time to evacuate, 10 minutes, 20 minutes, and 30 minutes or 600 seconds, 1200 seconds, and 1800 seconds. If the speed of this group is multiplied by the refugee walking speed of 0.751 m / s, the distance of each group is 450 meters, 900 meters and 1350 meters.

### 3. Result and Discussion

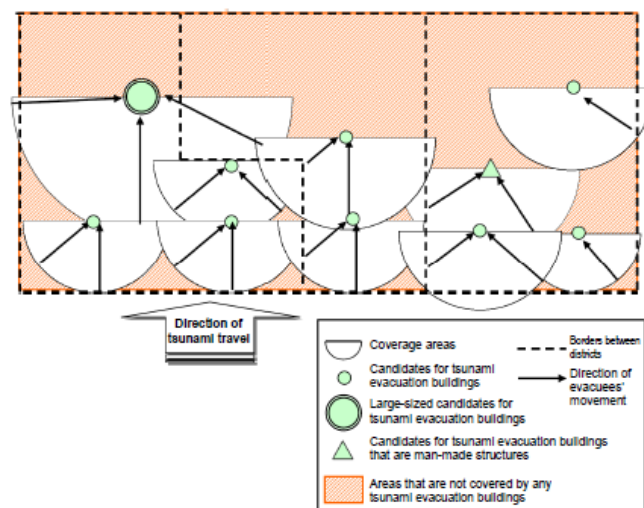
Potential Vertical Evacuation Site (PVES) is effectively accommodating the evacuees if the site is more than 500 meter far from the shore line. It prevents uncertainty impact of tsunami effect like debris, overtopping of the waves and gigantic first wave of tsunami. Based on the simple calculation based on the distance on the Google map, It shows PVES 3 (Pasar Inpres, Pasar Raya Padang) is the closest PVES from the shore line and PVES 5 (SMP 25 Padang) as the the farthest site from the shorelines. Figure 1 shows the condition of designated PVES distance from the shorelines.

Estimate the range allowing the Capacity [8], which has a population equivalent to the number of people who will be accommodated, as calculated the distance allowing accommodation (L2) (semicircle). Capacity of governor escape building is about 3500 people will accommodate 6573 people/km<sup>2</sup> [9] in Padang Barat District. Based on the calculation, it will have the effective radius PVES 1 is about 0.81 km or 81 meter

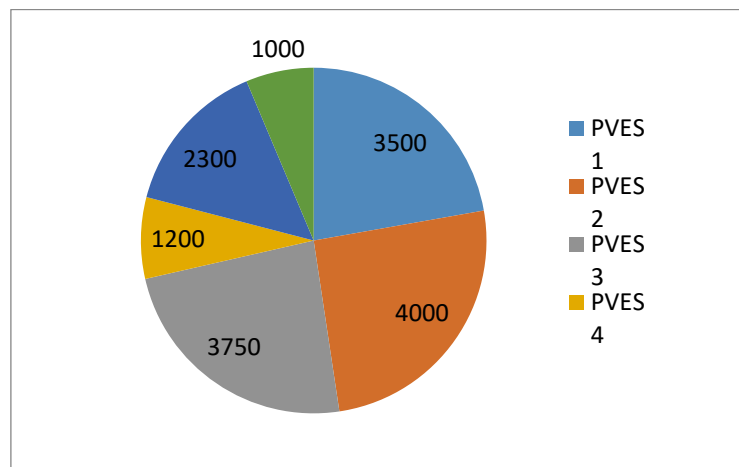


**Figure 3.** Distance PVES in Padang from the Shorelines

$$\begin{aligned}
 L2 &= \sqrt{\frac{Capacity(person)/Population\_Density}{3.14}} \times 4 \\
 &= \sqrt{\frac{3500/6573}{3.14}} \times 4 \\
 &= 0.81km
 \end{aligned}$$

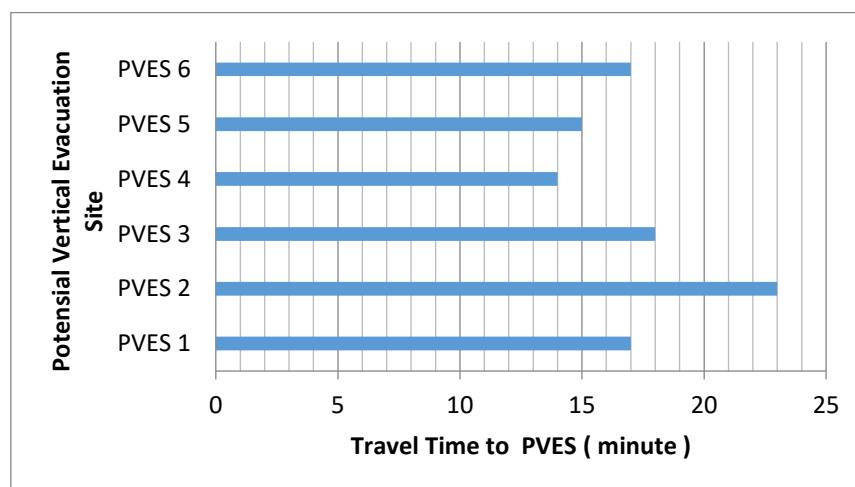


**Figure 4** Image of the selection of candidates for tsunami evacuation buildings



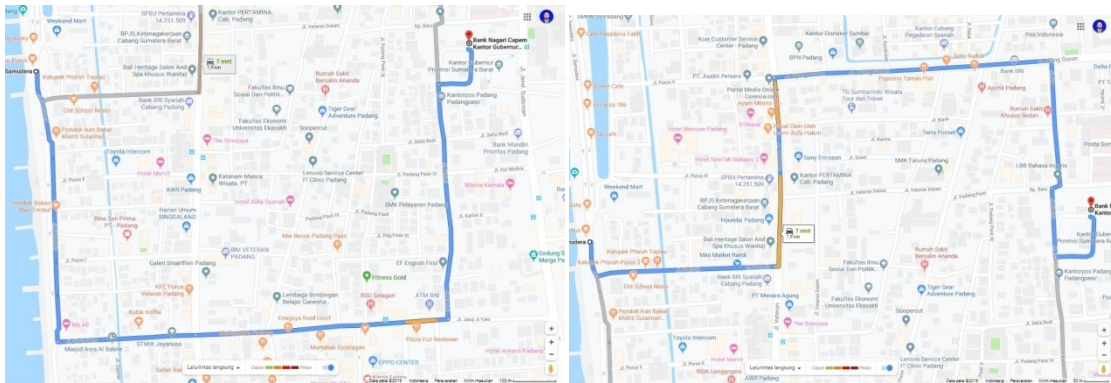
**Figure 5** PVES Capacity in person in Padang

Based on figure 5, PVES in Padang have an approximate travel time 15 minute to evacuate by walking the shortest route have been chosen based on the Google Map Traffic to the site. Generally, PVES2 (SMP 25 Padang) have the longest travel time to reach the site. It is longer than remaining time tsunami reach to the shoreline of Padang. It will not cover any evacuees from the shoreline able to reach the site. Otherwise, PVES 4 (SMPN 4 Padang) has the shortest travel time for the people who can reach the site immediately.



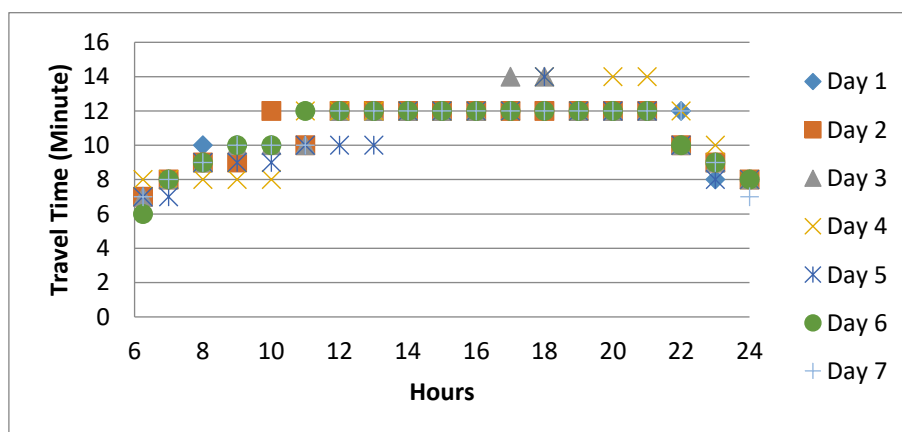
**Figure 6.** Travel Time Evacuation by walking to PVES in Padang

This paper will explain especially about the analysis of the evacuation route to PVES 1 (Governor's Office Escape Building) who has distance from the shoreline about 600 meters far with 3500 people capacity in the site. Based on this fact, it needs to be investigating how effective the accessibility people near by the shelter can reach the site promptly and safely to PVES 1. PVES 1 have two evacuation routes from the shoreline to the site. The Routes 1 is started from Samudra Street and continues to Ahmad Yani Street. It has 2.3 kilometers far from the shoreline and the Route 2 passes Ujung Gurun Street and it has 1.9 kilometers far from the shorelines.



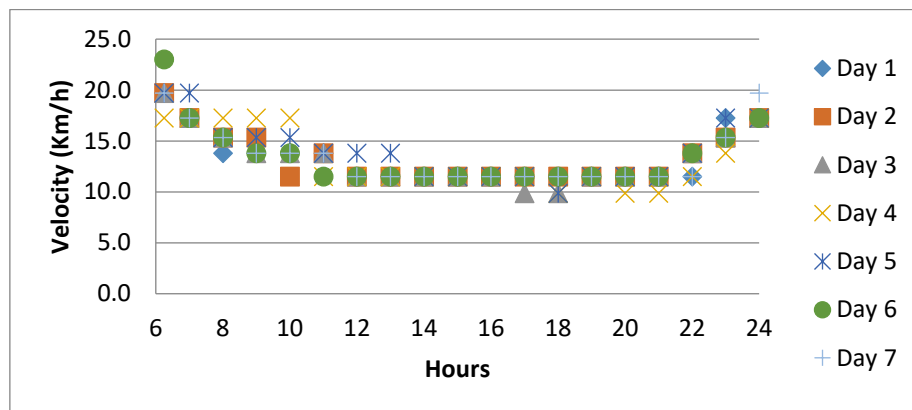
**Figure 7.** Route 1 and 2 for Evacuation to PVES 1

Based on analysis and data from 12 hours in 7 days it will take analysis on travel time, velocity and capacity ratio of traffic. Travel time for evacuation to PVES 1 in between 6 until 14 minute. It is still in the remaining time from tsunami arrival time to reach the shoreline of Padang. It has increasing the travel time as linear from 06.00 am until 14.00 pm but in the afternoon travel time for the people it takes 12 minute or more. Then in 21.00 am travel time the people will decreasing into normal around 8 minute for travel. Then, if we analyze based on the velocity for evacuation Route 1 may have decreasing velocity gradually start from 06.00 am until 10.00 am in the morning but have same velocity in between of 10.00 am until 22.00 pm with velocity is around 10 km/h to 12 km/h. Regarding to traffic capacity, Route 1 have the same flow for any day based on the research in 7 days. It has same condition in every day with the maximum capacity is around 17.00 pm until 21.00 pm with traffic capacity ratio around 0.6 to 0.4.

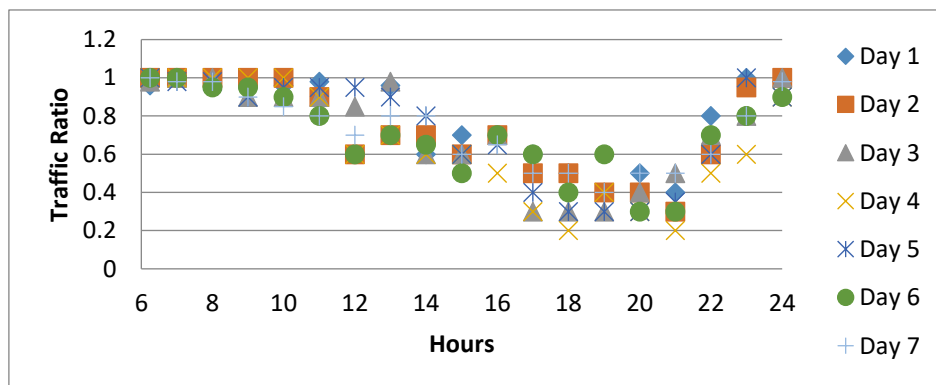


**Figure 8.** Route 1 Travel Time to PVES 1

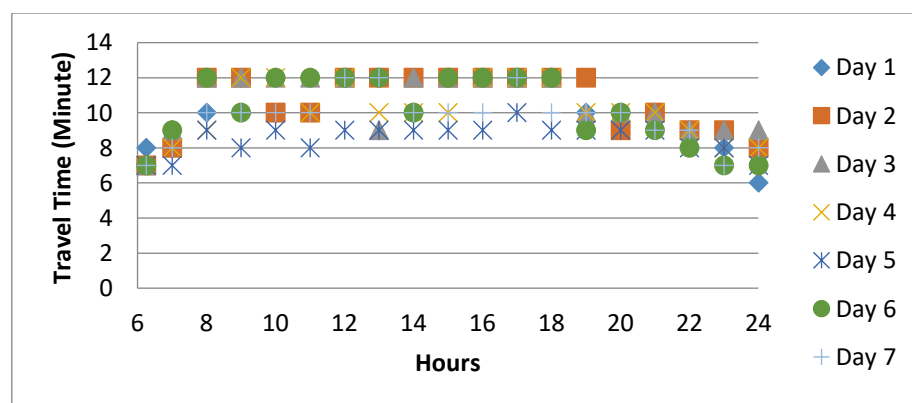




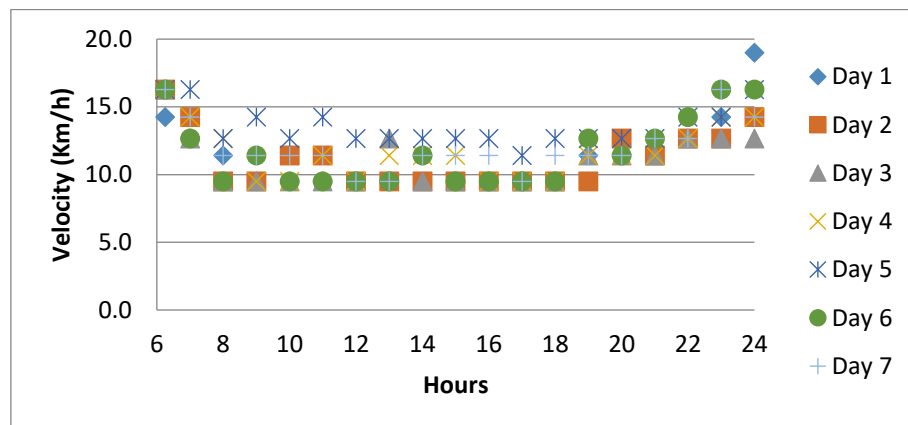
**Figure 9.** Route 1 Evacuation Velocity to PVES 1



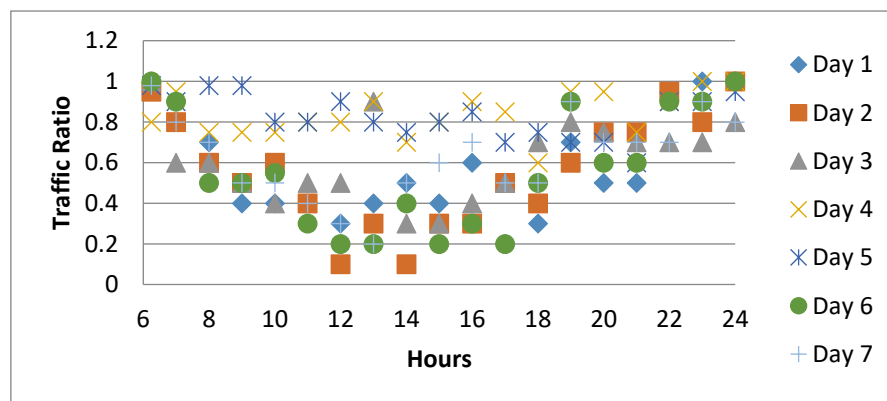
**Figure 10.** Route 1 Traffic Capacity Ratio to PVES 1



**Figure 11.** Route 2 Travel Time to PVES 1



**Figure 12.** Route 2 Velocity Evacuation to PVES 1



**Figure 13.** Route 2 Traffic Ratio

Based on analysis and data from 12 hours in 7 days it will take analysis on travel time, velocity and capacity ratio of traffic. Travel time for evacuation route 1 to PVES 2 in between 6 until 12 minute. It is still in the remaining time from tsunami arrival time to reach the shoreline of Padang. It has increasing the travel time as linear from 06.00 am until 08.00 pm but in the afternoon travel time for the people it takes less than 12 minute. Then in 19.00 am travel time the people will decreasing into normal around 6 minute for travel. Then, if we analyze based on the velocity for evacuation route 2 may have decreasing velocity gradually start from 06.00 am until 08.00 am in the morning but have same velocity in between of 08.00 am until 20.00 pm with velocity is around 10 km/h to 12 km/h. Regarding to traffic capacity, Route 1 have the discreet flow for any day based on the research in 7 days. It has same condition in every day with the maximum capacity is around 17.00 pm until 21.00 pm with traffic capacity ratio around 1 to 0.2. It means, there is a lot uncertainty traffic condition for evacuation in this route.

#### 4. Conclusion

This analysis is a one of accessibility analysis that has been doing for PVES in Padang, West Sumatra. It presents how analysis works for the eligibility of route for evacuation to designated PVES. Governor's Escape Building is one of the representative first escape buildings that have been built in Padang. It will give a lot contribution to the community surrounding. Base on the research (Syukri A. , 2018), PVES 1 is only able to accommodate 25% of the people who will evacuate from tsunami. So, analysis intervention to seek the ability of route can evacuate people safely should be determined. Route 1 base on the travel time to evacuation takes longer than Route 2 but and also in velocity but in traffic capacity ratio Route 1 is more adequate and safe for evacuation to PVES 1.

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