THE EFFECT OF THE ELASTICITY MODULUS OF ASPHALTED SURFACES ON RUTTING DEPTH ON NARROW CRACKING CONDITIONS

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Abstract

The increase in traffic growth on the Taweli - Pantoloan section, also increased the traffic load that passes through the section and caused rutting and cracking. The modulus elasticity is an important factor that affects the performance of asphalt pavement, therefore it is necessary to predict when narrow cracking, wide cracking, 50% cracking, and rutting will occur. HDM III is used to predict when it will occur, from CBR subgrade and annual average daily traffic data on Tawaeli – Pantoloan section, the pavement performance is planned for 5,10, 15, and 20 years. From the results of the study, it was found that the increasing road performance, the greater the value of the traffic load, which in increasing the thickness of asphalt pavement, and the faster the road will experience narrow cracking, wide cracking, and 50% cracking. Variation of modulus elasticity gives that the lower the modulus elasticity of asphalt mixture (SME), the faster the cracks occur on the asphalt pavement and vice versa. The effect of narrow cracking (TYN), wide cracking (TYW), and 50% cracking on the depth of rutting (RDM) are directly proportional.

Keywords: *Modulus Elasticity, Narrow Cracking, Wide Cracking, 50% Cracking, Rutting*

Abstrak

Pertumbuhan lalu lintas yang semakin meningkat di Ruas Jalan Taweli – Pantoloan mengakibatkan peningkatan beban lalu lintas yang melewati jalan tersebut dan mendorong terjadinya kerusakan berupa *rutting* dan retak pada perkerasan jalan. Modulus elastisitas merupakan faktor penting yang akan mempengaruhi kinerja perkerasan aspal, sehingga perlu diketahui bagaimana pengaruh modulus elastisitas terhadap prediksi waktu terjadinya kerusakan retak halus, retak lebar, retak 50% dan kedalaman rutting yang terjadi. Dalam memprediksi waktu terjadinya kerusakan terrsebut digunakan model HDM III, dari data CBR tanah dasar dan LHR di Ruas Jalan Tawaeli – Pantoloan direncanakan umur layanan selama 5, 10, 15 dan 20 tahun. Dari hasil penelitian didapatkan semakin meningkat masa layan maka semakin besar nilai beban lalu lintasnya, mengakibatkan semakin tebal lapis permukaan beraspal dan semakin cepat jalan tersebut diprediksi mengalami retak halus, retak lebar dan retak 50%. Dengan variasi modulus elastisitas didapatkan semakin rendah nilai modulus elastisitas campuran beraspal (Sme) maka semakin cepat terjadinya retak pada suatu perkerasan jalan dalam melayani beban lalu lintas yang ada dan begitu sebaliknya. Pengaruh Retak Halus (TYN), Retak Lebar (TYW) dan Retak 50% terhadap kedalaman *Rutting* (RDM) yaitu semakin lama masa layan suatu jalan sampai terjadinya retak halus, retak lebar dan retak 50% maka semakin dalam *rutting* yang terjadi.

Kata Kunci : Modulus Elastisitas, Retak Halus, Retak Lebar, Retak 50%, *Rutting*

INTRODUCTION

Pantoloan – Tawaeli section is part of the national road section, there are several essential government assets including the Custom Office and the main port of Pantoloan, which is the gateway to the economy of Central Sulawesi Province that integrated with KEK (Special

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Economic Zone). This area was designed by the government as an integrated logistics center and industry in Central Sulawesi. Pantoloan – Tawaeli section is also connecting between capital city to Tolitoli and Buol Regency. As a result, high traffic and a variety of vehicles pass along this section, from motorcycles to heavy vehicles.

The Increase in traffic loads caused early damage in the form of cracks and deformation of the pavement. Therefore, the road pavement must be planned to provide maximum service. Besides the quality of the mix design and aggregate gradation, the pavement thickness also affects road performance. Currently, road pavement thickness has used the modulus of elasticity to determine the coefficient of road pavement layers (AASHTO, 1993). The modulus of elasticity is an important factor that will affect the performance of asphalt pavements. If the modulus of elasticity of the material begins to decrease, the asphalt pavement will crack easily under heavy vehicle loads. Damage to pavement also occurs if there is a traffic jam which increases the loading time of the road pavement layer so that will be easily damaged (Widodo and Setyaningsih).

In predicting pavement damage in the form of cracks and rutting, the third generation Highway Development and Management (HDM) model can be used. HDM-III was developed by the World Bank in 1968, as a precursor to a fully integrated road investment assessment for developing countries and to develop a system for evaluating the effects of construction and maintenance standards on vehicle operating costs for low-volume roads. By using the HDM-III model, it is expected to be able to predict the occurrence of cracks and rutting that occur in the Pantoloan – Tawaeli section based on a load of passing vehicles with the variation of modulus elasticity.

RESEARCH METHOD

This study uses a survey method by taking traffic data located in Pantoloan – Tawaeli section. Traffic volume data for 2016 - 2019 was obtained from Balai Pelaksanaan Jalan Nasional Propinsi Sulawesi Tengah (BPJN), while annual average daily traffic (AADT) in 2020 was obtained by conducting a traffic survey. The traffic survey is conducted for 2 days and carried out for 16 hours, starting at 06.00 am until 10.00 pm.

The CBR data was obtained from DCP testing on the section. Traffic load data from 2015 – 2019 was obtained from Kementerian Perhubungan Direktorat Jendral Hubungan Darat UPTD Wilayah XX Provinsi Sulawesi Tengah, Satuan Pelayanan UPPKB Kayu Malue.

RESULT

Table 1. Annual Average Daily Traffic 2020

No.	Type of Vehicle	Group	AADT 2020
1	Motorcycle	1	7452
2	Sedans, Jeeps	2	2260
3	Pick Up, City Transportation	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	7a1	341
10	Trailer Truck	7b	16
11	Semi-Trailer Truck	7c1	18
12	Non-Motorized Vehicles	8	20

Table 2. Vehicle Load Data from UPPKB Kayumalue 30 July 2020

Group	Transportation Type	Axis Configuration	JBI (Ton)	Vehicles/ Day	Total Weight (Ton)	Overload (Ton)	Overload (%)
4	Pick Up	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	2	20540	6490	46.192
7a	3 Axis Truck	1.2.2	19380	1	28970	9590	49.484

Table 3. Traffic Growth Value (i)

No.	Transportation Type	Group	ADT 2017	ADT 2018	ADT 2019
1	Motorcycle	1	16871	16854	17451
2	Sedans, Jeeps	2	619		2675
3	Pick Up, City Transportation	3	2295	4516	453
4	Pick Up Box	4	1382		1294
5	Small Bus	5a	18	10	14
6	Big Bus	5b	5	2	3
7	2 Axis Light Truck	6a	401	30	78
8	2 Axis Medium Truck	6b	269	687	621
9	3 Axis Truck	7a	240	143	74
10	Trailer Truck	7b	0	5	2
11	Semi-Trailer Truck	7c	257	88	3
12	Non-Motorized Vehicles	8	47	0	13
	Amount		22404	22335	22681
	$x = ADT_n / ADT_{n-1}$			0.9969	1.0155
	$\sqrt[n]{x}$			0.9969	1.0155
	$\sqrt[n]{x} - 1$			-0.003	0.015
	i (%)			-0.308	1.549
	i (%) a year			1.241	

Determining the thickness of the pavement layer based on Manual Desain Perkerasan (MDP) 2017, based on ESA 5 uses for flexible pavement design (relate to fatigue asphalt concrete factor in design with empirical mechanistic approach). The cumulative standard axis load for each design age is presented in table 4.

Table 4. Cumulative Standard Axis Load for each Design Life

Pavement Age	5	10	15	20
I	1.24%	1.24%	1.24%	1.24%
R	5.126	10.577	16.376	22.543
CESA	8.73E+06	1.80E+07	2.79E+07	3.84E+07

The Thickness of the pavement layer is determined based on cumulative axis load on the lane so that the pavement thickness for each design life is obtained in table 5.

Table 5. Cumulative Standard Axis Load for each Design Life

Pavement Age	5	10	15	20
AC-WC	40	40	40	40
AC-BC	60	60	60	60
AC-Base	105	145	160	180
Subbase	300	300	300	300
Pavement Thickness	205	245	260	280

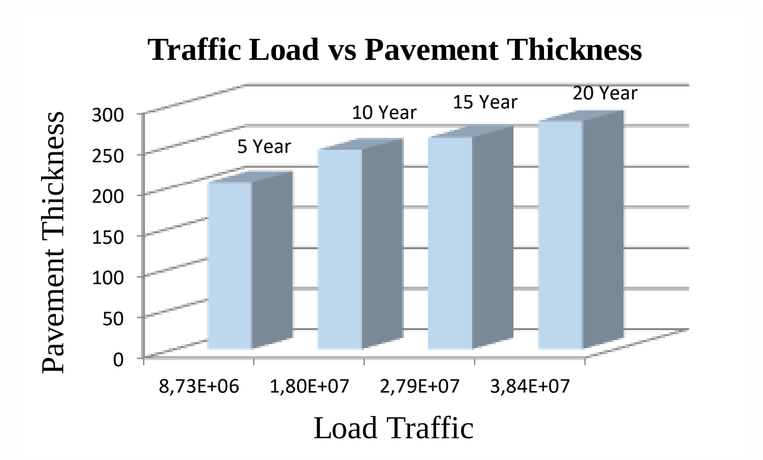

Figure 1. Graph of standard axis load with pavement age

Table 6. Modulus Elasticity of Bitumen (Sb)

Design Life	Pi (mm, 25°C, 5 Sec)	Pr	SPr	27 log Pi	76.35 log Pi	Plr	h (mm)	v (km/hour)	log t	t	Sb (Mpa)	Sb (Psi)
5	66.6	43.3	55.281	49.234	139.222	-0.2947	205	60	-1.769	0.0170	17.707	2568.23
10	66.6	43.3	55.281	49.234	139.222	-0.2947	245	60	-1.749	0.0178	17.410	2525.07
15	66.6	43.3	55.281	49.234	139.222	-0.2947	260	60	-1.741	0.0181	17.299	2509.07
20	66.6	43.3	55.281	49.234	139.222	-0.2947	280	60	-1.731	0.0186	17.153	2487.9

Modulus elasticity of bitumen (Sb) decreases with increasing pavement thickness (h), and flexible pavement thickness design is obtained based on cumulative axis load for each pavement age.

The modulus elasticity of asphalt pavement (SME) obtained VMA and the Modulus elasticity of bitumen (Sb). The percentage of VMA was obtained from the previous test, with the manufacture of a hot compacted asphalt mixture and the volumetric analysis mixture for each asphalt content.

Table 7. Modulus Elasticity of Asphalt Pavement (SME)

Pavement Age	VMA	Sb (MPa)	n	257.5 - 2.5 VMA	n (VMA - 3)	Sme (MPa)	Sme (Psi)
	17.78	17.707	2.784	213.048	41.145	2816.011	408428.597
	16.85	17.707	2.784	215.363	38.569	3362.013	487619.697
5	16.31	17.707	2.784	216.717	37.061	3750.329	543940.166
	16.34	17.707	2.784	216.661	37.122	3733.356	541478.527
	16.59	17.707	2.784	216.028	37.828	3545.530	514236.594
	17.78	17.410	2.790	213.048	41.237	2785.350	403981.593
	16.85	17.410	2.790	215.363	38.653	3326.498	482468.580
10	16.31	17.410	2.790	216.717	37.142	3711.468	538303.931
	16.34	17.410	2.790	216.661	37.204	3694.640	535863.246
	16.59	17.410	2.790	216.028	37.911	3508.423	508854.702
	17.78	17.299	2.792	213.048	41.270	2773.932	402325.504
	16.85	17.299	2.792	215.363	38.685	3313.268	480549.779
15	16.31	17.299	2.792	216.717	37.173	3696.990	536204.084
	16.34	17.299	2.792	216.661	37.234	3680.216	533771.220
	16.59	17.299	2.792	216.028	37.942	3494.600	506849.780
	17.78	17.153	2.795	213.048	41.316	2758.774	400127.120
	16.85	17.153	2.795	215.363	38.727	3295.703	478002.240
20	16.31	17.153	2.795	216.717	37.214	3677.766	533415.888
	16.34	17.153	2.795	216.661	37.275	3661.064	530993.421
	16.59	17.153	2.795	216.028	37.984	3476.245	504187.767

In the Prediction of the occurrence of Narrow Cracking (TYN), Wide Cracking (TYW), and 50% Cracking, cumulative standard axis load data is needed for each pavement design (5, 10, 15, and 20 years)

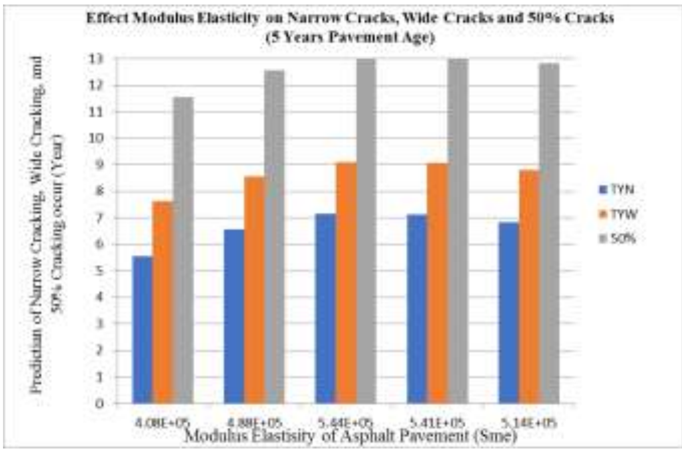

Figure 2. Effect Modulus Elasticity on Narrow Cracks, Wide Cracks, and 50 5 cracks (5 years pavement age)

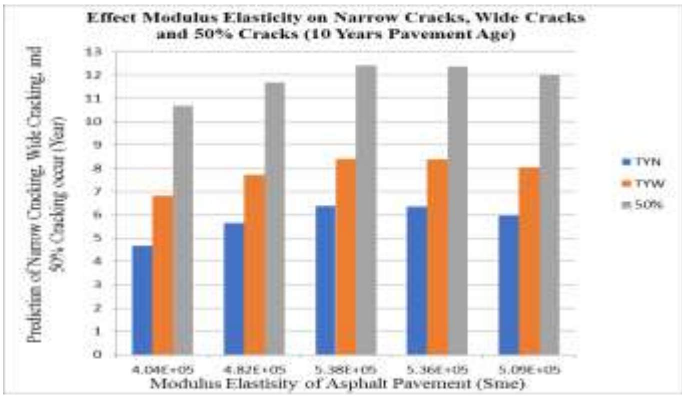

Figure 3. Effect Modulus Elasticity on Narrow Cracks, Wide Cracks, and 50 5 cracks (10 years pavement age)

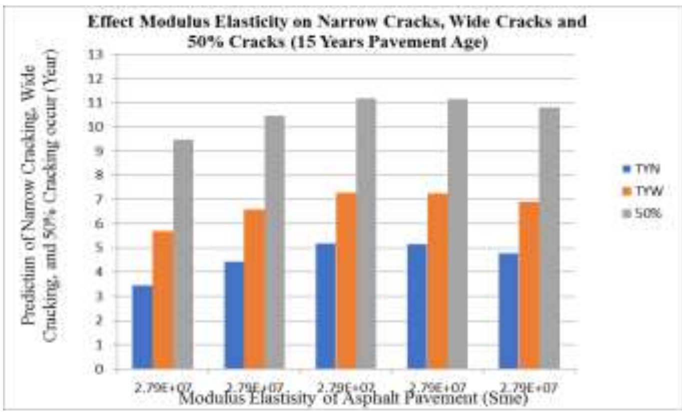

Figure 4. Effect Modulus Elasticity on Narrow Cracks, Wide Cracks, and 50 5 cracks (15 years pavement age)

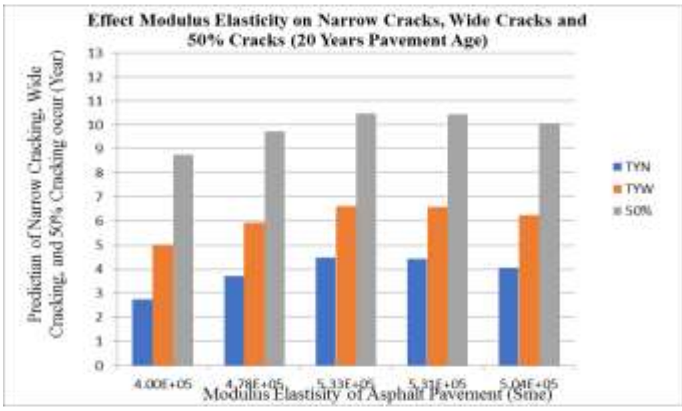

Figure 5. Effect Modulus Elasticity on Narrow Cracks, Wide Cracks, and 50 5 cracks (20 years pavement age)

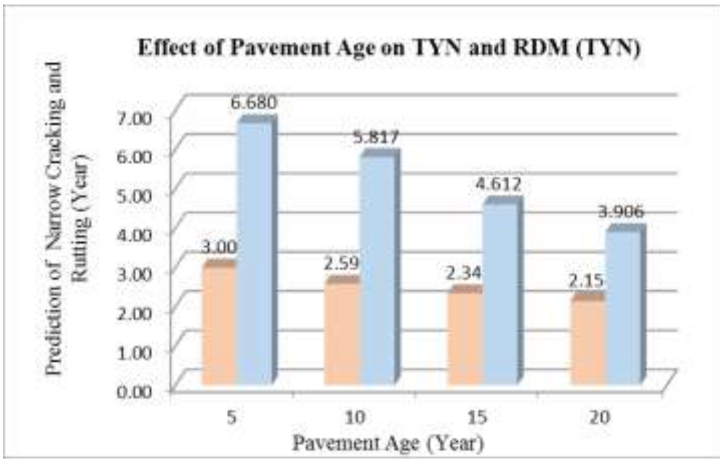

Figure 6. Effect pavement age on TYN and RDM

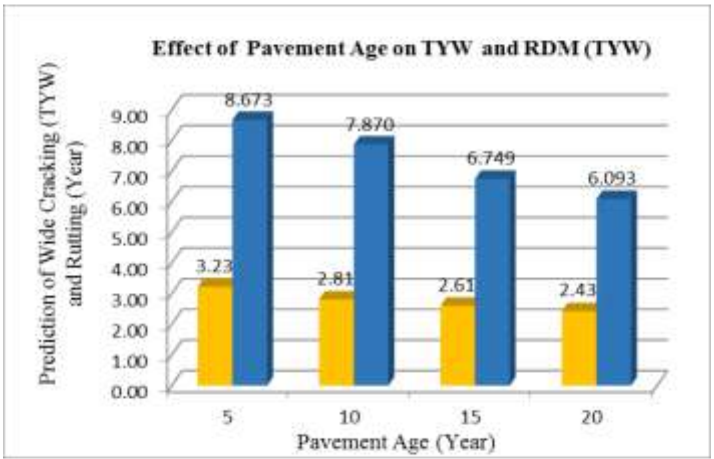

Figure 7. Effect pavement age on TYW and RDM

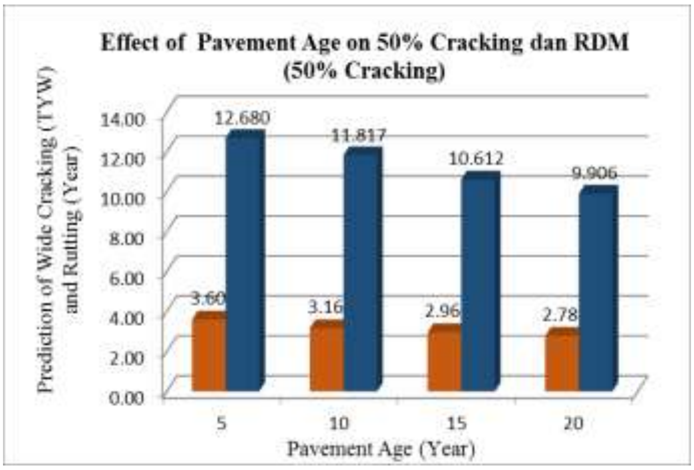

Figure 8. Effect pavement age on 50% Cracking and RDM

CONCLUSION

Based on laboratory data, traffic survey data, vehicle weight data, and CBR data, the following conclusions can be drawn:

1. Traffic survey data on Pantoloan - Tawaeli section with 1.241% annual vehicle growth obtained from traffic data in 2017, 2018, and 2019, found that the higher the service period or live performance of the section, the greater the value of the traffic load. As the traffic load increases, asphalt thickness is also thicker, and the faster the road will be predicted to experience narrow cracks, wide cracks, and 50% cracks.
   For 5 years life design, the cumulative value of axle load is 8.73×10^6 with a thickness of 205 mm. For 10 years life design, the cumulative value of axle load is 1.80×10^7 with a thickness of 245 mm. For 15 years life design, the cumulative value of the axle load is 2.79×10^7 with a thickness of 260 mm. and for 20 years life design, the cumulative value of the axle load is 3.84×10^7 with a thickness of 280 mm.
2. Effect of narrow Cracks (TYN), Wide Cracks (TYW), and 50% Cracks on the depth of rutting (RDM), namely the longer the service life of a road until narrow cracks, wide cracks, and 50% cracks occur, the deeper the rutting will be.
   - The highest rutting depth value when narrow cracks occur (TYN) is 2.99 mm at a design life of 5 years and narrow cracks occur after 6.68 years the road is opened. And the lowest rutting depth occurred at the design age of 20 years where the rutting depth is 2.15 mm and narrow cracks occurred after 3.96 years the road was opened.
   - The highest rutting depth value at the time of Wide Crack (TYW)occur is 3.21 mm at a design of 5 years and wide cracks occur after 8,673 years of the road being opened. And the lowest rutting depth occurs at the design of 20 years where the rutting depth is 2.43 mm and the Width Crack occurs after 6,093 years of the road being opened.
   - The highest value of rutting depth at 50% cracking is 3.58 mm at a design life of 5 years and 50% cracking occurs after 12,680 years of the road being opened. And

the lowest rutting depth occurs at the design age of 20 years where the rutting depth is 2.78 mm and 50% crack occurs after 9,906 years the road is opened.

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