Pavement analysis for road construction on expansive soil at Merauke District

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Abstract. Development in Merauke District for the last five years run in various fields such as education, government, health, trade, and housing. This development requires good infrastructure to support related activities. One development activity that becomes the focus of Merauke District government today is the construction of Regional General Hospital which is located at Veteran Street, Nggolar Village of Merauke District. Soil sub grade in Veteran Street is clay that easily occurs due to deformation caused by passing vehicle.
This research collected soil sub grade characteristic, number of vehicles, California Bearing Ratio, and traffic growth in Merauke District. Vehicle data collection through direct measurement at research location, sub-grade characteristic, and California Bearing Ratio data using Dynamic Cone Penetrometer tool, piknometer and hot plate. An analysis was performed using Pavement Design Manual 2013. The result obtained was a plastic limit of 34,72%, liquid limit of 55,8%, plasticity index of 21,07%. The potential for shrinkage is hight based on the plasticity index value, known as expansive soil. Pavement using flexible pavement with surface course composition of AC-WC as thick as 40mm and AC-BC as thick as 60mm, LPA course thickness of 40cm thus the total thickness of pavement in Veteran Road is 500mm.

1. Introduction

Roads are one of the infrastructures in Merauke District that supports the smooth flow of transportation. The development in Merauke District in various fields is immediately proportional to the movement of the people. Increased community movement needs to be supported by adequate transportation infrastructure. Road conditions will provide comfort for road users.

One part of the administrative area of Merauke District is Nggolar Village, the location of Regional General Hospital development. In order to support the development of this hospital, it is necessary to build a hardened road infrastructure. The condition of Veteran street is still a soft muddy road. Thus it is necessary to have planning and construction of road pavement in the area.

2. Methods

The research location is at Veteran Street, Merauke District to find out sub-grade condition and pavement suitable for use. Figure 1 shows the location of the measurement. The survey consisted of five stages; (1) Soil characteristic through laboratory testing to obtain water content, soil type, plastic limit, liquid limit, plasticity index, granular test result. (2) California Bearing Ratio using Dynamic Penetration Cone tool. Determination of CBR data retrieval point is done zigzag with a distance between point 50m. The data is processed to obtain the selected CBR at 90% percentage. (3) The dimension of the road by measuring the length and width of the planned road segment. (4) The number of vehicles through direct measurement of light and heavy ones passing through the observation location. Measurements took seven days from 06.00 to 18.00 local time. (5) Vehicle traffic growth in Merauke District was obtained from the Merauke

District Office of SAMSAT [5]. Planning of road pavement using Road Pavement Design Manual 2013[2].

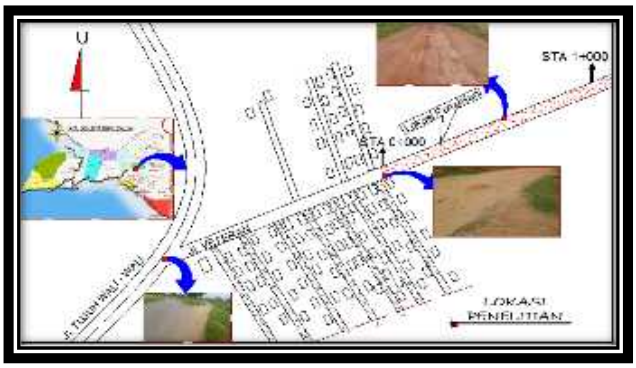

Figure 1. Research site in Veteran Road

2.1. Measurement of soil characteristic and California bearing ratio (CBR)

Soil type was assessed using piknometer and hot plate. The specific gravity of the test result was 2,68. The specific gravity of soil was included in inorganic clay type which ranged from 2,68 to 2,75. The result of water content test was 47,08%. Based on Atterberg boundary testing at 25th blow was obtained a liquid limit 55,80%, plastic limit 34,72%, plasticity index 21,07% [7], standard grain test using a standard sieve obtained 94,5% pass filter 200 [8, 9].

2.2. Measurement of vehicle and traffic growth

The number of Merauke Regency vehicles from 2012 to 2016 obtained from the Merauke District Office of SAMSAT [5] as well as the results of vehicle measurements on the types of light vehicles and heavy vehicles on Veteran Road for 2017 [6] presented in table 1.

Table 1. Number of vehicles

Vehicle Type	Number of vehicles					ADT (vehicle/day)
	2012	2013	2014	2015	2016	2017
Light vehicle 2t	53668	62642	70799	78000	85684	21
Heavy vehicle 8t	1299	1447	1568	1638	1740	5
Heavy vehicle 10t	126	180	245	259	267	13
Total	55093	64269	72612	79897	87691	39

3. Results

3.1. Sub-grade analysis

The specific gravity of the test result is 2,68. The specific gravity of soil was included in inorganic clay type, plastic limit 34,72%, liquid limit 55,80%. The plasticity index is obtained from the difference between the liquid and plastic limit to obtain a Plasticity Index (PI) of 21.07% [12]. Standard grain test using a standard sieve obtained 94,5% pass filter 200. According to AASHTO [1], this subgrade belongs to type A-7-5 type of clay soil where plasticity index > 11. The plasticity index value of 20% -55% falls into the high category. Soil with clay content and high potential for shrinkage is called expansionary soil in the study area is included in the expansive type of soil category [11]. In principle, the handling of road construction on expansive soil is to keep the water content change not too high or by changing the nature of expansive clay so as not expansive. The method of handling completed on Veteran Road is a method of replacing expansive soil material with non-expansive soil to avoid causing shrinkage problems under pavement, stockpiling and compacting structures. Material replacement method was a measure so that fluctuations in water content will occur around replacement ground thickness [2]. Stockpiling done as high as 40cm then compressed with the aim that soil particles close together so that the air cavity becomes smaller. Subgrade used in pavement design on Veteran Street is the replaced solid ground base so that the California bearing ratio used is derived from the compacted soil. The CBR value obtained from the Dynamic Cone Penetrometer test results on 90% cumulative percentage of 8.82% [6] (Figure 2).

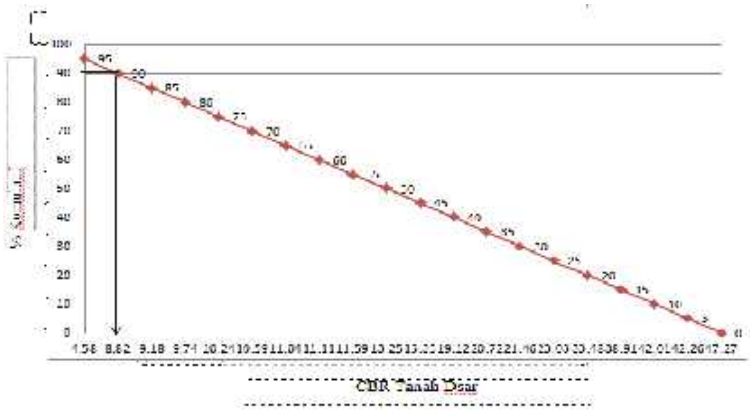

Figure 2. Graph of subgrade and cumulative percentage of CBR

3.2. Traffic analysis

Veteran Road Length 1km with a width of 4m lane consisting of 2 lanes and two directions. The lane distribution factor for commercial vehicles (trucks or buses) is determined by the number of lanes in each direction so that the lane distribution factor for Veteran Road is 100%. From the data of vehicle traffic growth for five years obtained traffic growth rate 9,742% per year. Age of pavement plan 20 years. Traffic Multiplier (TM) for over loading conditions in Indonesia ranges from 1.8 to 2 [2]. In this research used Traffic Multiplier 1.8. Traffic Multiplier is used to correct ESA4 due to asphalt layer fatigue. Table 2 shows the axle equivalent number for each vehicle of measurement results, while table 3 shows Cumulative Equivalent Single Axle Load (CESA) for each vehicle type.

Table 2. Equivalent Number

Vehicle Type	Equivalent Number (E)		
	Front axis	Rear axis	Total
Light vehicle 2t	0.0002	0.0002	0.0004
Heavy vehicle 8t	0.0183	0.1410	0.1539
Heavy vehicle 10t	0.0380	0.4169	0.4549

Table 3. Cumulative Equivalent Single Axle Load (CESA)

Vehicle Type	Average Daily Traffic	Equivalent Number	Lane Distribution	CESA
Light vehicle 2t	21	0.0004	100%	0.0084
Heavy vehicle 8t	5	0.1539	100%	0.7965
Heavy vehicle 10t	13	0.4549	100%	5.9137
		Total		6.7186

The traffic growth factor for the 20-year pavement age is 55.62. Cumulative Equivalent Single Axle Load ($CESA_4$) = 6.7186 x 365 x 55.62 = 136.405,18 and Cumulative Equivalent Single Axle Load ($CESA_5$) = 1.8 x 136.405,18 = 245.529,33. Veteran Road is a local road in urban areas so that it refers to the Road Pavement Design Manual is 80% reliability value.

3.3. Pavement design

The determination of the design procedure used is based on the minimum path foundation design solution [2] shown in table 4.

Table 4. Minimum Road Foundation Design Solution

CBR Subgrade	Subgrade Strength Class	Base Design Procedur	Description of Road Structure	Lane Traffic Design (million $CESA_5$)		
				<2	2 - 4	> 4
≥ 6	SG6	A	Subgrade improvements include lime stabilization or heap stabilization materials (layered compaction ≤ 200mm thick)	No need to upgrade		
5	SG5					100
4	SG4			100	150	200
3	SG3			150	200	300
2,5	SG2,5			175	250	350
Expansive soil (potential swell > 5%)		AE		400	500	600
Flexible pavement on soft soil	SG1 alluvial	B	capping layer or layer of geogrid	1000 dan 650	1100 dan 750	1200 dan 850
Peat with HRS or Burda for a small road		D	Granular subbase	1000	1250	1500

Sub-grade at the site is expansive soil with shrinkage> 5% repaired using expansive soil material replacement then dumped and compacted so that CBR value 8.82% and $CESA_5$ < 2 million then the foundation design procedure used is procedure A. The pavement thickness is designed based on the Cumulative Equivalent Single Axle Load (CESA5) value using alternate design chart 3A in table 5.

Tabel 5. Flexible Pavement Design with Granular Base

	Pavement Structure								
Solution	FF1	FF2	FF3	FF4	FF5 See note 3	FF6	FF7 See note 3	FF8	FF9
Repetition load axis design 20 years (rank 5) ($10^6 CESA_5$)	1 to 2	2 to 4	4 to 7	7 to10	10 to 20	20 to 30	30 to 50	50 to 100	100 to 200
Layer paved thickness (mm)									
AC WC	40	40	40	40	40	40	40	40	40
AC BC	60	60	60	60	60	60	60	60	60
AC-Base	0	70	80	105	145	160	180	210	245
LPA	400	300	300	300	300	300	300	300	300

Using table 5 obtained surface course thickness AC-WC 40mm, AC-BC 40mm, AC-base 0, 400mm base course The pavement structure design is illustrated in figure 3.

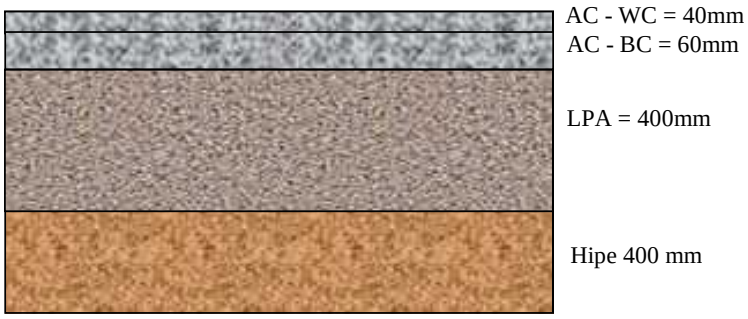

Figure 3. Design of veteran pavement structure

4. Conclusion

The thickness of pavement of Veteran Road equal to 500mm with details of thickness of surface course AC-WC 40mm and AC-BC 60mm, base course 40 cm.

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