THE EFFECT OF CBR VALUES ON THE SUBGRADE LAYER ON RUTTING DEPTH ON FINE CRACKS IN ASPHALT PAVEMENTS

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Abstract

Problems in the basic soil layer, which is generally sandy soil will greatly affect the life of the planned cracking and rutting in the construction of the paved layer. The purpose of this study was to determine the effect of CBR values on the Subgrade layer on the life of the paved road pavement plan until there began to be a fine crack on the paved road surface and predict the depth of rutting on the road surface when fine cracks began to occur. The method used in this study is the Determination of TYN and RDM Values using the HDM III. Based on the results of the analysis, it can be seen that the higher the CBR value, the longer it takes for a pavement to experience fine cracks as well as at the life of plans of 10, 15, and 20 years where the CBR value is directly proportional to the length of time a fine crack occurs. Predicted intensity of rutting (Decrease) at the time of the fine crack at the age of the 5-year plan, there was a decrease of 3.01 mm after 8.14 years of the road being opened. At the age of the 20-year plan, the value decreased by 2.33 mm after 5.438 years of the road being opened.

Keywords: CBR, Fine Cracks, Design life, TYN, Rutting

INTRODUCTION

In the Pantoloan Region, there is a Special Economic Zone (SEZ) which has an impact on increasing traffic flow. With high traffic, flexible road construction needs to be well planned so that it can bear the load that passes on it. In flexible road construction, we often encounter changes in the shape of the road surface such as cracks on the surface, potholes and road rutting. Problems in the Subgrade, which in general is sandy soil (Lose Sand) will greatly affect the design life of the occurrence of cracks and rutting in the construction of the asphalt layer. One of the factors causing the decline in the road area is the weakness of the subgrade.

Need for the study

To determine the effect of the CBR value on the Subgrade layer on the design life of the asphalt road pavement until fine cracks begin to occur on the asphalt road surface. Predict the rutting depth on the paved road surface when fine cracks begin to occur.

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METHODOLOGY

The research location is on the Tawaeli - Pantoloan road, Central Sulawesi Province. Meanwhile, when the traffic survey was conducted for 5 days, namely 4 working days and 1 holiday, the traffic survey was carried out for 16 hours, starting at 06.00 in the morning until 22.00 at night.

Primary Data
ADT data survey ADT data is obtained from vehicle surveys, which are carried out manually by surveyors at observation points on the Pantoloan road section. From this road section, traffic data is taken for 16 hours, ie from 6 am to 10 pm.

Subgrade CBR Data (CBRsg)
CBR data retrieval is carried out directly in the field (field CBR) using the DCP tool.

Secondary Data
In the form of a location map obtained from google earth. For existing road data and CBR sub base and CBR base data obtained from the Balai Jalan Nasional XIV. For the data on the density of the asphalt layer and the volumetric data of the asphalt mixture obtained from previous studies which are in accordance with the aggregates used on the Tawaeli-Pantoloan road section.

Data analysis
Value of Elastic Modulus (Stiffness) Asphalt Concrete, Sme Factors that affect the stiffness value of asphalt concrete are the stiffness of asphalt as a binding material and the density level of the mixture expressed in VMA.

Traffic Survey Results Data
Traffic survey data obtained from the calculation results of the equations, which include the equivalent figures for vehicle axle load (E), daily cumulative standard axle load (w18 days), annual cumulative standard axle load (w18 years), and standard axle load for the design lane during the design life (Wt)

Crack Prediction Models (Cracking Models)

The cracks that will be discussed in this study are structural cracks. Pavement structures that carry high traffic loads and continuously will cause a decrease in the quality of the pavement structure. Structural crack damage is one type of damage that often (dominant) occurs in road pavement structures. The main factor that causes structural cracks is due to the accumulation of traffic loads that the pavement structure is no longer able to bear. Crack damage that occurs in the pavement structure over time will cause holes if not repaired at the right time. Therefore, a model is needed that can predict crack damage in a pavement structure.

The following models have been developed to predict cracks on the pavement surface model, (Molenaar, 1994).

$$TYN = 4.21 \exp(0.139\ SNC - 17.1\ YE4/SNC2) \quad (1)$$

where:
TYN : The expected length of time will last until the initiation of cracking on the pavement (years).
SNC : Modified Structural Number
YE4 : Annual traffic load (millions 80 kN ESAL, damage factor 4)

The above model makes it possible to predict the initial period of narrow cracking since construction was opened to the public. The appearance of fine cracks in a limited number is not a reason to carry out repairs (maintenance) if the cracks can still be handled easily through crack filling. However, this condition can become critical when larger cracks (wide cracks) appear which turn into formations resembling potholes.

Pavement Characteristics According to HDM III

Based on various studies in several developing countries, the World Bank has developed a model that allows predicting cracking, known as the High Way Model (HDM) III, where the pavement strength is characterized using a "structural number (SNC)".

$$SNC = 0.04\sum ai\ hi + SNsg \quad (2)$$

where, SNC : Modified structural number
ai : Material and layer strength coefficient
hi : Pavement layer thickness (mm)
SNsg : 3.51 log CBR – 0.85 (log CBR)2 – 1.43
CBR : In situ CBR (Molenar, 1994)

FINDINGS

CBR Subgrade

Subgrade CBR data retrieval using a DCP (Dynamic Cone Penetrometer) tool data collection was carried out in the rainy season so that the original data was multiplied by the Correction Factor of 0.9

Table 1. CBR Subgrade

No	CBR (%)	FK	CBR used
1	4.02	0.9	3.618
2	4.47	0.9	4.023
3	4.58	0.9	4.122
4	5.58	0.9	5.022
5	7.41	0.9	6.669
6	7.44	0.9	6.696
7	10.8	0.9	9.72
8	11.9	0.9	10.71

No	CBR (%)	FK	CBR used
9	12.22	0.9	10.998
10	12.43	0.9	11.187
11	13.78	0.9	12.402
12	15.37	0.9	13.833

From the twelve CBR data above, four representative CBR values were taken to be used in the calculation of data analysis. CBR data are 3.618%, 6669%, 10.71% and 13.833%, respectively.

Traffic Survey

Table 2. Traffic Survey Results

No.	Vehicles Type	Class	LHR (Vehicles / day)
1	Motorcycle	1	7452
2	Sedans, Jeeps	2	2260
3	Pick Up, Public Transport	3	290
4	Pick Up Box	4	299
5	Small Bus	5a	10
6	Big Bus	5b	2
7	2 Axis Light Truck	6a	398
8	2 Axis Medium Truck	6b	489
9	3 Axis Truck	7a	341
10	Trailer Truck	7b	16
11	Semi-Trailer Truck	7c	18
12	Non-Motorized Vehicles	8	20

Table 3. UPPKB Kayumalue Vehicle Data Date 30 July 2020

Class	Vehicles Type	Axis Configuration	JBI (Ton)	Vehicles / Day	Total Weight (Ton)	Weight Overload (Ton)	Overload (%)
4	Pick Up, Public Transport	1.1	1950	20	2810	860	44.103
6a	2 Axis light truck	1.2	8000	40	10928.25	2928.25	36.603
6b	2 Axis Medium truck	1.2	14050	1	20540	6490	46.192
7a	3 Axle Truck	1.2.2	19380	1	28970	9590	49.484

Cumulative Standard Axle Load Calculation

Table 4. Standard axle load

No	Vehicle Type	Cl	LHR 2020	VDF 5 Normal	ESA5 (2020-2025)	ESA5 (2020-2030)	ESA5 (2020-2035)	ESA5 (2020-2040)
1	Motorcycle	1	7452					
2	Sedans, Jeeps	2	2260					
3	Pick Up, City Transportation	3	290					

No	Vehicle Type	Cl	LHR 2020	VDF 5 Normal	ESA5 (2020-2025)	ESA5 (2020-2030)	ESA5 (2020-2035)	ESA5 (2020-2040)
4	Pick Up Box	4	299					
5	Small Bus	5a	10	0.2	1.81E+03	3.74E+03	5.78E+03	7.96E+03
6	Big Bus	5b	2	1	2.01E+03	4.15E+03	6.43E+03	8.85E+03
7	2 Axis Light Truck	6a	398	0.84	3.11E+05	6.41E+05	9.93E+05	1.37E+06
8	2 Axis Medium Truck	6b	489	10.42	4.77E+06	9.84E+06	1.52E+07	2.10E+07
9	3 Axis Truck	7a	341	6.7	2.14E+06	4.41E+06	6.83E+06	9.40E+06
10	Trailer Truck	7b	16	90.4	1.36E+06	2.81E+06	4.36E+06	6.00E+06
11	Semi-Trailer Truck	7c	18	8.8	1.50E+05	3.11E+05	4.81E+05	6.62E+05
12	Non-Motorized Vehicles	8	20					
	Total ESA5				8.73E+06	1.80E+07	2.79E+07	3.84E+07

From the calculation, it is obtained that the Cumulative Standard Axis Load value for each plan age; for 5-year = 8.7×10^6, 10-year = 1.8×10^7, 15-year = 2.79×10^7 and 20-year = 3.84×10^7.

Asphalt Mixture Modulus of Elasticity (Sme)

The value of the modulus of elasticity of the asphalt mixture (Sme) was obtained based on the VMA and bitumen modulus (Sb) data, the percentage of VMA obtained from the previous test. The VMA value obtained was 16.53 from the graph of the relationship between asphalt content and VMA. Based on the 2018 Bina Marga General Specifications, the minimum VMA value is 15% so that the existing data meets the specifications.

Table 5. Calculation of the Elasticity Modulus of Asphalt Mixture (Sme)

Design Life	VMA	Sb	N	257.5 - 2.5 VMA	n (VMA - 3)	Sme (Mpa)	Sme (Psi)
5	16.53	17.707	2.784	216.175	37.664	3587.974	520392.539
10	16.53	17.410	2.790	216.175	37.747	3550.502	514957.664
15	16.53	17.299	2.792	216.175	37.778	3536.542	512932.969
20	16.53	17.153	2.795	216.175	37.819	3518.007	510244.672

Calculation of Pavement Thickness

Based on the CBR value and standard axle load, the total thickness of the pavement can be known. CBR data used in the calculation of the analysis were 3.618%, 6.669%, 10.71% and 13.833%.

Table 6. Pavement Thickness Total n^{th} year

CBR (%)	Pavement Thickness Total Year -n			
	5	10	15	20
3.6	705	745	760	780
6.7	505	545	560	580
10.7	355	395	410	430
13.8	355	395	410	430

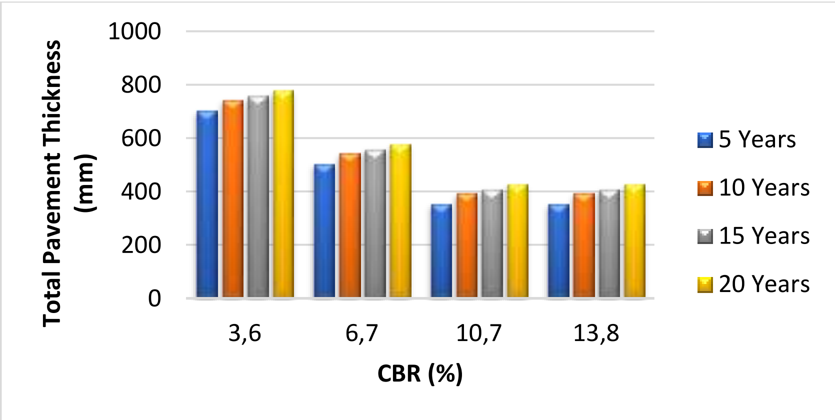

Figure 1. Effect of CBR Value on Total Pavement Thickness

Pavement Analysis to the Occurrence of Narrow Cracks (TYN), Wide Cracks (TW) and 50% Cracks

To predict the occurrence of Narrow Cracks (TYN), Wide Cracks (TW) and 50% Cracks, cumulative standard axis load data (wt) is needed for each design life, namely 5 years, 10 years, 15 years, and 20 years.

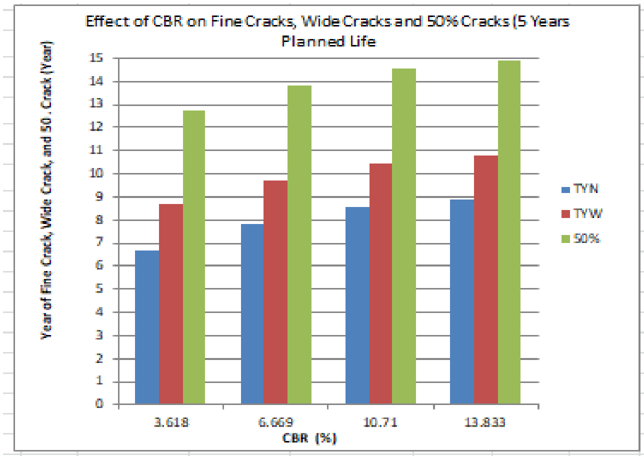

Figure 2. The Effect of CBR on Fine Cracks, Wide Cracks, and 50% Cracks for 5 Years Service

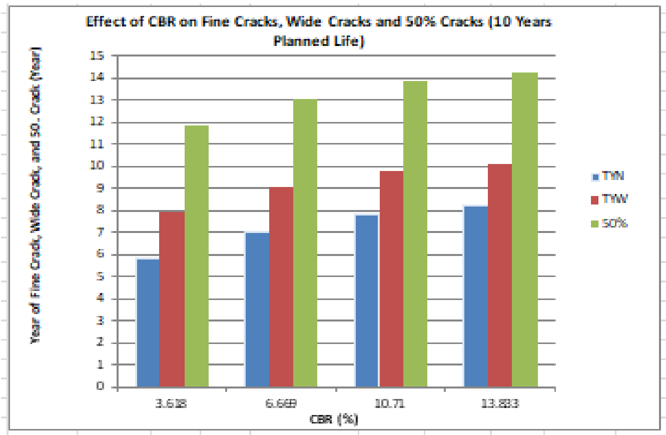

Figure 3. The Effect of CBR on Fine Cracks, Wide Cracks, and 50% Cracks for 10 Years Service

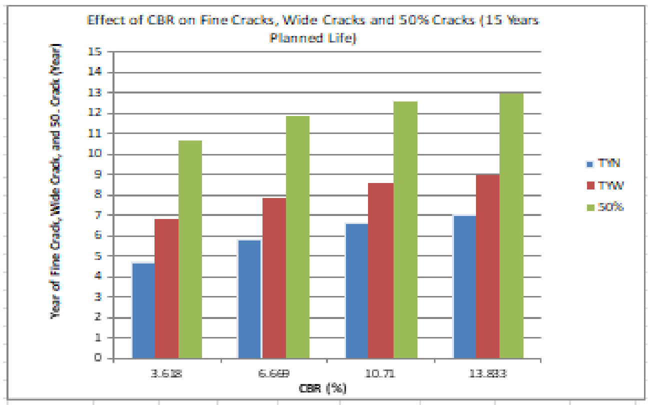

Figure 4. Effect of Peak Load on Narrow Cracks, Wide Cracks, and 50% Cracks for 15 Years Service

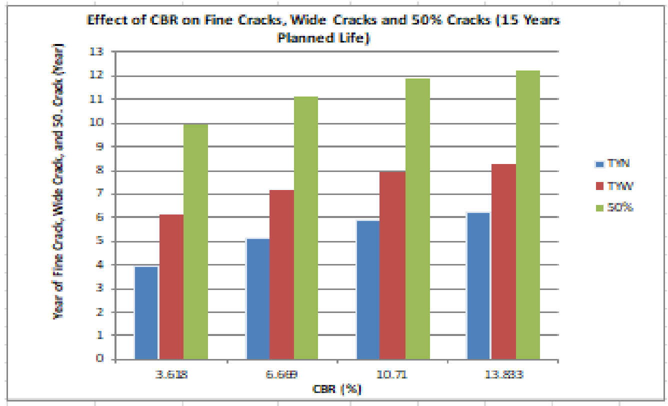

Figure 5. Effect of Peak Load on Narrow Cracks, Wide Cracks, and 50% Cracks for 20 Years Service

It can be seen that the higher the CBR value, the longer it takes for a pavement to crack, either fine cracks, wide cracks, or 50% cracks for each traffic load during the service life of 5 years, 10 years, 15 years, and 20 years.

Pavement Analysis of Narrow Cracks (TYN), Wide Cracks (TW), and 50% Cracks to Rutting Depth (RDM)

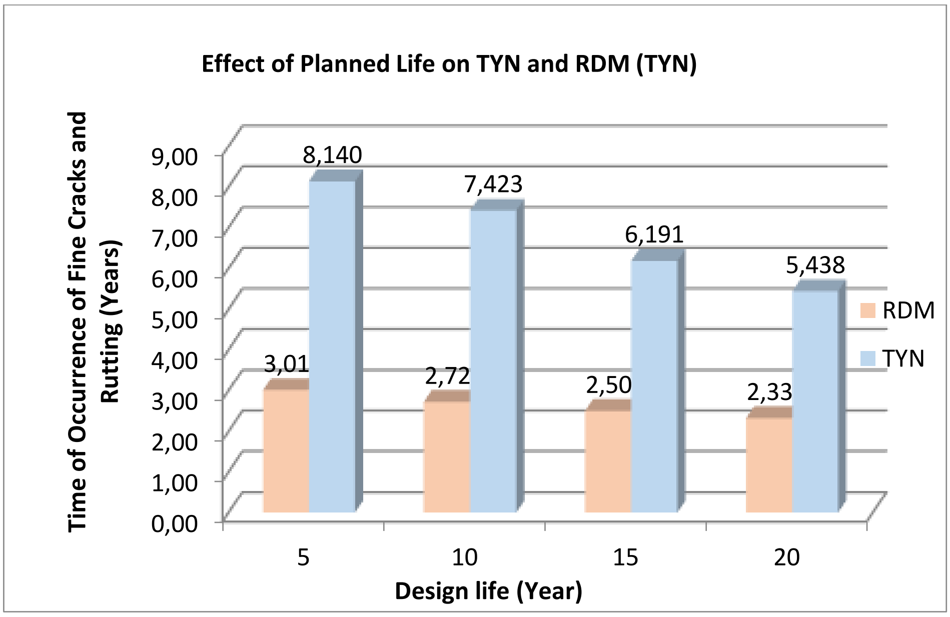

Figure 6. Effect of Planned Life on TYN and RDM

CONCLUSION

1. The higher the CBR value, the longer it takes for a pavement to crack, either fine cracks, wide cracks or 50% cracks for each traffic load during the service life of 5 years, 10 years, 15 years, and 20 years.
2. For the design life of 5 years, the predicted time for cracking occurs on average beyond the planned design life, the highest TYN value is 8.908 years and the lowest is 6.70 years. For wide cracks, the lowest occurred 10.74 years and the highest occurred 8.69 years, while the 50% crack occurred the lowest was 14.91 years and the highest occurred 12.70 years after the road was opened to public traffic.
3. For the design life of 20 years, the lowest predicted time for fine cracks was 3.977 years and the highest was 6.243 years, the lowest was 6.16 years and the highest was 8.27 years, while the 50% crack occurred at the lowest 9.98 years and the highest occurred 12.24 years after the road was opened to public traffic.
4. For the CBR value of 3.618% at the 5-year design life, the prediction time for fine cracks occurs after 6.7 years of the road being opened, and for the CBR value of

13.833%, the prediction time for fine cracks occurs after 8.908 years the road is opened. Based on the results of the analysis, it can be seen that the higher the CBR value, the longer it takes for a pavement to experience fine cracks. as well as at the design life of 10, 15, and 20 years where the CBR value is directly proportional to the length of time for fine cracks to occur.

5. Prediction of rutting intensity (decrease) at the time of the occurrence of fine cracks at the design age of 5 years, a decrease of 3.01 mm after 8.14 years the road was opened. At the design life of 20 years, the value decreased by 2.33 mm after 5.438 years the road was opened.

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