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PAVEMENT DESIGN COMPARATIVE ANALYSIS USING BINA MARGA DESIGN METHOD (Pt T-01-2002-B) AND PAVEMENT DESIGN MANUAL (NO.04/SE/Db/2017) (CASE STUDY: TRISAKTI PORT - LIANG ANGGANG)

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ABSTRACT

Traffic load repetition is the main variable in flexible pavement layers design. In addition, a soil bearing capacity factor is also required for determining the thickness of the flexible pavement layer so that the pavement had been designed will be in good perfomance during the that period. The determination of thickness layers using the 2002 method (Pt T-01-2002 B) is based on the traffic load during the design period and subgrade resilient modulus value. Meanwhile the 2017 method (Pavement design manual No. 04/SE/Db/2017), layers thickness was determined based on traffic load and CBR subgrade value. Based on the calculation using both methods, the pavement layers thickness with the pavement design manual 2017 method is more thick than 2002 method. While the ESAL calculation using both methods, the 2002 method value is more larger than the pavement design manual 2017 method.

Keywords: ***ESAL, Thickness layers, 2002 method, 2017 method***

1. INTRODUCTION

Port access roads have provided an important part of the movement in the port area. Therefore, it is necessary to design an effective highway structure for accommodate the traffic loads exceed during the service period. Especially for Trisakti port access road which is an important port in South Kalimantan.

Alongside with pavement technology development, there are many methods for thickness layer pavement design. Therefore, the Directorate General of Bina Marga trying to develop the design method in appropriate with the characteristics of Indonesia region.

Some of the pavement design methods that used in Indonesia are the Bina Marga method (Pt T-01-2002 B) and the Pavement Design Manual (No.04 / SE / Db / 2017). Bina Marga method (Pt-T-01-2002-B) is a method issued in 2002 which refers to the AASTHO 1993 method. Comparative result Bina Marga 2013 method and AASTHO 1993 method was obtained that Bina Marga 2013 method is more effective than AASTHO 1993 method, that because the design parameter assumptions is more simple than AASTHO 1993 method [7].

The pavement design manual (No.04 / SE / Db / 2017) is the result of a revision from Directorate General of Bina Marga in 2013. There have been several changes on this method when that compared with the previous method. Therefore, the comparative study should be done by using other methods to determine the effectiveness for design.

The purpose of this study was to compare the results of pavement thickness calculation using Bina Marga method (Pt T-01-2002 B) and Pavement design manual (No. 04 / SE / Db / 2017). Pavement design manual that used in this study is a revision of the previous version that releases in 2013

2. METHODOLOGY RESEARCH

The work program of this research described in a flowchart shown in Fig. 1. There are two methods used in this paper, Bina Marga method (Pt T-01-2002-B) and Pavement Design Manual 2017.

Bina Marga Method (Pt T-01-2002 B) Analysis

The analysis process using Bina Marga method (Pt T-01-2002 B) has illustrated with the flowchart in Fig. 2. For traffic data, will use for ESAL (equivalent single axle load) calculation. So, that the results in load repetition during the design period.

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In determining the equivalent number required assumption structure number (SN) value. SN assumption is the control for determining SN of flexible pavement. If that result SN was not equal with the assumption SN then it is necessary to repeat the equivalent number calculation with the other SN assumption [1].

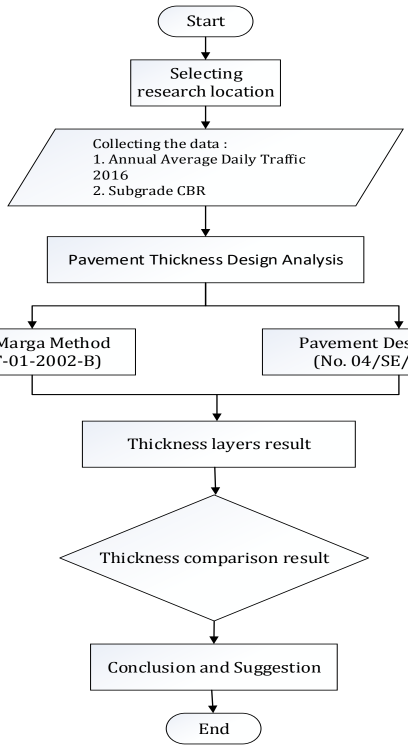

Figure. 1. Research Flow chart

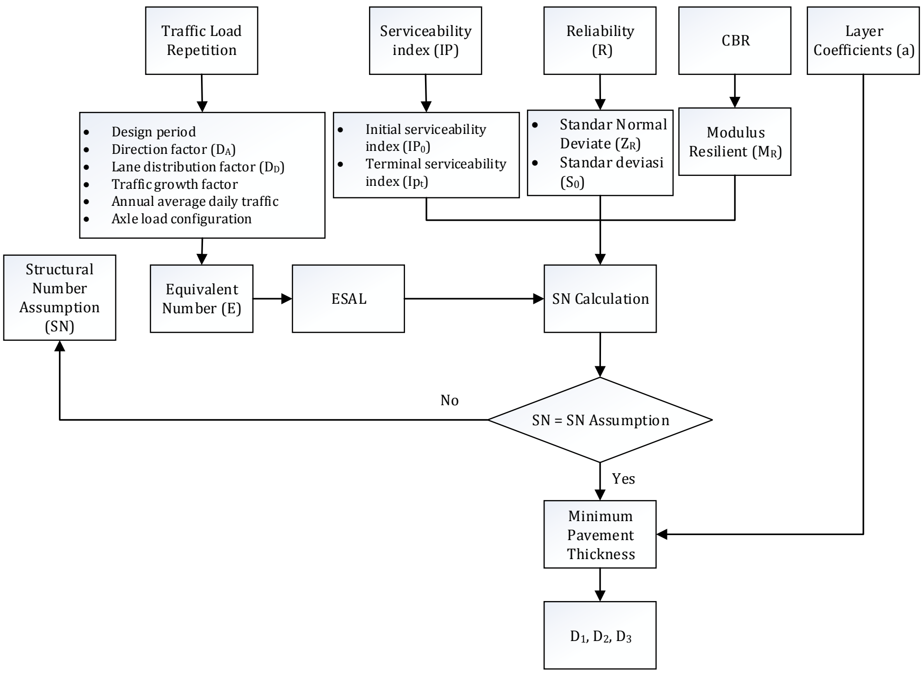

Figure. 2. Bina Marga method (Pt T-01-2002 B) flowchart analysis

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In determining of the thickness layers, is based on the minimum thickness of the pavement design according to the Bina Marga method (Pt T-01-2002 B). If the thickness result is smaller than the minimum, then used the minimum for design [2]

Pavement Design Manual Method (No. 04/SE/Db/2017) Analysis

The analysis process using Pavement Design Manual method (No. 04/SE/Db/2017) is illustrated in the flowchart in Fig. 3. Traffic loads calculation in this method uses multiplier coefficients based on Vehicle Damage Factor (VDF). VDF is a coefficient was obtained from the Weight In Motion (WIM) study when conducted in 2011/2012 in several regions in Indonesia [3].

The minimum thickness determination on this method is based on the value of subgrade CBR. If the thickness obtained from the Cummulative Single Axle Load (CESA) calculation is smaller then used the minimum thickness.

3. DATA PRESENTATION

The case study location was accessed road of Trisakti port (Trisakti - Liang Anggang) STA 10 + 300 - STA 23 + 300. Annual average daily traffic data as presented by table 1 was a data from traffic survey in 2016, so that necessary to forecast the data before analysis with the design period.

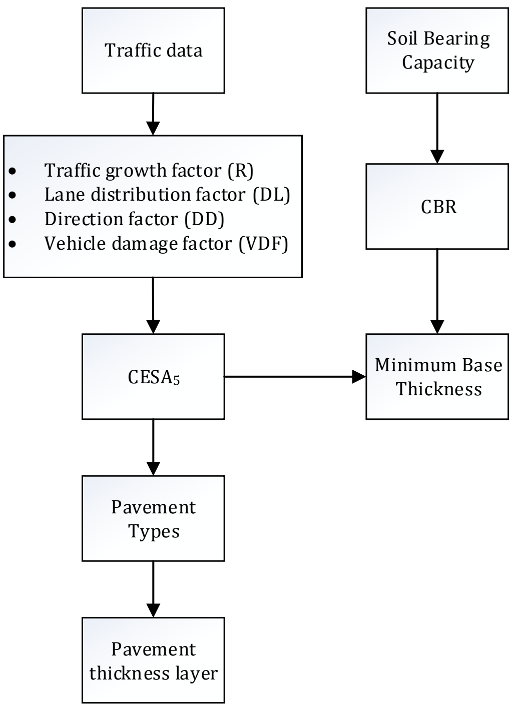

Figure. 3. Pavement design manual method (No. 04/SE/Db/2017) flow chart analysis

Table 1. Annual average daily traffic data

Vehicle Types		AADT 2016
Bus – small	5a	104
Bus - large	5b	8
Two axle truck – light cargo	6a.1	111
Two axle truck – light	6a.2	280
Two axle truck – medium cargo	6b1.1	25
Two axle truck – medium	6b1.2	76
Two axle truck – heavy cargo	6b2.1	139
Two axle truck – heavy	6b2.2	113
Three axle truck – light	7a1	71
Three axle truck – medium	7a2	16
Three axle truck – heavy	7a3	70
Two axle truck and double road train	7b	9
Four axle truck – Trailer	7c1	52
Five axle truck – Trailer	7c2.1	5
Five axle truck – Trailer	7c2.2	3
Six axle truck – Trailer	7c3	2

The CBR design used in this study is 3,8%. This data is obtained from a survey with dynamic cone penetration meter in 2016 then analyzed graphically for CBR design value that representing the segment.

4. DATA ANALYSIS

Bina Marga Method (Pt T-01-2002 B)

Vehicle equivalent number analysis was using the empirical formula based on AASTHO 1993 method, which caused by the IP_0 assumtion of 4 and IPt of 2,5 for the mayor road [4]. While SN assumption that used is 5,9. That equivalent number result then used to Equivalent single axle load (ESAL) calculation. ESAL is standard axle repetition line during the design period. ESAL is obtained by using Eq.1 [2].

$$W18 = \sum \mathrm{AADT_i} \times \mathrm{e} \times \mathrm{DA} \times \mathrm{DD} \times 365 \times \mathrm{N}$$

The direction factor (DA) was assumed to be 0,5 as the sections considered are two-way roads. The lane distribution factor (DD) was assumed to be 1. The life design factor (N) was obtained from life design and traffic growth factor calculation, so that the result of N value is 33,559. ESAL calculation results for each vehicle can be seen in table 2.

Reliability (R) is the probability that the pavement designed will perform satisfactorily

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during the design period [5]. The large value of R will show a good performance of pavement, however the thickness result will be large. The reliability level used for SN calculation is assumed to be 85% for urban arterial road classification with a deviate standard normal (Z_R) value of -1,037 and the standard deviation suggested in AASTHO 1993 method is 0,45 for flexible pavements [4].

Table 2. ESAL for each vehicle

Vehicle Types	AADT 2017	Load (ton)	Vehicle equivalent	ESAL
Bus – small	109,3	5	0,0331	2,21E+04
Bus – large	8,4	8	0,2420	1,25E+04
Two axle truck – light cargo	116,7	10	0,6324	4,52E+05
Two axle truck – light	294,4	10	0,6324	1,14E+06
Two axle truck – medium cargo	26,3	10	0,6324	1,02E+05
Two axle truck – medium	79,9	10	0,6324	3,09E+05
Two axle truck – heavy cargo	146,1	13	1,9375	1,73E+06
Two axle truck – heavy	118,8	13	1,9375	1,41E+06
Three axle truck – light	74,6	20	11,0626	5,06E+06
Three axle truck – medium	16,8	21	13,3329	1,37E+06
Three axle truck – heavy	73,6	22	15,9146	7,17E+06
Two axle truck and double road train	9,5	30	3,3788	1,96E+05
Four axle truck – Trailer	54,7	34	10,2320	3,43E+06
Five axle truck – Trailer	5,3	37	14,2855	4,60E+05
Five axle truck – Trailer	3,2	40	19,3321	3,73E+05
Six axle truck – Trailer	2,1	43	25,4976	3,28E+05
			ESAL Cum	**2,36E+07**

The resilient modulus (MR) is the quantity to determine the soil's ability resistance deformation from load repetitions [5]. The resilient modulus can be determined by conducting a CBR field test using a dynamic cone penetration meter. The result of the CBR design calculation at this location is 3.8% then multiplied by 1500 psi, so that subgrade resilient modulus is 5700 psi.

Structural number (SN) or better known as pavement thickness index (ITP) is a value derived from the amount of repetition loading, soil bearing capacity and regional factors. To determine the value of SN can use Eq. 2.[2]

$$LogW_{18} = Z_R(S_o) + 9{,}36Log(SN+1) - 0{,}2 + \frac{Log\left[\frac{\Delta PSI}{4{,}2-1{,}5}\right]}{0{,}4+\frac{1094}{(SN+1)^{5.19}}}$$

$$+2{,}32LogM_R - 8{,}07$$

From the calculation of SN values by using solver tools in excel program had obtained SN value of 5,9. SN result value is equal to SN assumption that used in the determination of the vehicle equivalent number.

The layer coefficient is the empirical relationship between SN for a pavement structure and layer thickness, which expresses the relatives ability of a material to function as a structural component of the pavement [6]. Based on the Bina marga method (Pt T-01-2002-B) which refers to AASTHO 1993 method got the coefficient value of pavement layer following:

- Surface layer (Laston) with a value of a_1 = 0,4 (Elastic Modulus = 360000 psi)
- Base layer (Stone crush class A) with the value a_2 = 0,14 (Modulus of Elasticity = 30700 psi)
- Subbase layer (sirtu class C) with value a_3 = 0,11 (Modulus of Elasticity = 15170 psi)

Using Eq. 2 we can determined SN value for each layer that are SN_1 of 1,2; SN_2 of 3,3 and SN_3 of 4,3. That SN numbers can be used to determine the thickness of each pavement layer using Eq.3 – Eq. 8 [2]

$$D1 = \frac{SN_1}{a_1}$$

SN1* = a1 x D1

$$D2 = \frac{(SN_2 - SN_1^*)}{a_2 x n_2}$$

SN2* = a2 x m2 x D2

SN1* + SN2* ≥ SN2

$$D3^* = \frac{SN_3 - (SN_1^* + SN_2^*)}{a_3 m_1}$$

So that the thickness of each pavement layer is 8.75 cm for D_1 layer, 5,5 cm for D_2 layer and 15 cm for D_3 layer which has been adjusted to minimum thickness as required by Bina marga method (Pt T-01-2002-B).

Pavement design manual (No.04/SE/ Db / 2017)

The traffic growth factor for standard axis load calculation used growth data series was contained in pavement design manual (No. 04 / SE / Db / 2017) to 5,14% for the urban arterial road of Kalimantan region. Then the values are used for cumulative equivalent single axle load (CESAL) calculation using Eq. 9 [3]. The result of $CESA_5$ calculation of each vehicle can be seen in table 3.

$$ESA_5 = \left(\sum AADT_{JK} \times VDF_{JK}\right) \times 365 \times DD \times DL \times R$$

Caused by the average CBR value obtained from dynamic cone penetration test, which needs to adjustments. This is because the bearing capacity test with DCP does not give equal results as a laboratory test. So that CBR design value becomes 3% after multiplied by the minimum adjustment CBR factor value based on DCP testing in pavement design manual method (No. 04 / SE / Db / 2017).

Based on the values of CBR and $CESA_5$, a minimum thickness of the foundation layer to 300 mm. Furthermore, with $CESA_5$ value can be determined the type of pavement design for the road segment is AC with a layer of grained foundation, So based on the type of pavement obtained thickness layer are AC-WC layer of 40 mm, AC-BC layer of 60 mm, AC- Base of 145 mm and for Class A LPA of 300 mm.

Table 3. Axis load standart cumulative result

Vehicle Types	AADT 2016	AADT 2017	AADT 2020	VDF_5 Factual	VDF_5 Normal	ESA_5 ('17-'19)	ESA_5 ('20-'37)
5a	104	109,3	120,9	1	1	3,99E+04	4,14E+05
5b	8	8,4	9,3	1	1	3,07E+03	3,19E+04
6a.1	111	116,7	129,0	0,5	0,5	2,13E+04	2,21E+05
6a.2	280	294,4	325,4	0,5	0,5	5,37E+04	5,58E+05
6b1.1	25	26,3	29,1	8,5	4,7	8,16E+04	4,68E+05
6b1.2	76	79,9	88,3	8,5	4,7	2,48E+05	1,42E+06
6b2.1	139	146,1	161,6	8,5	4,7	4,54E+05	2,60E+06
6b2.2	113	118,8	131,3	8,5	4,7	3,69E+05	2,12E+06
7a1	71	74,6	82,5	18,3	5,3	4,99E+05	1,50E+06
7a2	16	16,8	18,6	17,7	5,4	1,09E+05	3,44E+05
7a3	70	73,6	81,4	17,7	5,4	4,76E+05	1,51E+06
7b	9	9,5	10,5	18,2	13	6,29E+04	4,66E+05
7c1	52	54,7	60,4	20,4	10,2	4,07E+05	2,11E+06
7c2.1	5	5,3	5,8	14,7	5,2	2,82E+04	1,04E+05
7c2.2	3	3,2	3,5	24,2	8,5	2,79E+04	1,02E+05
7c3	2	2,1	2,3	22,9	15	1,76E+04	1,20E+05
					ESA_5	**2,90E+06**	**1,41E+07**
				$CESA_5$('17-'37)		**1,70E+07**	

4.1. Comparison pavement layer result

From table 4 shows the result between two methods that has been used, it clear that manual pavement method (No. 04 / SE / Db / 2017) is more thick on the surface layer and the base soil layer than Bina Marga method (Pt T-01-2002 B). In addition, there are differences in the traffic load result, which is using Bina Marga method (Pt T-01-2002 B) produced ESAL is more bigger than pavement design manual method (No. 04 / SE / Db / 2017).

In the calculation of pavement layer thickness using Pt T-01-2002 B method depended on SN value and SN value assumption. Where SN assumptions also affect the calculation of ESAL, if SN not equal as SN assumption then SN assumption value needs to be replaced

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until the value of SN is produced equal to SN assumption value. In addition, the equations used to determine the SN value of pavement have also accommodated subgrade resilient modulus.

Thickness layers calculation using pavement design manual (No. 04 / SE / Db / 2017) has depends on the ESAL value. If the ESAL value is bigger, so that the thickness result will be thick. This design method process has been accommodated the load design of pavement structures by value of critical strain that occurs when analyzing the pavement structure design.

Table 4. Thickness Layers Comparison

Thickness layers (cm)	Bina Marga Method (Pt T-01-2002-B)	Pavement Design Manual 2017 (No.04/SE/Db/2017)
D1	8.75	24.5
D2	5.5	3
D3	15	28

5. CONCLUSIONS DAN SUGGESTION

Based on the results of the analysis in the can summarize some conclusions below:

1. By using Pt T-01-2002 B method, the thickness of each pavement layer are 8.75 cm for laston surface layer, 5.5 cm for LPA class A, and 15 cm for LPB class C.
2. By using the Pavement Design Manual method (No. 04 / SE / Db / 2017), the thickness of each layer are 4 cm for AC-WC pavement layer, 6 cm for AC-BC layer, 14.5 cm fo AC-Base layer and 30 cm for LPA class A.
3. Based on the result of both method, thickness design layer from Pavement Design Manual is more thick than the thickness from bina marga method

The suggestions from this research can be are as:

1. For future research should be added evaluation for structural and functional for pavement design with other methods or another co0ndition.
2. A cost analysis analysis of the construction is required to know which methods is more effective can be used for pavement design.

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